
Fwd: EIR / FOI / SAR Request – ARIA's £56.8m “Exploring Climate Cooling” Programme & SRM Activities

----- Forwarded message -----

From: [REDACTED]

Date: Wed, 23 Jul 2025 at 19:10

Subject: EIR / FOI / SAR Request – ARIA's £56.8m “Exploring Climate Cooling” Programme & SRM Activities

To: info@aria.org.uk <info@aria.org.uk>

Dear ARIA Information Officer,

I am submitting this request under the Environmental Information Regulations 2004 (EIR). If applicable, I also request disclosure under the Freedom of Information Act 2000 (FOIA) and a Subject Access Request (SAR) under the UK GDPR/Data Protection Act 2018.

This request concerns ARIA's involvement in climate intervention research, specifically relating to solar radiation management (SRM) and the £56.8 million "Exploring Climate Cooling" programme referenced in a recent official government response I received.

The response, from a UK department, explicitly states:

> “The Advanced Research and Invention Agency (ARIA), an autonomous research and development agency sponsored by DSIT, is investing £56.8 million in their Exploring Climate Cooling programme, with the aim to begin gathering critical missing scientific data to better understand potential Earth cooling approaches and their impacts.”

In line with your legal obligations under EIR (and FOI where applicable), please provide:

♦ Information Requested:

1. All documents, planning materials, or research summaries related to the “Exploring Climate Cooling” programme, including any work involving:

Solar Radiation Management (SRM)

Stratospheric Aerosol Injection (SAI)

Marine Cloud Brightening

Albedo Modification

Aerosol-based cooling technologies

2. A breakdown of the £56.8 million funding allocation:

Which entities (private companies, universities, labs, think tanks) have received grants or contracts under this programme?

3. A list of all collaborators, research bodies, or international partners involved in the programme.

4. Any records of:

Field trials or test deployments

Proposed UK airspace experiments

Environmental risk assessments

Public engagement or consultation activities

5. Copies of any internal or external communications (emails, memos, reports) that reference SRM or climate intervention techniques.

◆ Additionally:

Please confirm whether ARIA holds or has processed any personal data relating to members of the public who have previously raised questions or concerns about solar radiation management or geoengineering, including whether ARIA has flagged or recorded any such contact. This is submitted as a Subject Access Request under UK GDPR.

If you are not the correct recipient for this request, please confirm who is, and forward it internally while maintaining the response deadlines under EIR, FOI, and SAR legislation.

I look forward to a full and timely response within 20 working days.

Yours sincerely,



Sent from Proton Mail Android

19 August 2025

Dear [REDACTED],

Environmental Information Regulations 2004 ("EIR") Request

We refer to your email dated 23 July 2025, in which you requested environmental information relating to our Exploring Climate Cooling Programme and a Subject Access Request.

We have set out our responses to your requests below. Please note that requests one and five have been dealt with together to minimise duplication.

We have responded to your Subject Access Request at the end of this letter.

Environmental information requests

"2. A breakdown of the £56.8 million funding allocation:

Which entities (private companies, universities, labs, think tanks) have received grants or contracts under this programme?"

ARIA is able to provide you with this information. A breakdown of the Exploring Climate Cooling programme's funding allocation and a list of the funding recipients is contained at Annex 1 and is available on our website: [Exploring Climate Cooling](#). You can locate the information under the heading "Funded projects", which contains details of each funding recipient, the amount of funding, the duration of funding and what is being funded as part of the award.

"3. A list of all collaborators, research bodies, or international partners involved in the programme."

ARIA is able to provide you with information about the collaborators, research bodies or international partners involved in the projects receiving ARIA funding.

This information is included at Annex 1 and is available on our website: [Exploring Climate Cooling](#).

The Exploring Climate Cooling programme is an ARIA funding programme and is not delivered jointly with other organisations. The programme has an 'Oversight Committee', consisting of a panel of experts (including international members) that is independent of the project teams and the programme director and that makes recommendations directly to ARIA's leadership. You can read more about the Oversight Committee [here](#).

"4. Any records of: Field trials or test deployments; Proposed UK airspace experiments; Environmental risk assessments; Public engagement or consultation activities"

Please note that no ARIA-funded outdoor experiments have yet taken place under ARIA's Exploring Climate Cooling programme. ARIA does not, therefore, hold records relating to field trials or test deployments that have taken place.

ARIA can instead provide you with details of the proposed controlled, small-scale outdoor experiments that it is funding. This information is included at Annex 1 and on our website: [Exploring Climate Cooling](#) (under the heading 'Controlled, small-scale outdoor experiments').

The initial proposals relating to the proposed experiments can be found on the ARIA website [here](#) (please see the heading EIR003 - Information Relating to Geoengineering). We have also included copies of the proposals at Annex 2 to this response. Please note that the proposals included at Annex 2 are only the initial research proposals provided by the funding recipients. They do not necessarily represent the final version of the activity that ARIA is funding.

More information about the detailed scope of each project and the associated outdoor experiments will be available on our website as soon as possible following finalisation. ARIA has started to publish finalised funding agreements relating to the projects on its website [here](#) - we have included copies of those agreements at Annex 3.

As mentioned above, please note that no ARIA-funded outdoor experiments have taken place in respect of our Exploring Climate Cooling programme. To date, no projects are yet at a stage where public engagement or consultation has taken place or environmental risk assessments have been undertaken. As such, ARIA does not hold these records. However, an environmental impact assessment must be performed and made publicly available before any experiment starts, and experiments will have to be developed through engagement with local

communities. All funded experiments will be time-bound and limited in size, scale so their effects dissipate within 24 hours or are fully reversible.

"1. All documents, planning materials, or research summaries related to the "Exploring Climate Cooling" programme, including any work involving: Solar Radiation Management (SRM); Stratospheric Aerosol Injection (SAI); Marine Cloud Brightening; Albedo Modification; Aerosol-based cooling technologies"

"5. Copies of any internal or external communications (emails, memos, reports) that reference SRM or climate intervention techniques."

Your requests for "[a]ll documents, planning materials, or research summaries" and "[c]opies of any internal or external communications (emails, memos, reports) that reference SRM or climate intervention techniques" would require ARIA to conduct searches across a wide range of systems to locate and retrieve the information you are seeking. This would result in an unreasonably high volume of electronic and paper records to locate, retrieve and review. This may result in ARIA being unable to respond to your request due to the associated cost and burden on resources.

Accordingly, to enable us to process your requests, we would advise you to limit the scope of your request to a narrower range of information. As ARIA has provided you with a significant quantity of material in relation to the other elements of your requests, you may be of the opinion that the information provided is sufficient.

In order to give sufficient time to limit the scope of your requests and to allow for ARIA to respond to such requests, ARIA will extend the original statutory deadline of 20 working days to 40 working days for requests 1 and 5.

Subject Access Request

"Please confirm whether ARIA holds or has processed any personal data relating to members of the public who have previously raised questions or concerns about solar radiation management or geoengineering, including whether ARIA has flagged or recorded any such contact. This is submitted as a Subject Access Request under UK GDPR."

A 'subject access request' gives individuals the right to obtain a copy of their own personal data, as well as other supplementary information, but not the information of other members of the public. If it is your intention to request a copy of the personal data that ARIA holds in respect of you, we can confirm that we only hold

the name and email address you provided in your initial request (" [REDACTED] " and " [REDACTED] ").

ARIA holds the personal data of any individuals who contact it in line with its privacy policy (available on the ARIA website [here](#)).

Yours sincerely,

ARIA

Enc.

Annex 1: Exploring Climate Cooling

Annex 2: Initial Proposals

Annex 3: Exploring Climate Cooling Contracts

You can ask us to conduct an internal review of our response to you. If you would like us to carry out a review, please let us know within 40 working days of this letter by emailing eir@aria.org.uk.

If you are still dissatisfied after our internal review, you may complain to the Information Commissioner's Office (ICO) for further investigation who can be contacted at: Information Commissioner's Office, Wycliffe House, Water Lane, Wilmslow, Cheshire, SK9 5AF.

Annex 1: Exploring Climate Cooling

Opp space: Future Proofing Our Climate and Weather

Programme: Exploring Climate Cooling



Exploring Climate Cooling

Motivated by the possibility of encountering damaging climate tipping points, and backed by £56.8m, this programme aims to transparently explore – under rigorous oversight – whether any climate cooling approaches that have been proposed as potential options to delay or avert such tipping points could ever be feasible, scalable, and safe.

[Overview](#)[FAQs](#)[Governance](#)[Funded projects](#)

Our goal

To gather critical missing scientific data to better understand potential climate cooling approaches and their impacts.

By investing in careful research today, we can build the fundamental scientific knowledge to make wiser, better-informed decisions about our future.

Why this programme

Climate change could cause global temperatures to increase by several degrees by the end of the century, which could lead to climate tipping points – abrupt changes in the Earth system that, if crossed, could have devastating and essentially irreversible consequences.

We don't know when a tipping point might happen, or how long it would take to feel the effects if it did; significant uncertainties remain regarding the probability and potential impacts of any given tipping point.

There is no substitute for decarbonisation, which is the only sustainable way to lower the chances of such tipping points and their effects from occurring.

Our current warming trajectory already makes a number of tipping points distinctly possible over the next century.

If faced with a climate tipping point, our understanding of the options available remains limited. This knowledge gap has driven increased interest in whether there are approaches (also known as “climate interventions”) that could actively reduce temperatures globally or regionally over shorter timescales.

Yet, in the absence of robust data, we currently have little understanding of whether such interventions are scientifically feasible, and what their full range of impacts might be. This programme aims to gather such data so that we can better understand these approaches and their potential effects.

How we’re doing it

As a publicly funded, non-profit agency, our research efforts are grounded in transparency, responsible stewardship, and a commitment to broad public benefit.

The programme will explore more than one potential climate cooling approach in order to be comprehensive and to allow a range of potential options to be explored thoroughly and objectively.

Successful outcomes from this programme include assessing the feasibility and risks of these approaches, as well as setting the standard for how research in this field can be conducted responsibly and inclusively. The programme will not fund, and does not support, the deployment of any climate cooling approaches.

[Read the programme thesis](#)

[Read the accessible version of the programme thesis](#)

FAQs

Why is ARIA funding this programme?

Are you funding any outdoor experiments? What do they involve?

What else are you funding (beyond outdoor experiments)?

Will the outdoor experiments begin?



What experiments do you expect to take place in the UK?



What experiments do you expect to take place outside the UK?



How will I know if an experiment is planned to take place in my local area?



Why are outdoor experiments necessary if lower risk methods, like modelling and indoor testing, are available?



What oversight measures are in place?



Have any outdoor experiments funded by ARIA taken place yet?



Are these experiments legal?



Are these experiments safe for humans and animals?



Will your experiments change the weather or seasons?



Will your experiments stop plants and crops from growing?



Are you funding activities to block the sun?



Will any of the experiments release toxic materials into the atmosphere?



Is ARIA funding the Stratospheric Aerosol Transport and Nucleation project?



Are you looking to deploy these approaches?



Oversight Committee

To ensure rigorous and responsible governance, this programme benefits from an independent Oversight Committee composed of international experts and chaired by Piers Forster. The committee advises ARIA leadership and plays a crucial role in scrutinising outdoor experiment plans, providing expert recommendations, and may advise against funding experiments unless certain modifications are made. While ultimate funding decisions rest with ARIA, the Oversight Committee has the authority to comment publicly and independently on experiment funding decisions and on other matters related to the programme and the wider field.

The committee focuses on:

- Supporting effective oversight of the programme's outdoor experiments and guiding transparent communication of findings.
- Shaping international norms and standards for the responsible governance of such experiments.
- Contributing constructively to the wider international discussion on potential governance mechanisms for climate cooling approaches.

Learn more about the Committee's remit, members, and work [here](#).

Read the Oversight Committee's note on the announcement of the Exploring Climate Cooling projects, published 7 May 2025, [here](#).

Funded projects

Our 22 funded research teams unite specialists across diverse disciplines – from atmospheric physics, chemistry, and climate modelling to chemical engineering, systems analysis, oceanography, and radiative transfer, alongside crucial expertise in governance and ethics – reflecting the programme's holistic approach. This group shares a deep commitment to objective research conducted transparently and responsibly, aiming to navigate the complex ethical dimensions and establish best practices within this field.

Projects will utilise a range of methodologies, including modelling, observations and monitoring, indoor testing and – where strictly necessary and in accordance with our oversight and governance principles – small scale, controlled outdoor experiments.

The programme will also fund projects exploring the broader societal aspects of this scientific research, including methods for public engagement, public attitudes to the field, and governance.

**All projects are subject to final contract negotiation.*

Strategic Foresight on Climate and Geopolitics: Toward governance of earth cooling approaches

Project Lead: Matthias Honegger, Centre for Future Generations

Award: £1.25 million over 17 months

Key Team Members and approximate budget breakdown: Matthias Honegger, Cynthia Scharf, Centre for Future Generations (£420k) | Trish Lavery, Australian National University Futures Hub (£150k) | Rafal Kierzenkowski, The Organisation for Economic Co-operation and Development (OECD) (£220k) | Danielle Young, University of Leeds (£460k)

Understanding if and how earth cooling approaches could be responsibly governed is critical in light of accelerating climate impacts and the risk of unwise use. This team will explore how these approaches could be responsibly governed at the global level in various future scenarios. They will start by outlining scenarios variously shaped by growing climate impacts, geopolitical challenges, the need for ongoing mitigation efforts, and the public's views. Their research will survey existing debates in both academic and policy circles, and discuss with policy makers and civil society organisations the risks, benefits and uncertainties they expect. Based on these scenarios, the project aims to develop foundational governance ideas to help ensure future decisions are socially and scientifically informed.

View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables [here](#).

How to speak about climate cooling? Co-creating an engagement toolkit in the Arctic and the UK

Award: £360k over 45 months

Key Team Members and approximate budget breakdown: Ine Steenmans + Chloe Colomer, University College London (£314k) | Cody Skahan, University of Oxford (£23k) | Albert van Wijngaarden, University of Cambridge (£23k)

Emerging climate cooling approaches raise profound ethical and societal questions. Meaningful dialogues are therefore a prerequisite for ensuring that research on, and governance of, these approaches will be just and inclusive. This is especially true in the Arctic, a region where the voices of people who will be amongst

the most impacted are often left out of conversations because of ongoing and historical power imbalances. The **ARIA** programme will explore how people want to speak about climate cooling, and how they form and change their views over time. It will move beyond social opinion research by co-designing engagement programmes with local communities and rightsholders across the Arctic and in three UK locations. Beyond the aim of empowering communities to participate more fully in governance, research, and decision-making around these new scientific approaches for cooling the earth, the learnings from these engagements will be captured in a practical, open access toolkit that can be used for future engagement projects around climate cooling.

We will publish the complete grant agreement for this project, including its key milestones, as soon as it is finalised.

Evidence-based Assessments to Guide Perceptions, Governance, and Ethical Frameworks for South Asia: Comparing Marine Cloud Brightening strategies vis-à-vis carbon dioxide removal and mitigation efforts

Project Lead: Athar Hussain, COMSATS University

Award: £574k over 3 years

Key Team Members and approximate budget breakdown: Athar Hussain, COMSATS University (£532k) | Thomas Fischer, University of Liverpool (£5k) | Sajida Kousar, International Islamic University (£8k) | Hassaan Sipra, The Alliance for Just Deliberation on Solar Geoengineering (£9k) | Muhammad Mumtaz, Fatima Jinnah Women University (£20k)

This project provides a comparative analysis of potential climate response pathways – evaluating the implications in South Asia of marine cloud brightening (MCB) against carbon dioxide removal efforts and conventional mitigation approaches. This analysis combines climate science, governance research, direct stakeholder engagement, and policy analysis, deepening our understanding of potential climate cooling technologies within the ethical, governance and social context of South Asia. This work will empower decisionmakers and communities in South Asia to develop inclusive, effective, and locally-grounded climate action strategies.

View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables [here](#).

PULSE Project: Public Understanding, Leadership, and Social Ethics in the governance of earth cooling technologies in communities impacted by volcanic activity in the Philippine context

Project Lead: Lorena Sabino, University of the Philippines Los Baños, College of Forestry and Natural Resources

£148k over 2 years



Communities in the Philippines living near volcanoes possess invaluable, real-world experience with atmospheric changes that share similar atmospheric processes to potential climate interventions like stratospheric aerosol injection (SAI). This project centers their unique perspectives, exploring the understanding, ethical viewpoints, and governance concerns surrounding such technologies directly within these communities through focused research. Gathering these insights is crucial for grounding abstract global discussions about SAI in lived reality, and ensuring that the voices of those most vulnerable to both climate change and potential interventions are central to the conversation. This work will help develop ethical, inclusive governance frameworks and foster informed climate leadership in the most affected regions.

View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables [here](#).

Ethics and Governance of Earth Cooling Research: from concepts to implementation

Project Lead: Ignacio Mastroleo, National Scientific and Technical Research Council (CONICET)

Award: £453k over 2 years

Key Team Members: Ignacio Mastroleo, Timothy Daly, María Inés Carabajal, National Scientific and Technical Research Council (CONICET) + Inter-American Institute for Global Change Research (IAI)

Researching potential Earth cooling approaches raises profound ethical and societal questions that require careful consideration and robust governance frameworks, especially ensuring diverse global perspectives are included. This project focuses on building research capacity and developing ethical frameworks, particularly within the Global South. This project will build a Latin America/Caribbean-UK research network that will address fundamental questions regarding the governance of these approaches, as well as nurturing a new community of experts in the region. The work will explore societal implications, ethics frameworks for managing trade-offs and the breadth of opinions, co-production of knowledge and regional governance, particularly in the Latin America/Caribbean context.

View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables [here](#).

GRID-CC: Global to Regional Impacts Downscaling for Climate Cooling

Project Lead: Andy Parker, The Degrees Initiative

Award: £2m over 3 years

Key Team Members and approximate budget breakdown: Andy Parker, The Degrees Initiative (£940k) | Babatunde Abiodun, Christopher Lennard, University of Cape Town (£770k) | Daniele Visoni, Cornell University (£290k)

Understanding the potential regional implications of earth cooling approaches is crucial, particularly for communities in the Global South which may be disproportionately affected. Yet, research capacity is often concentrated elsewhere. This project directly addresses this capacity gap by empowering researchers in the Global South. Through computational work, this project will build an open-access repository of detailed Global South climate data that will enable researchers to develop more accurate modelling of the global and regional impacts of these approaches. This project will create new research tools and hold expert convenings to help ensure that researchers in these regions have the evidence base to support scientifically-robust decision-making surrounding potential Earth cooling strategies.

View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables [here](#).

Ecological Impact Assessment of Earth Cooling Experiments in the Arctic (Eco-ICE)

Project Lead: Amanda Burson, British Antarctic Survey

Award: £4.9 million over 4 years

Key Team Members and approximate budget breakdown: Amanda Burson, Jeremy Wilkinson, Louise Sime, Kate Hendry, Rhiannon Jones, Clara Manno, Florence Atherden, Rachel Cavanagh, Simeon Hill, British Antarctic Survey (£4.3m) | Neven Fučkar, University of Oxford (£270k) | Dorothee Bakker, University of East Anglia (£140k) | David Schroeder, Danny Feltham, University of Reading (£130k)

Fragile polar ecosystems are critical to the global climate system, yet the potential ecological consequences of climate interventions at the poles are poorly understood. Through laboratory experiments and computer modelling, this project will provide an independent impact assessment of potential climate interventions in the Arctic marine environment. The team will develop physical, climate and ecosystem models with direct input from bespoke biogeochemical and biological laboratory experimentation. This independent assessment by experts in modelling and ecology is critical to provide a thorough and balanced evaluation of

potential climate interventions in the Arctic. The project will provide best-practice guidance for the theoretical risk assessment of future proposed interventions within the polar marine environment

ec
ARDA



View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables [here](#).

Investigating the Impacts of Earth Cooling Approaches on the Variability and Wet-Dry Spell Dynamics of the West African Monsoon

Project Lead: Amadou Coulibaly, Institut Polytechnique Rural de Formation et de Recherche Appliquée (IPR-IFRA)

Award: £257k over 3 years

Key Team Members and approximate budget breakdown: Amadou Coulibaly, Abdoulaye Ballo, Institut Polytechnique Rural de Formation et de Recherche Appliquée (IPR/IFRA) | Sabina Abba Omar, University of Cape Town (at no cost to the project)

The West African Monsoon is a vital climate system supporting agriculture and water resources for millions. Understanding how potential earth cooling approaches might affect this sensitive system is crucial for regional stability and food security. This research directly addresses this need by exploring potential impacts on critical rainfall patterns, including wet and dry spells. Using advanced climate models, observational data, and scenarios from established model intercomparison platforms (such as GeoMIP), the study aims to address critical gaps in understanding how earth cooling approaches might influence regional climate systems and how they might interact with existing climate vulnerabilities. The project will provide actionable insights, helping the region understand how these approaches might mitigate adverse climate impacts while avoiding unintended consequences.

We will publish the complete grant agreement for this project, including its key milestones, as soon as it is finalised.

Space Reflector Baseline Survey

Project Lead: Morgan Goodwin, Planetary Sunshade Foundation

Award: £400k over 14 months

Key Team Members and approximate budget breakdown: Morgan Goodwin, Planetary Sunshade Foundation (£275k) | Daniele Visoni, Cornell University (£85k) | Chantal Cappelletti, University of Nottingham (£40k) | Jeff Overbeek (via Ethos Space, at no cost to the project) | Saptarshi Bandyopadhyay (NASA Jet Propulsion Laboratory, California Institute of Technology, at no cost to the project)

To make informed choices about potential climate cooling strategies, society needs a clear understanding of possible options, including less-studied approaches like space-based reflectors. This theoretical study together leading space engineering teams with expert climate modellers to address a critical knowledge gap. This team will model six different conceptual designs for space reflector approaches and

then use climate models to simulate their potential climate impacts (including atmospheric dynamics, chemistry, and ocean/ice feedbacks). The goal is not to deploy this technology, but to provide an initial assessment of which concepts might warrant further study based on their modelled efficiency, scalability, and potential side effects, fostering collaboration between the space engineering and climate modelling communities.

View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables [here](#).

An assessment of the feasibility of a space-based solar reflector

Project Lead: Colin McInnes, University of Glasgow

Award: £342k over 1 year

Key Team Members and approximate budget breakdown: Colin McInnes, Matteo Ceriotti, University of Glasgow (£161k) | Onur Çelik, Delft University of Technology (£156k) | Derek Bennet, AAC Clyde Space (£25k)

Highly speculative technologies like space-based solar reflectors require careful, early-stage assessment. This team is exploring the technical feasibility of space-based approaches to cooling the earth. This project is a desk-based study exploring the initial engineering steps and challenges involved in a hypothetical small-scale space mission to test the feasibility of a space-based sunlight reflector. This purely conceptual work is aimed at understanding the requirements for such a mission. Its purpose is to inform whether, and how, further research into this specific Earth cooling approach might proceed, ensuring resources are directed effectively based on sound engineering principles.

View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables [here](#).

Towards Robust and Unbiased validation of SAI Simulations (TRUSS)

Project Lead: Heri Kuswanto, Institut Teknologi Sepuluh Nopember, Indonesia

Award: £345k over 3 years

Key Team Members and approximate budget breakdown: Heri Kuswanto, Kartika Fithriasari, Institut Teknologi Sepuluh Nopember

Responsible decisions about potential climate interventions like Stratospheric Aerosol Injection (SAI) depend on reliable, trusted data about their potential impacts, but current computer simulations have uncertainties. This project aims to significantly improve the accuracy and trustworthiness of the simulation outputs of these approaches. Using advanced statistical and machine learning techniques applied to climate model outputs, this project looks to ensure that impact predictions, especially crucial regional assessments, are robust and unbiased. This foundational modelling work is vital for building confidence in the science and enabling genuinely informed decision-making by policymakers and the public.

Simulating the effects of earth cooling approaches on the Dynamics and Thermodynamics of Monsoon and Precipitation Extremes

Project Lead: Byju Pookkandy, The Energy and Resources Institute

Award: £140k over 2 years

Key Team Members and approximate budget breakdown: Byju Pookkandy, Kaagita Venkatramana, The Energy and Resources Institute (TERI)

Stable and predictable rainfall is fundamental to societies in both India and the UK, underpinning agriculture, water security, and protecting communities from floods and droughts. This research provides essential foresight into how proposals for earth cooling could potentially disrupt these vital precipitation patterns – affecting everything from the timing of seasonal rains in India to the intensity of precipitation extremes. By analysing detailed climate simulations from established model intercomparison platforms (such as GeoMIP) specifically designed for earth cooling scenarios, the study will pinpoint why these changes might occur, disentangling the complex factors driving rainfall. This computational analysis will deliver crucial, regionally-specific evidence to help evaluate the potential risks these approaches may pose to indispensable water cycles and resources.

View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables [here](#).

Defining the minimum scale of an SAI test: A fundamental first step towards an outdoor experiment

Project Lead: Doug MacMartin

Award: £445k over 2 years

Key Team Members and approximate budget breakdown: Doug MacMartin, Daniele Visoni, Cornell University

Making informed decisions about potential future climate interventions like Stratospheric Aerosol Injection (SAI) requires reliable predictions of their effects. Currently, a major uncertainty – precisely how cooling aerosol particles would behave when released high in the atmosphere – significantly limits the accuracy of these predictions. This project addresses this critical knowledge gap through theoretical modelling and analysis, as it aims to determine the minimum scale for a potential outdoor experiment that could provide the real-world data needed to substantially reduce this uncertainty. Identifying this minimum threshold is essential foundational work. It paves the way for designing any future research in the most responsible, efficient, and low-impact manner possible. Understanding this scale is also crucial for proactively planning the appropriate governance and oversight frameworks that would be necessary before any such scale atmospheric research were to take place.

View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables

[here](#)



De-risking cirrus modification

Project Lead: Sebastian Eastham, Imperial College London

Award: £3.6m over 36 months

Key Team Members and approximate budget breakdown: Sebastian Eastham, Marc Stettler, Ed Gryspeerdt, Imperial College London (£740k) | Benjamin Murray, University of Leeds (£1.4m) | Blaž Gasparini, University of Vienna (£310k) | Takemasa Miyoshi, RIKEN (£270k)

High-altitude cirrus clouds have an overall warming effect on our climate, but how their formation is influenced by existing atmospheric particles (like dust or soot) remains a significant uncertainty in climate science. Improving our understanding of these natural processes is crucial for refining climate models and for establishing the knowledge needed to assess the potential risks and benefits of any future proposals to deliberately modify cirrus clouds. This project aims to gather vital real-world data on these natural cirrus cloud processes and how they are already being affected by the presence of aircraft engine soot.

The team will use a combination of computer modelling and analysis of existing satellite data. They will also conduct observational flights using research aircraft to directly measure how particles already present in the atmosphere, and the additional effects of aircraft engine soot, currently affect cirrus cloud properties. By observing and measuring these existing atmospheric processes, the team are looking to improve our fundamental understanding of cirrus cloud formation, providing essential baseline knowledge to help us understand if deliberately thinning cirrus clouds could ever offer a safe, predictable mechanism for cooling.

View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables [here](#).

Ice Nucleating Particles in the Upper Troposphere: Advancing Cirrus Control and Experimental Science Strength “INPUT:ACCESS”

Project lead: Thomas Whale, University of Leeds

Award: £1.3m over 36 months

Key Team Members and approximate budget breakdown: Thomas Whale, University of Leeds (£770k) | Alexandre Baron, Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado (£475k) | Joshua Schwarz, National Oceanic and Atmospheric Administration (NOAA) Chemical Sciences Laboratory (at no cost to the project) | Sebastian Eastham, Imperial College London (£63k)

Cirrus clouds have a significant impact on Earth's temperature, yet prediction and modelling of their formation is challenging and constitutes a key uncertainty in climate models and projections. Lack of knowledge of the concentration and nature of the tiny particles suspended in the atmosphere on which cirrus clouds form, known as ice nucleating particles (INPs), is a major contributor to this uncertainty. This project aims to address this knowledge gap by developing new methods to observe and analyse these naturally occurring INPs high in the atmosphere.

Operating out of Colorado, USA, the team will develop and operate a specialised balloon-borne collector designed to gather naturally present INPs from the upper troposphere where cirrus clouds form. These collected samples will then be brought back for detailed laboratory analysis in the UK. This focused monitoring and observation work will generate critical information about the types and concentrations of particles involved in natural cirrus formation. This data is essential for improving the accuracy of climate projections and enhancing our ability to monitor natural atmospheric processes, providing a crucial baseline for climate science.

View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables [here](#).

StratoGuard - Global Monitoring of Climate Engineering using Micro High-Altitude Balloons

Project lead: Steve Tate, Voltitude

Award: £600k over 33 months

Key Team Members and approximate budget breakdown: Steve Tate, Richard Nash, Paul Stevens, Voltitude Ltd (£575k) | Chris Stopford, University of Hertfordshire (£25k)

Improving our ability to monitor the Earth's climate, particularly in remote regions, and developing the tools needed to safely observe and measure potential future climate interventions are crucial needs for both climate science and the responsible assessment of climate cooling approaches.

Project StratoGuard focuses on creating low-cost, lightweight micro-balloons (under 4kg, <5m diameter) equipped with sensors, capable of navigating the stratosphere above 55,000 feet for up to 30 days. This capability would support affordable, detailed, and sustained climate data collection across the globe. It

would also enhance the capability for sophisticated and cost-effective monitoring of any future outdoor climate intervention activities. With test launches planned from 2026 and potential global launch capabilities (subject to local approvals), this project seeks to miniaturise core technologies for global sensing using small, safe balloons, operating in full compliance with existing regulatory frameworks. The overarching goal is to provide a vital new tool for comprehensive climate observation, as well as providing a monitoring capability essential for responsible research and assessment of potential climate interventions.

View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables [here](#).

Monitoring Aerosol Climate Engineering (MACE)

Project lead: Matt Watson, University of Bristol

Award: £4.3m over 48 months

Key Team Members and approximate budget breakdown: Matt Watson, Arthur Richards, Tom Richardson, University of Bristol

Natural events, particularly volcanic eruptions, release tiny particles (aerosols) into the atmosphere and offer invaluable real-world opportunities to study processes relevant to climate science and potential climate interventions, such as how aerosols affect clouds and the Earth's energy balance. However, safely and rapidly collecting data from these events is challenging. This project aims to address this by developing advanced, automated drone technology specifically designed for observing and analysing emissions from active volcanoes.

The team will design, build, and test lightweight, easily operationalised drones capable of flying safely at high altitudes (10 km). Following initial test flights in the first year, the plan is to use the drones to study emissions from selected, regularly erupting volcanoes – Volcán de Fuego (Guatemala), Soufrière Hills (Montserrat), and Lascar (Chile). The team have flown in all three countries in the past under suitable permits. By analysing these natural volcanic emissions in situ, the research will investigate how tiny cloud droplets form and how natural aerosol layers affect radiation. A key goal is to develop a rapid-response capability using these drones, enabling the scientific community to safely gather crucial data from future significant volcanic eruptions, thereby improving our understanding of natural climate processes.

View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables [here](#).

Re-Thickening Arctic Sea Ice (RASi)

Project Lead: Shaun Fitzgerald, Centre for Climate Repair

Award: £9.9m over 42 months

Key Team Members and approximate budget breakdown: Shaun Fitzgerald, University of Cambridge (£1.4m) | Geoff Evatt, University of Manchester (£0.63m) | Michel Tsamados, University College London (£0.63m) | Einar Ólason, Nansen Environmental and Remote Sensing Center (£0.4m) | Andrea Ceccolini, Real Ice (£3.5m) | Fonger Ypma, Arctic Reflections (£3.3m) | Edward Blanchard, University of Washington (£90k) | Steven Desch, Arizona State University (~£10k travel costs funded from Real Ice's share)

The Arctic is warming much faster than the global average, leading to dangerous sea ice loss with far-reaching consequences. This project investigates whether deliberately thickening sea ice during winter could be a viable way to slow summer melt, reduce Arctic warming, and mitigate further ice loss. The research aims to provide critical data on the feasibility, scalability, potential ecological impacts, and overall effectiveness of this approach, which involves accelerating natural freezing processes using seawater from underneath the ice.

Researchers will conduct controlled, small-scale experiments in Canada across three winter seasons (2025-26 to 2027-28). The process involves pumping seawater from beneath existing ice and spreading it on top, where the frigid air freezes it quickly, creating thicker ice patches. Over the course of the project (and if the early experiments suggest the approach is ecologically sound), later experiments will aim to cover areas up to 1 km² per experiment site. The key questions are whether this thicker ice lasts longer into the summer, how it might affect ice movement, and what the local ecological impacts are. These experiments will be conducted in close collaboration with local communities and under ARIA's stringent governance framework, prioritising safety and environmental monitoring. The goal is to gather essential real-world data to rigorously assess if this intervention warrants further consideration.

View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables [here](#).

Marine Cloud Brightening in a Complex World

Project lead: Daniel Harrison, Southern Cross University

Award: £1m (potentially rising to £5m with matched funding) over 5 years, contingent upon security and ARIA's £10m of funding from other sources



Key Team Members and approximate budget breakdown: Southern Cross University | Commonwealth Science and Industrial Research Organisation | University of New South Wales | University of Munich | Queensland University of Technology | Shaun Fitzgerald, University of Cambridge (contributing and funded via the REFLECT project)

This project investigates Marine Cloud Brightening (MCB), a potential way to cool specific areas by enhancing cloud reflectivity using a spray of seawater. Building on their experience conducting previous small-scale outdoor experiments in partnership with local communities around the Great Barrier Reef, Australia, this team seeks to deepen our understanding of MCB. While the concept could potentially protect vulnerable ecosystems like coral reefs from heat stress, its real-world effectiveness remains uncertain. This research aims to address this critical knowledge gap by investigating the complex atmospheric dynamics and microphysical processes involved, moving beyond basic principles to assess if, and how, MCB could work safely and effectively.

The research combines advanced computer modelling with the development and indoor testing of sea salt sprayers. If these findings suggest promise, and subject to meeting ARIA's governance requirements, the project plans to conduct small-scale, controlled outdoor experiments over the Great Barrier Reef in years 3 and 4 of the 5-year project. These outdoor experiments are strictly contingent on prior results, rigorous independent safety reviews, regulatory approvals, and continued co-design and partnership with Traditional Owner groups, local stakeholders, and the broader community of the Great Barrier Reef Marine Park. If approved, these controlled experiments could involve brightening clouds within areas up to 10 km × 10 km, with seawater spraying taking place over 5-6 weeks, for 6 to 8 hours per day. All activities will fully adhere to ARIA's robust governance framework, emphasising transparency, environmental risk minimisation by design, and community engagement. The overall goal is to generate crucial real-world data to determine the effectiveness and risks of MCB, and its potential for protecting vulnerable ecosystems at a regional scale.

We will publish the complete grant agreement for this project, including its key milestones, as soon as it is finalised.

A Responsible innovation Framework for assessing novel spray technology research To examine local albedo changes from marine brightening and its multi-scale impacts (REFLECT)

Project Lead: Hugh Coe, University of Manchester

Award: £6.1m over 3 years (initial phase)

Key Team Members and approximate budget breakdown: Hugh Coe, Robert Bellamy, University of Manchester (£2.1m) | Shaun Fitzgerald, University of Cambridge (£1.8m) | Dan Mace, Archipelago Technology (£0.9m) | James Haywood, University of Exeter (£1.1m) | Lindsay Bennett, University of Leeds (£22k) | Sami Romakkaniemi, Finnish Meteorological Institute* (£160k)

* Finnish Meteorological Institute are contributing to the modelling exercises in this proposal and are not involved in any outdoor experimentation

Marine Cloud Brightening (MCB) and Marine Sky Brightening (MSB) – ideas for cooling the Earth by increasing the reflectivity of clouds or the sky using tiny droplets of seawater – depend critically on having the right technology to generate sprays of these droplets effectively. However, the technical feasibility and optimal methods for doing so are poorly understood. This project aims to address this gap by developing and responsibly testing the necessary spray technologies to determine if these approaches could be viable.

Over an initial three-year period, the team will undertake computer modelling, build bespoke sprayers based on the modelling results, and conduct indoor tests. A crucial part of this phase involves beginning collaborative engagement with local communities to co-design potential future outdoor experiments. Any small-scale, controlled outdoor experiments to test sprayer performance would only occur after this initial phase, contingent on further funding, successful co-design demonstrating community engagement and support, and strict adherence to ARIA's safety and governance protocols. These potential tests are expected to be undertaken in the UK (location to be determined). Initial tests, if approved, would be very limited, lasting only a few seconds and creating small plumes of seawater spray just a few hundred metres in size. Only if these initial tests prove successful and safe might later experiments explore brightening larger cloud areas, potentially up to 10 km long and a few hundred metres wide. These tests are inherently benign, replicating natural processes that generate sea spray over the ocean developing spray systems such as those that are already employed to cool crowds with fine mists of water and dampen construction sites to suppress pollution. The overall goal is to establish a robust and responsible experimental framework to assess the technical feasibility and optimal methods for MCB and MSB.

We will publish the complete grant agreement for this project, including its key milestones, as soon as it is finalised.

BrightSpark – Cloud brightening with electric charge

Project Lead: Giles Harrison, University of Reading

Award: £2m over 36 months

Key Team Members and approximate budget breakdown: Giles Harrison, Maarten Ambaum, Keri Nicoll, University of Reading (£1.75m) | John Mooney, Menapia Ltd (£170k)

Finding ways to influence cloud reflectivity is a key research challenge. This project investigates using controlled electric charge, a natural atmospheric phenomenon, to influence water droplets in fogs and clouds as an alternative to spraying seawater. The research aims to determine if carefully managed electrical charges could offer a safe and effective method for enhancing cloud reflectivity.

The team will investigate the fundamental science of how artificial charge release affects cloud and fog droplets. The project includes plans for very small-scale (on the order of 100 m × 100 m), controlled outdoor experiments in the UK during the third year of the project. These experiments are strictly conditional on demonstrating appropriate levels of community engagement, co-design, and adherence to ARIA's rigorous safety and ethical governance framework. The core goal is to gather foundational data to assess if this method is viable and safe enough to warrant further investigation.

View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables

Project Lead: Hugh Hunt, University of Cambridge

Award: £5.5m over 36 months

Key Team Members and approximate budget breakdown: Hugh Hunt, University of Cambridge (£2.5m) | Frank Keutsch, Harvard University (£2.5m) | Sebastian Eastham, Imperial College London (£0.54m)

Stratospheric Aerosol Injection (SAI) is a widely discussed potential climate cooling method, but the most commonly proposed materials (sulfates) carry significant hazards in this context, including potential ozone depletion and toxicity. Addressing whether safer, alternative materials could ever be feasible or effective for SAI is therefore a critical, unanswered scientific question. This project will undertake fundamental research to investigate the properties and behaviour of innovative, non-toxic, non-sulfate materials in a very controlled manner.

The research combines laboratory studies and computational modelling with unique and contained material exposure experiments. In these experiments, tiny (milligram) amounts of materials that occur in natural mineral dust (such as limestone, dolomite, or corundum) will be secured onto supports inside the gondolas of specially adapted weather balloons. These balloons are likely to be launched from sites in the USA and/or the UK; the specific site will be determined in line with ARIA's requirements for community engagement. The balloons will carry the samples into the stratosphere for exposure periods ranging from hours to weeks before performing controlled descent for recovery. **Crucially, no materials will be released into the stratosphere;** this approach effectively brings the stratosphere to the samples. Studying the recovered samples will reveal how stratospheric conditions affect their properties over time. This foundational science is essential to advance understanding of the potential impacts of SAI and for determining if less harmful alternatives to sulfates might exist (and if they might warrant further study in the context of SAI).

View the full grant agreement for this project, which outlines its objectives, milestones, and deliverables [here](#).





Mark is an electrochemist with a 15-year career developing sustainable fuels in the drive towards net zero. He joined ARIA from the University of Glasgow, where he is Professor of Electrochemistry and Electrochemical Technology.

"Decarbonisation is essential, but our current climate trajectory puts us at risk of triggering temperature-driven tipping points in the coming decades. This has sparked growing interest in approaches that could cool the Earth on short timescales, potentially delaying or avoiding such thresholds. However, we currently have very little understanding of whether these approaches would even work, or what their risks and impacts might be. This programme will explore critical unanswered questions as to the feasibility, scalability and safety of some of these proposed approaches. By investing in careful research today, we can build the evidence base needed to make wiser, better-informed decisions about the future."

Mark Symes

Programme Director

Help us drive momentum

Contact

Careers

Follow our progress



Privacy Policy

Cookie Policy

Accessibility Support

Careers

Terms and Conditions

Accessibility Statement

Social Media Policy

Supply to us

Annex 2 – Initial Proposals

Please note the documents which follow in this Annex are the initial proposals which were submitted by applicants to ARIA. However, the proposals have been subject to further discussion and the finalised scope of what will be funded may differ from the initial submission. Final agreed scopes of work will be published in due course.

This project will evaluate whether it is possible to intentionally modify the properties of cirrus clouds to achieve a useful ($>100 \text{ mW/m}^2$) global cooling effect. This includes understanding (1) **how much susceptible cloud exists**, (2) **whether we can increase outgoing longwave radiation (OLR)**, and (3) **whether we can predict the circumstances under which this can be done**. We will address these questions in a two-phase experiment, starting with (P1) data mining followed by (P2) an aircraft campaign to resolve where and when cirrus modification can produce beneficial effects. We also have the ambition for a Phase 3 with dedicated cloud seeding trials, pending success of P1 & 2. The phased nature of this work is a safe and cost-effective option to produce a measurable advance towards a near-term, practical option for regional and global cooling, evaluation of which is currently unable to proceed through modelling alone¹.

1 Cirrus clouds: a potential climate dial

Globally, cirrus clouds lead to a warming effect of $\sim 5 \text{ W/m}^2$. Inadvertent cirrus cloud modification by aircraft, where cirrus-forming regions are “overseeded” by ice nucleating particles (INPs) resulting in long-lived warming clouds, already causes² a radiative forcing of $\sim 100 \text{ mW/m}^2$. By instead “underseeding” the areas, upper-tropospheric water could be made to form large crystals which rapidly sediment and sublimate – pre-empting an impending cirrus cloud (Figure 1)^{3,4}. Such cirrus cloud modification (CCM) has a maximum possible global benefit³ of $2\text{--}3 \text{ W/m}^2$. It is attractive from a safety and controllability perspective, given its limited temporal and spatial scope and that aircraft already modify cirrus daily; furthermore the recent CLOUDLAB project showed that it’s possible to modify (less widespread and less warming) mixed-phase clouds deliberately⁵, as industrial emissions do inadvertently⁶. The true efficacy of CCM is however uncertain, with some models showing negligible benefit⁷ and a key uncertainty being the challenging-to-measure concentration of background ice nucleating particles (INPs) at altitude⁸. **We need to know if CCM can work so that we can either ramp up research into a potentially powerful climate tool, or confidently refocus our efforts elsewhere.**

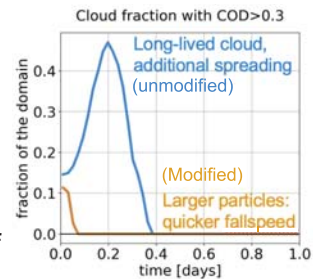


Figure 1. Homogeneous (blue) and heterogeneous (brown) cirrus lifecycles in an idealized LES model (Gasparini et al., in prep).

Due to the magnitude of this uncertainty, Tully et al.¹ recommended that modelling studies be paused until observation-based evidence could be collected. To do so, we need:

- A. A **safe method of testing** which doesn’t creating new risks or ethical concerns;
- B. Proof that the method produces **observable changes in cirrus** so that efficacy can be measured;
- C. Instruments which can **measure background INPs**;
- D. Models which can **accurately predict CCM-susceptible regions**; and
- E. Models which can **forecast the efficacy of CCM** in light of these findings.

We propose a response to this challenge. We will test in Phase 1 whether **soot emissions from existing aircraft (A)** into soon-to-be ice supersaturated air already produce a **satellite observable change (B)** in outgoing longwave radiation. If successful, we will go to Phase 2: a dedicated flight campaign with **accurate INP measurements (C)**, using a **custom-trained saturation prediction model (D)** to verify that CCM can be achieved on demand; this will in turn allow us to determine the **potential efficacy of CCM (E)**.

The key science questions are:

1. Is an observable increase in outgoing longwave radiation (OLR) produced due to the presence of aircraft aerosol during formation of an otherwise unperturbed cirrus cloud?
2. Can we predict when aircraft aerosol will yield increased OLR, verified by an aircraft experiment?
3. Can we increase the likelihood and magnitude of an increase in outgoing radiation by using dedicated ice nucleating particles, rather than relying on engine soot emissions?

These in turn define **seven project objectives**:

- **O1A:** Verify that clear-air aircraft soot produces observable changes in OLR from downwind cirrus.
- **O1B:** Establish instrument capabilities to measure ice nucleating particles (INPs) in-situ and therefore enable CCM in practice.
- **O1C:** Provide laboratory measurements of the ice nucleating properties of aircraft soot to inform O1A and Phase 2 campaign region selection.
- **O1D:** Establish modelling capabilities to predict the meteorological conditions under which aircraft soot produces an observable change in downwind cirrus.
- **O1E:** Develop a model which can translate research findings into an assessment of CCM efficacy.
- **O2A:** Execute an aircraft campaign testing our ability to achieve targeted CCM with exhaust soot.
- **O2B:** Translate findings into an assessment of the potential for at-scale CCM with optimal INPs.

1.1 Research and methodology

We propose a phased observational experiment, with three phases (two of which are included in this project budget): **data mining and trial preparation** (P1, years 1-2), **passive trial** (P2, year 3), and **active trial** (P3, not budgeted). Neither P1 nor P2 introduce novel risks nor emit anything new in any new location compared to a conventional passenger flight or aircraft-based monitoring campaign.

1.1.1 Phase 1 (P1): Identify observed changes in cirrus cloud properties due to the inclusion of aviation soot in upwind air, and prepare for an airborne experiment (years 1-2)

O1A: Data mining to study the link between aviation soot and cirrus clouds. The first phase of the trial focuses on using available data from pre-existing observations. Many of the necessary instruments (airborne, orbital, and ground based) have been in service for many years, producing potentially-relevant observations.

The basic concept is to identify times in historical data where an aircraft has passed through ice pre-saturated conditions within view of a relevant geostationary thermal infrared (TIR) instrument. We will then “follow” the affected air using wind data from reanalysis data, using Lagrangian trajectory analysis and limited plume modelling to evaluate whether air masses through which the aircraft were passing would form cirrus clouds. We will exclude any cases in which a persistent contrail would be expected to form (i.e. which are already ice supersaturated). The signal will be evaluated as a function of time since aircraft passage, but a provisional six-hour limit between aircraft passage and observation will be imposed to mitigate the effect of errors in reanalysis wind estimates. This is similar to techniques used to assess the effect of aircraft soot on existing cirrus^{9,10} or the impact of ships on clouds¹¹.

Table 1. Data sources to be used in Phase 1.

Source	Description	Positive	Negative
Aircraft campaigns	>100 hours of measurements of upper tropospheric water vapour, temperature, and aerosol (1 Hz) ¹²	Accurate measurement of initial conditions for aerosol and water vapour	Small dataset with limited coverage, instruments vary
IAGOS	Water vapour, temperature, and cloud particle count from >6,000 flights (IAGOS-CORE , 4 Hz) ¹³	Large, spatially diverse dataset (vs. campaign), limited initial conditions	Limited aerosol data, capacitive water sensor less accurate
Commercial aircraft	Flight path and estimated soot from >80% of commercial flights worldwide for 2019 onwards ¹⁴	Maximum temporal and spatial scope, good for data mining	Initial conditions must be inferred from models and reanalysis

Three different sets of aircraft will be analysed (Table 1). First, we will collect information from public databases of observations from prior aircraft campaigns^{12,15–17}. These will provide a set of cases where we have a high degree of certainty in the initial conditions of the air mass based on data from the aircraft instruments and which are mostly in UK airspace (relevant for P2), but where the total data volume is limited. For example, the FAAM aircraft database for 2023 includes around 625,000 individual observations (sampling at 1 Hz), but only 22,600 of these observations are at above 5 km pressure-altitude, and most would not go on to form cirrus cloud. To augment this dataset we will include observations from IAGOS, an ongoing campaign in which commercial aircraft take high-quality scientific measurements during standard daily operations^{18,19}. Although the observations are less comprehensive and of lower quality than the FAAM observations, the IAGOS observations will still provide an opportunity to observe changes to downwind cirrus while still having some data on initial conditions and providing a more global context. Finally, flight tracks for commercial aircraft from 2019 onwards¹⁴ will be analysed (using ADS-B transponder data) for the same purpose. This will provide a much larger dataset but will rely on the temperature and estimated water vapour content at the flight locations being reasonably well estimated in meteorological data.

Observations of the pre-saturated aviation-affected air masses will be monitored in geostationary satellite data over the six-hour period following aircraft passage to assess whether outgoing radiation in satellite TIR measurements is increased – indicating a potential contribution to global cooling - relative to air masses which were upwind of (unaffected by) the flight. This will leverage the fact that, as shown by observations of contrails, an aircraft exhaust plume can spread by only 10-20 km within the first several hours such that cirrus cloud outside this region will be unaffected. Opportunistic evaluations of CCM effects from aviation soot will also be performed using both the LIDAR and TIR imager aboard the CALIPSO satellite, which was operational for 17 years until August 2023. Particular focus will be given to estimates of the ice crystal

number²⁰. Ice crystal number in particular has been shown to be increased in the case of aircraft flying through existing cirrus clouds, based on CALIPSO and CloudSAT observations processed using the DARDAR-Nice algorithm for the 2006-2013 period^{9,20} and the CALIOP-IIR method for later periods²¹. Past work²¹⁻²³ has highlighted that mid- and high-latitude regions over or downstream of mountain ranges are key hotspots for cirrus cloud formation, often characterized by high ice crystal number concentrations. These conditions strongly favor homogeneous cirrus formation. While intense mountain waves can generate updrafts too strong for INPs to influence cirrus formation, regions with moderately elevated mountain ranges and steady large-scale flow, such as the Scottish Highlands or the Pennines, offer a unique opportunity. In these settings, cirrus clouds are more likely to respond to perturbations from additional INPs, making them ideal for targeted CCM studies.

A challenge in our proposal is that, even if CCM is theoretically possible, aviation soot may simply not be an effective enough INP^{24,25}. We will therefore include in our analysis evaluation of changes in OLR associated with wildfires and lofted mineral dust¹⁷, applying the same techniques as will be used in evaluation of changes due to commercial aircraft. This will allow us to verify whether a different strategy may be needed in Phase 2. *Key deliverables: testing of the hypothesis that aircraft passing through subsaturated air modify the properties of downwind cirrus; quantification of radiative effects; identification of meteorological conditions with a high susceptibility for cirrus modification for use in development of Phase 2. Data mining and analysis will be led by Imperial College.*

O1B: Addressing the world's inability to measure background INP relevant for cirrus clouds. The accelerated timeline of this work demands that we also begin preparation for an aircraft trial on the assumption that Phase 2 will be approved. Accordingly, we will perform the development, integration, and certification of a new instrument for measuring ice nucleating particles at altitude (PINEair) into the FAAM research aircraft (see Phase 2 description for details of intended use). PINEair is based on the established PINE instrument²⁶, in which parcels of ambient air are passed into a cooled chamber and then subjected to adiabatic expansion to simulate cloud formation conditions in the atmosphere. The resulting ice crystals are then counted using an optical counter, which allows us to determine the concentration of INPs active at a defined set of conditions. PINEair can make measurements of cirrus INPs down to -60°C at defined saturation ratios between ice and water saturation. It has an excellent time resolution of 2 minutes as a result of its design with three separate chambers, so while one chamber is used to make a measurement the other two are being flushed with air in preparation for a measurement. PINEair quantifies both homogeneous and heterogeneous ice nucleation. The only other online instrument capable of making measurements from an aircraft is known as a continuous flow diffusion chamber (CFDC). Existing CFDCs are limited to ~-40°C (i.e. they barely reach cirrus conditions, <-40°C)²⁷, and suffer from frost flake artefacts where ice falling off the walls contaminates the signal.

Work under O1B will involve purchasing a lab-based PINetri instrument from Bilfinger GmbH. PINetri is the three-chamber version of PINE, with Stirling engine cooling, which allows it to be cooled to cirrus temperatures. Enviscope GmbH will convert PINetri into PINEair by rebuilding it in a FAAM rack in a manner consistent with the FAAM technical requirements (suitable wiring, a rack of specific dimensions, a defined centre of gravity etc), performing the necessary testing (magnetic and electromagnetic) and supply the documentation for certification. In Leeds we will then test and characterise PINEair with INP types we anticipate will be important in the upper troposphere using our aerosol chamber. These INP types will include mineral dusts mixed with varying quantities of sulphate, organic and nitrate (using samples we have used for mixed-phase cloud work) as well as proxies of soot aerosol particles (making use of experience in the existing NERC funded aircraft emission project SAFice, NE/Z503848/1). PINEair will be installed on the FAAM aircraft, connecting it to the new community inlet system that is being constructed as part of the mid-life upgrade. Work will be done to verify that aerosol losses in the cirrus INP relevant size range are minimal (<~2 µm). Once installed on FAAM PINEair will need to be certified by BAE and when we receive certification we will conduct flight tests of PINEair using flights funded by other projects.

Key deliverables: FAAM will be one of just two aircraft worldwide capable of measuring temperature, RH, cloud properties, and INP at conditions relevant for cirrus clouds; without these measurements CCM is not feasible¹. This will put the project in an excellent position for Phases 2 and 3. Also, the UK will benefit from having an aircraft that has the capability of addressing cirrus modification, placing the UK in a world-leading position to research and execute cirrus modification. This work will be led by Leeds.

O1C: Quantifying ice nucleation by aviation soot. Given the contradiction in evidence discussed above in the role of aviation soot in defining cirrus properties^{24,25,28,29} it is necessary to use our new tools to experimentally probe ice nucleation on aviation soot under well-controlled laboratory conditions. Previous work on ice nucleation on soot directly from jet engines²⁴ clearly shows that at most only a very small fraction (less than 1%) of soot particles typically nucleate ice. We hypothesise that it is this small fraction

that may be particularly important for defining cirrus ice crystal concentrations. It has been shown previously that the gradual appearance of ice crystals as an air parcel cools can draw down the relative humidity, limiting the nucleation of further crystals³⁰. Hence, materials such as soot that slowly form ice crystals will naturally prevent overseeding of a cloud. Thermal gradient diffusion chambers used in the prior research on this topic²⁴ are not well suited to studying very small fractions since they tend to have substantial background ice signals. In contrast, PINE has a very low background and can therefore be used to study these small activated fractions at modest supersaturations.

We will conduct a set of laboratory based PINE measurements in Leeds of the ice nucleating activity of aviation soot proxies under cirrus conditions. This will build on our current contrail formation work where we have used PINE to study the role of jet engine lubrication oil droplets³¹, and will be studying soot in a new NERC funded project (SAFice - NE/Z503848/1). As well as studying the ice nucleation activity of soot under cirrus conditions, we will study the potential role of impurities from fuel additives and metal oxides from engines (known to nucleate ice under cirrus conditions³²) on the ice nucleating activity of aviation aerosol. This will be done by adding materials to the fuels in the burner so that we produce contaminated soots. *Key deliverables: data on aviation soot ice nucleating activity, with and without impurities focused on low supersaturations where active fraction is expected to be small. This work will be led by Leeds.*

O1D: Developing modelling capabilities to predict susceptible air masses. In preparation for Phase 2, we will develop a dedicated meteorological forecast informed (where possible) by in-situ and satellite observations which is focused on the UK. The RIKEN models^{33–35} can integrate live satellite data and will be run using already-available time on the Fugaku supercomputer, the [6th most powerful in the world](#). RIKEN's modelling approach has already proven highly capable in near-term predictions of precipitation when deployed to forecast weather during the 2020 Tokyo Olympics (see Figure 2). The model will be optimized to identify pre-saturated air masses with a one-day lead time, based on the same observations as are described above. *Key deliverables: continuous five-day forecast capability of cirrus cloud formation over the UK, developed using and validated with past observations. This work will be led by RIKEN.*

O1E: Understanding the observationally-constrained maximum potential of CCM. We will also begin preparatory work for Phase 3 of the project, incorporating the lessons being learned from Phase 1. We will conduct simulations of the potential efficacy of CCM for both soot and ideal ice nuclei, focusing on process accuracy. These will incorporate the latest information from Phase 1, using km-scale atmospheric modelling. Low-resolution climate models, the only tool used so far to estimate the cooling potential of CCM, are too coarse to explicitly simulate updrafts and cirrus lifecycle and are thus relying on uncertain parameterizations of small-scale vertical wind variability, cloud micro- and macrophysics. This has prevented a clean physical connection between dynamics, relative humidity variability, and ice formation.

Our modeling efforts will estimate the geophysical limits of CCT based on atmospheric modeling of INP perturbations. The potential cooling effects of CCM, constrained by Phase 1 data, will be quantified through regional 100 m-scale (LES) and global kilometer-scale (cloud-resolving) simulations using the ICON model already running at Vienna. The model currently includes only warm cloud-aerosol interactions; the first step in this work will be to extend that with a reasonable scheme to account for aerosol-cirrus interactions³⁶. This will allow us to evaluate the regional sensitivities and atmospheric feedbacks of CCM, and will be crucial for understanding both the highest-potential target regions and the potential risks resulting from Phase 3. A particular focus of this work will be to increase confidence that, even if CCM is effective, the results of seeding are mostly confined to the target region. *Key deliverables: extension of ICON to include aerosol-cirrus interactions; incorporation of data analysis results into ICON; estimation of the spatial domain of influence of a potential Phase 3 trial. This work will be led by Vienna.*

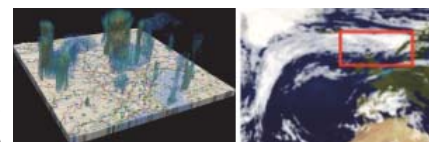


Figure 2. Left: near-term precipitation forecasts from RIKEN's SCALE model. Right: global 5 km ICON simulation, to be used in estimating CCM cooling potential of CCM (using P1&2 results) and drive regional ICON-LEM simulation.

1.1.2 Phase 2 (P2): demonstrate that we can predict and achieve CCM with aviation soot (year 3)

In P2 we will seek to test our ability to induce a signal based on forecast conditions. This is needed to both verify P1's findings and evaluate our ability to forecast modifiable cirrus (see Figure 3).

O2A: Target FAAM flights to deliberately modify cirrus properties. We will use the exhaust of the FAAM research aircraft to try and modify the properties of cirrus forming in UK airspace, and then to observe the changed cirrus in satellite imagery using the protocol from Phase 1. This modification is inherently low-risk, as such modification is performed inadvertently by flights worldwide every day and the FAAM routinely measures and monitors cirrus clouds. We plan for 50 flight hours across 10 sorties.

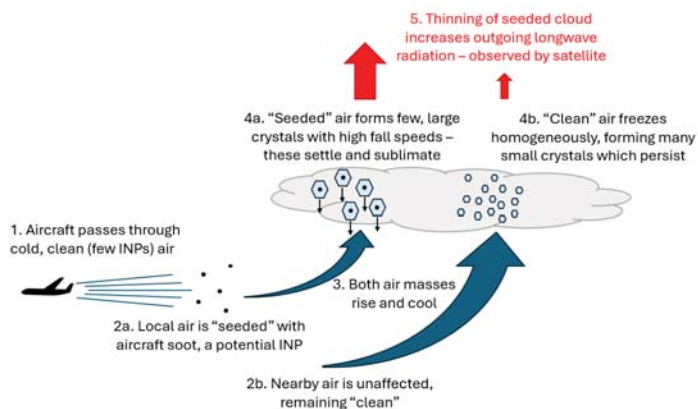


Figure 3. Target outcome of the P2 experiment.

Experimental design: Prior to each sortie UK airspace will be analysed using the RIKEN model which was tested during Phase 1 to find locations where a) pre-saturated air exists, b) the aircraft is expected (based on P1) to cause an observable change downstream, and (if possible) c) higher-resolution observations will be available from a ground station or overpassing low Earth orbit (LEO) satellite. During the one-month FAAM campaign period, we expect to make continuous 5-day forecasts to support this effort. Flight days will be chosen based on identification of a cirrus-forming region which is within the FAAM flight envelope, within range of the FAAM home base (Cranfield), and large enough that we can

expect to see both modified and unmodified areas. A high-potential target is the Scottish Highlands, where orographic uplift often produces mountain waves with updraft velocities large enough to support homogeneous cirrus nucleation in conditions with low background INP concentrations. These conditions make this region a promising area for testing CCM strategies. Aircraft campaign management will be led by Leeds, with the following strategy:

- *Before each flight:* Five-day meteorological forecasts will be produced for all UK airspace continuously over the one-month trial period. Candidate dates and locations will be chosen based on a daily review of the expected likelihood of cirrus formation from air which will be within the flight envelope of the FAAM aircraft, the visibility of the region for MTG-I1, and the possibility of coincident measurements from a LEO satellite overpass (ideally from the EarthCARE satellite, but also considering others such as Sentinel 3's VIIRS and SLSTR depending on local time and orbital parameters) or from a relevant ground station. A go/no-go decision will be made 18 hours ahead of each flight to permit flight planning. *Forecasting and meteorological modelling will be led by RIKEN.*
- *During each flight:* In-situ measurements will be taken of three crucial parameters in order to provide high-quality initial conditions for trajectory analysis. We will need to measure (with high accuracy) **(1) the water vapour mixing ratio** and **(2) the ambient temperature**. These, along with pressure, aerosol concentrations, and aerosol properties, will be determined by existing FAAM core instruments. PINEair, integrated into the FAAM in P1 (O1B), will be used to determine **(3) the number of background INPs** present in the air as a function of temperature and saturation ratio. This is necessary to understand the baseline which is being modified by the passage of the aircraft, and therefore the change in the number of potential INPs as a result of the soot produced in the aircraft exhaust. *Instrument data collection and coordination will be led by Leeds.*
- *After each flight:* Satellite measurements from MTG-I1 and static/LEO instruments identified during pre-flight planning will be gathered and analysed for the air downstream of the flight, using the protocols developed during P1. We will seek to establish whether the properties of the cirrus cloud were measurably changed by the passage of the research aircraft. *Satellite data analysis will be led by Imperial.*

When predicting the effect of emissions, we will need not only the background INP (from PINEair) but also the aircraft soot emissions. These will be estimated based on ground testing which has already been performed with the FAAM research aircraft to characterize its exhaust in terms of the number of particulates produced per unit of fuel burned (manuscript currently in preparation; personal communication from [REDACTED]), translated to cruise conditions using existing empirical relations³⁷. *Emissions estimation will be performed by Imperial.*

O2B: Translate findings into an estimate of potential CCM efficacy. Simultaneous to this phase, we will conduct an observation system simulation experiment (OSSE) to identify INP characteristics which would maximize the expected observationally-verifiable negative radiative forcing (climate benefit) resulting from CCM. This work, conducted with the ICON model will be directly informed by the results of the campaign (where we are using soot as an INP), taking advantage of the large-scale modelling capabilities developed during P1. *The OSSE will be led by Vienna.*

Phase 2 will be deemed complete once all flights are complete and analysed. The key metric of success will be the total outgoing longwave radiation integrated along the trajectory from initial cirrus formation to 24 hours subsequently, calculated using geostationary satellite measurements and compared to outgoing longwave radiation from nearby (upstream) cirrus.

1.1.3 Phase 3 (P3): extend beyond aircraft soot to support INP-optimal CCM (year 4 onwards, not budgeted)

If CCM using aircraft engine soot can be proven to both modify the cloud properties and increase the trajectory-integrated outgoing longwave radiation, and if the conditions for this can be predicted using weather forecast data, then P3 will proceed. This phase, shown in Figure 4, will expand the project to include artificial seeding and will constitute the first step towards a full CCM trial.

These trials are again expected to take place over the northern British Isles during wintertime, possibly based in Stornoway (where FAAM has operated in the past). This location and season is particularly well suited due to the likelihood of homogeneous ice nucleation (HOM) events as described for P2.

The seeding strategy will involve the release of custom seeding particles over a defined part of the Highlands, followed by a downstream measurement campaign to assess the effects on cloud properties. The research aircraft will attempt to sample the same air parcels - identified through operational trajectory analysis and flow calculations - both before and after seeding to provide a robust comparison.

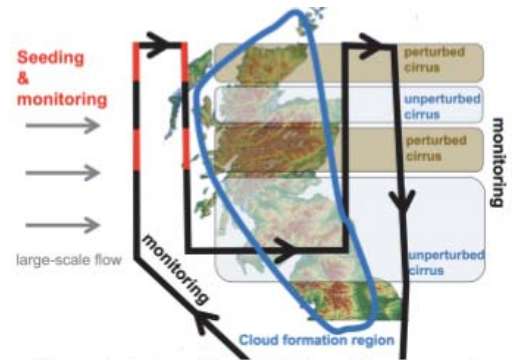


Figure 4. Schematic of the P3 seeding approach.

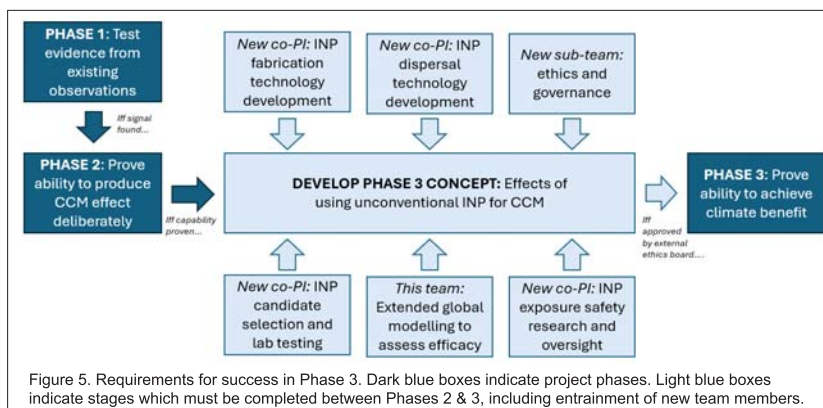


Figure 5. Requirements for success in Phase 3. Dark blue boxes indicate project phases. Light blue boxes indicate stages which must be completed between Phases 2 & 3, including entrainment of new team members.

Key objectives of Phase 3 would be:

1. Baseline sampling: Verify that the dynamical and aerosol conditions are sufficiently uniform across the trial region. This will ensure that any subsequent changes can be attributed to the seeding intervention.

2. Seeding experiment: Verify that a seeding experiment can be conducted in regions where homogeneous cirrus formation is expected.

3. Post-seeding observations: Monitor

and sample seeded and unseeded air parcels downstream to determine if measurable differences in cloud properties and radiative effects occur, and to verify that these differences are of the expected magnitude.

The decision on the seeding agent and the design of the device for producing the seed aerosol will be part of Phase 3. We envisage the choice being between: **silver iodide**, already used⁵ for cloud seeding but may cause overseeding as it is so effective; **glassy sugar solutions**, found to nucleate ice under cirrus conditions with very gradual nucleation onset (perfect for cirrus cloud seeding³⁸), can be nebulised into the atmosphere, and would not have a detrimental effect on lower altitude mixed-phased cloud (unlike silver iodide); or a **designed nucleator** as described in an ARIA proposal by [REDACTED] to create designer ice nucleating materials with ideal properties for cirrus modification.

Before progressing to Phase 3, the team would need to be expanded (Figure 5). Of particular importance would be a dedicated ethics and governance team, an ethics review board, and a safety assessment team to ensure there would not be unintended side effects from the deployment of artificial seeding materials.

1.2 Why has this not been done before?

As previously stated, CCM research is in a deadlock which pure modelling studies cannot break¹. Resolving this with observations has been challenging because cirrus clouds are hard to reach, monitor, and model. The advent of high-resolution geostationary imagers and improved LEO capabilities, alongside a large and growing archive of in-situ upper-tropospheric observations, heralds an unprecedented opportunity to test the hypothesis of CCM. The launch of the GOES-R satellites means we have an archive of 6 years of continuous US observations coincident with LIDAR data from the (now-defunct) CALIOP orbital LIDAR, which can be merged with copious upper-tropospheric observational data from aircraft campaigns to inform P1. We can now observe in real time over the UK/Europe at a resolution of ~2-5 km using the MTG-I1 satellite at 0° longitude, which has now been [declared fully operational](#). With the new EarthCARE low Earth orbit satellite we also have access to a top-down view of cirrus properties, including high-resolution imaging and LIDAR. The availability of these instruments means that we can learn from experience (as described above) and translate this knowledge into a trial over the UK. Finally, we have lacked the ability to make measurements of INP under cirrus conditions in the mid-upper troposphere, which has limited our ability to assess the efficacy of cirrus cloud modification. With PINEair and this project, we can break the deadlock.

1.3 Project plan and staging

Our project is staged to facilitate project expansion, extension, merging, or termination depending on results. If the P1 null hypothesis is not rejected at the end of year 2, then P2 will not be justified without significant revision. Similarly if P2 is unable to produce a statistically-significant signal, then P3 (not budgeted) will not be justified without significant revision. A full timeline is given in Figure 6.

1.3.1 Risk to the public

We have deliberately split this project into three phases to minimize risk to the public. P1 carries essentially zero physical risk, as it involves no outdoor experiments and is mostly concerned with data analysis, model development, instrument construction and laboratory measurements. P2, although it does involve outdoor flights, emits nothing into the atmosphere other than the engine emissions which would be associated with any flight by the FAAM. As such it carries the same minimal risk as any conventional aircraft campaign. P3 will require a deeper evaluation of potential risk, and for this reason is not budgeted under this project. Its execution would require, at the very minimum, entrainment of an internal ethics and governance team, evaluation of any potential for human health risks resulting from exposure to the candidate ice nucleating particles, and establishment of an integrated ethics team to assist with trial design and an external ethics review board tasked with the power to halt the project (see Figure 5).

1.3.2 Risk mitigation

Our stage gates also minimize project risk. At the end of P1 there is a go/no-go decision predicated on whether a statistically significant signal could be found in the analysed satellite data. If it cannot, P2 will not proceed. All activities planned in P1 are nonetheless expected to yield longer-term benefits including improved modelling of humidity and enhanced UK instrument capabilities.

Possible external risks include the possibility that the PINEair instrument cannot be built, integrated, or certified in time, or the possibility that the FAAM mid-life upgrade is delayed. The former risk is considered low, as the PINE instrument is already commercially available from Bilfinger such that only integration and certification is necessary, and PINEair integration was already provisionally approved for the FAAM. The latter risk is also considered low, as the FAAM mid-life upgrade has been subject to thorough planning and review for several years. However, if these events do occur it will result in a delay of the project only.

With regards to meteorological forecasting, RIKEN is highly experienced in short-term forecasting and will be collaborating with Vienna to advance the representation of cirrus formation in their models. ECMWF forecasts will be used as a fallback if we cannot improve formation prediction during P1.

Finally, this proposal will require a substantial hiring push. Given the short timeline, it may not be possible to hire all of the necessary postdoctoral researchers in time for the April 2025 start date. This may delay parts of the project by up to 3 months; if so we may need to seek a no-cost extension, to ensure that data produced from the P2 experiments can still be processed.

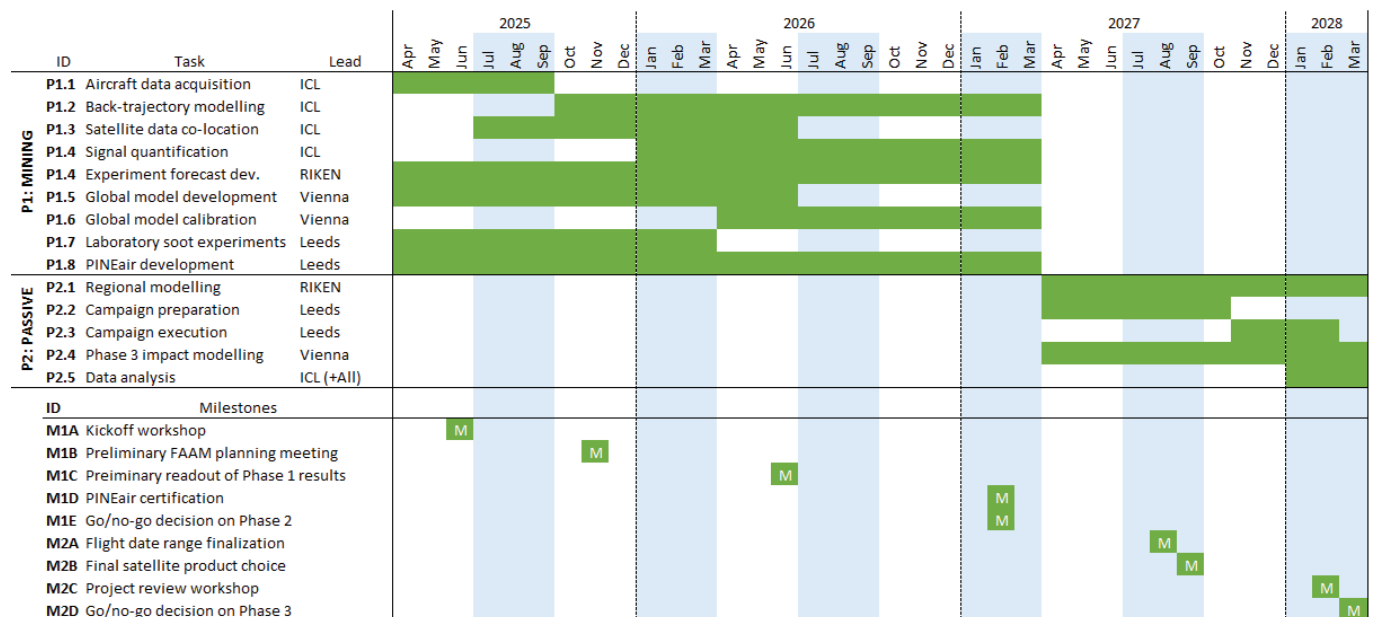


Figure 6. Gantt chart for the project. Phase 3 is not shown as it is not budgeted in this proposal.

2 The Team

We are a team of six investigators, motivated by concern over the combination of a lack of reliable data on the robustness and safety of climate interventions and the urgency of the climate crisis. This team has the necessary skills to evaluate, soberly and objectively, whether cirrus modification is a promising avenue for climate cooling, an artifact of model assumptions, or even counterproductive. The entire team will be engaged throughout both P1 and P2, with further team expansion anticipated if P3 goes ahead.

[REDACTED]

[REDACTED] and will dedicate 10% of [REDACTED] time to this project while supervising a PDRA for 3 years.

[REDACTED]

[REDACTED] will dedicate 20% of [REDACTED] time to this project while supervising a PDRA for 3 years.

[REDACTED]

[REDACTED] will be supervising a junior researcher (100%) and senior researcher (50%) at [REDACTED] in the development of a specialized model to predict sub-saturation conditions which are likely to result in later cirrus cloud formation.

B [REDACTED]

[REDACTED] will commit 15% of [REDACTED] time, supervising 1 PDRA (years 1-3) to work with the instrument, and another PDRA (year 3) to coordinate flight planning, trial execution, and campaign measurements.

[REDACTED]

[REDACTED] will commit 5% of [REDACTED] time to co-supervise the Imperial College PDRA, focusing on satellite data acquisition and interpretation.

[REDACTED]

[REDACTED] will commit 5% of [REDACTED] time to co-supervise the Imperial College PDRA, focusing on characterization of commercial aircraft soot emissions for Phase 1 and of the FAAM in particular for Phase 2.

Project management will be conducted at Imperial College through a dedicated Project Manager, due to the size of the project. This is a staff position, with 50% of their time dedicated to the project throughout the full 3-year duration.

3 References

1. Tully, C., Neubauer, D., Villanueva, D. & Lohmann, U. Does prognostic seeding along flight tracks produce the desired effects of cirrus cloud thinning? *Atmos. Chem. Phys.* **23**, 7673–7698 (2023).
2. Lee, D. S. *et al.* The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018. *Atmos. Environ.* 117834 (2020).
3. Lohmann, U. & Gasparini, B. A cirrus cloud climate dial? *Science* **357**, 248–249 (2017).
4. Mitchell, D. L. & Finnegan, W. Modification of cirrus clouds to reduce global warming. *Environ. Res. Lett.* **4**, 045102 (2009).
5. Henneberger, J. *et al.* Seeding of supercooled low stratus clouds with a UAV to study microphysical ice processes: An introduction to the CLOUDLAB project. *Bull. Am. Meteorol. Soc.* **104**, E1962–E1979 (2023).
6. Toll, V. *et al.* Glaciation of liquid clouds, snowfall, and reduced cloud cover at industrial aerosol hot spots. *Science* **386**, 756–762 (2024).
7. Gasparini, B., McGraw, Z., Storelvmo, T. & Lohmann, U. To what extent can cirrus cloud seeding counteract global warming? *Environ. Res. Lett.* (2020) doi:10.1088/1748-9326/ab71a3.
8. Gruber, S. *et al.* A Process Study on Thinning of Arctic Winter Cirrus Clouds With High-Resolution ICON-ART Simulations. *JGR Atmospheres* **124**, 5860–5888 (2019).
9. Marjani, S., Tesche, M., Bräuer, P., Sourdeval, O. & Quaas, J. Satellite observations of the impact of individual aircraft on ice crystal number in thin cirrus clouds. *Geophys. Res. Lett.* **49**, (2022).
10. Tesche, M., Achtert, P., Glantz, P. & Noone, K. J. Aviation effects on already-existing cirrus clouds. *Nat. Commun.* **7**, 12016 (2016).
11. Tippet, A., Gryspeerdt, E., Manshausen, P., Stier, P. & Smith, T. W. P. Weak liquid water path response in ship tracks. *Atmos. Chem. Phys.* **24**, 13269–13283 (2024).
12. Krämer, M. *et al.* A microphysics guide to cirrus—Part 2: Climatologies of clouds and humidity from observations. *Atmospheric Chemistry and Physics* **20**, 12569–12608 (2020).
13. Sanogo, S. *et al.* Variability in the properties of the distribution of the relative humidity with respect to ice: implications for contrail formation. *Atmos. Chem. Phys.* **24**, 5495–5511 (2024).
14. Teoh, R., Engberg, Z., Shapiro, M., Dray, L. & Stettler, M. E. J. The high-resolution Global Aviation emissions Inventory based on ADS-B (GAIA) for 2019–2021. *Atmos. Chem. Phys.* **24**, 725–744 (2024).
15. Patnaude, R. & Diao, M. Aerosol Indirect Effects on Cirrus Clouds Based on Global Aircraft Observations. *Geophys. Res. Lett.* **47**, (2020).
16. Voigt, C. *et al.* ML-CIRRUS: The Airborne Experiment on Natural Cirrus and Contrail Cirrus with the High-Altitude Long-Range Research Aircraft HALO. *Bull. Am. Meteorol. Soc.* **98**, 271–288 (2017).
17. Froyd, K. D. *et al.* Dominant role of mineral dust in cirrus cloud formation revealed by global-scale measurements. *Nat. Geosci.* **15**, 177–183 (2022).
18. Petzold, A. *et al.* Global-scale atmosphere monitoring by in-service aircraft – current achievements and future prospects of the European Research Infrastructure IAGOS. *Tellus B Chem. Phys. Meteorol.* **67**, 28452 (2015).
19. Petzold, A. *et al.* Ice-supersaturated air masses in the northern mid-latitudes from regular in situ observations by passenger aircraft: vertical distribution, seasonality and tropospheric fingerprint. *Atmos. Chem. Phys.* **20**, 8157–8179 (2020).
20. Sourdeval, O. *et al.* Ice crystal number concentration estimates from lidar–radar satellite remote sensing – Part 1: Method and evaluation. *Atmos. Chem. Phys.* **18**, 14327–14350 (2018).
21. Mitchell, D. L., Garnier, A., Pelon, J. & Erfani, E. CALIPSO (IIR-CALIOP) retrievals of cirrus cloud ice particle concentrations. *Atmos. Chem. Phys.* **18**, 17325–17354 (2018).
22. Gryspeerdt, E. *et al.* Ice crystal number concentration estimates from lidar–radar satellite remote sensing—Part 2: Controls on the ice crystal number concentration. *Atmospheric Chemistry and Physics* **18**, 14351–14370 (2018).
23. Gryspeerdt, E., Quaas, J., Goren, T., Klocke, D. & Brueck, M. An automated cirrus classification. *Atmospheric Chemistry and Physics* **18**, 6157–6169 (2018).
24. Testa, B. *et al.* Soot aerosols from commercial aviation engines are poor ice-nucleating particles at cirrus cloud temperatures. *Atmos. Chem. Phys.* **24**, 4537–4567 (2024).
25. Testa, B., Durdina, L., Edebeli, J., Spirig, C. & Kanji, Z. A. Simulated contrail-processed aviation soot aerosols are poor ice-nucleating particles at cirrus temperatures. *Atmos. Chem. Phys.* **24**, 10409–10424 (2024).
26. Möhler, O. *et al.* The Portable Ice Nucleation Experiment (PINE): a new online instrument for laboratory studies and automated long-term field observations of ice-nucleating particles. *Atmos. Meas. Tech.* **14**, 1143–1166 (2021).
27. McCluskey, C. S. *et al.* Observations of Ice Nucleating Particles Over Southern Ocean Waters.

- Geophysical Research Letters* **45**, 11,989–11,997 (2018).
28. Groß, S. *et al.* Investigating an indirect aviation effect on mid-latitude cirrus clouds – linking lidar-derived optical properties to in situ measurements. *Atmos. Chem. Phys.* **23**, 8369–8381 (2023).
 29. Kärcher, B., Marcolli, C. & Mahrt, F. The role of mineral dust aerosol particles in aviation soot-cirrus interactions. *J. Geophys. Res.* **128**, e2022JD037881 (2023).
 30. Murray, B. J. *et al.* Heterogeneous nucleation of ice particles on glassy aerosols under cirrus conditions. *Nat. Geosci.* **3**, 233–237 (2010).
 31. Ponsonby, J., King, L., Murray, B. J. & Stettler, M. E. Jet aircraft lubrication oil droplets as contrail ice-forming particles. *Atmospheric Chemistry and Physics* **24**, 2045–2058 (2024).
 32. Saunders, R. W. *et al.* An aerosol chamber investigation of the heterogeneous ice nucleating potential of refractory nanoparticles. *Atmos. Chem. Phys.* **10**, 1227–1247 (2010).
 33. Terasaki, K. & Miyoshi, T. Including the horizontal observation error correlation in the ensemble Kalman filter: idealized experiments with NICAM-LETKF. *Mon. Weather Rev.* (2023) doi:10.1175/mwr-d-23-0053.1.
 34. Yashiro, H., Terasaki, K., Miyoshi, T. & Tomita, H. Performance evaluation of a throughput-aware framework for ensemble data assimilation: the case of NICAM-LETKF. *Geoscientific Model Development* **9**, 2293–2300 (2016).
 35. Satoh, M. *et al.* Nonhydrostatic icosahedral atmospheric model (NICAM) for global cloud resolving simulations. *J. Comput. Phys.* **227**, 3486–3514 (2008).
 36. Kärcher, B. A parameterization of cirrus cloud formation: Revisiting competing ice nucleation. *J. Geophys. Res.* **127**, (2022).
 37. Ahrens, D., Méry, Y., Guénard, A. & Miake-Lye, R. C. A new approach to estimate particulate matter emissions from ground certification data: The nvPM mission emissions estimation methodology. *J. Eng. Gas Turbine. Power* **145**, 031019 (2023).
 38. Wilson, T. W. *et al.* Glassy aerosols with a range of compositions nucleate ice heterogeneously at cirrus temperatures. *Atmos. Chem. Phys.* **12**, 8611–8632 (2012).
 39. Sanz-Morère, I., Eastham, S. D., Allroggen, F., Speth, R. L. & Barrett, S. Effect of contrail overlap on radiative impact attributable to aviation contrails. *Atmos. Chem. Phys.* 1–62 (2020).
 40. Prashanth, P. *et al.* Near-zero environmental impact aircraft. *Sustainable Energy & Fuels* (2024) doi:10.1039/D4SE00419A.
 41. Fritz, T. M. *et al.* Identifying the ozone-neutral aircraft cruise altitude. *Atmos. Environ.* **276**, 119057 (2022).
 42. Fritz, T. M., Eastham, S. D., Speth, R. L. & Barrett, S. R. H. The role of plume-scale processes in long-term impacts of aircraft emissions. *Atmos. Chem. Phys.* (2020) doi:10.5194/acp-2019-498.
 43. Eastham, S. D., Chossière, G. P., Speth, R. L., Jacob, D. J. & Barrett, S. R. H. Global impacts of aviation on air quality evaluated at high resolution. *Atmos. Chem. Phys.* **24**, 2687–2703 (2024).
 44. Meijer, V. R. *et al.* Contrail coverage over the United States before and during the COVID-19 pandemic. *Environmental Research Letters* (2022).
 45. Agarwal, A., Meijer, V. R., Eastham, S. D., Speth, R. L. & Barrett, S. R. H. Reanalysis-driven simulations may overestimate persistent contrail formation by 100%–250%. *Environ. Res. Lett.* **17**, 014045 (2022).
 46. Haslehner, K., Gasparini, B. & Voigt, A. Radiative heating of High-Level clouds and its impacts on climate. *J. Geophys. Res.* **129**, e2024JD040850 (2024).
 47. Gasparini, B. *et al.* Opinion: Tropical cirrus – from micro-scale processes to climate-scale impacts. *Atmos. Chem. Phys.* **23**, 15413–15444 (2023).
 48. Gasparini, B., Meyer, A., Neubauer, D., Münch, S. & Lohmann, U. Cirrus cloud properties as seen by the CALIPSO satellite and ECHAM-HAM global climate model. *J. Clim.* **31**, 1983–2003 (2018).
 49. Gasparini, B., Blossey, P. N., Hartmann, D. L., Lin, G. & Fan, J. What drives the life cycle of tropical anvil clouds? *J. Adv. Model. Earth Syst.* **11**, 2586–2605 (2019).
 50. Kalnay, E., Li, H., Miyoshi, T., Yang, S.-C. & Ballabrera-Poy, J. 4-D-Var or ensemble Kalman filter? *Tellus A* **59**, 758 (2007).
 51. Sekiyama, T., Tanaka, T., Shimizu, A. & Miyoshi, T. Data assimilation of CALIPSO aerosol observations. *Atmospheric Chemistry and Physics* **10**, 39–49 (2009).
 52. Miyoshi, T. *et al.* Big data assimilation: Real-time 30-second-refresh heavy rain forecast using fugaku during Tokyo Olympics and paralympics. in *Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis* (ACM, New York, NY, USA, 2023). doi:10.1145/3581784.3627047.
 53. Raif, E. N. *et al.* High ice-nucleating particle concentrations associated with Arctic haze in springtime cold-air outbreaks. *EGUsphere* 1–38 (2024) doi:10.5194/egusphere-2024-1502.

54. Righi, M., Hendricks, J. & Beer, C. G. Exploring the uncertainties in the aviation soot–cirrus effect. *Atmos. Chem. Phys.* **21**, 17267–17289 (2021).
55. Kärcher, B., Möhler, O., DeMott, P. J., Pechtl, S. & Yu, F. Insights into the role of soot aerosols in cirrus cloud formation. *Atmospheric Chemistry and Physics* **7**, 4203–4227 (2007).

Planetary Sunshade Baseline Survey

Section 1: Programme & Technical

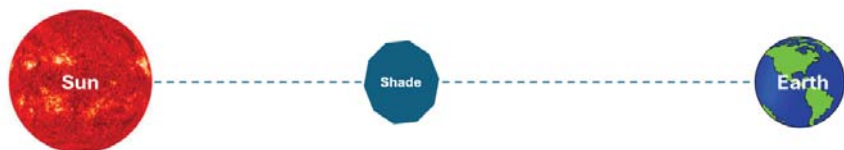
The Planetary Sunshade Project aims to advance our understanding of space-based Solar Radiation Modification (SRM) architectures. Our work will involve developing and comparing various SRM options, assessing key factors, and conducting climate modeling. While conducting an outdoor experiment—specifically a spacecraft-based test—is beyond the scope of ARIA's funding, there is an urgent need to advance space-based SRM to a level of understanding comparable to existing in-atmosphere SRM interventions. At the conclusion of our project, we will propose a space-based experiment, deliver a rigorously modeled set of potential space interventions, and establish a comprehensive baseline for ARIA and the global community.

Section 1.1 Proposed Project

This project will study the practical feasibility and predicted climate impacts of the set of all plausible space based SRM solutions. Previous climate modeling efforts have looked at general Solar Dimming (SD) in the abstract from feasible space architectures, and until now, specific space architectures have not been modeled by climate scientists. To understand a plausible intervention, we need to consider the full range of possible architectures from both engineering and climate modeling perspectives. The representative architectures we will use for our study are:

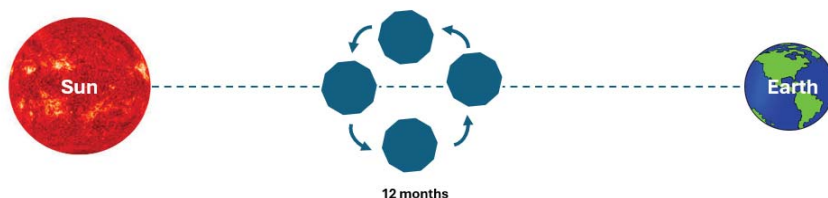
A: Reflective spacecraft at Sun Earth Lagrange 1 (SEL1) with minimal preferential seasonal hemisphere shading

This intervention is a constellation of spacecraft, with a total area of the magnitude of 2 M km² stationed the SEL1. This location is, by definition, constantly in line with the Earth and Sun, providing constant shading that is diffused evenly across the globe.



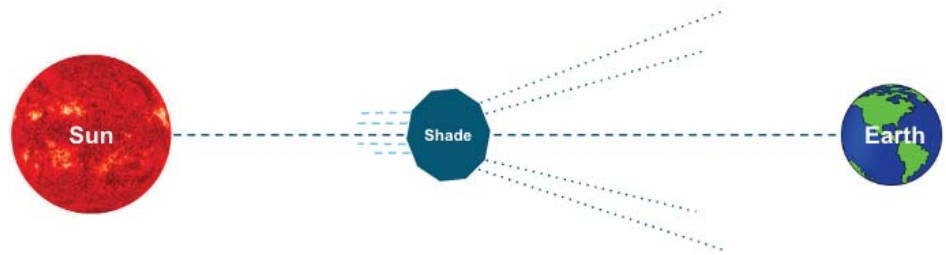
B: Reflective spacecraft at SEL1 in an orbit with preferential seasonal hemisphere shading

This intervention is a constellation of spacecraft, with a total area larger than the 2 M km² in architecture A, orbiting the SEL1 point in a 12 month period such that the northern hemisphere is shaded more in the northern summer and the southern hemisphere is shaded more in the southern summer. This intervention studies the engineering and orbital mechanics feasibility of Visoni et. el's 2021 work [1]. The goal of this intervention is to achieve solar dimming in three independently adjusted patterns (globally uniform, linear with sine of latitude, and quadratic with sine of latitude) to maintain global mean temperature, the interhemispheric temperature gradient.



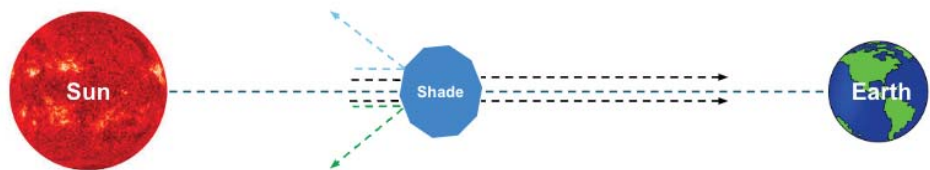
C: Diffractive spacecraft at SEL1

This intervention is similar to A and B, but instead of reflecting or blocking all wavelengths of light, this diffracts that light away from the Earth. Prismatic materials can be created to alter the trajectory of solar radiation. Diffraction could result in a smaller sunshade mass for similar cooling benefits.



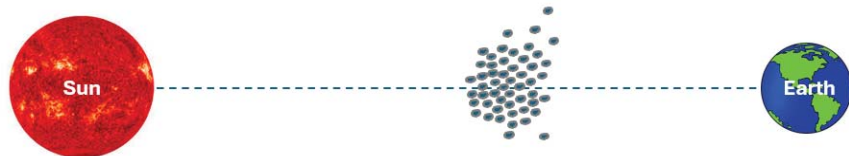
D: Selective Wavelength blocking spacecraft at SEL1

This intervention is similar to C, but only blocks selective wavelengths. This intervention uses materials that filter some wavelengths while blocking others. The ability to specify wavelengths could be an advantage to achieving specific cooling outcomes. Specifically, infrared wavelengths most directly linked to the earth's warming could be blocked with spectrally selective coatings or low-emissivity coatings commonly used in architecture.



E: A dust cloud made from asteroids at SEL1

This intervention is a dust cloud made of pulverized regolith sourced from asteroids or the moon which diffuses across the SEL1 area, providing constant and even shading across the earth. Work on this architecture builds on the JPL team's work on the DimSun concept [2]. This studies the construction and climate properties of a dust cloud composed of $\approx 4.52 \times 10^{23}$ particles of $1.6 \mu\text{m}$ -radius at SEL1. Since most of the Sun's energy is in wavelengths smaller than $2.5 \mu\text{m}$, these particles will block the Sun's rays along specific wavelengths.



F: Reflective spacecraft in Low Earth orbit

This intervention is a constellation of spacecraft in low earth orbit, which shade the earth as they pass between it and the sun. While not typically considered viable due to the small amount of time that an object is shading the earth on any orbit, this is included in the study because of the need for a comprehensive look at the options. Unique challenges include a distinct increase in



orbital debris and collision risks as well as the chemical impact of so much metallic mass re-entering the atmosphere.

Climate Modeling Work

The impacts of the different space based constellations on the Earth System will be studied with the NCAR Community Earth System Model (CESM). The model includes comprehensive processes in the atmosphere that are coupled to land, ocean, and cryosphere and can be run in more or less complex configurations, reaching from more simplified simulations for climate impact studies, to very comprehensive configurations that include interactive aerosols microphysics, chemistry, radiation, and transport, well suited to assess effects on the whole atmosphere, the ozone layer, including climate feedbacks.

Modeling approach

Different space based constellations will potentially differ in details of solar dimming reaching Earth. This may be a simple dimming of incoming solar radiation globally and through the solar spectrum or it may vary depending on the sophistication of the ability to modulate latitudinal gradients of dimming as well as wavelength specific dimming. The more degrees of freedom a solar shield may offer in terms of modulating location and strength of the dimming the more it is possible to adjust climate impacts towards more optimal deployments in terms of climate impacts as well as impacts on societies and ecosystems.

Climate model simulations are a useful tool to explore possibilities that may be offered by the different space based constellations and help to assess most beneficial options. We'll first run general sensitivity analysis on all the architectures. We will increase the complexity of models run, pursuing interesting discrepancies and surprising results, leading to more in depth modeling work. More simplified (single column runs) will be used for assessing details of changes in incoming radiation on chemistry, while more comprehensive CESM model configurations will be used to look at the complicated feedbacks between the whole atmosphere, land, ocean and cryosphere. The interventions will be applied to a couple of future scenarios (potentially a high forcing scenario and a more optimistic scenario), in order to assess unintended consequences for stronger and weaker applications. With this work, will develop a set of GeoMIP experiments proposed to run in a multi-model setting.

In addition to intended impacts, we must also study unintended climate impacts. The GHG emissions from rocket launches will be considered alongside the chemical and heating impacts of spacecraft re-entry. Re-entry impacts are potentially significant for both reusable rockets and spacecraft intentionally burning up in the atmosphere. This discussion will reference the Montreal Protocol on the Ozone layer.

Section 1.2 Technical and Non-Technical Risks

Each architecture will be modeled to better understand its value as a possible SRM option. The modeling work can help map out potential impacts of out-door test cases and assess potentially measurable impacts depending on the scale and type of SD intervention. In addition, we must compare the challenges and risks of each of these approaches. Our work will compare the following factors for each of the architectures:

- Technological Readiness Levels (TRLs): what we know about the technologies needed for construction?
- Total mass to achieve the specified level of cooling, and a discussion of the possibility of sourcing mass from space resources.
- Cost is perhaps the least accurate factor that we can assess, given the wide unknowns of economies of scale of building space infrastructure, but we will offer general cost parameters.
- Orbital considerations: What orbits are physically possible, and for each architecture, what amount of energy to reach and maintain the desired orbit?

- Ongoing maintenance. How often do spacecraft or debris need to be replaced and what sort of work is required to do so?
- System reversibility. How might the system be reversed assuming a correctly functioning spacecraft constellation, and what would happen if there is a general loss of control of the constellation?
- Other key risk factors include the system durability to meteor impacts, the risk of collisions among spacecraft in the constellation, the possibility of damaging solar storms and degradation caused by long term radiation.
- We will calculate the visual impacts for the general public and for scientists observing the sun and sky.

Section 1.3 Differentiation From Other Approaches

Our project is the first sunshade effort to bring leading researchers on the aerospace and climate science fields into the same project. Here is a brief overview of the significant advances to date from the respective fields:

Aerospace Engineering Concept Development

Aerospace engineers have studied the planetary sunshade concept for decades, laying the groundwork for current explorations of space-based solar geoengineering. The concept first gained traction in the 1980s with James Early's (1989) proposal of a large reflective shield positioned at the Sun-Earth Lagrange Point 1 (L1). [3] Early's work emphasized the feasibility of mitigating global warming by reducing incoming solar radiation, introducing the idea of a single, monolithic structure. This early design, while visionary, faced substantial challenges due to the immense mass required for deployment and the associated launch costs.

Subsequent research sought to address these engineering obstacles. In the 1990s, Lowell Wood and colleagues at Lawrence Livermore National Laboratory expanded on Early's ideas, proposing the use of multiple smaller, lightweight reflectors instead of a single monolithic structure. [4] This shift toward modular designs was a significant innovation, as it reduced the overall system weight and increased redundancy, making the concept more practical for implementation.

Sanchez and MacInnis (2015) advanced the planetary sunshade concept by investigating optimal configurations designed not only to offset global temperature increases but also to address regional and seasonal variations in temperature. [5] Using a globally resolved energy balance model, they demonstrated how the motion of sunshades could be dynamically coupled to the Earth's climate to mitigate latitudinal and seasonal temperature disparities. Their work revised earlier studies by identifying families of forced orbits near SEL1 which required only minimal adjustments to the sunshade orientation to maintain their desired trajectories. This innovation marked a breakthrough in integrating orbital mechanics with geoengineering goals, offering a more efficient and nuanced approach to mitigating climate change on both global and regional scales. However, Sanchez and Macinnis used the GREB, a simple climate modeling tool which does not incorporate many of the elements used by state-of-the-art climate models.

Other noteworthy studies include a group at MIT who developed a concept to build a sunshade out of bubbles. [6] Scientists have proposed dust clouds, which could even be 'anchored' by a larger asteroid towed into place. A physicist proposed using an asteroid to anchor a very light-weight sail. These studies contribute to our understanding of the range of options.

Sunshade Development Prototype Efforts

With the increased urgency of the climate crisis and the dramatically falling cost of access to space, a number of private initiatives have emerged in recent years to launch prototype missions. While actual launches are far from certain, it is worth noting here the efforts underway.

The private company Earthguard.space is developing a diffractive film deployment technology and making plans to launch test missions. They are privately funded, and they have done their own in-house

climate modeling. Our proposal will study their technology as architecture C. Cool Earth is a demonstration sunshade effort led by Israel's Asher Space Research Institute. While their project has not made notable advances in the past year, they have developed a simple demonstration concept of Architecture A. A group organized around the Cosmos Club in DC is working with a Rocket Lab engineer to develop very small sunshade elements which they plan to fly in a test mission soon. Ethos-space.com has a sunshade as the goal, and is focused on the more immediate aims of building a spaceport and developing industrial capacity to use lunar resources.

NASA has developed and partially built the Solar Cruiser mission. While not described as a space SRM prototype, the spacecraft is an exact demonstration of a sunshade element. The 1600m² solar sail is designed to fly at SEL1. The project's funding was cut and it is not currently scheduled to fly. [7]

Climate Modeling Existing Work

The climate modeling community has long relied on Solar Dimming (SD) as a baseline scenario to compare the impacts of solar radiation management (SRM) interventions. GeoMIP (Geoengineering Model Intercomparison Project) has played a critical role in advancing this research, standardizing SD scenarios to facilitate cross-model comparisons. The GeoMIP framework has enabled researchers to evaluate the climatic and hydrological effects of SD across various regions, but its simplicity may obscure the complex dynamics of feasible space architectures. For instance, Kravitz et al. (2013) noted that while SD offers a convenient reference point, it falls short in capturing the intricate, spatially heterogeneous outcomes that more targeted interventions might achieve. [1]

Recent research examines whether SD is as uniform of a comparison as previously thought. In 2021, Visioni, MacMartin and Kravitz published a paper asking "Is turning down the sun a good proxy for stratospheric sulfate geoengineering", and found that a uniform dimming across all latitudes has drawbacks with regard to equatorial vs. polar cooling. They further also considered a hypothetical SD with a latitudinal dependence determined by a combination of the first three Legendre Polynomials in order to, together with reducing global temperatures, maintain the equator-to-pole and interhemispheric temperature gradient. They found this preferential shading to produce more even effects over the earth than a general SD, or then even more sophisticated forms of SAI using various injection locations. [8] However, the purpose of that research was to develop a better baseline for comparing stratospheric aerosol injection methods. The team did not discuss what sort of architecture could actually achieve such preferential shading.

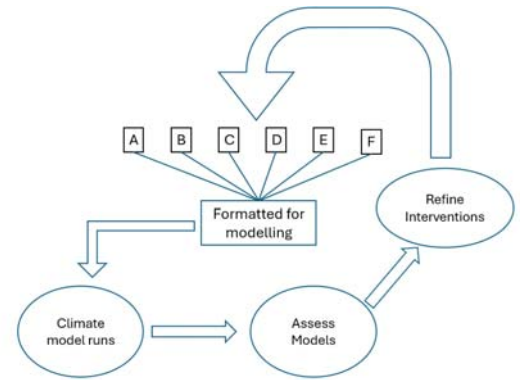
ARIA Sunshade Project Proposal

Our project will bridge the gap between these two bodies of work. We will bring realism and technical capability to SD models used by climate modelers. One result of this would ideally be developing a GeoMIP experiment for realistic SD could be an outcome of this proposal. By creating a standard experiment, other researchers can compare and study the sunshade concept in a repeatable way.

Finally, our project will consider the minimum measurable impact for a test sunshade. We will describe what sized test shield would have a measurable effect. To answer this we'll consider the solar cycle fluctuations and the measuring tools that could determine that. This will set out a definition of 'test' vs. 'pilot' vs. 'implementation' and inform demonstration missions. This should establish a framework for governance and policy discussions.

Section 1.4 Activity of Work, Key metrics and Milestones

As a multidisciplinary project, we are seeking to create parallel but interacting workstreams. Our work is split generally into the engineering and modeling teams. Each architecture will be scaled to match the same level of cooling, and described in terms of latitudes, ramp-up time, wavelengths and other factors relevant to modeling. While the engineering teams continue to develop their concepts at higher levels of engineering detail, the climate modeling team will run analysis.



Key Milestones:

1. Week 1: Project kickoff. Team aligns on standardized parameters to compare different space based options, and align on what we mean by hardware capabilities. Climate Modeling team clarifies formats and definitions of data and inputs.
2. Week 10: Engineering teams present basic conceptual design reviews of interventions. First guess at ramp-up times, how many watts/sq M would be achieved over time, and in what orbit, what wavelengths.
3. Week 12: Alignment between engineering and modeling teams to clarify understandings
4. Week 20: Modeling team completes investigation of climate impacts of proposed options
5. Week 30: Engineering teams have refined proposals. Conceptual Design Review, including assessment of risks, mitigation strategies, costs, timelines.
6. Week 40: Modeling team completes second round of modeling and produces results for final publication
7. Week 45: Report drafted and published, including space based experiment recommendation. This includes buffer time to complete project and work with the ARIA team on final forms and presentations.

Dependencies and assumptions:

As with all geoengineering research, we assume that climate models are an effective way to study proposed interventions. We assume that different architectures can be compared by the models in a meaningful way. We are depending on the climate modeling expertise to adapt existing models to the unique characteristics of space based architectures.

We are assuming that the architectures we have selected are representative of desirable and feasible possible constructions, and that we have assembled a team of researchers who are the best in their fields and can provide accurate details. We are depending on this expertise being informed by the history of study as well as ongoing developments.

Collaboration across disciplines assumes that we have sufficient understanding, language, trust and time to be effective, and allow each group to make meaningful contributions. We are dependent on that willingness to collaborate toward a holistic common goal.

Section 2: The Team

The Planetary Sunshade Foundation (PSF) is a newly established, US-based 501(c)3 nonprofit dedicated to advancing space based SRM. Our organization is a global network of researchers which has developed out of a shared belief that space can contribute to climate solutions. We committed to bridging the gap between geoengineering climate scientists and aerospace engineers, and over the past 4 years have worked hard to build trust. We have also worked hard to find collaborators with a rigorous approach and far-ranging curiosity. Our contributors are intrinsically motivated, as evidenced by so much willingness to

donate time. This proposal seeks funding to enable key PSF staff to focus full time on developing the sunshade concept by deepening collaboration across disciplines.

Core PSF Leadership:

Engineering Expertise from Ethos Space:

Climate Modeling Leadership:

Sub-contracted in-kind engineering specialty contributions: Due to institutional constraints around grant funding, the following individuals are excited to contribute their time in-kind for this project.

2.1 Coordination and Management

To coordinate and manage the teams, we will facilitate regular meetings focused on identifying gaps in understanding, aligning on key milestones, and ensuring accountability. The climate modeling team operates as a tightly-knit unit and has the capability to work independently. Our approach will include structured check-ins and a consistent format for the exchange of information to maintain alignment and progress.

The core engineering team, anchored by Ethos Space, is able to meet in person in Los Angeles on a frequent basis for brainstorming sessions. We will leverage the Ethos shop space, equipped with collaboration tools, to foster innovation and streamline communication. [REDACTED] will be responsible for collaborating with specialized engineers to define work milestones and rigorously assess underlying assumptions.

As project coordinator, [REDACTED] role will involve establishing and maintaining systems that ensure effective collaboration and timely progress. [REDACTED] will also be responsible for communicating with both internal and external stakeholders, providing regular updates and ensuring transparency throughout the project lifecycle.

References:

- [1] Visioni, D., MacMartin, D. G., & Kravitz, B. (2021). Is turning down the sun a good proxy for stratospheric sulfate geoengineering? *Journal of Geophysical Research: Atmospheres*, 126(7), e2020JD033952. DOI:10.1029/2020JD033952
- [2] S. Bandyopadhyay, S. Bhamidipati, M. Saboia da Silva, M. Richardson, M. Hakuba, M. Lebsock, A. Paranjape, A. Nanjangud, T. Jadhav, C. Percival, E. Fishbein, J. Reager, "Dimming the Sun (DimSun) using Controllable Swarm of Smallbody Regolith Particles," IEEE Aerospace Conference, Big Sky, MT, Mar. 2025. accepted. ([PDF](#))
- [3] Early, J. T. (1989). Space-based solar shield to offset greenhouse effect. *Journal of the British Interplanetary Society*, 42, 567–569.
- [4] Teller, E., Hyde, R., & Wood, L. (1997). Global warming and ice ages: Prospects for physics-based modulation of global change. Lawrence Livermore National Laboratory Report.
- [5] Sánchez J-P, McInnes CR (2015) Optimal Sunshade Configurations for Space-Based Geoengineering near the Sun-Earth L1 Point. *PLoS ONE* 10(8): e0136648. <https://doi.org/10.1371/journal.pone.0136648>
- [6] Ratti, C., Primmerman, C., Rus, D., McKinley, G., Buehler, M., Lozano, P., et al., *Space Bubbles*, MIT Senseable City Lab, <https://senseable.mit.edu/space-bubbles/> (accessed December 8, 2024).
- [7] Johnson, L. (2023). *The NASA Solar Cruiser Solar Sail System - ISSS 2023 Presentation*. NASA. Retrieved December 8, 2024, from <https://ntrs.nasa.gov/api/citations/20230007241/downloads/The%20NASA%20Solar%20Cruiser%20Solar%20Sail%20System%20-%20ISSS%202023%20Presentation%20-%20Les%20Johnson.pdf>
- [8] Kravitz, B., et al. (2013). Climate model response to geoengineering with stratospheric sulfate aerosols. *Journal of Geophysical Research: Atmospheres*, 118(15), 8320–8332. DOI:10.1002/jgrd.50646

Investigating the Impacts of Solar Geoengineering on the Variability and Wet-Dry Spell Dynamics of the West African Monsoon

Section 1:

1. Programme and Technical

1.1 Introduction

The West African Monsoon (WAM) is a pivotal climatic system that profoundly influences the livelihoods of millions in the West African region. Characterized by its variability and the occurrence of wet and dry spells, the WAM governs agricultural productivity, water resources, and ecosystem services, making it a critical element for regional sustainability (Abiodun et al., 2021). Climate change threatens to exacerbate WAM variability, posing risks to food security, water availability, and economic stability. The IPCC 5th report provides evidence with high confidence that dryness will continue to increase in West Africa as the climate is forced by increasing anthropogenic warming. To mitigate these adverse effects, solar radiation management (SRM) has been proposed as a potential approach to counteract the warming influence of human activities and help avert the worst impacts of climate change.

SRM is a proposed method of reducing the adverse effects on weather and climate associated with climate change in order to temporarily counteract some of the imbalance produced by the increase in atmospheric greenhouse gases (GHGs) and to avoid the worst consequences of climate change (Vioni et al., 2021). Some of the widely proposed approach of SRM include marine cloud brightening, space shading, stratospheric aerosol injection, and cirrus cloud thinning (Abiodun et al., 2021; Stjern et al., 2018). To date, the most common suggested approach is via injection of SO₂ into the stratosphere in order to produce a layer of sulfate aerosols capable of partially reflecting incoming solar radiation; this is usually defined as stratospheric aerosol intervention (SAI) or sulfate geoengineering (Pinto et al., 2020). Previous studies have shown that SRM could alter global as well as regional climate scales, mostly reduce the intensity of extreme precipitation and associated impacts (Muthyala, R., Bala, G., & Nalam, 2018), significantly reduces temperature means and extremes (Pinto et al., 2020), decrease surface ocean hydrogen ion concentration and attenuates the seasonal amplitude of [H⁺] (Jin et al., 2022). However, its regional impacts, particularly on complex systems like the WAM, remain poorly understood.

This research focuses on exploring the implications of SRM on WAM variability, with a specific emphasis on wet and dry spell dynamics. By employing advanced climate models, observational data, and scenarios from the Geoengineering Model Intercomparison Project (GeoMIP), the study aims to address critical gaps in understanding how SRM interventions might influence the WAM system. Furthermore, the project seeks to provide actionable insights into how SRM might be leveraged to mitigate adverse climate impacts while avoiding unintended consequences, thereby supporting the overarching goals of the ARIA Exploring Climate Cooling programme.

1.2 Scientific Rationale and Objectives

The ARIA Exploring Climate Cooling programme seeks to advance innovative solutions for mitigating climate change impacts, with a particular focus on avoiding tipping points in global and regional systems. This project aligns closely with these objectives by:

- a) Investigating the effects of SRM on a critical regional climate system, the WAM.
- b) Exploring the potential for SRM to reduce extreme weather variability, including prolonged wet and dry spells, which are significant drivers of socio-economic vulnerability in West Africa.
- c) Generating high-resolution projections of WAM behavior under SRM scenarios to inform policy and adaptation strategies.

Key Objectives:

- Assess how SRM modifies rainfall variability and the occurrence of extreme wet and dry spells.
- Evaluate the implications of these changes for water resources, agriculture, and regional sustainability.
- Examine the performance of high-resolution climate models in capturing the dynamics of WAM under SRM scenarios.
- Assess the predictability of WAM onset and cessation through dynamical modeling.

- Compare the outcomes with baseline scenarios (SSP2-4.5 and SSP5-8.5) to determine the distinct impacts of SRM.

1.3 Methodology

a) Study Area

The study focuses on the West African region, spanning latitudes 5°N to 20°N and longitudes 15°W to 20°E. This area encompasses diverse climatic zones, ranging from arid Sahelian to humid Guinean, making it an ideal natural laboratory for studying monsoon dynamics and their response to external forcings.

b) Data Sources

This research will utilize a diverse array of data sources, including long-term meteorological and hydrological datasets as follow:

i) Regional climate models

CORDEX-CORE: CCLM5-0-15, REMO2015, RegCM5 forced with ERA5 reanalysis data, spatial resolution of 0.25°, 1981-2009/2010

ii) Reference data

- CHIRPS V2.0, 1981 to present, spatial resolution of 0.25° (~28 km) (Funk et al. 2014, 2015)
- GPCC V2020, 1891 to 2019, spatial resolution of 1.0° (Schneider et al. 2020)
- TAMSAT V3.1, 1983 to present, spatial resolution of 0.25° (Maidment et al., 2017)
- CRU TS V4.06, 1901 to present, spatial resolution of 0.5° (Harris et al., 2020)
- ERA5 reanalysis data, 1979 to present, spatial resolution of 0.25°, the Copernicus Climate Change Service (C3S) (2019) (Hersbach et al., 2020).
- Alongside outputs from Geoengineering Model Intercomparison Project (GeoMIP) simulations. Four distinct simulation sets will be analyzed: two baseline scenarios without geoengineering interventions and two geoengineering scenarios.

The baseline scenarios correspond to the Shared Socioeconomic Pathways (SSPs) SSP2-4.5 and SSP5-8.5 (Meinshausen et al., 2020). SSP2-4.5 represents a moderate emissions trajectory with balanced challenges for mitigation and adaptation, while SSP5-8.5 reflects a high-emissions pathway associated with limited climate change mitigation efforts and a fossil-fueled development scenario (Burgess et al., 2020).

The geoengineering scenarios include G6solar and G6sulfur, which are part of the GeoMIP framework. The G6solar scenario involves a reduction in solar constant to offset radiative forcing associated with a high-emissions scenario like SSP5-8.5. Conversely, the G6sulfur scenario simulates the injection of sulfur dioxide into the stratosphere to increase sunlight reflection and reduce surface warming (Kravitz et al., 2015). These scenarios will be instrumental in evaluating the potential impacts of Solar Radiation Management (SRM) on regional climate systems, particularly the West African Monsoon (WAM).

Additionally, high-resolution simulations using the Regional Climate Model (RegCM5) will be conducted, tailored specifically to the study region. RegCM5 is chosen for its demonstrated ability to accurately simulate WAM dynamics, including monsoon onset, spatial rainfall patterns, and extreme weather events. To ensure robust and reliable results, the performance of RegCM5 will be thoroughly evaluated against observational datasets.

c) Methods

The simulations will be performed using regional climate models highlighted in *section i)*, configured with high spatial and temporal resolution to accurately capture key monsoon processes. A comprehensive evaluation of the model's performance will compare its outputs with observational datasets and other models within the GeoMIP ensemble, focusing on its capacity to simulate monsoon onset, intensity, and spatial variability.

To achieve a holistic understanding of WAM variability under SRM scenarios, this study will integrate observational data with model outputs. Multi-model ensemble simulations, based on CORDEX regional climate models, will also be employed to address uncertainties, leveraging high-performance computing facilities for computationally intensive tasks.

Several indices will be applied for monsoon analysis, including the Standardized Precipitation Evapotranspiration Index (SPEI), Precipitation Concentration Index (PCI), Precipitation Concentration Degree (PCD), and Precipitation Concentration Period (PCP). These indices will facilitate detailed assessments of monsoon variability and its broader implications.

Statistical methods such as trend analysis, correlation analysis, and anomaly detection will be employed to uncover patterns and relationships within the data. This comprehensive approach will ensure that the study provides robust and actionable insights into the impacts of SRM on WAM dynamics.

1.4 Technical and Non-Technical challenges, and Mitigation Strategies

One of the primary technical challenges of this project is establishing and maintaining the computational infrastructure required for high-resolution climate modeling. These tasks demand substantial computing power, efficient storage systems, and expertise in managing large datasets. Key technical challenges include:

- Running high-resolution Regional Climate Models simulations and performing multi-model ensemble analyses, which require access to high-performance computing (HPC) systems. These simulations are computationally intensive, necessitating not only advanced hardware but also skilled personnel to manage and maintain these systems. In West Africa, where resources for climate modeling are often limited, establishing such infrastructure presents a considerable challenge.
- Dynamical downscaling of global datasets to the regional scale involves complex modeling techniques and precise data processing tools to ensure accurate and regionally relevant results for studying the West African Monsoon (WAM).

Mitigating these challenges, the project will utilize regional climate centers equipped with HPC facilities, such as the West African Climate Science Service Centre on Climate Change and Adapted Land Use (WASCAL) HPC in Ouagadougou, Burkina Faso. The WASCAL HPC infrastructure includes 20 nodes, 320 cores, 1TB of RAM per node, 2 Mgmt, 2 Object, 2 Metadata servers, and over 250TB of storage, supported by a 10G network system based on SFP. This robust infrastructure will provide the necessary computational capacity for the project's simulations.

Additionally, the project will benefit from collaboration with the Climate Systems Analysis Group (CSAG) at the University of Cape Town (UCT). CSAG has extensive experience in managing computational resources and offers technical support for climate research through its local data center, which is staffed by skilled software and hardware engineers. Their expertise will help ensure smooth execution of computationally demanding tasks.

The project will also engage with the Degrees Initiatives team, supported by ARIA, to enhance access to critical data and computational resources. Furthermore, collaboration with initiatives such as the **Global to Local Impacts of SRM Project (GLISP) project teams** will provide access to global expertise in climate modeling and downscaling. GLISP's commitment to maintaining accessible repositories of high-quality climate data will help address existing gaps in data availability for the Global South, providing significant benefits to this project.

A major non-technical challenge involves selecting the most appropriate downscaling methods for precipitation and other key climatic variables.

In mitigating this, the **Global to Local Impacts of SRM Project (GLISP) project teams** from UCT have capacity for both statistical and dynamical downscaling. Collaborations in conjunction with ARIA's support, connected this project to the UCT, **GLISP** project aims to make downscaled global climate data accessible to researchers in the global south.

1.5 Description of the proposed activity of work

WP 1 – Data Collection and Preprocessing

This work package involves assembling meteorological, hydrological, and climate model dataset necessary for understanding the variability of the WAM under baseline and geoengineering scenarios. This phase forms the foundation for subsequent modeling and analysis by ensuring high-quality and consistent data inputs. Therefore, the activities include:

- a) Collection of observational datasets, including precipitation and temperature, from GPCC, TAMSAT, CRU, and CHIRPS.

- b) Acquire reanalysis datasets such as ERA5, which provide a comprehensive historical record of atmospheric conditions.
- c) Model outputs from Shared Socioeconomic Pathways (SSPs) SSP2-4.5 and SSP5-8.5 to establish baseline scenarios, offering insights into climate variability without SRM interventions.
- d) Collect outputs from Geoengineering Model Intercomparison Project (GeoMIP) simulations under G6solar and G6sulfur scenarios for the evaluation of SRM's potential impacts on WAM dynamics.
- e) Perform quality control and preprocessing to standardize datasets, ensuring compatibility across different data sources. This includes regridding data to a uniform resolution, addressing missing values, and correcting biases.

WP 2 - Climate Modeling and Simulations

This work package focuses on leveraging the capabilities of the Regional Climate Model (RegCM5) to simulate WAM dynamics under baseline and SRM scenarios. The WP include:

- f) Configure RegCM5 with region-specific parameters to ensure accurate representation of WAM features, such as monsoon onset, spatial variability, and extreme weather events.
- g) Use of high-resolution grids to enhance the model's ability to capture fine-scale processes critical to WAM dynamics.
- h) Conduct simulations for SSP2-4.5 and SSP5-8.5 scenarios to provide a reference for understanding the natural variability of WAM under moderate and high-emission pathways.
- i) Perform simulations for G6solar and G6sulfur scenarios, assessing the impacts of SRM interventions on WAM variability and wet-dry spell dynamics.
- j) Compare simulated outputs with observational datasets to evaluate the model's performance in capturing key climatic features. Iteratively refine the model configuration to improve accuracy.

WP3 - Analysis of Wet-Dry Spell Dynamics

This work package utilizes statistical indices (SPEI, PCI, PCD, PCP) to analyze WAM variability.

This work package focuses on applying statistical methods to analyze the variability of WAM under the simulated scenarios. The statistical methods include:

- k) The use of indices such as the Standardized Precipitation Evapotranspiration Index (SPEI), Precipitation Concentration Index (PCI), Precipitation Concentration Degree (PCD), and Precipitation Concentration Period (PCP) to quantify the characteristics of wet and dry spells.
- l) Assess changes in the frequency, duration, and intensity of extreme wet and dry spells under baseline and SRM scenarios.
- m) Trend analysis to identify long-term changes in WAM variability.
- n) The use of correlation analysis to explore relationships between climatic variables and WAM behavior.
- o) Examination of spatial patterns of rainfall distribution and their temporal evolution across the West African region. Highlight potential hotspots of vulnerability to SRM-induced changes.

WP4 - Evaluation of Model Performance

The final work package evaluates the reliability and robustness of RegCM5 simulations by benchmarking them against observational and ensemble datasets. The activity will consist to:

- p) Evaluate the accuracy of RegCM5 outputs by comparing them with observational datasets (GPCC, TAMSAT, CRU, CHIRPS) and reanalysis data (ERA5).
- q) Compare RegCM5 results with other models in the GeoMIP ensemble to assess consistency and identify sources of uncertainty.
- r) Use statistical metrics such as bias, root mean square error (RMSE), and correlation coefficients to quantify model performance.
- s) Conduct sensitivity analyses to determine how model outputs respond to variations in key parameters, ensuring robust interpretations of the results.

1.6 Estimated Timelines and Project Plan

Role and Contribution: [REDACTED] will oversee all aspects of the project, ensuring seamless integration of activities across work packages. [REDACTED] will dedicate 100% of his time to managing the project, supervising the modeling efforts, coordinating data acquisition, and leading the analysis of WAM variability under SRM scenarios and report writing (publications article).

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Role and Contribution: [REDACTED] will lead the project, dedicating 70% of [REDACTED] time to supervising the climate modeling and dynamical downscaling tasks. [REDACTED] primary focus will be on configuring RegCM5 and analyzing its performance in simulating monsoon features under SRM scenarios. [REDACTED] will also provide expertise in evaluating the physical processes influencing WAM variability and contribute to capacity-building activities for junior researchers. [REDACTED] will also act as the primary liaison with external collaborators such as the Climate Systems Analysis Group (CSAG), **Global to Local Impacts of SRM Project (GLISP) project teams under ARIA funding** and WASCAL Competence Centre for HPC access.

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Role and Contribution: [REDACTED] will dedicate 30% of [REDACTED] time to statistical analysis and quality control of the datasets. [REDACTED] will be responsible for preprocessing observational and reanalysis data, applying indices like SPEI, PCI, PCD, and PCP, and conducting trend and correlation analyses. [REDACTED] role is critical in deriving actionable insights from the modeled data and ensuring its alignment with the project's objectives.

[REDACTED]

[REDACTED]

Expertise and Role: [REDACTED]

[REDACTED] Working closely with [REDACTED] will be responsible for data preprocessing, quality control, and the organization of large datasets for analysis. [REDACTED] will also contribute to the calculation of statistical indices and assist in developing visualization tools for presenting the results.

Time Dedication: [REDACTED] will dedicate 30% of [REDACTED] time to the project, focusing on data management, statistical analysis, and model validation tasks.

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Role and Contribution: [REDACTED] will dedicate 20% of [REDACTED] time to analyzing the impacts of SRM scenarios on water resources and agricultural systems in West Africa. [REDACTED] will collaborate on the evaluation of rainfall variability and extreme weather events, ensuring that the results are directly applicable to agricultural planning and water management. [REDACTED] insights will enhance the relevance of the findings for policy and adaptation strategies.

- [REDACTED]
[REDACTED] **Role: Technical guidance and model refinement.**
- [REDACTED]
[REDACTED]
[REDACTED] **Role: Support in downscaling techniques and analysis of SRM impacts.**

2.1 Collective Contribution and Integration

The project team will adopt a collaborative approach, leveraging their diverse expertise to address the multifaceted challenges of SRM and WAM variability. Each team member will contribute to multiple work packages while maintaining clear delineation of roles and responsibilities:

- Data Collection and Preprocessing (WP1):** [REDACTED] and [REDACTED] will lead the quality control and standardization of datasets, with support from [REDACTED] and [REDACTED] will oversee the integration of data from various sources, ensuring compatibility and consistency.
- Climate Modeling and Simulations (WP2):** [REDACTED] and [REDACTED] will co-lead the configuration and execution of RegCM5 simulations, with technical input from [REDACTED] and [REDACTED] on data integration. [REDACTED] will provide domain-specific expertise on interpreting simulation outputs.
- Wet-Dry Spell Dynamics Analysis (WP3):** [REDACTED] and [REDACTED] will take the lead in applying statistical indices and conducting trend analyses. [REDACTED] and [REDACTED] will guide the interpretation of findings in the context of WAM dynamics and SRM impacts.
- Model Performance Evaluation (WP4):** [REDACTED] will lead the benchmarking of RegCM5 outputs, collaborating with [REDACTED] to compare model performance against observational and ensemble datasets.

2.2 Time Allocation and Commitment

- [REDACTED]: 100% time commitment.
- [REDACTED]): 70% time commitment.
- [REDACTED] 30% time commitment.
- [REDACTED] 30% time commitment.
- [REDACTED]: 20% time commitment.

2.3 Team Coordination and Management

The project team will adopt a collaborative management structure, emphasizing efficient communication, clear role delineation, and task integration. [REDACTED] as the Lead Principal Investigator, will spearhead project coordination, ensuring seamless collaboration among team members and external partners.

e) **Internal Coordination:**

- Bi-Weekly virtual meetings will be held during the first 6 months of project to review progress, address challenges, and allocate tasks for the upcoming week. After 6 months the virtual meetings will be held monthly.
- Each work package will have a designated lead (e.g., [REDACTED] for WP2, [REDACTED] for WP3), ensuring accountability and clarity.
- Shared digital platforms like Google Drive and project management tools will be used for document sharing and task tracking.

f) **Collaboration with Third Parties:**

- Monthly consultations with UCT collaborators ([REDACTED]) will provide technical input and ensure alignment with project objectives.
- Periodic check-ins with GLISP project representatives will address challenges in data acquisition and downscaling methods.

2.4 Addressing Potential Gaps in Core Competencies

The team's interdisciplinary expertise covers most areas required for the project. However, some gaps may arise, particularly in:

- **Advanced computational expertise:** While the WASCAL HPC infrastructure is robust, technical support may be required for optimizing model performance and troubleshooting.
- **Specialized SRM knowledge:** Collaborations with GLISP and ARIA experts will provide additional insights into the nuanced impacts of SRM.
- **Policy translation:** While the team is scientifically strong, translating findings into actionable policy recommendations may require additional support from policy specialists.

Mitigation Strategies:

- Engage technical experts from CSAG for computational troubleshooting and system optimization.
- Leverage GLISP's knowledge-sharing platforms to fill gaps in SRM expertise.
- Collaborate with regional policy institutes to bridge the gap between scientific findings and policy formulation.

2.5 Motivation and Suitability

The team's motivation is driven by a shared commitment to addressing the pressing challenges posed by climate variability and change in West Africa. The profound impacts of WAM on regional livelihoods highlight the urgency of this research, which seeks to inform sustainable development and climate resilience strategies. Additionally, the team is motivated to contribute to the scientific exploration of SRM and its impacts on the West African climate. This includes analyzing both the potential positive and negative implications for climate tipping points across different subregions and regions of West Africa.

Another key motivation is to actively support and build a well-connected community of African SRM researchers. Strengthening this network is crucial to enhancing Africa's capacity to engage in the global discourse on SRM. By contributing in placing Sub-Saharan Africa – the continent most vulnerable to climate change and its impacts at the forefront of scientific and policy discussions, the team seeks to contribute addressing the historical dominance of the Global North in climate research and policy development, ensuring a more inclusive and equitable approach to addressing climate challenges.

Why This Team is the Right Fit:

- The team's collective experience in climate modeling, SRM, and monsoon dynamics ensures the scientific rigor required for the project.
- **Regional Focus:** With team members rooted in West Africa, the project is well-positioned to address context-specific challenges and engage local stakeholders effectively.
- Existing partnerships with institutions like CSAG - UCT, The Degrees Initiative and WASCAL highlight the team's ability to work collaboratively across disciplines.
- By involving junior researchers like [REDACTED] and [REDACTED] the project contributes to building local expertise, ensuring long-term benefits beyond the project's lifecycle.

2.6 References

- Abiodun, B. J., Odoulami, R. C., Sawadogo, W., Oloniyo, O. A., Abatan, A. A., New, M., Lennard, C., Izidine, P., Egbebiyi, T. S., & MacMartin, D. G. (2021). Potential impacts of stratospheric aerosol injection on drought risk managements over major river basins in Africa. *Climatic Change*, 169(3–4), 1–19. <https://doi.org/10.1007/s10584-021-03268-w>
- Burgess, M. G., Ritchie, J., Shapland, J., & Pielke, R. (2020). IPCC baseline scenarios have over-projected CO₂ emissions and economic growth. *Environmental Research Letters*, 16(1). <https://doi.org/10.1088/1748-9326/abcdd2>
- Funk, C., Peterson, P., Landsfeld, M., Pedreros, D., Verdin, J., Shukla, S., Husak, G., Rowland, J., Harrison, L., Hoell, A., & Michaelsen, J. (2015). The climate hazards infrared precipitation with stations - A new environmental record for monitoring extremes. *Scientific Data*, 2, 1–21. <https://doi.org/10.1038/sdata.2015.66>
- Hersbach, H., Bell, B., Berrisford, P., Hirahara, S., Horányi, A., Nicolas, J., Peubey, C., Radu, R., Bonavita, M., Dee, D., Dragani, R., Flemming, J., Forbes, R., Geer, A., Hogan, R. J., Janisková, H. M., Keeley, S., Laloyaux, P., Cristina, P. L., & Thépaut, J. (2020). The ERA5 global reanalysis. *Q J R Meteorol Soc.*, March, 1999–2049. <https://doi.org/10.1002/qj.3803>
- Kravitz, B., Robock, A., Tilmes, S., Boucher, O., English, J. M., Irvine, P. J., Jones, A., Lawrence, M. G., MacCracken, M., Muri, H., Moore, J. C., Niemeier, U., Phipps, S. J., Sillmann, J., Storelvmo, T., Wang, H., & Watanabe, S. (2015). The Geoengineering Model Intercomparison Project Phase 6 (GeoMIP6): Simulation design and preliminary results. *Geoscientific Model Development*, 8(10), 3379–3392. <https://doi.org/10.5194/gmd-8-3379-2015>
- Jin, X., Cao, L., & Zhang, J. (2022). Effects of solar radiation modification on the ocean carbon cycle: An earth system modeling study. *Atmospheric and Oceanic Science Letters*, 15(3), 100187. <https://doi.org/10.1016/j.aosl.2022.100187>
- Maidment, R., Grimes, D., Black, E. et al. A new, long-term daily satellite-based rainfall dataset for operational monitoring in Africa. *Sci Data* 4, 170063 (2017). <https://doi.org/10.1038/sdata.2017.63>
- Meinshausen, M., Nicholls, Z. R. J., Lewis, J., Gidden, M. J., Vogel, E., Freund, M., Beyerle, U., Gessner, C., Nauels, A., Bauer, N., Canadell, J. G., Daniel, J. S., John, A., Krummel, P. B., Luderer, G., Meinshausen, N., Montzka, S. A., Rayner, P. J., Reimann, S., ... Wang, R. H. J. (2020). The shared socio-economic pathway (SSP) greenhouse gas concentrations and their extensions to 2500. *Geoscientific Model Development*, 13(8), 3571–3605. <https://doi.org/10.5194/gmd-13-3571-2020>
- Muthyala, R., Bala, G., & Nalam, A. (2018). Regional scale analysis of climate extremes in an SRM geoengineering simulation, Part 1: precipitation extremes. *Current Science*, 114(5), 1024–1035.
- Pinto, I., Jack, C., Lennard, C., Tilmes, S., & Odoulami, R. C. (2020). Africa's Climate Response to Solar Radiation Management With Stratospheric Aerosol. *Geophysical Research Letters*, 47(2), 1–10. <https://doi.org/10.1029/2019GL086047>
- Stjern, C. W., Muri, H., Ahlm, L., Boucher, O., Cole, J. N. S., Ji, D., Jones, A., Haywood, J., Kravitz, B., Lenton, A., Moore, J. C., Niemeier, U., Phipps, S. J., Schmidt, H., Watanabe, S., & Kristjánsson, J. E. (2018). Response to marine cloud brightening in a multi-model ensemble. *Atmospheric Chemistry and Physics*, 18(2), 621–634. <https://doi.org/10.5194/acp-18-621-2018>
- Yu, Y., Schneider, U., Yang, S. et al. Evaluating the GPCC Full Data Daily Analysis Version 2018 through ETCCDI indices and comparison with station observations over mainland of China. *Theor Appl Climatol* 142, 835–845 (2020). <https://doi.org/10.1007/s00704-020-03352-8>

**Ice-Nucleating Particles in the Upper Troposphere:
Advancing Cirrus Control and Experimental Science Strength
“INPUT:ACCESS”**

Abstract: We will advance process-level understanding of three climate cooling approaches focused on cirrus clouds and water vapor controls at high altitudes. Cirrus processes are one of the largest sources of uncertainty in surface temperature response to climate change, and central to several intervention ideas. Hence, in situ measurements are needed to assess specific drivers of ice nucleation. We will address this need by combining our respective expertise in 1) balloon-borne measurements, 2) ice nucleating particle measurements, and 3) cirrus modeling. Our proposed efforts will enable us to advance both the measurement technology and the understanding of ice processes and parameters relevant to cirrus interventions. We will launch small weather balloons with novel instrumentation to collect ice nucleating particles from the cirrus regime, analyze them under laboratory recreations of cirrus conditions, and port our findings to improve model assessment of cirrus intervention impacts. These capabilities, which have never previously been achieved, will dramatically change the landscape of cirrus-relevant research. If large-scale outdoor testing – or deployment – ever occurs in regards to related climate interventions, then the balloon payload and analysis techniques developed in this proposal will be essential for monitoring. Climate intervention via manipulating upper troposphere cirrus may provide significant surface cooling with minimal environmental effects; this study will strengthen confidence in evaluating cirrus cloud related interventions, as well as identifying the most efficient ways to apply them.

I. Background: Water vapor (WV) and cirrus ice clouds in the upper troposphere (UT) strongly affect Earth’s radiation balance by trapping long-wave radiation. Three climate intervention (CI) approaches focus specifically on manipulating UT/lower stratospheric water vapor and/or cirrus thickness/lifetime to reduce global climate forcing. They are: **cirrus cloud thinning** (CCT, focused on reducing homogeneous nucleation of UT cirrus(1)), **contrail management** (CM, focused on diverting civilian aircraft to influence cirrus cloud formation for climate benefits (2)), and **intentional stratospheric dehydration** (ISD, focused on reducing WV at the tropical tropopause layer (TTL) entry to the stratosphere by seeding short-lived cirrus (3)). However, these approaches rely upon manipulation of some of the least well understood phenomena in the climate system. As models do not represent cirrus cloud formation well, confidence in the effectiveness of these approaches to cool our climate is low. Currently available measurements are inadequate to constrain the models. This is due to the fact that:

1) Small variations in water vapor (WV) concentrations, which can only be measured in situ, can have large impacts on relative humidity and thereby cloud formation. Direct in situ measurements are not widely available for model initialization, and global model resolution is too coarse for realistic representation. Consequently, models have poor skill in predicting ice-super-saturated airmasses in the UT; however this is a necessary capability on which all three interventions depend.

2) Measurements of ice nucleating particles (INP) composition and concentration in the UT are critically rare, and development of off-line analysis abilities is an ambitious paradigm changer for such research. Presently, our understanding of the most relevant sources of INP depend on extremely limited determinations primarily from high altitude aircraft campaigns that, by nature, are not global in representation. Laboratory determinations of INP nucleating properties at temperatures in the cirrus regime below ~240K depend on equipment available at only a few institutions, and are not suitable for routine measurement or for samples collected in situ.

3) Direct measurements even of cirrus cloud spatial and crystal size distributions are rare and usually only associated with research aircraft campaigns. Without these data, the connections between INP, WV, ambient temperature and actual cloud and radiative impact are very tenuous. In sum, these limitations severely hinder confident assessment of the potential of cirrus/WV controls as effective climate interventions. We propose to develop and apply technologies that will provide unprecedented data on ambient INP to assess applicability and to guide implementation of high-altitude cirrus climate interventions. Specifically, we will enhance our knowledge of UT WV and ice supersaturation distributions, and their dependence on INP type and concentration through new measurements.

II. Concept: We will simultaneously measure UT WV, INP, and cirrus crystal vertical profiles using balloon-borne instruments. Providing INP characteristics and concentrations within the context of the larger aerosol population and air mass humidity and temperature in the cirrus regime is a new and innovative approach to evaluating cirrus-relevant interventions. This effort will address the critical issues relevant to all three of the cirrus cloud related climate cooling approaches and to natural cirrus and UT WV controls more generally. First, we will advance measurement technology by developing balloon-borne INP collectors and cirrus crystal measurements. We will extend UK capabilities to provide routine cirrus-regime INP measurements in a laboratory setting (which will also support evaluation of synthetic INP for other ARIA efforts). These advances will provide critically needed constraints for models on the actual background UT INP available to influence cirrus formation and dehydration. Second, we will correlate our observations with air mass history and evolution focusing on cirrus formation/evaporation, convective anvil injections, and possible air-traffic corridor radiative processes. Third, we will document actual cirrus ice crystal size distributions and frequencies, elucidating formation and aging processes. Finally, we will integrate our findings into regional and global models to ensure that these efforts translate into usable information relevant to CM, CCT and ISD.

III. Research methodology:

III.1 Develop ability to collect INP from cirrus regions:

Large uncertainties about the sources, distribution, and ice nucleating ability of INP relevant to cirrus persist. Methods to measure them are extremely limited. For example, ice crystal residuals have been measured from a specialized high-altitude aircraft with Particle Ablation by Laser Mass Spectrometry PALMS (4), but these measurements are spatially limited, and, as they were performed on residuals, include additional uncertainties associated with potential post-nucleation coagulation.

Our first goal is to develop the technology necessary to collect INP from cirrus regimes onto substrates for off-line analysis. Although INP collection for offline sampling has been carried out routinely at the surface and even in the lower-mid troposphere with high-volume samplers (e.g. Sanchez-Marroquin et al. 2019 (5)), the challenges of collection in the low pressures of the upper troposphere have not yet been overcome. These challenges include 1) low concentrations of INP (1/liter marks the minimum concentration that we have identified as necessary to constrain) 2) cold temperatures and dry conditions, and 3) Reaching cirrus altitudes. INP at the surface can activate at temperatures as high as 270 K. However, cirrus conditions are much more extreme, with temperatures of 210 K (~10-12 km) in the midlatitudes to as low as 185 K (~17 km) in the tropics. Hence sampling of INP under cirrus conditions is much more difficult than those relevant to low altitudes. Deploying INP collectors at cirrus regime altitudes can only be done with balloons or aircraft. As balloons are cheaper, more versatile, and provide an excellent testbed to develop and test new instrumentation, they are the proposed for this work.

Hence, we will develop collectors for use on small balloons that are potentially extendable to aircraft deployment. The proposal team has long expertise in balloon-borne observations for rapid-deployments in response to specific events and long-term monitoring of aerosol, ozone, and WV vertical profiles (Balloon Baseline Stratospheric Aerosol Profiles, B²SAP, csl.noaa.gov/projects/b2sap/). We are very well positioned to apply this expertise to INP collection and are currently building an aerosol collector for balloon deployment. This development effort is underway, funded via NOAA/U. Colorado, and first flights are expected in Spring, 2025. This collector may be appropriate for INP, providing the ability to collect multiple samples in different altitude ranges. For this proposal, we will also explore an alternate design using an electrostatic precipitator. This approach stems from a proven design applied to INP collection and analysis (6). The electrostatic precipitator has excellent collection efficiency at even 5 lpm, a very high flow rate we believe is achievable even in the extremely thin air of the UT. At this rate, and a standard balloon climb/descent rate of 5 m s⁻¹, we will be able to sample aerosol from ~60 liters of air in a two-kilometer deep layer at the top of the troposphere. The minimum INP concentration of interest for cirrus is a few per liter. At this concentration, we would expect to collect on order 200 INP on a filter, which would then provide an uncertainty in the concentration of less than 10%. This provides a very reasonable expectation for success, assuming that we can port this design to balloon use. Our expectation is that the collector will gain efficiency in aerosol collection at high altitude relative to lower altitudes, but we will test this in an environmental chamber at NOAA.

III.2 Develop off-line analyses of INP relevant to cirrus formation and controls:

Our team includes experts from the UK whose research focuses on ice nucleation research in a variety of atmospheric conditions. UT ice formation is a particularly challenging area of research that will require extending existing techniques to colder and drier conditions. We will begin our effort by designing an ice nucleation chamber based on the FRIDGE isothermal diffusion chamber (IDC) (6,7) constructed at Goethe University Frankfurt. FRIDGE has been used for INP analysis on collected filters down to 238 K, but is not suitable for mid-latitude cirrus temperatures (down to ~210 K) or TTL conditions (ideally down to 185 K) as unwanted ice tends to form in the silicon substrate used. Studies using quartz substrates coated with silanising agents are known to resist ice formation in the conditions we need to access. The new IDC will be built at UoL and tested using relevant concentrations of known INPs sampled from the Leeds Aerosol Chamber (LAC) to establish that we can make the types of measurements needed for both this proposal, and those of Phase 2 of the MAD-INC: Machine learning Assisted Design of Ice Nucleators for Climate Engineering ARIA proposal led by [REDACTED]

We anticipate using a liquid nitrogen cooling system to achieve temperatures, along with high-vacuum equipment produced by the School of Earth and Environment mechanical workshop. The Leeds team has very extensive experience of building ice nucleation equipment ranging from simple droplet freezing assays to cloud chambers. The existing FRIDGE design uses a rather large substrate, to enable good statistics on INP measurements without the problem of nucleation on substrate imperfections at lower temperatures. Our new design will reduce the size of the substrate, allowing a more optimal balance between INP detection and influences from the substrate. We will apply the new IDC to evaluating our experimental procedure for preparing, loading, transporting and analyzing INP collection substrates for cirrus study. Ultimately, this system will provide INP activity and concentration for the collected samples. The approach also allows individual INPs to be localized after which Scanning Electron Microscopy (SEM) and Energy-dispersive X-ray spectroscopy (EDX) analysis will be used to generate compositional information for the INP, constraining future focus to specific sources of cirrus INP.

III.3 Develop in situ measurements of cirrus crystals

Cirrus ice crystal concentration and size distributions are critical measurements necessary to evaluate impacts of injected INP in CCT and ISD, and relevant to perturbed cirrus from some CM approaches. Crystal size affects cirrus lifetime and radiative impacts. At NOAA, we are developing an In situ Balloon-borne Ice Spectrometer (IBIS). This is a new, provisionally patented instrument, designed for deployment on small free-release balloons. First test flights of the prototype are expected in Spring, 2025. IBIS has been shown to resolve particles to below 3 μm diameter, a requirement for detecting TTL cirrus and more than adequate in the mid-latitudes. IBIS samples a cross-section of 0.5 $\times$ 0.5 cm, corresponding to a sample volume of 25 $\text{cm}^3 \text{s}^{-1}$, approximately 8 times higher than used for total particle measurements with the POPS instrument.

III.4 Apply these technological advances to measurements in the mid-latitudes

We will perform a measurement campaign using the technical capabilities developed above. At least 10 balloon launches from Boulder, CO, USA will be carried out in year two. Boulder, CO is the longest-standing site for B²SAP, with more than 100 successfully launched and recovered balloon payloads. Hence it is the ideal location to allow easy operations and scientific evaluation of the observations in the context of a multi-year climatology of aerosol, ozone, and WV. Launch timing will be optimized based on transport model forecasting coupled with initialization via GPS-radio occultation temperature measurements. Modeling work from Imperial College London (see below) will help with these forecasts, with potential further improvement if results are available from the “De-risking cirrus modification” project proposed by Dr Eastham. This measurement series will provide first determinations of INP concentration, composition, and relevance to mid-latitude cirrus formation and controls. We have optimized our plans for the balloon payloads to minimize complexity and maximize value. We will deploy IBIS, the INP sampler, and a suitable WV measurement with balloon telemetry and position information only. WV concentration is extremely relevant to cirrus, and can be used as an indicator of stratospheric influence in the mid-latitudes (hence dispensing with the need for inclusion of an ozone measurement). A low-cost, very lightweight WV measurement that we have determined is as good as that from a frost-point hygrometer in the mid-latitudes upper troposphere can be provided by a Vaisala RS41 radiosonde. The

use of the RS41 radiosonde requires the use of a proprietary ground receiver (NOAA operates one in Boulder, CO).

III. 5 Apply our observations to advance modeling of cirrus-relevant climate cooling strategies:

Finally, we propose a period of analysis to ensure that the measurements will be fully QA/QC'd, publicly archived, integrated into models, and assessed for relevance to potential climate interventions and cirrus science more broadly. As part of this work, we will compare our observations to model output and infer potential model improvements which could support CM, CCT, and ISD trials. Of particular relevance is the Community Earth System Model Version 2 (CESM2) climate model, already established at Imperial College London. Global cirrus frequency and properties will be generated using an ensemble of conventional model runs (Year 1), which will in turn be used to inform launch timing (Year 2). The output from these runs will be compared to the INPUT:ACCESS observations, with the goal of generating statistical corrections (Year 3). These will in turn be used to assess the degree to which efficacy of different climate cooling approaches might have been historically over- or under-estimated. If funded, results from the "De-risking Cirrus Modification" ARIA proposal will also be incorporated into this effort. Conclusions will be disseminated to the community via conference presentations and peer-reviewed publications.

IV. Budget Narrative, Timelines with work packages

Budget narrative: The budget will support coordinated efforts at three different institutions, two in the UK, and one in the USA. The University of Leeds (UoL) is the primary applicant, with NOAA in the USA and the Imperial College London as subcontractors.

The work at UoL will focus on the INP analyses, including substantial effort on developing the new IDC for measurement of INP concentrations in cirrus conditions. A dedicated postdoctoral research fellow will be hired for the duration the project, tasked with constructing and testing the IDC, developing methods for safely transporting slides carrying cirrus INPs, conducting measurements on INPs collected from balloon launches in Colorado and performing SEM analysis on test and collected INPs. We have budgeted £88,000 to cover workshop costs, materials and equipment needed to construct and test the IDC. This includes high-vacuum equipment, a high-end turbopump, chillers capable of cooling the equipment to below 180 K and instrument PCs. We have also requested £12,000 to cover SEM measurements and other consumables that will be needed for the project. [REDACTED] will devote 0.2 FTE for the three years of the project allowing him to work hands-on with postdoc and the instrument to ensure success. [REDACTED] will contribute his extensive experience in INP measurements and help coordinate efforts with other ARIA projects and the wider atmospheric science community.

The work in the USA will be focused on the balloon-instrument development, testing, and deployment. ARIA will support a full time scientist, hired through the cooperative agreement between NOAA and the University of Colorado, and a part time scientist to support ARIA specific balloon flight forecasting, balloon operations, and post flight analysis (0.2 FTE during year 1, 0.4 FTE during year 2) NOAA will provide very substantial in-kind funding in the form of additional scientist support (including the efforts of [REDACTED]), engineering and software support, cover materials and instrument costs (i.e. IBIS, the INP collector, balloons, the water vapour measurement, helium, etc., publications, and travel).

The efforts at Imperial College London will support [REDACTED] contributions to directing optimal deployment of the balloons and using data collected to improve process understanding of cirrus formation, and consist of labor (1 month/year support for [REDACTED] and travel costs.

Timeline and work packages: We envision three years of support, with the following support level (funding tranches) and deliverables:

Year 1: Scientist at UoL focused on instrument development incurring materials and equipment costs. Scientist at NOAA focused on balloon instrument development. 0.2 Scientist equivalents of effort at NOAA supporting balloon launches for testing. 1 month support for engagement of [REDACTED] to establish baseline model runs at ICL.. (Material/deployment costs for the balloon instruments will be borne by NOAA). **Deliverables:** Anticipated start of efforts to hire is February 2025. Hire at Leeds within 3 months; hire at NOAA within 3 month, making month zero May 2025. By end of year 1 new IDC will be functional; testflight(s) of IBIS conducted; INP collector designed and constructed.

Year 2: Scientist at UoL focused on developing methods for off INP analysis and analysis of INP on slides. PostScientist at NOAA focused on balloon instrument deployment/collaborative testing of collected INP assays. 0.4 Scientist equivalents at NOAA supporting balloon launches for deployment, data archiving, etc. 1 month support for engagement of [REDACTED] on model support for launch timing. **Deliverables:** Finalization of INP chamber build and testing; successful balloon deployment in mid latitudes; first successful INP measurements on resulting slides

Year 3: Scientist at UoL focused on the INP analysis findings, manuscript preparation. Scientist at NOAA focused on balloon instrument manuscript writings and analyses relevant to cirrus interventions. 1 month support for [REDACTED] on modelling incorporating observational findings. **Deliverables:** IBIS and INP collector established and available for launch as part of B2SAP launches from the tropics. Analysis of year 2 findings, incorporation of findings into cirrus model. Manuscript preparation relevant to: a) INP chamber performance and design, b) IBIS, c) INP collector, D) INP findings, relevance to cooling strategies and impacts on model performance. In year 3, all INP measurements will be made publicly available after quality assurance evaluations.

Workplan:

Month	Year 1				Year 2				Year 3			
NOAA activities – WP1												
Ballon instrument development (electrostatic precipitator, In situ Balloon-borne Ice Spectrometer (IBIS)).												
Balloon instrument deployments in Colorado with associated measurements and INP collections												
Support deployment of IBIS and INP collector for other balloon launches												
Joint analysis of data from balloon flights												
University of Leeds activities – WP2												
Design and construction of new isothermal diffusion chamber (IDC) for INP measurements												
Development of transport methods for slide carrying cirrus INPs												
Development of scanning electron microscope techniques for characterisation of cirrus INPs												
Testing of IDC using aerosol sampled from the Leeds Aerosol Chamber												
Measurement of balloon-collected INP samples using IDC and SEM												
Joint analysis of data from balloon flights												
Imperial College activities – WP3												
Establishment of baseline model runs												
Modelling support for timing balloon launches												
Model runs incorporating findings from balloon flights												

Budget options: There are possibilities to reduce the cost and scope of effort proposed here. We believe that the proposal presented provides the strongest and most synergistic support to addressing CM, CCT, and ISD possibilities. However, isolated efforts for example to 1) develop a cirrus-relevant ice nucleation chamber for routine measurements, 2) develop an INP collector for the cirrus regime, or 3) develop the IBIS instrument for cirrus crystal measurements, would all independently provide significant strengthening of the technical infrastructure needed to evaluate cirrus interventions. Each of these isolated efforts could be supported by a single dedicated scientist/technician at the appropriate institution for ~ 1 year, with associated materials costs.

Technical and Non-technical challenges: The balloon payloads and flight trains will comply with local airspace regulations and each flight is coordinated with local aviation authorities for safety. An important advantage of using weather balloons and instrument packages of the size we propose is that they fall outside of rigid requirements for coordination in aircraft airspace, and thus enable flexible deployment. Although forecasts of balloon trajectories are generally reliable, recovery of balloon packages can be complicated by issues such as access to private land and terrain. We have successfully launched balloon payloads from multiple international locations including New Zealand, Réunion Island, Antarctica, and

Costa Rica. Here we propose a set of measurements from Colorado, USA, where we have a superb record of recovery. In future deployments, our international connections will be critical for ensuring high recovery rates, smooth interactions with international communities hosting launches, and sufficient infrastructure to support launches. So long as we incorporate INP collection, we will only operate from locations where we anticipate reasonable chances to recover the payloads. For example, in the tropics we have had good success recovering launches from San Jose, Costa Rica.

V. Program Alignment, Synergies with other ARIA proposal: CCT, CM, and ISD are highly uncertain but potentially useful climate cooling approaches, strongly relevant to the call. By developing the ability to acquire concurrent measurements of WV, RH_i, and INP, we will advance the technology necessary to understand these approaches, as well as extend understanding of the fundamental processes that they hope to manipulate. In a world where interventions are being actively tested or deployed, our highly flexible and low-cost balloon-borne approach will be a critical tool for assessing impacts.

The technical developments proposed here (airborne INP collector, demonstrated balloon-borne ice crystal detector, extended-range ice nucleation chamber) will form the basis for future deployments on other platforms. Hence, they are synergistic with several other ARIA proposals.

The “De-risking cirrus modification” effort led by [REDACTED] which proposes to track changes in cirrus caused by passage of the FAAM BAe-146 research aircraft, will benefit from our work on developing the INP collection approach that will inform designs for airborne platforms. Presently, that aircraft has an INP collection system that is only effective below 20,000’ (too low to address cirrus issues). The prognostic modeling needed to plan FAAM flights for “De-risking cirrus modification” will also serve to enhance selection of balloon launch times, and will gain validation data from our launches for the following aircraft mission. Similarly, phase 2 of the ‘MAD-INC’ proposal led by PI Whale will benefit from the cirrus-regime INP evaluations enabled by the IDC chamber development.

Further, the longer-duration balloon approaches of the Voltitude ARIA proposal could support multi-filter collections and longer-term tracking of air parcel evolution and cirrus formation. Finally, our proposal is relevant to large-scale questions of WV controls and cirrus generation/radiative impacts, and the possibility that WV/CIRRUS forcing will change in future climate or under other, non-cirrus focused CI efforts.

VII. Future consequences of the proposed work:

The efforts funded by this proposal will result in long-term value for cirrus and cirrus-intervention relevant science. Briefly:

- 1) The development of the technology and experimental methodology for post-collection analysis of cirrus relevant INP will enable studies from all relevant platforms (long and short term balloons, UAVs, manned aircraft), as well as in future studies such as those proposed for ARIA exploring synthetic INP.
- 2) The balloon-borne instrumentation for collecting INP and measuring cirrus in situ will transition from development stage to operational. They will be able to support fast science deployments (for example, as were done by B2SAP for the Hunga Volcano Response), as well as long-term measurements (for example as an extension of B2SAP). NOAA anticipates pursuing a tropical deployment once the payload is fully operational; as B2SAP supports regular (but low frequency) launches from the tropics, this is a likely early opportunity for deployment.
- 3) We anticipate that the work on developing the INP collector for balloon deployment as described here will also apply to design development for research aircraft and alternate platforms. This would enable the collection of INP referred to in point 1, above.
- 4) Long-term monitoring of cirrus and UT INP properties in a changing atmosphere.

Overview of Proposal Team: Our multinational team is uniquely suited to carry out the proposed measurements and apply them to assessing and steering relevant climate cooling interventions. We include senior, mid-career, and early-career scientists with specific expertise in the topics we explore:

Cirrus processes, UT and stratospheric water vapor measurements and modeling: [REDACTED]

Balloon-borne observations: [REDACTED]

Ice nucleation measurements [REDACTED]

Regional-to-global modeling relevant to aviation emissions and impacts: [REDACTED]

Proposal Facilities:

NOAA Chemical Sciences Laboratory: provides a highly supportive environment for the finalization, testing, and mid-latitude deployment of the balloon packages. We are equipped with environmental chambers for low-pressure testing, design and manufacturing facilities, and aerosol testing equipment. This US Federal facility will house all the US scientists and technicians supporting the effort (consisting of both federal and cooperative institute employees).

University of Leeds: [REDACTED]

Imperial College London has world-class high-performance computing capabilities, already configured to support meteorological simulations across scales and used regularly in simulations of contrails and UT WV.

VIII. Response to Proposal Encouragement Feedback – Why ARIA?

We have addressed most review feedback from the NOI within the proposal body above. One question we did not address was: “Please expound on why ARIA is the best (or only) funder of such work. Why is no one else funding this already?”

Firstly, the questions we seek to address in this proposal are most specifically relevant to climate intervention proposals. While uncertainties surrounding upper tropospheric conditions are significant, there are many knowledge gaps that create similar-or-larger uncertainty in current understanding of the climate system, notably around the effects of mixed-phase clouds (e.g. ref 10). As such, proposals looking at cirrus conditions would have to compete with important research on many other uncertain processes for general climate-focused funding. Only ARIA is providing resources to quickly advance intervention-relevant research and development. Without this support, no clear timeline or pathway to its completion can be anticipated. For example, the aerosol filter collection

work, envisioned as a possible extension to B²SAP was not inspired by climate cooling interventions, but rather by the recent findings from our laboratory of meteoric and space debris impacts on stratospheric aerosol composition (11). This effort found limited external funding (<\$30,000) only sufficient for material costs and is being supported only fractionally as a potential extension from a team supported for B²SAP base operations. NOAA doesn't have the resources to expand efforts directed to this or the IBIS development (which has been a side project of a semi-retired scientist and a group leader). On the side of the UK INP measurement team, cirrus-relevant measurements have received relatively little attention because collecting INPs in cirrus conditions is so challenging, meaning proposals have mostly been directed at lower-hanging fruit in other areas.

Secondly, the ARIA call catalyzed interactions between the NOAA team developing the balloon-borne instrumentation with the UK teams with foci on ice nucleation measurements and cirrus intervention modeling. Previously, the balloon effort did not consider INP, and UK measurement efforts were not appropriate for cirrus conditions. Further, opportunities for multinational teams to collaborate are very rare, especially in the context of national government support. Here, the unique strengths that enable this proposal are dispersed on either side of the Atlantic. ARIA funding is the only route that will directly harness these existing strengths in a cost effective, rapid manner.

References

1. D. L. Mitchell, W. Finnegan, Modification of cirrus clouds to reduce global warming. *Environmental Research Letters*, **4**, 045102, (2009).
2. D. Avila, L. Sherry, T. Thompson, Reducing global warming by airline contrail avoidance: A case study of annual benefits for the contiguous United States. *Transportation Research Interdisciplinary Perspectives*, **2**, 100033, (2019).
3. J. P. Schwarz, R.-S. Gao, T. D. Thornberry, A. W. Rollins, K. H. Rosenlof, R. W. Portmann, T. Bui, E. J. Jensen, E. A. Ray, *Science Advances*, **10**, eadk0593, (2024)
4. D. J. Cziczo, K. D. Froyd, C. Hoose, E. J. Jensen, M. Diao, M. A. Zondlo, J. B. Smith, C. H. Twohy, D. M. Murphy, Clarifying the dominant sources and mechanisms of cirrus cloud formation. *Science* (1979) **340**, 1320–1324 (2013).
5. A. Sanchez-Marroquin, D. H. P. Hedges, M. Hiscock, S. T. Parker, P. D. Rosenberg, J. Trembath, R. Walshaw, I. T. Burke, J. B. McQuaid, B. J. Murray, Characterisation of the filter inlet system on the FAAM BAe-146 research aircraft and its use for size-resolved aerosol composition measurements. *Atmospheric Measurement Techniques*, **12**, 5741–5763 (2019).
6. H. Klein, W. Haunold, U. Bundke, B. Nillius, T. Wetter, S. Schallenberg, H. Bingemer, A new method for sampling of atmospheric ice nuclei with subsequent analysis in a static diffusion chamber. *Atmospheric Research*, **96**, 218–224 (2010).
7. U. Bundke, B. Nillius, R. Jaenicke, T. Wetter, H. Klein, H. Bingemer, The fast Ice Nucleus chamber FINCH. *Atmos Res* **90**, 180–186 (2008).
8. A. Agarwal, V. R. Meijer, S. D. Eastham, R. L. Speth, S. R. H. Barrett, Reanalysis-driven simulations may overestimate persistent contrail formation by 100%-250%. *Environmental Research Letters*, **17**, 014045, (2022).
9. A. W. Rollins, T. D. Thornberry, R. S. Gao, J. B. Smith, D. S. Sayres, M. R. Sargent, C. Schiller, M. Krämer, N. Spelten, D. F. Hurst, A. F. Jordan, E. G. Hall, H. Vömel, G. S. Diskin, J. R. Podolske, L. E. Christensen, K. H. Rosenlof, E. J. Jensen, D. W. Fahey, Evaluation of UT/LS hygrometer accuracy by intercomparison during the NASA MACPEX mission. *Journal of Geophysical Research: Atmospheres* **119**, 1915–1935 (2014).
10. Hofer, S., Hahn, L. C., Shaw, J. K., McGraw, Z. S., Bruno, O., Hellmuth, F., Pietschnig, M., Mostue, I. A., David, R. O., Carlsen, T., Storelvmo, T. Realistic representation of mixed-phase clouds increases projected climate warming. *Communications Earth and Environment* **5**, 390 (2024).
11. D. M. Murphy, M. Abou-Ghanem, D. J. Cziczo, K. D. Froyd, J. Jacquot, M. J. Lawler, C. Maloney, J. M. C. Plane, M. N. Ross, G. P. Schill, X. Shen, Metals from spacecraft reentry in stratospheric aerosol particles. *Proceedings of the National Academy of Sciences* **120**, 43, e2313374120 (2023).

knowledge is incomplete - much can be learned from the next eruptions that impinge on the stratosphere or strongly alter cloud microphysics. The last eruption with a strong cooling was Pinatubo in 1991⁴, over thirty years ago. However our knowledge of the climatological impacts of volcanic eruptions continues to expand with, for example, unexpected climatic responses from the recent Hunga Tonga-Hunga Ha'apia eruption⁵. Studying climate impact of eruptions at this scale presents unique measurement challenges, requiring precise 4D sampling in evolving hazardous conditions, rapid deployment, and zero emissions. This demonstrates a clear need for new aerial robotic systems (also known as uncrewed aerial systems (UAS) or drones) that can monitor and learn from smaller eruptions whilst also being ready to be deployed in the event of large-scale events⁶.

We propose to develop and test aerial robotics that will quantify droplet and aerosol behaviour at injection altitudes from the lower troposphere to the lower stratosphere. The system, a modular, fully automated monitoring-focused UAS will be developed using volcanoes as analogues for SRM, in order to both better understand natural processes and prepare for outdoor experiments that aim to emulate them. Specifically, this system will be developed to (a) investigate natural analogues for both MCB and SAI and learn from frequent, smaller scale eruptions (injection altitudes up to 10 km AMSL) and passive volcanism, with a focus on aerosol and cloud formation and associated changes in radiative forcing, (b) standby aerial systems and expertise in UAS based volcanic monitoring ready for deployment during the next significant global volcanic eruption and (c) monitor and measure outdoor SRM experiments within this programme and beyond.

Our investigation will first focus on three volcanic systems, Soufriere Hills Volcano, Montserrat (1,050 m AMSL (above mean sea level), which degases into the marine boundary layer, Fuego Volcano, Guatemala (3,768 m AMSL) a persistent emitter of volcanic gas and ash into the free troposphere, and Lascar, Chile (5,592 m AMSL) a passive emitter of SO₂ into the high dry troposphere of the Atacama desert. The team have gathered data at active volcanoes in all three countries and regularly at Soufriere Hills and Fuego. Cloud formation and the importance of cloud condensation nuclei (CCN) will be investigated at Soufriere Hills and will act as an analogue for MCB, whereas at Lascar the focus will be on the conversion of SO₂ and the production of aerosol as an analogue for SAI. Fuego, where the team have deployed various UAS over a decade will act as a final-stage test bed for aircraft and instrument development. The team has a strong relationship with the relevant authorities in Guatemala where Fuego's frequent eruptions has necessitated the closure of airspace to cruise altitude (~10 km AMSL). Before this stage aircraft and instruments will be tested in the laboratory (e.g. wind tunnels), at the university's outdoor flight testing facility, and at selected test sites in the UK.

We propose to develop the capability to monitor subsequent testing for both SAI and MCB technologies, whilst also investigating the natural processes that make volcanism important analogues for SAI and MCB. The outcomes of this research project will be a system ready to be deployed quickly in the event of a significant volcanic eruption, a framework for monitoring, a capability demonstrator for higher altitude sampling and more complete understanding of volcanoes as analogues for SAI and MCB. We will build a system that can (a) be used during the project to quantify physical processes that relate to climate engineering, (b) prepares the community for a more significant event (in the troposphere or the stratosphere) that would have a regional-global scale climate perturbation and (c) be deployed as part of the broader programme to assess the efficacy and impacts of small scale outdoor experiments.

1.2 The Risks

Technical Risks.

Technical risks focus on the limits of current technologies. It is not trivial, at the intersection of technology and cost proposed here, to remotely lift the necessary instrumentation to 10 km AMSL and keep it there for several hours. Specific technical risks include failure to (i) design and assemble a capable aircraft system (ii) adequately test the aircraft at altitude working within technical and regulatory constraints (iii) plan for a change in volcanic activity and (iv) failure to gain permission to fly at target sites. Technical risks are ameliorated by the team's previous expertise and a robust annual stage-gating process. The Bristol Flight Lab has successfully designed and build many UAVs for different purposes including radiation monitoring in Ukraine, high altitude meteorological sampling over the Ascension Islands, volcanic plume sampling worldwide and

conservation biology in Africa. The team have flown beyond visual line of sight (BVLOS) to 18,000ft AMSL with aerosol sampling instrumentation over volcanoes (Figure 2). We have local (university owned) testing facilities, access to UK testing facilities (e.g. Llanbedr) and have already secured flight BVLOS (beyond visual line of sight) permissions on multiple occasions in multiple countries. Fuego, Soufriere Hills and Lascar are significant emitters of SO₂ and have been for several decades, but fieldwork could be refocused on other active systems if needed / desired. For example, if there were a significant eruption in Iceland or there was a requirement to deploy during a programme experiment the MACE project could support it. One previous Bristol Flight Lab example of this was the deployment of UAS to help monitor the Cumbre Vieja volcano eruption on the island of La Palma, Canary Islands in 2021.



Figure 2. Images captured by the University of Bristol in 2019 from drones over Fuego, Guatemala: (a) eruption monitoring prior to in-plume ash sampling and (b) crater overflight for imagery between eruptions.

Non-technical Risks.

Other risks would include (a) political opposition to climate engineering research, in the UK and elsewhere, (b) objection to the research by the University's ethics committee and (c) general unsettling of research staff working in a controversial field. Climate engineering is a challenging field which solicits strong responses from government, scientists and the public. Our mitigation strategies will be formed of previous experience. We have chosen to focus upon learning from natural analogues and monitoring deployment, not deployment itself, based around the idea of preparedness. We will operate with absolute transparency and have a PI that is uniquely experienced in this challenge, having led SPICE⁸ (Stratospheric Particle Injection for Climate Engineering), a more controversial project that included a deployment technology field test¹³. Transparency will be required by the University's ethics committee (who also oversaw SPICE) and will reassure all researchers that, albeit in a controversial field, the work will be undertaken in good faith. Absolute clarity will be provided to new staff upon application about the ethos of the research (described below).

1.3 How is this different from commercial or emerging technologies

This is an end-to-end solution that is designed to give UK researchers a new capability. It requires the adaptation and integration of commercially available lightweight sensors with a newly designed aircraft system, capable of flying in challenging environments up to an altitude of 10 km AMSL. The aircraft will operate autonomously with smart flight systems and control based upon machine learning recognition of volcanic emissions⁸ with on-the-fly route planning for multiple intercepts within a predetermined geofence. The new platform will have a flight envelope not easily achieved with a COTS solution. No such integration of an uncrewed (UAS) high altitude platform, AI-based automated real-time route planning and particle and radiation detection capability currently exists in the commercial world, with a very limited number of research groups worldwide having the capability to deliver and operate such a system.

1.4 Proposed Activity of Work (see also Figure 3).

WP1 Development of platform capable of operating in the troposphere and lower stratosphere. WP1 is made up of three sub-tasks. (T1.1) MCB typically operates in the boundary layer whereas SAI efficacy broadly increases, per delivered volume of material, as a function of altitude. The aircraft will be modular in terms of the onboard sensor systems, and capable of undertaking measurements that pertain to both target

technologies. The nominal design brief is to have an electric fixed-wing aircraft, capable of lifting the required sensor payload from WP2, plus the associated avionics for autonomous operation, to 10 km AMSL. The team has extensive experience with both modifying existing COTS airframes and original new designs to meet stringent mission requirements. **(T1.2)** Software development will deliver an integrated simulation environment for the aircraft system and its controlling AI in digital representations of the target environments, including plume models. Autonomous guidance will permit dynamic re-sampling in 4D to measure evolution of the same air ‘parcel’ over time, exploiting machine learning and dynamic replanning to track and revisit the plume. On-ground, in-air and remote automation will support pilot and science situational awareness with manageable workloads. **(T1.3)** Initial flight tests of the MACE aircraft will be carried out at the university field site in Bristol, moving to Llanbedr as the required airspace increases. An agile approach will be used for UAS development with regular flight tests throughout the project. The data collected during these UK tests will lead to rapid airframe iteration and code development, as well as performance analysis for AI based mission optimization and preparation for field deployments. **Stage-gate deliverables: D1.1 (Year 1)** Development, performance testing and flight demonstration of a viable prototype aircraft system.

WP2 Payload selection, integration and field testing. With a functional prototype aircraft, the aircraft systems and operations will also be developed iteratively during the payload integration phase. WP2 is made up of three subsections. **(T2.1)** We will down select from a larger suite of instrumentation capable of quantifying two critical types of coupled observations. Firstly, we will consider in-situ measurement of gas, aerosol and droplet properties such as concentration, shape, number density and particle size distribution⁷. There are a wide variety of lightweight electrochemical gas sensors (e.g. H₂O, SO₂) and laser-based optical particle counters designed to measure CCN at submicron scale, coarse mode sulphate aerosols (0.5-10 µm) and cloud droplets at a range of 5-50 µm that will be reviewed according to scientific and engineering requirements. Radiative transfer observations constitute the second suite of observations from which we will delimit radiative forcing. Pyrometers will measure diffuse and direct upwelling and downwelling SW radiation across the visible and near-infrared spectrum (~0.4-2.7 µm wavelength). This will be coupled with LW radiation (5-100 µm) measurement using pyrgeometers capable of quantifying broad spectrum upwelling and downwelling thermal radiative fluxes (Table 2).

Target parameter	Science question (?)	Example instrument	Mass(g)
[SO ₂]	What is the conversion rate of SO ₂ > SO ₄ ²⁻	DD Scientific 4 Series	20
CCN size and #density	How quickly do CCN evolve	Naneos Partector 2	483
Cloud droplet size	What rate do cloud droplets form/evolve	DMT CDP-2	1670*
Aerosol size distribution	What is the aerosol size distribution	Met One 212	1200*
Up/down SW radiation	How is SW radiation altered by species	AT SPN-1	786
Up/down LW radiation	How is LW radiation altered by species	Apogee SL510/610	190
T, P, Rh	What are ambient atmospheric conditions	Trisonic Mini	50

Table 1. Example instrument suite (not all instruments need to be flown simultaneously) * mass with housing

(T2.2) Laboratory and field testing of the onboard sensors will be carried out at selected sites in the UK including Llanbedr in Wales, and at Fuego volcano, Guatemala. During a careful programme of flight tests, we will increase flight altitudes whilst working within regulatory frameworks. Active volcanoes present significant opportunities as airspace above them is often closed to above cruise altitudes, as has been the case at Fuego since 2015. **(T2.3)** Preparation for rapid deployment. By the end of year 1 the MACE team will assemble an initial UAS capability for rapid (48hr) deployment in response to a large scale volcanic eruptive event. This will develop annually with the project, incorporating step changes in sensing, processing, aircraft and expertise. **Stage-gate deliverables: D2.1 (Year 2)** An integrated aircraft and payload with onboard computer for data processing, ground control station, real-time route planning with AI-based optical sensors. The system will include equipment for in-field support. Instrument suite selected, tested and integrated into aircraft from WP1. Repeatable successful flights to target 10 km AMSL altitudes with active payloads by the end of year two. **D2.2 (Year 3)** Fully automated flights with onboard AI and on-the-fly route planning for multiple intercepts that have successfully achieved science goals.

WP3 Volcanic plume and secondary aerosol sampling across a range of altitudes. (T3.1) We will conduct a two-phase campaign at reliable producers of SO₂. Our first target is Fuego, Guatemala (3,780 m AMSL) where the team have flown UAS extensively to > 5,000 m AMSL. We have a longstanding relationship

with both the national institute for atmospheric, geophysical and hydrological hazards (INSIVUMEH) and the Guatemalan civil aviation authority (DGAC) and have hundreds of hours of experience flying beyond visual line of sight^{8,9} (BVLOS). Here we will fly within established flight envelopes, and gather preliminary data from within, above and below the plume. We will use machine learning¹⁰ to train the system to repeatedly intersect the same section of the plume at Fuego and investigate SO₂ loss, aerosol formation and radiative transfer across the vertical profile of the plume. **(T3.2)** Following two Fuego campaigns, two other sites, the Soufriere Hills Volcano, Montserrat (1,050 m AMSL and British Overseas Territory) and Lascar in Chile, will become the focus of the project. The Soufriere Hills Volcano, Montserrat, is an MCB analogue, where SO₂ is rapidly converted into sulphate aerosol¹¹, an effective source of cloud condensation nuclei observed at volcanoes during passive degassing¹². Lower plume altitudes mean potential heavier payloads and/or longer flight times and, given the rapid conversion of SO₂, allows us to investigate a series of physico-chemical reactions from heterogenous nucleation of aerosols through to cloud formation and brightening. We will observe radiative transfer processes as a function of time, potentially through coordinated multi-aircraft campaigns. In contrast, Lascar is one of the highest persistent emitters in the world at ~5,600 m AMSL, which emits into the dry free troposphere of the Atacama desert. Here we will undertake plume characterisation experiments in conditions as close to those of the stratosphere as is possible from a passive degasser, again looking at aerosol microphysics and radiative transfer through the plume. **(T3.3)** If other funded projects require monitoring support the team will assist in co-designing observational capabilities, and provide support around logistics and regulations. **Stage-gate deliverables: D3.1** (1st quarter, Year 3) Successful deployment of aerosol measurement instrumentation on the MACE UAS at Fuego volcano, Guatemala and radiative profiling above, in and below the volcanic plume. **D3.2** (3rd quarter, Year 4) Successful deployment into volcanic plumes and downstream clouds during years three and four across a range of altitudes and environmental conditions, leading to an improved understanding of the relationship between aerosol physico-chemical processes and radiative properties across a range of altitudes and atmospheric conditions using MACE UAS.

WP4 Readiness planning, monitoring deployment strategies and targets of opportunity. This WP is dedicated to putting in place the processes, protocols, software and paperwork required to operate at short notice internationally. Due to technological and regulatory challenges, relatively few in-situ measurements of sulfur-bearing species have been made, particularly in the stratosphere. The next volcanic eruption and/or small-scale experiment will require monitoring, and small scale SRM deployments are highly likely to operate at scales below those easily detected from orbital platforms. In addition to the hardware preparations for rapid deployment identified in WP2, we will prepare for targets of opportunity, including, but not limited to volcanic eruptions, noting that kgs of SO₂ are already being released by companies, such as Make Sunsets, in the US. The MACE team at Bristol have extensive experience operating UAS internationally including Papua New Guinea, Cameroon, Chile, Italy and Kenya. **(T4.1)** We will develop the capacity for rapid response deployment to targets of opportunity such as a significant volcanic eruption, leveraging simulation capability and automated planning from WP1 to design, train and verify missions in advance, as far as possible, and during the 48-hour response window. **(T4.2)** The required permissions can often be just as challenging as the hardware and software. The team will be building on previous research in the automation of UAS safety cases and in-flight operations around regulation planning. Selected potential operational vignettes will be used as test cases. **(T4.3)** A 20 km altitude safety case will be developed to facilitate further development of UAS monitoring at likely SAI injection altitudes. **Stage-gate deliverables: D4.1** (3rd Quarter, Year 2). An initial safety case for deploying UAS above cruise altitude during the next large (20 km injection height) volcanic eruption. Note we have pulled this effort forward in response to feedback. **D4.2** (1st Quarter, Year 4) Successful discussions and future planning with relevant authorities in volcanically active regions (Caribbean, Central and South America, Indonesia, Japan) for rapid response during periods of high sulfate aerosol load at altitude. If requested by national authorities the team will carry out demonstration flights at selected sites.

WP5. Project Management, Impact and Outreach. **(T5.1)** We will have regular project meetings involving teams members on at least a weekly basis and **(T5.2)** in person, all hands quarterly review meetings **(T5.3)** Outreach materials and publications **(T5.4)** We will conduct six monthly project progress reviews and annual reporting, including deliverables for stage-gates at year end 1,2 and 3. **Stage-gate deliverables: D5.1** (End of years 1,2,3 and Final Year 4) Demonstration of deliverables and project reporting to inform stage-gate decision making **D5.2** (End of years 1,2 and 3, 3rd Quarter, Year 4) We will develop outreach videos, as part of a broader suite of materials to inform stakeholders, academics and the public of our work and our findings.

Previous research has generated significant interest, and outreach has allowed us to connect with a wide array of people, an outcome that can be argued to be particularly important in the field of climate engineering.

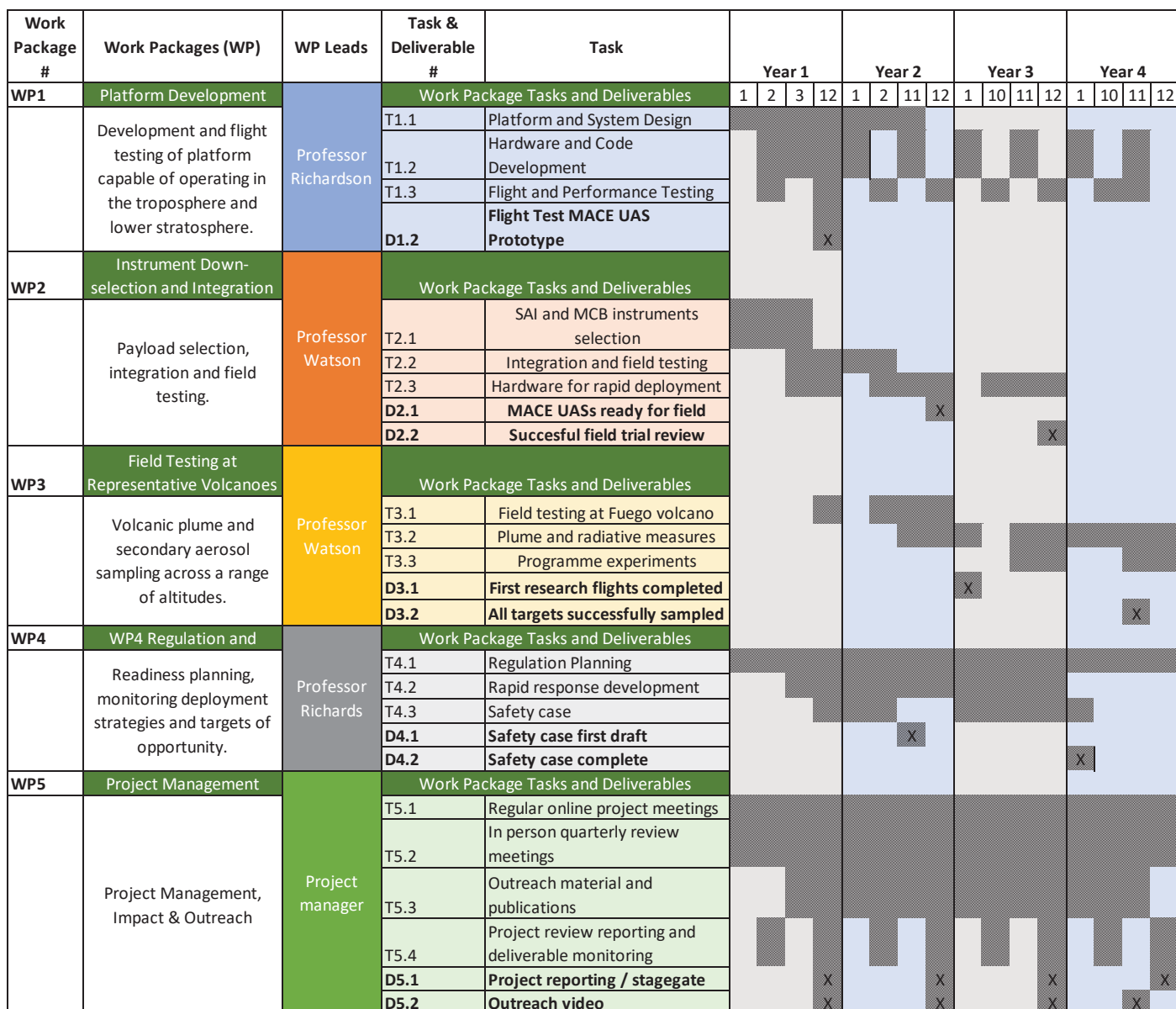


Figure 3. MACE Gantt Chart with Work Packages (WP), Tasks (Tx.x), Deliverables (Dx.x) and denoted by X on the timeline, shown over the four years of the project.

1.6 Justification for physical experimentation, regulatory, legal ethical risks and their mitigation.

Volcanoes, as sources of both CCN and aerosol precursors allow us to investigate natural analogues to SRM to investigate the efficacy of both MCB and SAI. Experimentation using natural analogues present less risk and less opposition than outdoor experiments, particularly those that are perturbative. Because we are explicitly not releasing material, nor are we developing the capability to do so, our experiments should be considered as passive monitoring of processes that SRM would seek to enhance and, if required, supporting small scale outdoor experiments within this programme. We do not propose to work on geopolitical risk directly, but note that constraining epistemic uncertainty will reduce broader risk by better quantifying physical processes that will control outcomes of any potential deployment. This project's primary regulatory and legal risks are around airspace management. We are measuring natural systems using established measurement technologies, a new airframe and a new autonomous control system that will facilitate quantification of aerosols and cloud physical and radiative properties. Whilst the team (see below) has extensive experience of high-altitude plume sampling, regulatory challenges around safe operations increase in complexity as airline cruise altitude is approached. Our mitigation strategy is to use our experience as an opportunity to develop protocols for a safety case to operate at, and beyond, cruise altitudes.

[REDACTED]

[REDACTED]

This effort is built on a decade of focused collaboration across the University of Bristol and is self-contained. We work closely with many other groups, and are keen to provide significant additional value to the broader ARIA programme by offering monitoring capability to those groups undertaking outdoor experiments. The senior team have worked together for over a decade and currently co-supervise several PhD students. We are collectively motivated by ambitious and difficult challenges, working in extreme environments and, most importantly, by delivering societal benefits. Investigating potential solutions to climate change is the challenge of our age and could have profound implications at a planetary scale. We feel it is critical to work in these spaces transparently and openly and we aspire to put all our designs into the public domain for others to

emulate if helpful. The team are keen to publish any and all relevant data and the project will have a public-facing element, coordinated by the research manager with support from [REDACTED]. Both have significant media experience and will also utilise the University of Bristol's press office as appropriate.

Each of the three senior academics will take responsibility for the line management of one of the post-doctoral researchers, noting that we have deliberately designed the programme so that all PDRAs can contribute to all of the four work packages. There is funding for a 20% FTE research/project manager who will be responsible for interface with the funder (along with the PI), management of deliverables and coordination of regular (at least bi-monthly) project-wide meetings. These will be augmented by both smaller group meeting and by integration into Bristol Flight Lab and Volcanology Group meetings and discussions. The three PDRAs and senior technical specialist will work at 100% FTE for four years, the PI at 25% FTE and the co-PI's at 15% FTE. We have front-loaded the equipment and consumables budget to years 1 (prototype test) and particularly year 2 (with a stage-gate to enter year 2), where the majority of the funding will be used to build three complete UAS. We estimate the cost of the prototype to be ~£100K and each system to be ~£200K (including £100K of instrument package) but will present detailed cost estimates for the three mission-ready UAS at the first stage-gate based upon down-section in WP1. A second stage-gate exists in year 2, where the UAS will need to demonstrate the required flight and measurement capabilities. We imagine a final lighter touch review and will be required to demonstrate progress in addressing the science questions in year 3.

3. References [REDACTED]

- [1] Marshall, L.R., et al., 2022. **Volcanic effects on climate: recent advances and future avenues.** *Bulletin of Volcanology*, 84(5), p.54.
- [2] Robock, A., et al., 2013. **Studying geoengineering with natural and anthropogenic analogs.** *Climatic Change*, 121, pp.445-458.
- [3] Ebmeier, S.K., et al., 2014. **Systematic satellite observations of the impact of aerosols from passive volcanic degassing on local cloud properties.** *Atmospheric Chemistry and Physics*, 14(19), pp.10601-10618.
- [4] Russell, P.B., et al., 1996. **Global to microscale evolution of the Pinatubo volcanic aerosol derived from diverse measurements and analyses.** *Journal of Geophysical Research: Atmospheres*, 101(D13), pp.18745-18763.
- [5] Sellitto, P., et al., 2022. **The unexpected radiative impact of the Hunga Tonga eruption of 15th January 2022.** *Communications Earth & Environment*, 3(1), p.288.
- [6] Cassidy, M. and Mani, L., 2022. **Huge volcanic eruptions: time to prepare.** *Nature*, 608, pp.469-471.
- [7] Ramana, M.V., et al., 2007. **Albedo, atmospheric solar absorption and heating rate measurements with stacked UAVs.** *Quarterly Journal of the Royal Meteorological Society*: 133(629), pp.1913-1931.
- [8] Schellenberg, B., et al., 2019. **Remote sensing and identification of volcanic plumes using fixed-wing UAVs over Volcán de Fuego, Guatemala.** *Journal of Field Robotics*, 36(7), pp.1192-1211.
- [9] Schellenberg, B., et al., 2019. **On-board real-time trajectory planning for fixed wing unmanned aerial vehicles in extreme environments.** *Sensors*, 19(19), p.4085.
- [10] Rolland, E.G., et al., 2024, **Autonomous UAV volcanic plume sampling based on machine vision and path planning.** In *2024 International Conference on Unmanned Aircraft Systems (ICUAS)* (pp. 1064-1071). IEEE.
- [11] Rodríguez, L.A., et al., **SO₂ loss rates in the plume emitted by Soufrière Hills volcano, Montserrat.** *Journal of Volcanology and Geothermal Research*, 173(1-2), pp.135-147.
- [12] McCoy, D.T. and Hartmann, D.L., 2015. **Observations of a substantial cloud-aerosol indirect effect during the 2014–2015 Bárðarbunga-Veiðivötn fissure eruption in Iceland.** *Geophysical Research Letters*, 42(23), pp.10-409.
- [13] Stilgoe, J., Watson, I.M. and Kuo, K., 2013. **Public engagement with biotechnologies offers lessons for the governance of geoengineering research and beyond.** *PLoS Biology*, 11(11), p.e1001707.

Evidence-based Assessments to Guide Perceptions, Governance, and Ethical Frameworks for South Asia: Comparing Marine Cloud Brightening Deployment Strategies vis-à-vis Carbon Dioxide Removal and Mitigation Efforts

Section 1: Project & Technical Information

Introduction

Highly populated and climate-vulnerable South Asia is home to nearly a quarter of the world's population (Yeung et al., 2018; Majaw, 2020). Geographically diverse—spanning vast coastlines, fertile plains, and mountainous terrains—South Asia faces climate risk exposure includes extreme weather events, rising sea level, glacial melt, and prolonged heatwaves, significantly threatening regional ecosystems, socio-economic/resource security, and geopolitics. Coastal countries such as India, Pakistan, and Bangladesh increasingly face threats from sea level rise and cyclonic storms, while non-coastal nations like Nepal and Bhutan are grappling with glacial melt, water scarcity, and rising temperatures. Addressing these challenges requires innovative and region-specific solutions. One potential approach is Marine Cloud Brightening (MCB), a 'regional' Solar Radiation Modification (SRM) technique that aims to cool atmospheric temperatures and mitigating some climate change impacts. MCB increases cloud albedo, reflecting more sunlight back into space. Its cooling effect has the potential to offset some of the severe consequences of climate change. For instance, Wan et al. (2024) concluded that regional MCB interventions in the North Pacific could significantly reduce heat exposure in the Western United States under present-day conditions, although their efficacy diminishes or even exacerbates heat stress under mid-century warming. This finding highlights the governance challenges and risks of assuming consistent outcomes from MCB as climate systems evolve. Similarly, Haywood et al. (2023) introduced a novel MCB experiment (G6MCB) using the UKESM1 Earth-system model, targeting areas of the eastern Pacific. The experiment compared G6MCB results with the G6sulfur Stratospheric Aerosol Injection scenario, revealing significant cooling, but also side effects like altered monsoon precipitation and La Niña-like responses.

Considerations for assessing potential deployment of MCB in South Asia require a holistic, tailored approach that address the region's specific socio-economic, political, environmental, and ethical complexities. The climate of South Asia is dominantly monsoon dependent (Athar et al., 2021). To demonstrate a strong scientific basis for perceptions, governance and framings activities of this proposal, climate models-based projections of MCB (GeoMIP), CDR (CDRMIP), mitigation and business-as-usual (CMIP) scenarios will be assessed (see Figure 1 for prototype output), and relevant information will be gleaned for key project outcomes: stakeholder engagement, policy analysis, and development of actionable and ethical recommendations.

CDR faces technology development limitations – high expenses, almost untested, and unclear pathways to scalability at present. Traditional mitigation efforts, such as renewable energy transitions and energy efficiency improvements, while essential, may not prevent climate tipping points in the near term (Nordahl et al., 2024). Researching SRM, and MCB, in this context of the need for time and cost-effective solutions is explored as a complementary strategy to CDR and mitigation, while acknowledging that SRM and MCB are not substitutes for mitigation, and CDR (Long and Shepherd, 2014). This is important, as developing simultaneous/side-by-side understanding of the differences in the projected climate of South Asia under MCB, CDR, and mitigation will aid in decision making about the research and potential use or non-use of MCB. This approach will help convey data driven information developed through this project by basic and social scientists to other key stakeholders.

While some research has been conducted in the Global North on MCB and its potential impacts (e.g.: Haywood et al., 2023; Wan et al., 2024), no such study has been conducted for South Asia. While these studies have primarily focused on technical outcomes, extensive stakeholder engagement has been largely missing. This study aims to fill these gaps by integrating both technical evaluations and broad stakeholder participation. By integrating climate assessments of various technologies, perceptions of MCB will be elucidated, vis-à-vis CDR and mitigation, among local communities, policymakers, academics, civil society, and the media; an assessment of governance and ethical frameworks relevant for South Asia, will also be accomplished, and provide pathways for integrating the lessons derived. This research will ensure that socio-economic, political, and ethical factors are considered alongside scientific innovation, highly relevant for such controversial technologies.

In this context, Carlson et al. (2022) noted that SRM could alter disease (malaria) transmission patterns, benefiting some regions while worsening conditions in others, particularly in the Global South, thus raising significant concerns about their implications for public health and anticipatory governance deliberative democracy (Kessler, 2019). Rahman et al. (2018) argue that developing countries that are the most vulnerable

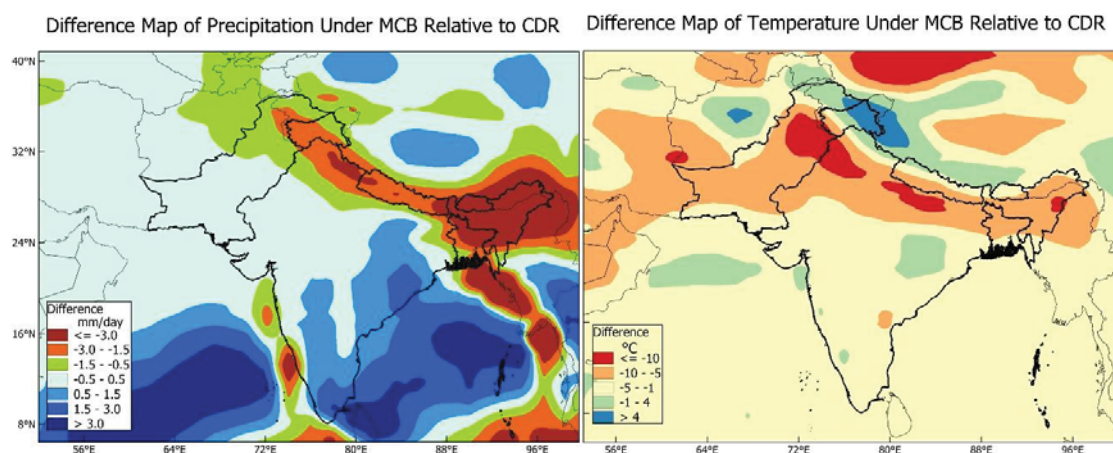


Figure 1: Mean difference of precipitation (left) and temperature (right) of MCB, relative to CDR, over South Asia (2021-2090)

countries to climate change impact must drive discussions of modelling, ethics and governance. Similarly, Sugiyama et al. (2020) critique the narrow focus of SRM research on public perceptions in the Global North, overlooking the Global South where the impacts of such technologies may be more profound. Addressing this imbalance is essential for ensuring equitable governance and avoiding a top-down imposition of SRM.

This project aims to address this disparity by centering South Asian perspectives, offering a framework for more inclusive and ethically grounded MCB research that holds global relevance. This proposal aims to explore the feasibility and implications of MCB deployment in South Asia through a comprehensive assessment of public perceptions, governance structures, and ethical frameworks. The study will compare the across selected coastal countries (India, Pakistan, Bangladesh) and non-coastal nations (Nepal and Bhutan), focusing on the socio-economic, political, and environmental dimensions critical to decision-making around its potential use/non-use. The research will integrate stakeholder perspectives—including policymakers, academics, civil society, and the media—alongside ethical considerations and policy frameworks, to develop inclusive and equitable SRM strategies tailored to the region. By bridging the gap between scientific innovation and socio-economic and political realities, this research seeks to contribute to a deeper understanding of how SRM strategies, particularly MCB, can be responsibly and effectively implemented in South Asia, if and when needed.

Proposed Idea / Solution and Alignment with Programme Objectives

This proposal focuses on the implications of potentially deploying MCB in South Asia, a region critically vulnerable to climate change.

Scientific Rationale and Justification: By increasing cloud reflectivity, MCB directly alters the Earth's energy balance. This approach aligns with the programme's goal of exploring interventions that can alter planetary albedo in measurable and statistically significant ways, offering a potential short-term, stopgap solution to mitigate immediate climate risks while longer-term strategies, such as CDR and mitigation, ramp up. Unlike energy-intensive and costly CDR techniques, i.e., direct air capture (DAC), MCB could provide a scalable and cost-effective option, particularly suitable for resource-constrained regions like South Asia.

How MCB Works: By reflecting more sunlight, MCB reduces heat absorption and delivers localized cooling, which is especially beneficial for South Asia's coastal regions facing sea level rise, cyclonic storms, droughts and heatwaves. Climate models-based risk maps will visually demonstrate MCB cooling potential and impact on phenomena such as monsoons, coastal precipitation, and temperatures.

How the Solution Supports the Objectives of the Programme: This project addresses urgent climate vulnerabilities in South Asia by exploring MCB's potential to mitigate near-term risks, particularly in coastal and low-lying areas, and comparing them against inland areas of South Asia. It advances SRM knowledge by evaluating the feasibility, effectiveness, and side effects of MCB, contributing to global understanding of this SRM technique. A key focus is fostering public/stakeholder engagement in key South Asian countries, exploring whether MCB deployment is ethically sound, socio-economically and environmentally appropriate, and politically feasible. The study will also develop an ethical framework addressing fairness, equity, and environmental justice, guiding future MCB research and deployment in South Asia and beyond. By integrating stakeholder engagement,

and ethical considerations, this proposal not only meets the programme’s objectives but also strengthens the foundation for scalable, ethical climate interventions globally.

Research Objectives

- **Comparative Analysis of MCB (GeoMIP) CDR (CDRMIP), mitigation (CMIP) Projections:**
 - Compare the efficacy of MCB and ocean alkalization (CDR) in addressing climate vulnerabilities.
 - Assess socio-political dimensions of MCB deployment strategies in coastal (India, Pakistan, Bangladesh) vs. non-coastal (Nepal, Bhutan) countries, focusing on public perceptions, technical feasibility, governance, and ethical challenges.
- **Perceptions and Stakeholder Engagement:**
 - Investigate public perceptions of MCB and CDR across coastal and non-coastal countries.
 - Examine socio-economic factors influencing acceptance of MCB and assess stakeholder engagement, including governments, civil society, and local communities.
- **Policy Analysis:**
 - Analyze national and regional policies to identify gaps and opportunities for integrating MCB into climate strategies.
- **Ethical Frameworks and Socio-Economic Dimensions:**
 - Review existing SRM ethical frameworks and develop guidelines for South Asia’s geopolitical context.

Methodology: A **mixed-methods approach** will be employed, integrating qualitative and quantitative tools to achieve a comprehensive analysis.

Literature Review: Conduct an in-depth review of MCB-related studies South Asia, focusing on ethical, socio-economic, political, and climatologic/projection aspects. **(a) Surveys and Focus Groups:** Develop questionnaire-based surveys targeting diverse stakeholders in the region, including policymakers and intergovernmental/international organizations, academics, civil society members/organizations, and journalists, regarding the feasibility and implications of MCB deployment. In this context we will collect 500 feedback forms from each country, for a total of 2,500. **(b) Key informant interviews** will be held with key experts/stakeholders, alongside focus group discussions/roundtables with diverse stakeholders across three categories (academia, civil society, and policy makers), to gather qualitative insights (See details in Table 1). **(c) Advanced Decision-Making Tools:** Use Fuzzy Multi-Criteria Decision-Making (Fuzzy AHP and Fuzzy TOPSIS), Fuzzy Cognitive Maps, and Fuzzy Clustering to analyze complex data and prioritize ethical and policy considerations. Employ **multi-objective optimization** to assess trade-offs between competing environmental, socio-economic, and geopolitical goals. **(d) Climate and Policy Analysis:** Conduct sectoral policy analyses of South Asian countries, identifying gaps and opportunities for integrating MCB into national and regional climate strategies.

Table-1 The breakdown of surveys and focus group activities by country.

Country	Key Informant Interviews	Focus Group Discussions
India	12	3
Pakistan	12	3
Bangladesh	10	3
Nepal	8	3
Bhutan	8	3

Expected Outcomes: (a) **Climate Projection Comparisons:** In-depth analysis of the project climate impacts of MCB, CDR, and mitigation, on South Asia’s diverse regions, focusing on regional weather patterns and the potential effects on coastal and non-coastal areas.(b) **Policy Analysis:** Comprehensive analysis of existing policies related to SRM in South Asia, focusing on how MCB could be integrated into these frameworks. (c) **Perception Analysis:** Insights into public and stakeholder perceptions of MCB and CDR technologies across South Asia’s diverse geographies and societies. (d) **Ethical Framework:** Development of a detailed ethical framework for MCB deployment, addressing equity, inclusivity, and transparency, and informed by South Asia’s socio-economic and geopolitical contexts. (e) **Policy Recommendations:** Propose practical guidelines for integrating MCB into South Asia’s climate policies, including stakeholder engagement strategies and governance structures.

Technical and Non-Technical Risks - Mitigation Strategies: This proposal identifies and addresses both technical and non-technical risks associated with deploying MCB in South Asia, ensuring a comprehensive

approach to achieving the project's objectives. Technically, uncertainties about MCB's impact on critical regional climate phenomena, such as monsoons and precipitation patterns, are underexplored. These risks will be mitigated through advanced climate modelling, localized simulations, and on the non-technical front. Also, public and stakeholder skepticism about MCB's ethical implications and socio-economic and political barriers/reservations could hinder progress. This will be mitigated by robust implementation of stakeholder engagement through surveys, focus groups, and transparent consultations across South Asia, to elucidate drivers for building understanding and trust. Governance and regulatory challenges, particularly in resource-constrained and geopolitically sensitive regions, will be tackled by analyzing existing policy gaps and developing region-specific governance frameworks that align with international ethical standards. Addressing equity and inclusiveness in decision-making, the project will create a tailored ethical framework that ensures community involvement and fair distribution of benefits and risks. Geopolitical tensions arising from transboundary impacts of MCB can be mitigated by emphasizing collaborative governance mechanisms, enabling equitable regional participation. By proactively identifying these risks and presenting clear, actionable mitigation strategies, this proposal demonstrates its feasibility, readiness, and alignment with the goals of funding agencies. Through a rigorous, multi-dimensional approach, the project aims to deliver comprehensive, scientifically robust, ethically sound, and socio-economic and politically inclusive risk assessments and outcomes, thereby contributing to equitable and effective climate interventions in South Asia. This underscores the project's capacity to responsibly advance MCB research and aligns with the funding program's emphasis on innovation, governance, and societal impact.

Differentiation from Commercial and Emerging Technologies: The proposed approach to MCB is distinctly differentiated from commercial or emerging technologies currently being funded or developed elsewhere, primarily in its focus, scale, and integration of socio-economic, political, and ethical dimensions, specific to South Asia. While many MCB initiatives and SRM technologies focus on technical efficacy in isolation, this proposal emphasizes a comprehensive framework that incorporates public perceptions, governance structures, and ethical considerations tailored to the unique socio-economic, political, and environmental context of the region based on strong scientific rationale. This integrated approach addresses the critical gap between technical innovation and societal acceptance or rejection, which is often overlooked in commercially driven projects. Additionally, the project explicitly compares MCB with CDR strategies, such as ocean alkalization, and mitigation efforts, as SRM strategies can only be decided upon as part of an overarching climate response portfolio (Long and Shepherd, 2014). Unlike CDR, which is constrained by high costs, energy demands, and scalability challenges, especially in resource-limited regions like South Asia, this project aims to evaluate MCB as a potentially cost-effective and localized solution for addressing immediate climate vulnerabilities. By focusing on region-specific deployment strategies, the approach is better suited to address the acute climate challenges of South Asia, such as monsoon variability and coastal impacts, which are not adequately addressed by broader, globally oriented SRM studies. The project's use of advanced decision-making tools, such as Fuzzy Multi-Criteria Decision-Making (Fuzzy AHP and Fuzzy TOPSIS), for analyzing complex data and prioritizing policy considerations further sets it apart by integrating quantitative rigor with ethical and governance frameworks. By adopting a multidisciplinary, stakeholder-inclusive approach, this proposal ensures its alignment with public values, governance requirements, and ethical principles.

Proposed Activity of Work, Key Metrics, Milestones, and Assumptions. This project focuses on assessing the implications of potentially deploying MCB in South Asia. The activities are designed to integrate technical, governance, and ethical dimensions, ensuring a responsible and region-specific approach. The work will be conducted through five interrelated research components. **(a) MCB Climate Projection and Impact Modelling:** Advanced simulations and climate modelling will predict the impact of MCB on regional phenomena like monsoons and coastal weather patterns, with a focus on localized cooling and precipitation variability. **(b) Comparative Analysis with CDR and Mitigation Strategies:** The project will evaluate the efficacy, cost, and scalability of MCB relative to CDR techniques, and traditional mitigation strategies. **(c) Stakeholder Engagement and Perception Analysis:** Surveys, focus groups, and consultations will assess public and stakeholder perceptions of MCB and CDR in both coastal and non-coastal countries, identifying socio-cultural and economic barriers to acceptance. **(d) Policy and Ethical Framework Development:** Policy analyses will identify gaps in integrating MCB into national and regional climate strategies, while ethical frameworks will address equity, inclusivity, and governance concerns specific to South Asia. **Key Metrics.** **(a) Climate Impact Metrics:** Assessment of regional temperature reduction in targeted areas, effects on

precipitation patterns, particularly monsoons. **(b) Public Perception Metrics:** Stakeholder survey completion rate (2,500 responses across five countries). Levels of public and stakeholder acceptance of MCB as measured by qualitative and quantitative analyses. **(c) Governance and Policy Metrics:** Policy gaps identified and addressed in proposed frameworks. Drafting of region-specific governance and ethical guidelines for MCB.

Milestones. Phase 1 (Months 1-6): Literature review and climate model assessment. Development of stakeholder surveys and focus group frameworks. Initial consultation with policymakers and civil society. **Phase 2 (Months 7-12):** Completion of climate modelling and simulation studies. Data collection from surveys and stakeholder engagement activities. Policy and ethical framework draft development. **Phase 3 (Months 13-18):** Execution of surveys in five different countries of South Asia, and their analysis. Preliminary analysis of survey and engagement results to refine governance frameworks. **Phase 4 (Months 19-24):** Completion of survey analysis and virtual/physical meetings with stakeholders, and key experts for feedback. Finalization of governance and ethical guidelines. **Phase 5 (Months 25-36):** Synthesis of findings and preparation of final recommendations. Dissemination of results through publications, workshops, and policy briefs.

Dependencies and Assumptions. (a) Data and Technology Availability: The project assumes access to advanced climate models, satellite data. **(b) Stakeholder Participation:** The project assumes robust participation from policymakers, civil society, and the public for surveys and consultations. **(c) Funding and Collaboration:** The activities are contingent on adequate funding and partnerships with regional and international experts.

Developing Principles for Outdoor Experiments: This study critically examines the societal, environmental, and governance dimensions of potential MCB deployment, focusing exclusively on exploring public perceptions and stakeholder attitudes and their relations to outdoor experiments. Such an approach allows for an in-depth assessment of the challenges and opportunities posed by future experiments, laying the groundwork for informed and ethically robust decision-making. Below is a critical evaluation of how the study aligns with the principles for outdoor experiments outlined in the programme thesis while emphasizing gaps and limitations that must be addressed before real-world implementation: **(a) Minimizing Risk by Design:** While hypothetical outdoor experiments are discussed conceptually, the study refrains from direct implementation to avoid unnecessary environmental or social risks. It interrogates the feasibility of designing experiments at minimal scales to ensure reversibility and control. Stakeholder feedback will critically inform the trade-offs between scientific data quality and the potential for unintended consequences. The study challenges assumptions about "natural and benign" perturbations, emphasizing the need for a robust scientific and ethical justification for any future deployment **(b) Transparency and Public Participation:** Transparency is foundational, yet this study critiques the limited extent to which public participation has been integrated into prior SRM research. By directly engaging communities, policymakers, and other stakeholders, the study highlights gaps in trust and knowledge about MCB technology. Public consultations aim to elicit critical concerns about governance, inclusivity, and accountability, ensuring that future experiments are not only scientifically rigorous but also socially acceptable. **(c) Risk Assessment and Impact Monitoring:** The study underscores significant uncertainties and potential blind spots in assessing the risks of MCB experiments. It critically examines how risks—technological, environmental, and socio-economic—are perceived by various stakeholders and identifies the challenges of designing monitoring systems that can adequately address these concerns. This exploration aims to highlight the disparity between scientific risk modeling and public perception, advocating for more integrative and precautionary approaches in future experiments. **(d) Reversibility and Containment:** Public skepticism about reversibility and containment is a major focus of this study. By exploring stakeholder concerns, the research highlights the ethical challenges of ensuring that unintended consequences can be mitigated in real-time. The study critiques over-reliance on technological solutions for containment, instead advocating for a precautionary approach that prioritizes minimizing risks before deployment. This critical lens aims to ensure that future experiments do not proceed without a proven ability to halt or reverse potential harms. **(e) Governance and Legal Compliance:** Governance remains a contentious and underdeveloped area for SRM in South Asia. This study critiques existing legal and regulatory frameworks for their inability to adequately address the complexities of MCB experiments. By engaging stakeholders, the research identifies gaps in domestic and international laws, emphasizing the need for robust, inclusive, and enforceable governance mechanisms that prioritize ethical

and environmental integrity. The findings aim to challenge the status quo of fragmented and reactive regulatory approaches. (f) **Independent Review and Oversight:** Independent oversight is not merely a procedural formality but a critical safeguard against conflicts of interest and ethical lapses. This study questions the adequacy of current oversight mechanisms and highlights the need for transparency, diversity, and impartiality in future review processes. Stakeholder input will help define the criteria for truly independent and representative oversight committees, ensuring that public trust is not compromised by opaque or biased decision-making processes. This critical evaluation exposes the complexities and challenges inherent in planning outdoor MCB experiments. By centering public perceptions and stakeholder concerns, the study aims to bridge the gap between technical feasibility and societal acceptance, underscoring that robust governance, transparency, and precautionary measures are prerequisites—not afterthoughts—for future experimentation.

Areas Requiring Support. (a) **Regulatory Navigation:** Assistance may be required to navigate the regulatory frameworks of South Asian countries, particularly for ensuring alignment with national and international SRM governance standards, if any. (b) **Community Engagement:** Additional support in organizing large-scale public consultations and managing cross-border stakeholder collaboration will help address regional sensitivities. (c) **Access to Technical Expertise:** Guidance in refining dispersal technologies and monitoring systems to meet high precision and safety standards. **Estimated Timelines and Project Plan:** The following project plan outlines the estimated timelines and key deliverables across the lifecycle of the proposed MCB scientific-socio research project. The project will span approximately 36 months, with clear milestones for each phase. Below is a breakdown of activities and expected outcomes by period:

Timeline Overview

Phase	Months	Key Milestones
Phase 1: Project Initiation	1-6	Literature review completion, climate modelling, finalizing survey and focus group frameworks.
Phase 2: Data Collection	7-13	Survey data collection, initial policy framework, first round of focus groups.
Phase 3: Experiment Design	14-19	Final design and completion of ethical framework.
Phase 4: Stakeholder Engagement and Ethical Frameworks	20-27	Stakeholder engagement, public consultations, data collection on public perception, mid-phase analysis of findings, refinement of ethical frameworks.
Phase 5: Analysis and Reporting	28-36	Data analysis, report preparation, dissemination of findings through reports, workshops, and publications.

Regulatory, Legal, and Ethical Risks and Mitigation Plans.

Regulatory Risks: The deployment of MCB in South Asia may face significant regulatory challenges, particularly related to environmental regulations, SRM protocols, and international laws governing climate interventions. These challenges could impede the approval and execution of hypothetical future outdoor experiments and potentially hinder the broader adoption of MCB in the region. (a) **Approval for Future Outdoor Experiments:** Obtaining the necessary regulatory approvals for potential future outdoor experiments in South Asia, particularly in countries like India, Pakistan, and Bangladesh, may face delays or resistance due to stringent environmental and safety regulations. (b) **Cross-border Regulatory Concerns:** MCB interventions may have transboundary effects, especially on neighboring countries with shared resources (e.g., monsoons, river systems). This could trigger geopolitical concerns and require international cooperation and regulation. (c) **Alignment with International Agreements:** South Asian countries may be hesitant to engage in SRM strategies like MCB due to concerns about compliance with international climate agreements, such as the Paris Agreement or the Convention on Biological Diversity (CBD).

Mitigation Plans (a) **Engage with Regulatory Authorities:** Early and continuous dialogue with national and local regulatory bodies in the project’s target countries will be essential to align with existing environmental regulations. This will ensure that the project complies with local environmental laws and international obligations.(b) **International Collaboration:** To address cross-border regulatory challenges, the project will seek cooperation and consultation with neighboring countries and international bodies, including UNFCCC, to ensure that MCB deployment is aligned with broader climate policy frameworks. (c) **Detailed Impact Assessments:** Comprehensive environmental impact assessments and strategic environmental assessments will be conducted to evaluate the potential risks of MCB. These assessments will provide the necessary documentation for any

future regulatory approvals. Independent third-party reviews will ensure transparency and credibility in the process.

Legal Risks: Legal risks associated with MCB deployment primarily concern the potential liability for unintended environmental harm, property damage, or adverse health impacts resulting from SRM interventions. Additionally, there may be issues related to intellectual property (IP) and the management of patents for technologies developed as part of the research. **Key Legal Risks:** (a) **Liability for Environmental Harm:** If MCB causes unintended environmental consequences (e.g., alterations in rainfall patterns, disruption of marine ecosystems), it may lead to lawsuits or legal challenges from affected communities or environmental groups. (b) **Cross-border Legal Implications:** Since the effects of MCB may cross borders, there could be conflicts with neighboring countries regarding the legality of deploying such technologies within shared environmental spaces (e.g., rivers, oceans). (c) **Intellectual Property (IP) Issues:** New technologies developed for MCB may encounter challenges related to IP rights, especially if commercial interests become involved in scaling the technology. **Mitigation Plans:** (a) **Risk Mitigation and Liability Insurance:** The project will ensure proper legal protection by obtaining appropriate liability insurance to cover potential environmental damage or unforeseen impacts from any future interventions. Legal counsel will be consulted regularly to ensure the project complies with national and international laws governing environmental and SRM risks. (b) **Cross-border Agreements:** To address legal concerns over cross-border impacts, the project will advocate for agreements with neighboring countries outlining the terms of potential future MCB deployment. These agreements will emphasize shared responsibility and mutual consent under international law.

Ethical Risks: The ethical risks of MCB are substantial, given that SRM interventions directly modify natural systems with the potential for unforeseen and unequal consequences. These concerns include equity issues, environmental justice, and the involvement of affected communities in decision-making processes. **Key Ethical Risks:** (a) **Equity and Inclusivity:** future MCB deployment may disproportionately affect marginalized or vulnerable communities, particularly those in coastal areas or regions directly impacted by changes in weather patterns. (b) **Public Consent and Transparency:** Ethical concerns could arise around the lack of public consent, especially if MCB is discussed or implemented without sufficient consultation or public engagement, leading to distrust in the project. (c) **Environmental Justice:** If the risks and benefits of MCB are not distributed equitably, it may exacerbate existing environmental and social injustices. For example, cooling effects might disproportionately benefit wealthy regions while poorer communities bear the costs of unforeseen side effects.

Mitigation Plans: (a) **Community Engagement and Consent:** The project will prioritize an inclusive approach to stakeholder engagement, ensuring that all affected communities can participate meaningfully in decision-making. Surveys, focus groups, and public consultations will be conducted regularly to assess public perceptions and concerns. A consent-based decision-making process will be employed, ensuring that local communities are well-informed and empowered to influence key project decisions. (b) **Ethical Framework Development:** A comprehensive ethical framework will be developed in consultation with local communities, policymakers, and ethical experts. This framework will address issues of equity, inclusion, transparency, and environmental justice, ensuring that the potential risks and benefits of MCB are fairly distributed. (c) **Independent Ethical Review:** An independent ethical review committee will be established to monitor the project's implementation. This committee will ensure compliance with ethical guidelines and monitor the impact of the project on vulnerable populations and the environment. Recommendations for mitigation and corrective actions will be made as necessary to address any negative outcomes or ethical concerns that arise during the research process.

Section 2: The Team

Research Team: Relevant Experience, Expertise, Skills, and Capabilities: Our CUI research team specializes in several aspects of SRM research. [REDACTED]

[REDACTED]

Additional Expertise: As the project progresses, we anticipate the need for additional expertise in legal frameworks related to environmental interventions and socio-economic impact assessments. The strategy for integrating this expertise will be developed in consultation with the team members, based on project timelines and specific resource needs. The PI understands the value of engaging with various entities already working in the SRM space, such as The Degrees Initiative and the Resources for the Future, particularly with respect to the scientific, governance and stakeholder engagement aspects. The PI has strong linkages to these organizations and is currently (or was previously) working with these entities on SRM projects and seeks to expand engagement with other organizations in and looking to enter this space. Furthermore, we have a potential collaborator, [REDACTED], who will serve as a technical expert for the project. [REDACTED] with a focus on making policies, plans, programs, and project developments which are environmentally sustainable and climate resilient. [REDACTED] guidance will be instrumental in shaping the project's guidelines and ethical framework, ensuring they are grounded in practical, evidence-based approaches that promote balanced, sustainable, and climate-adaptive decision-making processes. Expertise of other team members comes from a mix from basic sciences ([REDACTED]), social sciences ([REDACTED]), governance ([REDACTED]), with support for data development ([REDACTED]).

References

- ATHAR, H., NABEEL, A., NADEEM, I. & SAEED, F. 2021. Projected changes in the climate of Pakistan using IPCC AR5-based climate models. *Theoretical Applied Climatology*, 145, 567-584.
- CARLSON, C. J., COLWELL, R., HOSSAIN, M. S., RAHMAN, M. M., ROBOCK, A., RYAN, S. J., ALAM, M. S. & TRISOS, C. H. J. N. C. 2022. Solar geoengineering could redistribute malaria risk in developing countries. 13, 2150.
- HAYWOOD, J. M., JONES, A., JONES, A. C., HALLORAN, P. & RASCH, P. 2023. Climate intervention using marine cloud brightening (MCB) compared with stratospheric aerosol injection (SAI) in the UKESM1 climate model. *Atmospheric Chemistry Physics*, 23, 15305-15324.
- KESSLER, J. 2019. Novel Non-State Sources of De Facto Governance in the Solar Geoengineering Governance Landscape: The Case of SRMGI and C2G, Wageningen, the Netherlands: Wageningen University and Research.
- LONG, J. & SHEPHERD, J. G. 2014. The strategic value of geoengineering research. Springer.
- MAJAW, B. 2020. *Climate Change in South Asia: Politics, Policies and the SAARC*, Routledge India.
- NORDAHL, S. L., HANES, R. J., MAYFIELD, K. K., MYERS, C., BAKER, S. E. & SCOWN, C. D. 2024. Carbon accounting for carbon dioxide removal. *One Earth*, 7, 1494-1500.
- RAHMAN, A. A., ARTAXO, P., ASRAT, A. & PARKER, A. 2018. Developing countries must lead on solar geoengineering research. *Nature* 556, 22-24.
- SUGIYAMA, M., ASAYAMA, S. & KOSUGI, T. 2020. The north-south divide on public perceptions of stratospheric aerosol geoengineering?: a survey in six Asia-Pacific countries. *Environmental Communication*, 14, 641-656.
- WAN, J. S., CHEN, C.-C. J., TILMES, S., LUONGO, M. T., RICHTER, J. H. & RICKE, K. 2024. Diminished efficacy of regional marine cloud brightening in a warmer world. *Nature Climate Change*, 1-7.
- YEUNG, W.-J. J., DESAI, S. & JONES, G. W. 2018. Families in southeast and South Asia. *Annual Review of Sociology*, 44, 469-495.

**Defining the minimum scale of an SAI test:
A fundamental first step towards an outdoor large scale experiment**

Introduction and Program alignment: Stratospheric aerosol injection (SAI) could be used to reflect a small amount of sunlight back to space, cooling the planet. We know with certainty that this would cool, and if it were started at high latitudes where the tropopause is lower, it could potentially be conducted using existing (but modified) aircraft, making this the most near-term option for radically reducing the risks of climate change. Nonetheless, there are still critical uncertainties that would need to be narrowed before informed decisions about a deployment could be considered robust.

We start from the assumption that the nearest-term deployment of SAI is highly likely to be with sulfate aerosols, with gaseous dispersal of a precursor (SO_2 being the obvious candidate), and released from aircraft. The expectation that sulfate is the nearest-term option is due to the close similarity with natural analogues, and due to our knowledge of the environmental impacts of sulfate compared to novel materials; releasing as a gaseous precursor is expected to be more straightforward, and is again consistent with natural analogues. (And analyses consistently show that aircraft are likely the cheapest means of lofting material, e.g., Smith and Wagner, 2018). This makes reducing the remaining uncertainties associated with SO_2 release a high priority for near-term research.

With SO_2 , the biggest source of testable uncertainty that could be reduced at a scale relevant for an outdoor experiment is associated with aerosol microphysics, leading to uncertainty in the aerosol size distribution, and hence both lifetime and radiative efficacy; this ultimately affects the overall amount one needs to inject to achieve a given amount of cooling. This uncertainty comes from the potential competition between nucleation (new particle formation) and condensation/coagulation (particle growth) of H_2SO_4 vapors and already nucleated sulfate aerosols, which in turn is strongly dependent on spatial inhomogeneity, as well as on initial conditions (such as ion-induced nucleation within the plume of an aircraft). In a climate model, these small-scale processes are represented by simplified parametrizations, based on a small amount of existing observations after volcanic eruptions, pyrocumulus etc. However, these representations have already been demonstrated to be highly model dependent (roughly a factor of two range across models), including even dependent on the physical timescale of the calculations (Vattioni et al., 2023), due to competition between different simultaneous processes (nucleation versus coagulation) that need to be resolved at a high temporal scale. Even more critically, the existing observations that lead to current parameterizations are from analogues that are not fully representative of the conditions that would happen during SAI, and there is little basis to guess how large an effect this might have on predictions without direct experimentation.

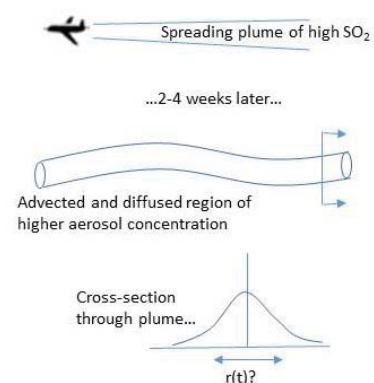
An outdoor experiment could be designed specifically aimed at reducing this uncertainty, but it is unclear what scale this experiment would need to be. This is the primary question we address here - not the detailed experiment design, but rather a robust scientific definition of the scale that such an experiment would need to be conducted at in order for it to meaningfully constrain some of the key microphysical uncertainties. This would not just be a critical first step in the

design of the experiment, but would provide critical information for supporting evidence-based conversations on research governance.

There are two key observations that guide our thinking in the potential design of such an experiment:

1. It would be essential to conduct the experiment in as close a way as possible to the way SO_2 would be released in an actual deployment, in order to ensure that the conclusions are applicable to a realistic deployment. This requires release from an aircraft, and at release rates (kg/s or kg/km of travel) similar to rates expected in an actual deployment. This ensures both that the initial plume concentrations are relevant, and also that the test does not over- or under-represent effects from exhaust ions or aircraft wake turbulence for example.
2. It would be essential to be able to track the resulting plume until oxidation and aerosol formation are mostly complete, so 2-4 weeks. This requires a sufficiently large initial injection of material to ensure that after several weeks of mixing, the aerosol concentrations remain locally high enough that the plume can be found.

The initial plume of SO_2 from the aircraft would gradually spread, advecting with the local winds, and diffusing (see sketch at right), but even after a few weeks would lead to a broad plume or tube of higher aerosol concentrations that is not at all close to uniformly mixed throughout the scale of a climate model grid cell (Newman et al., 2001).



The first of the observations above sets both a lower and upper bound on the possible scale. E.g., the payload of a business jet capable of reaching 15km (adequate for high-latitude dispersal) is of order 10 tons; this is similar to the high-altitude bespoke design of Bingaman et al. (2020). If all of the mass is released over no more than 5 minutes, to avoid excessive loiter requirements (which would drive cost both through fuel and number of aircraft needed), this would produce an initial “tube” with higher concentrations of SO_2 that is of order 100 km long, probably longer than is necessary for an experiment. A reasonable expectation is thus that an experiment that captures relevant conditions will be at least a few thousand kilograms, but not likely to be more than 10 tons. Larger experiments are plausible but only with larger aircraft, as any deployment involving multiple aircraft would result in multiple plumes, and thus the single-aircraft payload sets the upper bound on the size of any plume one might track: furthermore, one would be expected to only move to larger scales once smaller scales have been explored. More critically, the second requirement above sets a lower bound on the size of the experiment, but one that requires quantification - what is the minimum size experiment that could still be tracked for a month? Note that over this period, the plume would have circled around the world; continuous tracking over this time is not likely plausible.

Designing an experiment would thus ultimately involve three components: (i) how to loft and release material, (ii) how to track that material for the next month, and (iii) how to sample and

observe the resulting plume. If one knows exactly where the resulting plume is, it is straightforward to use existing observational assets (see Fiske and Siggurdson, 1979; Hòrvat et al., 2022; Li et al., 2023 for various airborne and satellite-derived data from at least two small-sized eruptions from the Soufriere Volcano; for background conditions see also Froyd et al., 2019, Schneider et al., 2021 and NOAA's SABRE mission¹) to fly into the plume and sample the aerosols to determine size distribution. Designing modifications to existing aircraft to store and release SO₂ is in part dependent on the second task, because the second task determines the scale that the experiment would need to be conducted at.

As pointed out above, similar observational systems exist already, both for monitoring after volcanic eruptions and for monitoring background stratospheric conditions. Therefore, the main constraint is not as much observational (balloon-borne or aircraft measurements of particle number, size and chemical composition, tracking from satellites, etc.) but experimental: a controlled release will always be different from a volcanic eruption, due to its lower concentrations over time (as an example, the last Soufriere eruption released 0.3-0.4 Tg of sulfate in 6 hours, so 5-6 orders of magnitude larger than what we're thinking about) and the lack of co-injection of other materials (such as volcanic ash, or water vapor), and therefore exploring the lower bounds of such an experiment is crucial to inform its potential future development. However, there is also the potential to leverage existing observations of smaller volcanic eruptions as a means to bound our results in terms of limits of detectability of current and future satellites observations (Gorkavyi et al., 2021).

The most critical aspects to designing such an experiment thus address how one would find the plume, which depends not just on observational capability but on how rapidly the plume spreads, and how well one could predict its location with forecast modeling. Once that aspect is well understood, then of course a more complete experimental design would involve designing both how the material would be released, and the details of the in-situ sampling observations that would be conducted assuming that the location of the plume is already found. Our proposal therefore focuses on this first step - the modeling that is required to answer the question of the minimum size for such an experiment.

Our goal is to determine the minimum size of an experiment that would allow for a substantial reduction in this uncertainty. This is critical information both for defining future research needs, and for informing the governance of research. Therefore, it is highly aligned with the program scope of “developing a strong predict → test → monitor → validate loop” for SAI. We are not planning on performing the experiment, nor even thoroughly designing it, but rather that, before somebody does, there are crucial steps that need to be taken to be ready to fully take advantage of one.

Description of research and methodology:

The ability to track the plume depends not only on initial concentrations, but on (i) the ability to forecast the plume location given current location (to reduce the search space), (ii) how rapidly the plume diffuses, which affects the concentrations, and (iii) observational capabilities. These

¹ SABRE: <https://csl.noaa.gov/projects/sabre/>

will be addressed in the first 3 tasks below. In addition, the scale of this class of experiment, while negligible compared with current anthropogenic emissions, would involve significantly larger material released than the previously proposed SCoPEX experiment² or the somewhat arbitrarily-proposed 1000 kg limit suggested in the 2021 US National Academies report³. Just as it is important to be able to track the plume in order to sample it, it is essential to be able to provide information to policy and the public about the detectability and transboundary implications of a test, and the dependency of these impacts on the size and location of the test, as this will also influence experimental design. Task 4 addresses this.

1. The first task is to assess the ability to forecast the future location of the center of the plume if the current location is known. The Whole Atmosphere Community Climate Model (WACCM) can be used in forecast mode⁴, where it is initialized with stratospheric winds (based on re-analysis). By comparing short-term WACCM forecasts of volcanic aerosols against observations, initialized at different times in the evolution of the volcanic plume, this tool will allow us to quantify the likely predictive accuracy with lead time, better constraining the search region that would need to be explored to find the aerosol plume (assuming that it is not always continuously tracked).
2. The second task is to quantify the range of plausible rates of plume diffusion over the first month. To answer this, we will use satellite observations from TROPOMI⁵ after volcanic eruptions, which have been demonstrated to be capable of tracking plumes of SO₂ at a scale relevant to a large-scale SAI experiment (Theys et al., 2022). While this can only be used to determine spreading rates for spatial scales larger than the spatial resolution of TROPOMI (about 25 km horizontally), that can be extrapolated to bound spreading rates at smaller spatial scales as well. Analysis after different volcanic eruptions will provide information about how variable these rates might be under different stratospheric conditions. This will therefore allow us to determine, as a function of the initial SO₂ mass release rate, estimates for how broad the resulting plume is as a function of time and the estimated peak aerosol concentration within the plume; this will feed into the next task associated with the detectability threshold.
3. The third task is to clarify the potential sensitivity of observational capability for remotely detecting SO₂ and detecting sulfate aerosols. The aerosols can be detected through upwards-facing LIDAR on aircraft; these instruments are already in use (on the NOAA SABRE missions, for example⁶), but we will engage in conversations about the potential for modifications or redesign for this particular mission.
4. Task 4 aims to provide statistical information about the movement of air plumes at different geographical locations and altitudes based on reanalyses and trajectory models

² <https://www.keutschgroup.com/scopex>

³ <https://nap.nationalacademies.org/catalog/25762/reflecting-sunlight-recommendations-for-solar-geoengineering-research-and-research-governance>

⁴ <https://www.acom.ucar.edu/waccm/forecast/>

⁵ <https://www.tropomi.eu/>

⁶ <https://ntrs.nasa.gov/citations/20230008368>

(e.g. Sun et al., 2024, Peace et al., 2024) in order to inform future discussions around potential transboundary issues with outdoor SAI experiments. This will allow us to clarify under which conditions and injection amounts there might be foreseeable chances of some of the plume material falling into the troposphere within a country's airspace and hence the potential for deposition. This will provide information for the modality of "safe" outdoor experiments that do not significantly infringe on other countries' airspaces. This will allow us to address the potential relevance of the experiment in light of current, established protocols around environmental pollutants, such as the Convention on Long-Range Transboundary Air Pollution, by communicating at which scales, and from which locations, detectable transboundary effects could be relevant. This task can also inform the first task, as it can clarify whether there are altitudes or locations that an experiment could be conducted at that would lead to more or less predictability.

Collectively, these tasks will be integrated to determine what spatial scale of experiment would be needed to allow reliably finding the plume if it is not continuously observed. Once the plume location is known, existing observational assets could be used for in-situ sampling to determine aerosol concentrations, size distribution, etc. Knowing the required mass release is an essential precursor to designing details of aircraft release system as well. **Thus the work proposed herein is the first step towards designing a plausible test of SAI with SO₂.** Furthermore, the process one would use to follow and subsequently sample the plume in the first aircraft-scale test of SAI, considered herein, is essentially the same process that would be needed on the first days, weeks, or months of a deployment, to validate that the observed behaviour is sufficiently consistent with predictions; this effort is therefore also useful in defining observational needs more generally, and thus is complementary to the research proposed by [REDACTED] and colleagues.

There are of course other uncertainties associated with SAI. However, uncertainties in the climate response at scale (how would surface climate respond to a certain aerosol layer in the stratosphere) cannot be addressed through experiments, while many of the other uncertainties in stratospheric processes would primarily affect the response to SAI at high cooling and would not substantively affect results if SAI is used to cool by, for example, 0.5°C. Given that that level of cooling would not be reached for *at least* a decade after the start of deployment, some of these stratospheric uncertainties will not meaningfully affect a decision on whether or not to start a deployment, and thus are not as high a priority today. For SAI using SO₂ injections, the potential experiment described here would thus be both the most scientifically relevant perturbative experiment to pursue in terms of reducing policy-relevant uncertainty, and also the smallest perturbative experiment that is relevant; as a result it is likely the first such experiment that would be conducted for SO₂-based SAI. Yet despite more than a decade of discussions around research governance of SAI, there has not yet been an effort to quantify the size or the transboundary impacts of such experiments. We thus believe that our research could significantly improve debates around SAI experiments, highlighting detection and design needs, as well as strengthening discussions around future governance by providing a robust, science based foundation of topics such as detectability and long-term fate of the plume.

In parallel with the proposed work it would be valuable to conduct more detailed small-scale modeling that captures fluid turbulence and aerosol microphysics; as this can be decoupled from the work above we do not include it herein, but are discussing with other funders.

Metrics, Milestones and Timeline: The work described above will be completed over two years. The bulk of the effort is in the modeling and analysis in tasks 1, 2, and 4. As this will largely be conducted by one postdoc and one graduate student (see below), tasks 2 and 4 will be largely sequential, and conducted in parallel with task 1. Key milestones include (1a) identifying key volcanic eruptions and downloading reanalysis data (Q2, yr1), (1b) testing WACCM in forecast mode (Q3, yr1), and (1c) generating a data-base of forecast errors as a function of lead-time and location (Q2, yr2); (2a) identifying relevant volcanic eruptions and downloading TROPOMI data (Q2, yr1), (2b) analysis of TROPOMI spreading rates (Q4, yr1); (4a) testing of Langragian transport models (Q1, yr2), (4b) simulating transport for a range of stratospheric conditions and experimental locations/seasons (Q3, yr2), (4c) summarizing transboundary implications from that (Q4, yr2). All results will be documented in archival journal articles throughout (with expected publications corresponding to tasks 1, 2, and 4).

Section 2: Project team:

[REDACTED]

[REDACTED]

Working closely together, our group at Cornell University has over the years been at the forefront of SAI research. Our combined expertises would allow us to push forward this yet underexplored venue, which requires a tight coupling between the atmospheric sciences and engineering disciplines. We thus believe that we are ideally situated to address these questions.

The research above will be conducted by a postdoctoral associate and a graduate research assistant, under the guidance of the project PIs.

[REDACTED]

[REDACTED]

In addition there are potential collaborations that we will explore to strengthen the effort if funded, including [REDACTED]

Motivation

Early research on SRM was highly idealized, often simply “turning down the sun” in coarse resolution climate models or specifying aerosol distributions. Over the last decade there has been extensive research conducted with injecting SO₂ into the stratosphere in higher resolution climate models that capture stratospheric aerosol processes; this research includes exploring the dependence of the response on the latitude of injection, considering different strategies, applying feedback to manage temperature targets despite uncertainty, as well as an increasing body of research looking at the effects on a wide variety of impacts throughout the world based on this climate modeling. All of this research to date points to the potential for a limited deployment of SAI to reduce many climate impacts, provided that it is a supplement to mitigation and not a substitute. In order to provide better support for future decision makers, it is time to take another fundamental step towards realism in our assessments. That must include a willingness to consider perturbative outdoor experiments provided that there is a clear scientific justification, and no other pathway available to reduce the uncertainty. Thinking clearly about experiments is important first because such experiments will improve model predictions and hence improve the information available to support decisions, it is also important for improved clarity on thinking about what the first steps would look like outside of model-land; thinking about the evolution of a single plume is not only the first experiment, but what one would see in the first days or months of early deployment. And finally, it is also essential to ground discussion of research governance in actual rather than hypothetical experiments, and their actual impacts. For all of these reasons we could not be more excited to take this next step in SAI research!

References

- Bingaman, D.C., et. al., (2020), “A stratospheric aerosol injection lofted aircraft concept: brimstone angel”, *AIAA Scitech 2020 Forum*, doi.org/10.2514/6.2020-0618.
- Fiske et al., (1982), “Soufrière Volcano, St. Vincent: Observations of its 1979 eruption from the ground, aircraft, and satellites”, *Science*, [10.1126/science.216.4550.1105](https://doi.org/10.1126/science.216.4550.1105).
- Froyd, K.D., et al., (2019), “A new method to quantify mineral dust and other aerosol species from aircraft platforms using single-particle mass spectrometry”, *Atmospheric Measurement Techniques*, <https://doi.org/10.5194/amt-12-6209-2019>.
- Gorkavyi, N., et al., (2021), “Tracking aerosols and SO₂ clouds from the Raikoke eruption: 3D view from satellite observations”, *Atmospheric Measurement Techniques*, <https://doi.org/10.5194/amt-14-7545-2021>.
- Horváth, Á., et al., (2022), “Measurement report: Plume heights of the April 2021 La Soufrière eruptions from GOES-17 side views and GOES-16–MODIS stereo views”, *Atmospheric Chemistry and Physics*, <https://doi.org/10.5194/acp-22-12311-2022>.

- Li, Y., et al. (2023), “In situ measurements of perturbations to stratospheric aerosol and modeled ozone and radiative impacts following the 2021 La Soufrière eruption”, *Atmospheric Chemistry and Physics*, <https://doi.org/10.5194/acp-23-15351-2023>.
- Newman, P. et al (2001), “Chance encounter with a stratospheric kerosene rocket plume from Russia over California”, *Geophys. Res. Letters.*, <https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2000GL011972>
- Peace, A.H., et al (2024), “In-plume and out-of-plume analysis of aerosol–cloud interactions derived from the 2014–2015 Holuhraun volcanic eruption”, *Atmospheric Chemistry and Physics*, <https://doi.org/10.5194/acp-24-9533-2024>.
- Quaglia, I., et al (2023), “ Interactive stratospheric aerosol models' response to different amounts and altitudes of SO₂ injection during the 1991 Pinatubo eruption”, *Atmospheric Chemistry and Physics*, <https://doi.org/10.5194/acp-23-921-2023>.
- Schneider, J. et al (2021), “Aircraft-based observation of meteoric material in lower-stratospheric aerosol particles between 15 and 68 N”, *Atmospheric Chemistry and Physics*, <https://doi.org/10.5194/acp-21-989-2021> .
- Smith and Wagner (2018), “Stratospheric aerosol injection tactics and costs in the first 15 years of deployment”, *Environmental Research Letters*, <https://iopscience.iop.org/article/10.1088/1748-9326/aae98d>
- Sun, H.-W. et al. (2024), “Stratospheric transport and tropospheric sink of solar geoengineering aerosol: a Lagrangian analysis”, *npj Climate and Atm. Science* <https://www.nature.com/articles/s41612-024-00664-8>
- Theys, N. et al. (2022), “Improved retrieval of SO₂ plume height from TROPOMI using an iterative Covariance-Based Retrieval Algorithm”, *Atmospheric Measurement Techniques* <https://doi.org/10.5194/amt-15-4801-2022>.
- Vattioni, S. et al., (2024), “Importance of microphysical settings for climate forcing by stratospheric SO₂ injections as modeled by SOCOL-AERv2”, *Geoscientific Model Development*, <https://doi.org/10.5194/gmd-17-4181-2024>.
- Winker, D.M. et al., (2007), “Initial performance assessment of CALIOP” , *Geophysical Research Letters*, <https://doi.org/10.1029/2007GL030135>.

PULSE Project: Public Understanding, Leadership, and Social Ethics in the Governance of Earth Cooling Technologies in Communities Impacted by Volcanic Activity in the Philippine Context.

Section 1: Technical Aspect

Project Research Summary

As climate change intensifies alarmingly, the global community is urgently exploring geoengineering solutions like Solar Radiation Management (SRM) to reduce global temperatures by reflecting solar radiation back into space (Harding & Moreno-Cruz, 2019). In addition, SRM, particularly stratospheric aerosol injection (SAI), could offer climate benefits but raise significant ethical, social, and governance concerns. These considerations and uncertainties in the risks and effectiveness underline the immediate need for vigorous research on climate science and social responses in anticipation of large-scale deployment.

The PULSE Project (Public Understanding, Leadership, and Social Ethics) addresses several critical gaps in understanding and governance of SRM technologies. This two-year project examines public perceptions in volcanic regions, ethical considerations, and governance and leadership frameworks concerning the deployment of SRM in the future.

The Philippines, located on the Pacific Ring of Fire, is highly vulnerable to climate change impacts, natural disasters, and the activity of many active volcanoes. These intersecting challenges give the country a unique perspective that could be valuable in informing SRM. The volcanic eruptions, such as Mount Pinatubo in 1991, serve as natural analogs for SRM technologies like stratospheric aerosol injection, providing critical lessons on the likely environmental, social, and governance implications of geoengineering as a climate intervention strategy. According to a 1997 USGS publication, the 1991 eruption of Mount Pinatubo in the Philippines released approximately 17 million tons of sulfur dioxide into the stratosphere, forming sulfate aerosols that reduced global temperatures by about 0.5°C (0.9°F) over the following two years.

By adopting a multidisciplinary team, the project will contribute to inclusive, transparent, and ethical decision-making processes regarding climate interventions that must respect community needs and future generations. The proposed research project addresses how to respond to these challenges by studying public understanding of SRM, especially in communities near active volcanoes in the Philippines. The project will investigate how past experiences of those communities with volcanic eruptions influence their perception of SRM technologies, focusing on Luzon Island (Mt. Mayon in Albay province, Mt. Pinatubo in Zambales, Mt. Taal in Batangas), Visayas Island (Mt. Kanlaon in Negros Oriental) and Mindanao (Mt. Hibok-Hibok in Camiguin). Surveys, focus group discussions, workshops, and key informant interviews will be conducted to gauge local awareness of issues and ethical considerations regarding the possible deployment of SRM in such vulnerable regions.

This project aims to comprehensively examine the community's views about SRM, explore ethical issues, analyze the present governance frameworks, and design policy recommendations that provide ample opportunities for inclusive decision-making. This mixed-method research approach will involve surveys, interviews, and expert workshops to facilitate open ethical leadership within climate governance. Expected outputs from this research include capacity-building workshops, academic presentations, policy briefs, and peer-reviewed journal articles toward responsible and

equitable approaches to technologies for cooling the Earth that set up a robust foundation to underpin informed climate governance.

Research Plan

Problem Statement

Solar Radiation Management (SRM) is a promising yet quite controversial technology. It is a geoengineering method that involves influencing climate by reflecting sunlight from the Earth's atmosphere. However, SRM is extremely controversial due to its likely environmental impacts, ethical implications, and governance challenges, though it has some potential applications in mitigating global warming (Union of Concerned Scientists, n.d.).

SRM may provide a potentially transformative pathway to countries like the Philippines, which are highly susceptible to climate change and natural disasters. However, introducing SRM technologies in such regions may raise ethical, social, and governance challenges, especially within communities that have already been disturbed by volcanic activities and other environmental disasters.

Understanding the social and ethical implications before widespread implementation is more pressing than ever. SRM would provide solutions to the problem of climate change, but it will also give rise to new risks and uncertainties (McLaren & Corry, 2021). Many uncertainties persist about SRM; therefore, further research must be conducted in climate science and the social sciences before policymakers seriously consider developing capabilities for deploying SRM. Secondly, SRM presents significant governance and accountability challenges that must be addressed through an ethical framework to protect future generations and vulnerable populations.

The proposed PULSE Project will seek to meet the challenges outlined above by exploring the perception, ethical, and governance/leadership concerns about using SRM technologies in the context of the volcanic community of the Philippines. This is historically and culturally attached to their environmental setting; the relationship and experience of this community with natural disasters would strongly shape views about new technological interventions such as SRM. The PULSE Project, therefore, plays a crucial role in investigating how these communities perceive SRM, particularly SAI, their awareness of it, and their concerns concerning the potential risks and benefits. Through this research, regional governance structures and leadership can be informed and guided to ensure that any SRM technologies deployed in the future are used transparently, ethically, and in a manner that is respectful to local needs and intergenerational justice.

There is a critical research gap concerning localized, context-specific ethical and governance issues of SRM deployment in the volcanic region of the Philippines. Without framing for public comprehension and accountability in SRM governance, ethically sound decision-making concerning its development and deployment becomes undermined. The lack of clarity creates uncertainties that may alienate vulnerable communities and potential risks, increasing social divides and undermining trust in climate interventions. The PULSE Project will fill this gap in knowledge by investigating the social, ethical, and governance challenges that SRM technologies pose for these communities to foster inclusive and responsible decision-making processes.

The project will yield necessary insights through comprehensive surveys in communities situated around areas where volcanic eruptions have occurred in the Philippines, with an emphasis on Mt. Mayon (Albay), Mt. Kanlaon (Negros Island), Mt. Pinatubo (Pampanga, Tarlac, and Zambales), Taal Volcano (Batangas), and Mt. Hibok-Hibok (Camiguin). The historical volcanic activities of the sites selected will be assessed, along with the likelihood of similar issues concerning SAI, a proposed SRM technique. The survey aims to determine the communities' stand on SAI, their awareness, knowledge, and concerns, and how this relates to their past experiences concerning volcano eruptions, changing climate, and aspects of their environment. Focus group discussions and workshops will also be conducted to complement policy recommendations and governance frameworks and ensure that SRM technologies characterized by transparency and accountability concerning the welfare of vulnerable populations may be deployed. The project aims to "gauge society's pulse" and ensure future climate interventions are grounded in ethical leadership, inclusive governance, and public accountability.

Study Objectives

The main focuses of the PULSE projects are

Study 1: Investigate the awareness, understanding, and perceptions of communities in the volcanic regions concerning Earth cooling technologies and the associated impacts and risks,

Study 2: Examine ethical issues and intergenerational perspectives of SRM, including equity, justice, and protection in communities prone to volcanic eruptions;

Study 3: Analyze leadership roles and governance frameworks for assuring transparency, accountability, and inclusivity in decision-making for cooling of the earth technologies and

Study 4: Recommend the structures of governance and policy recommendations for making decision-making inclusive and ethical.

Significance and Justification

The PULSE Project identifies and addresses ethical, social, and governance challenges surrounding Solar Radiation Management in communities affected by volcanic activity in the Philippines. The study will ensure that SRM interventions are ethically founded, socially responsible, and inclusive by assessing local perceptions, awareness, and concerns. Therefore, the project shall explore governance frameworks and propose policy recommendations to fill the critical research gaps responsible for climate decision-making in the most vulnerable volcanic regions, particularly in the Philippines as a developing country.

Area of Studies

The Philippines is in a tectonic setting, ideal for volcanic and earthquake activity (Philippine Institute of Volcanology and Seismology, nd.). In addition, there are 24 active volcanoes in the country, which means these volcanoes have erupted within the last 10,000 years. However, volcanologists have no consensus agreement on how to define active volcanoes. According to

Klemetti (2015), volcanoes that are unrest or showing signs such as earthquakes, inflation, and abundant release of carbon dioxide and sulfur dioxide are also considered active.

This proposed research project will conduct a case study in communities near active volcanoes in the Philippines, such as those around Mt. Mayon, Mt. Kanlaon, Mt. Pinatubo, Taal Volcano, and Mt. Hibok-Hibok. These volcanoes pose significant threats to surrounding communities, as their eruptions lead to environmental destruction, displacement, economic loss, and psychological impacts. These communities near active volcanoes experienced extreme impacts of volcanic eruption that can also be impacted by the subsequent effect of geoengineering on the environment.

Research Methodology

The PULSE project will apply a mixed-method approach by combining qualitative and quantitative research in a single study of SRM's public understanding and trust, social acceptability, and governance challenges.

- Comprehensive surveys will be conducted across communities surrounding active Philippine volcanoes, such as Mt. Mayon, Mt. Kanlaon, Mt. Pinatubo, Taal Volcano, and Mt. Hibok-Hibok. The comprehensive survey measurements of public awareness, trust in the scientific institution, and support for SRM will be anchored on knowledge of SRM, safety concerns, and confidence in governance frameworks.
- FGDs will be carried out in volcanic regions among diverse participants, such as local community members, government officials, scientists, and civil society representatives. The FGDs shall examine public attitudes, knowledge gaps, and factors influencing SRM acceptability, including transparency, trust, and risk perception.
- In-depth interviews with policymakers, scientists, environmental activists, and industry leaders will capture perceptions of SRM's feasibility, safety, and potential role in global climate strategies.
- Workshops and expert panels on ethical frameworks, focusing on intergenerational justice and the fair distribution of risks and benefits, would ensure that SRM does not cause disproportionate harm to vulnerable populations.

Method of Data Analysis

Data analysis in the PULSE Project will use qualitative and quantitative methods to address the different research objectives. Quantitative analysis will be done through statistical techniques to analyze the results of the surveys regarding awareness and understanding of SRM technologies in the target communities. Qualitative analysis will include thematic and content analysis of the ethical concerns, governance issues, and local perceptions gathered through interviews, focus groups, and expert workshops. Comparative analysis will also explore differences in attitudes and concerns from communities affected by volcanic activities. A meta-synthesis approach will also integrate findings across data types, giving a comprehensive view of the social and ethical implications of deploying SRM in such regions.

Expected Outcomes

1. Capacity Building. Training workshops will help stakeholders better understand SRM technologies and governance challenges and instill ethical leadership in climate governance.
2. Paper Presentations and Conferences. Present research findings at relevant academic and policy conferences to engage a broad audience and stakeholders.
3. Policy Briefs. Produce policy briefs that summarize key findings and recommendations for policymakers to use in the decision-making on SRM governance.
4. Publishable Journal Articles. Produce peer-reviewed journal articles to enrich the academic discourse on SRM, ethics, and governance.

Research Activities

Year 1:

1. Project Kick-Off. Team meetings and project planning, completion of research ethics review, and site visits to target communities Mt. Mayon, Mt. Kanlaon, Mt. Pinatubo, Taal Volcano, and Mt. Hibok-Hibok.
2. Literature Review. Conduct a comprehensive review of existing studies on public perceptions, ethical concerns, and governance frameworks regarding SRM technologies.
3. Questionnaire Design and Administration. Design and administer questionnaires to gauge community awareness, knowledge, and attitudes regarding SRM, emphasizing the local perception of risks and benefits.
4. Community Engagement. Use focus groups and interviews among community members and local leaders to explore ethical concerns and governance priorities related to SRM.
5. Data Analysis. Analyze survey data and qualitative responses from focus groups and interviews to identify trends and patterns in public perceptions, ethical concerns, and governance issues.

Year 2:

1. Governance and Ethical Frameworks. Review the governance frameworks and ethical considerations of SRM in vulnerable communities. Based on data from Year 1, identify gaps and issues.
2. Stakeholder Workshops. Hold workshops with local leaders, policymakers, scientists, and NGOs to discuss and refine governance frameworks and the ethical implications of deploying SRM in volcanic regions.
3. Policy Development. Synthesize the data analysis and the stakeholder workshops into policy recommendations that ensure inclusive and ethical decision-making on SRM technologies.
4. Final Report and Dissemination. Prepare and present the final research report, including academic papers, policy briefs, and governance recommendations. Disseminate findings through conferences, workshops, and publication in peer-reviewed journals.

Section 2: The Team

Individual	Role / Expertise	FTE	Total time on project (months, rounded)
[REDACTED] [REDACTED]	[REDACTED] [REDACTED] [REDACTED]	50%	12
[REDACTED] [REDACTED] [REDACTED]	[REDACTED] [REDACTED]	50%	12
[REDACTED] [REDACTED]	[REDACTED] [REDACTED] [REDACTED]e	50%	12
Hiring of Full-time Research Assistant		100%	24
[REDACTED] [REDACTED]	[REDACTED] [REDACTED]	10%	2.4
[REDACTED]	[REDACTED] [REDACTED]	20% (Policy workshop/dialogue and give critics on the research protocols)	4.8
[REDACTED]	[REDACTED] [REDACTED]	20% (Policy workshop/dialogue and give critics on the research protocols)	4.8
[REDACTED] [REDACTED]	[REDACTED] [REDACTED] [REDACTED]	20% (Policy workshop/dialogue and give critics on the research protocols)	4.8
[REDACTED]	[REDACTED] [REDACTED] [REDACTED]	20% (Policy workshop/dialogue and give critics on the research protocols)	4.8
[REDACTED]	[REDACTED] [REDACTED] [REDACTED]	20% (Policy workshop/dialogue and give critics on the research protocols)	4.8
[REDACTED]	[REDACTED]	20% (Policy workshop/dialogue and give critics on the research protocols)	4.8

Project Budget

EXCHANGE RATE OF GBP TO PESO: Php73.98 (DEC. 04, 2024)

GBP CONVERSION					
	73.98				
Particular	Quantity	Amount		Total	
		GBP	PHP	GBP	PHP
1. Personnel					
Research Assistant	1 x 24 months (2025 - 2027)	543.00	40,171.14	13,032.00	964,107.36
Research Assistant	1 x 12 months (2026 - 2027)	543.00	40,171.14	6,516.00	482,053.68
Subtotal		1,086.00	80,342.28	19,548.00	1,446,161.04
2. Materials and equipment					
Laptop	1 unit	800.00	59,184.00	800.00	59,184.00
Supplies		1,300.00	96,174.00	1,300.00	96,174.00
Subtotal		2,100.00	155,358.00	2,100.00	128,100.00
3. Project Team Meetings / Updating (food / snacks)	11 pax	150.00	11,097.00	1,650.00	122,067.00
Subtotal		150.00	11,097.00	1,650.00	122,067.00
4. Travel and Accommodation during data gathering					
4.1 Community-level Data Gathering					
Transportation cost: Van rental + driver going to communities to conduct surveys, FGDs, and dialogues	3 visits x 5 sites x 4 days	300.00	22,194.00	18,000.00	1,331,640.00
Air Fare: Plane ticket going to Camiguin (Mt.	Camiguin / CDO: Max. 5 pax per travel x 3 times	250.00	18,495.00	3,750.00	277,425.00

Hibok-hibok), and Negros (Mt. Kanlaon)	Bacolod: Max. 5 pax per travel x 3 times	230.00	17,015.40	3,450.00	255,231.00
Accommodation	3 visits x 5 sites x 4 days x 11 pax	40.00	2,959.20	26,400.00	1,953,072.00
Per diem	3 visits x 5 sites x 4 days x 11 pax	21.00	1,553.58	13,860.00	1,025,362.80
Subtotal		841.00	62,217.18	65,460.00	4,842,730.80
Food during workshops / FGD and policy dialogues	35 pax x 5 sites x 2 events	25.00	1,849.50	8,750.00	136,826.01
Community Survey Cost	35 pax x 5 sites	30.00	2,219.40	5,250.00	164,191.21
Subtotal		55.00	4,068.90	14,000.00	301,017.22
4.2 Policy forum and workshop					
Van Rental to conduct policy forum/workshops	5 sites	300.00	22,194.00	1,500.00	110,970.00
Food during workshops / FGD and policy dialogues	30 pax	28.00	2,071.44	4,200.00	310,716.00
Policy presentations and validation	35 pax x 5 sites	25.00	1,849.50	4,375.00	323,662.50
Per diem	5 sites x 11 pax	21.00	1,553.58	1,155.00	85,446.90
Invite resource persons to discuss SRM technologies	2 persons at 2000 per hour for 5 hours	28.00	2,071.44	280.00	20,714.40
Subtotal		402.00	29,739.96	11,510.00	851,509.80
5. Project write shop/workshops among the project members of policy paper, report writing and publication	Per diem: 11pax x 3 times or days x GBP 21 Transportation: GBP 2000 (3 times or days, 10 pax)	2,693.00	199,228.14	2,693.00	199,228.14
Total		3,991.00	295,254.18	93,663.00	6,194,485.96
6. Travel Insurance		21.00	1,553.58	231.00	17,089.38

Overall Total		7,348.00	543,605.04	117,192.00	7,907,903.38
7. Institutional fee for the UPLB Foundation Incorporated	15%			17,578.80	1,300,479.62
Grand Total		7,348.00	543,605.04	134,770.80	9,208,383.01

References

1. Harding, A., & Moreno-Cruz, J.B. (2019). The economics of geoengineering. *Managing Global Warming*, 729-750. <https://doi.org/10.1016/B978-0-12-814104-5.00025-9>
2. McLaren, D., & Corry, O. (2021). Clumsy governance: Climate change experiments as a new form of governance. *Environmental Politics*, 30(2), 159-179. <https://doi.org/10.1080/09644016.2019.1558515>
3. Felgenhauer, T., & Pizer, W. (n.d.). The future of solar geoengineering research. Resources for the Future. Retrieved September 15, 2024, from <https://www.resources.org/common-resources/the-future-of-solar-geoengineering-research/>
4. Philippine Institute of Volcanology and Seismology. (n.d.). Introduction to volcanoes. Department of Science and Technology. <https://www.phivolcs.dost.gov.ph/index.php/volcano-hazard/introduction-to-volcanoes>
5. Klemetti, E. (2015). How we tell if a volcano is active, dormant, or extinct. WIRED. <https://www.wired.com/2015/08/tell-volcano-active-dormant-extinct/>
6. Abante, M. (2020). *The eruption history of Mayon volcano: Its impact on the surrounding communities*. Bicol University Journal of Science and Technology, 1-14. Retrieved from https://journal.bicol-u.edu.ph/assets/journal_pdf/1%20Abante_1-14.pdf
7. National Disaster Risk Reduction and Management Council. (2023). *Situational report for the Mayon volcanic activity, 2023*. Retrieved from <https://monitoring-dashboard.ndrrmc.gov.ph/page/situation/situational-report-for-the-mayon-volcanic-activity-2023>
8. Encyclopaedia Britannica. (n.d.). *Mount Canlaon*. Encyclopaedia Britannica. Retrieved December 1, 2024, from <https://www.britannica.com/place/Mount-Canlaon>
9. National Disaster Risk Reduction and Management Council (NDRRMC). (2024). *SitRep No. 21 for Kanlaon volcanic activity*. Retrieved from https://monitoring-dashboard.ndrrmc.gov.ph/assets/uploads/situations/SitRep_No_21_for_Kanlaon_Volcanic_Activity_Whole_Report1.pdf
10. United States Geological Survey (USGS). (1991). *The 1991 eruption of Mount Pinatubo*. Retrieved from https://volcanoes.usgs.gov/volcanic_ash/pinatubo_1991.html
11. Geological Society. (n.d.). *Mount Pinatubo*. Retrieved from <https://www.geolsoc.org.uk/Policy-and-Media/Outreach/Plate-Tectonic-Stories/Cwm-Idwal/Mount-Pinatubo>

12. Allen, T.S. (2021). *Remembering Mt. Pinatubo: A look back at the eruption's legacy*. NASA Applied Sciences. Retrieved from <https://appliedsciences.nasa.gov/our-impact/story/remembering-mt-pinatubo>
13. Smithsonian Institution. (n.d.). *Taal*. Global Volcanism Program. Retrieved from <https://volcano.si.edu/volcano.cfm?vn=273070>
14. Macaraeg, P. (2020). *Timeline: Taal volcano eruption and the devastation it caused*. Rappler. Retrieved from <https://www.rappler.com/newsbreak/iq/249127-timeline-taal-volcano-eruptions/>
15. UNESCO. (n.d.). *Taal Volcano (Philippines) - Tentative List*. Retrieved from <https://whc.unesco.org/en/tentativelists/6714/>
16. ASEAN Centre for Biodiversity. (n.d.). *Mount Timpoong-Hibok-Hibok Natural Monument*. Retrieved from <https://asean.chm-cbd.net/mt-timpoong-hibok-hibok-natural-monument>
17. Oregon State University. (n.d.). *Mount Hibok-Hibok*. Retrieved from <https://volcano.oregonstate.edu/hibok-hibok#:~:text=The%20volcano%20has%20four%20historic,earthquakes%20that%20preceded%20the%20eruption.>
18. Arguillas, C.O. (2020). *Camiguin's Mt. Hibok-Hibok eruption gave birth to today's PHIVOLCS*. MindaNews. Retrieved from <https://mindanews.com/top-stories/2020/01/camiguins-mt-hibok-hibok-eruption-gave-birth-to-todays-phivolcs/>
19. U.S. Geological Survey (USGS). 1997. The Cataclysmic 1991 Eruption of Mount Pinatubo, Philippines. U.S. Geological Survey Fact Sheet 113-97. https://pubs.usgs.gov/fs/1997/fs113-97/?utm_source=chatgpt.com
20. Union of Concerned Scientists. (n.d.). *What is solar geoengineering?* Retrieved December 7, 2024, from <https://www.ucsusa.org/resources/what-solar-geoengineering>

1. SAFE GEOGOV's Programme Contribution & Technical Description

 The ARIA funding program asks whether one or more climate cooling methods may one day be used to effectively, responsibly, and ethically prevent or counter severe climate outcomes, including from tipping points. This question needs two types of answers: one on the technical capabilities and another on decision-makers' ability to make wise decisions. On the latter, the feasibility of responsible climate cooling is powerfully shaped by geopolitical dynamics. Examining political scenarios may allow the identification of a range of non-ideal deployments that can inform the technical research on the physical consequences of deployment under various conditions, including cases of imperfectly rational decision-making.

The proposed project examines plausible futures of solar radiation modification (SRM) deployment by 2035. A baseline and four geopolitical SRM scenarios will be developed in partnership with the OECD – a major, highly credible, multilateral organisation with direct, high-level Ministerial access across its 38 member states and a positive impact far beyond those.¹ The project contributes to the social science research on the geopolitics and anticipatory governance options for SRM, and it may inform the scientific research on SRM impacts in case of non-optimal deployment conditions. The project develops four strategic foresight scenarios with input from a broad range of scientific and policy experts and practitioners. This work would help bridge the science-diplomacy chasm, which – alongside the lack of technical research – poses a severe obstacle to informed decision-making.

A slowdown in climate policy and broader political developments, as well as the crossing into increasingly dangerous climate territories above 1.5°C raise the spectre of a sudden rise in interest in SRM use at a time when the scientific knowledge is not sufficient and international governance of SRM is inadequate – as is decision-makers' awareness of the stakes. Knowledge levels about the coming climate impacts as well as about the science and potential politics of SRM, remain very low amongst key officials, including in developed countries.

The project bridges the chasm between science and policy by serving both communities: the tangible future scenarios make the – otherwise abstract – climate intervention techniques “more real” and help policymakers understand the potential risks, benefits and uncertainties – and why they should care. It also helps researchers better understand the kind of questions policymakers – and the public they serve – want answered. It allows for the identification of non-ideal scenarios in which SRM testing or use may happen. Researchers and decision-makers will learn from each other's realities, empowering more judicious and informed decision-making. Advancing a nuanced and humble understanding that SRM is not ‘just’ a science issue but an ‘everything’ issue is crucial and most governance literature outlines extremes – either a top-down ban (however enforced) or unilateral deployment followed by conflict. Geopolitical analyses may show both unlikely. More nuanced scenarios may examine how threats from climate change and interests associated with SRM might intersect with geopolitics, security, migration, human rights and other social objectives. The development of the scenarios starts with baseline political realities of the next ten years in which it grounds testing and deployment scenarios.

¹ The OECD's senior leadership is intent on collaborating and willing to confirm this publicly once CFG can assure the funding and a formal cooperation agreement can be signed on such basis.

SAFE GEOGOV – Strategic Foresight on Climate and Geopolitics: Toward Governance of Solar Radiation Modification

The project's insights could help devise solutions to reduce the chances of dangerously uninformed decisions and uncertainties on multiple levels. They would also help identify and advance no-regret, near-term governance solutions, which would be desirable regardless of one's views on a future with or without SRM. Such measures may include strengthening the transparency of research and monitoring of testing/deployment, clear criteria for large-scale outdoor testing, actionable opportunities for significant public engagement along the way, and exploration of possible governance bodies. The project would also unearth additional questions requiring further technical and scientific research.

The four scenarios will be developed through a rigorous process involving a wide range of expert and practitioner perspectives; our interlocutors have already raised some ideas – and the literature also provides suggestions – toward SRM testing and deployment scenarios, including under non-ideal conditions: SRM deployment by one or more major economies to slow or avert a global climate tipping point related to the Arctic; a unilateral and unannounced large-scale test of SRM; unilateral global deployment by a major power reducing temperatures excessively); geopolitical tensions from a proposed global-scale deployment by several permanent members of the UN Security Council – opposed by another (considering each has veto power); a multilateral deployment in the Amazon or the Sahel by climate-vulnerable countries jointly with Northern European Nations; intentional mis- and disinformation and their implications for political debate and decision-making will also be examined and woven into one or more of these scenarios. We intend to strike a careful balance to ensure that the scenarios do justice to the range of possibilities – including the significant benefits of successful SRM protection from climate harm.

SAFE GEOGOV empowers policymakers and researchers with a shared understanding of the stakes involved with climate change and SRM. It

1. contributes to ethical, governance, law, security and geopolitical research,
2. highlight implications of using - or not using - SRM and the consequences for the SDGs,
3. identifies factors of (non-)feasibility (social, political, scientific, and engineering),
4. identify cross-cutting questions,
5. and co-creates evidence for informed and effective decision-making.

The participatory development of scenarios, briefings, and subsequent policy engagements places the SRM governance issue squarely on the diplomatic agenda of the OECD and its members' Ministries of Foreign Affairs, Finance, Energy and Economy, including those tasked with the clean energy transition.

State of SRM governance

Governance research remains highly theoretical and inadequately grounded in political realities. Decisionmakers have told us they need concrete governance proposals and have explicitly asked us to develop them. Existing literature highlights ethical, environmental, and technical issues of SRM governance, but often without delving into options that could help address them. When options are given, such as for a sweeping non-use agreement or calls for broad deliberation, they have not been backed by analyses of the political interests and institutional structures that would largely determine their feasibility. Few studies delve deeply into the

SAFEGEOGOV – Strategic Foresight on Climate and Geopolitics: Toward Governance of Solar Radiation Modification

practical geopolitical dynamics or strategic decision-making scenarios surrounding individual countries' potential decisions for strategies of testing, deployment or deterrence of SRM.

A key gap in the field is the lack of forward-looking exploration grounded in realpolitik: With limited use of geopolitical and game-theoretical analyses examining strategic testing, deployment or non-deployment decisions, most governance research relies on stylized, extreme cases, such as direct great power conflicts weaponizing SRM on the one hand or idealized fully cooperative rational actors under UN decision-making on the other. These approaches fail to capture the complex, iterative, and often fragmented nature of the geopolitical undercurrents that would likely shape SRM governance. We are aware of a separate proposal for expert-involved work on analyses of non-ideal deployments forward by [REDACTED] and are highly supportive of such endeavors. We plan to draw on early insights from [REDACTED] 3-year project in SAFEGEOGOV and vice-versa, offer insights from our work to [REDACTED] team (see below).

Most discussions on potential governance frameworks have emphasized a predetermined outcome (use or non-use of SRM) – mirroring the presumed preferences of authors. The weakness of a sweeping “non-use agreement”, for example, becomes evident based on three observations: 1. An international norm seeking to prevent the use of SRM is only as strong as its capability to deter the government(s) most keen on using SRM; 2. Growing climate impacts and tipping point threats will increase the perceived attractiveness of SRM in a world of 2-3°C of warming; 3. Countries proved reluctant even on an international assessment of SRM - for fear of prematurely locking in a particular international process or negotiation venue.²

The SRM governance literature is heavy on arguments and light on rigorous analysis. This creates a false impression of certainty and coherence. More exploratory analysis of governance proposals' feasibility, enforceability, and/or long-term implications - including in the context of overall global climate policy, growing public mistrust of both science and the state, and social media echo chambers - is critically needed. The current state of governance studies also emphasizes extremes and lacks a range of intermediate governance contexts and models. This is required to balance diverse stakeholders' interests while addressing risks and opportunities associated with SRM. This underdeveloped state of SRM governance research underscores the urgent need for studies integrating political realities, exploring a wider range of geopolitical scenarios, and incorporating robust strategic modelling for effective and equitable governance.

State of governance activities

Several actors have sought to empower international decision-makers and UN fora to strengthen governance mainly by raising awareness and fostering dialogue among policymakers (C2G) and civil society (Alliance for Just Deliberations on Solar Geoengineering - DSG, Heinrich Böll Foundation). Some have focussed on individual national governments (e.g. Silver Linings in the US). The issues are increasingly discussed in English-speaking media and among some UN entities (UNEP, UNCBD, UNESCO, WMO). However, these discussions remain abstract and lack a real-world understanding of crisis decision-making and the political

² We believe that agreement for greater cooperation and information sharing under the UN (incl. UNEA and IPCC) was stifled to date by a lack of a shared understanding of what may be at stake and an inadequate vision of what is to gain by cooperating. Our scenarios should help with both.

SAFE GEOGOV – Strategic Foresight on Climate and Geopolitics: Toward Governance of Solar Radiation Modification

factors that heavily influence policymaking at the highest levels. There is no public, transparent registry of SRM research and who funds it, nor is there any agreement on what constitutes SRM research and how it could be monitored across borders. No major government has yet pronounced its position on questions of future use of SRM. Even the question of selecting an agency to conduct an international assessment of the scientific evidence of SRM and its governance challenges remains contested.

Approach and timeline

In contrast to many existing governance studies, we favour a more outcome-agnostic approach, prioritizing the exploration of multiple potential futures using strategic foresight that is grounded in the input of a wide range of perspectives: we will involve relevant practitioners and experts from a range of fields (including game theory, international relations, behavioural economics and/or risk communications) as input and helpful complements to strategic foresight. Such involvement through interviews or workshop participation can strengthen our analytical base (reference scenarios) and vice-versa, stimulating reflection on a broader range of possible geopolitical dynamics. Consequently, policymakers should see themselves or their peers in these scenarios and take much more seriously the awesome responsibilities they will soon face as the climate crisis worsens and decisions on SRM are thrust to the top of the global agenda.

The strategic foresight process for scenario development is at the project's core – accompanied by extensive communication and engagement activities. Strategic foresight is a structured way to think about the future through the eyes of multiple stakeholders, each of whom can bring distinct insights to broaden or deepen the range of considerations. Its purpose is to equip governments, societies, and researchers with the capacity to explore and prepare for multiple plausible futures, risks, opportunities and challenges to guide decision-making today.

The strategic foresight methodology used in this project is a comprehensive deductive approach that allows for generating evidence-based, defensible and robust SRM future scenarios. It mirrors processes employed by other International Organisations, including the UNIDIR, and is widely considered one of the most rigorous strategic foresight processes. [ScMI software](#) will be used for structured data analysis that supports the scenarios. The scenario development includes the following five steps:

1. Conducting Delphi interviews with SRM, technology, climate policy, geopolitical, governance, and foresight experts to map the analytical background and create a long list of factors that are defining aspects of SRM presently and in the future;
2. Prioritizing a shortlist of the most impactful factors and assessing possible future projections for each;
3. Assessing the consistency between projections to elucidate groups of factors that are logically most likely to co-occur;
4. Developing four reference scenarios about the future of SRM to explore tensions, trade-offs and potentially fitting (global) governance arrangements;
5. Modelling of the broad geopolitical and socio-economic-environmental implications of SRM future scenarios with an international set of thematic and policy experts.

SAFE GEOGOV – Strategic Foresight on Climate and Geopolitics: Toward Governance of Solar Radiation Modification



The synthesis report will show and explain the four 2035 SRM scenarios in a clear and concise format. For each scenario, the opportunities and challenges that might have to be anticipated and managed by policymakers will be clearly articulated. The report will be complemented with one or more research articles and at least 5 customised briefings (meetings or phone calls) for specific actors (policymakers, NGOs, the media). Additionally, 2-3 written policy briefs may introduce specific governance opportunities, including potential multilateral and international measures for anticipating and minimising risks and research funding design options for responsible and transparent SRM research, testing, and monitoring.

Target audiences: The synthesis report and its key findings will be presented in research and policy contexts and multiple tailored briefings to senior policymakers and their advisors in the EU and other major economies, as well as with climate-vulnerable countries and civil society networks. Relevant policy fora may include the Climate Vulnerable Forum, G7, G20 and World Bank annual preparatory meetings, Arctic Council's Arctic Monitoring and Assessment Programme (AMAP) working group meetings, and more. Relevant international research conferences may include AGU, DEGREES' Global Forum, and Gordon Research Conferences. Relevant science-policy contexts may include WCRP, IPCC, and IPBES meetings or those by the Ozone Secretariat's science panels. Relevant multilateral contexts include UN venues such as UNEP, WMO, UNFCCC, UNCBD, or Montreal Protocol.

Targeted media outreach will also help create an impact by informing NGO and public discussions. The aim is to stimulate and broaden balanced (risk-risk) reflections on the future contexts in which SRM might be tested or deployed and the consequences - socio-economic, environmental, geopolitical and social (in)stability of each. This will include the range of climate change-related impacts and the associated governance needs, as well as potential SRM field tests or deployments and the potential geopolitical, socio-economic and environmental consequences thereof.



The OECD's involvement and the presentation of the scenarios to senior officials immediately raise awareness of the challenges of SRM governance to new heights.

Work Arrangement and Timeline

The work would be conducted from Brussels, New York, Australia, and Paris, with regular meetings held at CFG's headquarters in Brussels and the OECD's office in Paris. Additional regular meetings can be arranged with ARIA, ARIA-funded researchers, and other UK-based stakeholders to inform this project and, vice versa, convey insights to other projects.

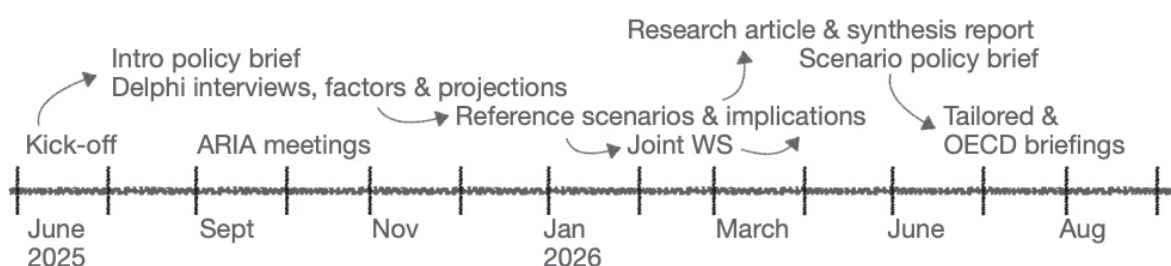


This substantive work is done in a staggered sequence, whereby the five scenario-development steps (Delphi interviews, impact factors short- and longlist, projections, reference scenarios, and implications analysis) are undertaken sequentially and in consultation with thematic experts and policymakers from the OECD Environment and OECD Science, Technology and Innovation Directorates. From the beginning, the project scope and objectives will be communicated to policymakers, including a first policy brief seeking to ensure interest and buy-in. Engagements with other ARIA-funded groups and broader scientific communities are also planned in parallel. We primarily seek to mobilize experts' feedback on key scientific, technical, geopolitical and governance aspects of the scenarios, including the

SAFE GEOGOV – Strategic Foresight on Climate and Geopolitics:
Toward Governance of Solar Radiation Modification

pace and scale of potential deployment, hardware development bottlenecks and the plausible pace of development under varying assumptions, as well as the pace and scale of earth system responses, including in cases of tipping points.

One specific cooperation we can already foresee is a joint workshop with the project proposed by ██████ in which we would seek to cross-pollinate the respective works, including by participating – where appropriate – in ██████ (online) symposia, two in-person meetings between project teams, and an in-person joint workshop – tentatively scheduled for January or February 2026. The latter will allow us to overlay and compare our draft scenarios with the simulation space framework of ██████ project to identify similarities and differences in assumptions and policy/technology implications. Additionally, we foresee two coordination meetings between the two teams – one in London or Leeds and another in Brussels for which we include travel costs for at least one mutual visit of each team.



Seven months into the project (December 2025) could constitute a milestone to assess progress, adjust the work plan, and start 2026 with fresh momentum and guidance from ARIA—in addition to brief quarterly meetings (if desired).

Opportunities to expand the scope: Beyond testing and deployment scenarios, synthesis reports, policy briefs, and outreach activities, CFG may pursue additional complementary work (funding permitting): deeper dives into specific scenarios of interest, informed by deliberations and analyses. This could involve follow-up workshops with SRM researchers and policymakers and targeted dissemination activities focusing on areas like the Arctic, tipping point emergencies, or unilateral large-scale testing or deployment. It may also include the potentially more positive possibilities of relatively coordinated testing or deployment. Further analytical and policy engagement efforts – involving workshop engagements with academic and policy communities – might explore issues such as deliberate climate policy sequencing that ensures robust application of all relevant climate action strategies, including scale-up of CO₂-removal, robust SRM assessment and communication, as well as deeper analysis of geopolitical or domestic policy factors shaping future SRM decisions. These activities could extend beyond SAFE GEOGOV's scope, requiring further fundraising if such gaps persist.

Project risks and mitigation measures

The project does not include any physical experiments. Yet it includes potential political risks and, therefore, will also consider whether or how the principles for outdoor experiments outlined

**SAFE GEOGOV – Strategic Foresight on Climate and Geopolitics:
Toward Governance of Solar Radiation Modification**

in the programme thesis might apply. Political risks include the project's own contribution to the growing salience of SRM testing or deployment – that some governments might eventually consider or threaten in the future. It may be important to anticipate regular interaction with ARIA staff to monitor such risks and to identify options for additional (communication or engagement) measures. The table shows risks, issues at stake and our plan to manage them.

Project risk	Key issue at stake	Risk mitigation measure
Criticism from anti-SRM NGOs for unduly normalizing or legitimizing the issue.	The project's legitimacy and the assertion of moral hazard levelled against it.	Proactive, honest communication: Whether one abhors or supports the possibility of SRM used, it needs governance; for this, policymakers need to grasp what's at stake – tangible scenarios convey that despite short attention spans.
Lack of interest among policy communities – SRM is too “out there” as an issue.	Diversity of policymakers' viewpoints in the analysis & awareness-raising impact.	The team leverages its unparalleled global network to mobilize further voices to underscore the urgency of foresight and SRM governance: SRM researchers and experts in governance, climate policy, and climate science, as well as policy advisors and decision-makers in national and regional governments, the UN system, climate (e.g. climate envoys), security, economic, and foreign affairs.

2. SAFE GEOGOV's Team, its Collaboration, and Motivation

The Brussels-based [Center for Future Generations \(CFG\)](#) provides key EU officials with governance options, timely research and international contacts to help inform decision-making. As the only organization in the Union's de facto Capital with a team dedicated to [SRM governance](#), it supports European leadership in stepping up (as the US steps away from international efforts). With excellent relations in global research communities, key UN system actors, NGOs, and media, we ensure strategically relevant findings – are communicated to key decision-makers informing governance of SRM in Europe, various UN fora, among the G20 and wherever else opportunities to safeguard the interests of present and future generations arise.

The project's PI is

[REDACTED]

SAFE GEO GOV – Strategic Foresight on Climate and Geopolitics:
Toward Governance of Solar Radiation Modification

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Additional supporting research and corresponding staff input will be commissioned from relevant OECD Directorates (Environment and Science, Technology and Innovation) to ensure methodological rigour and the full briefing of all 38 OECD countries of the resulting report and policy briefs. The OECD prides itself on delivering analyses on emerging issues to its members – ahead of the curve and with excellent quality – this project promises to do just that.

Novel Materials for Stratospheric Aerosol Injection

Section 1: Programme & Technical

1.1 Background and Programme Alignment

This document outlines a proposal for a 3-year study of Stratospheric Aerosol Injection (SAI) as a potential intervention to mitigate the effects of global warming.

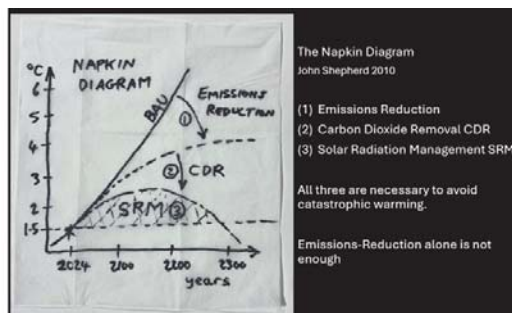


Figure 1. Napkin Diagram

The importance of SAI was made plain by a graphic from John Shepherd in 2010 which soon became known as “The Napkin Diagram”, shown here. Emissions reduction alone is insufficient and must be supplemented by Carbon Dioxide Removal (CDR) and Solar Radiation Management (SRM). SAI is one of the most-studied forms of climate engineering, but research has virtually exclusively been limited to numerical simulations. Most of the studies investigating different strategies look at the effects of introducing sulphur dioxide (SO_2) into the stratosphere, which reacts to become sulphuric acid aerosol (H_2SO_4)¹⁻⁶ and which reflects some of the radiation from the

sun back into space increasing the planetary albedo (α in equation for T_{surf} in Programme Thesis). This has in part been inspired by observations from volcanic eruptions, especially 1991 Mount Pinatubo which lofted ~20 million tonnes of SO_2 into the stratosphere resulting in global cooling by approximately 0.5°C for around a year.⁷⁻⁹ Injection of aerosols into the stratosphere rather than the troposphere reduces the required mass injection rate in part due to longer residence times. Depending on the latitude of injection, the aerosol cloud will be dispersed across the globe within a period of weeks. SAI is considered by a number of scientists as a potential way of actively cooling the earth.¹⁰⁻¹¹

1.2 Research Methodology

For stratospheric SO_2 injections¹⁻⁶, the resulting sulphuric acid aerosol has the potential for undesirable side effects, such as stratospheric warming and ozone loss, which changes atmospheric circulation, precipitation patterns and ultraviolet radiation.¹²⁻²⁴ The composition and size of volcanic sulphuric acid particles are not optimal for scattering solar radiation²⁵ and other materials could reduce the injection mass per unit of radiative forcing (cooling).^{19,26,33} This is because the refractive index of manufactured aerosols is much larger than that of sulphuric acid. Alternative SAI materials (ASAIMs) are solid/crystalline in nature, e.g., alumina, calcite, silicon dioxide, diamond and other materials. These have the potential to reduce risk to the chemical balance and the dynamics of the stratosphere.²¹ Particles engineered to a specific size range can optimise their scattering efficiency and their stratospheric lifetime. ASAIMs have been studied using models investigating global and regional effects^{6,19-21,28-35} and laboratory-based experimental studies³⁶⁻⁴³. To understand the efficacy, deliverability and risks of ASAIMs validated models are required. ASAIMs are instantaneously effective whereas SO_2 develops optical effectiveness over a period of weeks thus small-scale indoor experiments are relatively easy with ASAIMs.

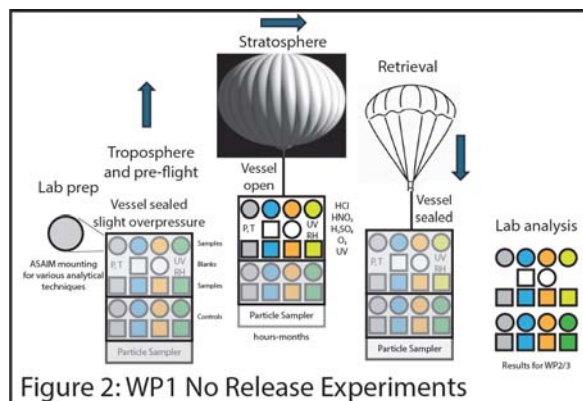
Central issues are the (i) scattering efficiency per injection mass, (ii) amount of radiation absorbed, primarily in the long-wave atmospheric window, and (iii) chemical impact on stratospheric composition. First-order questions are what is the ideal ASAIM with respect to radiative and chemical impacts and can these materials be delivered and dispersed effectively? Radiative impacts depend on bulk composition while the chemical ones depend on the particle surface layer. A key feature of this proposal is a unique approach to investigating these aspects of real stratospheric surfaces, in contrast to previous laboratory studies that have largely studied fresh aerosol surfaces or those aged under idealized conditions.

Particles will be investigated in terms of i) practical aspects of system engineering including the near-point source dispersal of material (because agglomeration of materials in a container or the coagulation of particles after their release could seriously impede the overall viability), ii) the medium-scale mixing of material in the stratosphere (because the current spatial resolution of modelling used to assess a global cooling effect is too coarse to examine the behaviour of plumes), iii) the options for delivery of candidate aerosols to the stratosphere, and iv) the lifetime of the aerosols/particles in the stratosphere, their effects on stratospheric circulation and ozone, and regional deposition rates tied to potential biosphere impacts. Other questions, such as impact on cloud formation⁴² and surface particulate matter exposure⁴⁴ are beyond the scope of this proposal.

1.3 Project Overview: Three Parallel Work Packages

The research will involve three integrated work packages configured to identify which novel ASAIMs are most effective at light scattering relative to potential risks and deliverability.

1.3.1 Work Package 1 (WP1): Stratospheric evolution of chemical and physical properties of ASAIMs



WP1 addresses the evolution of chemical and optical properties of ASAIMs, which control efficacy and risks. A non-release ASAIM field experiment (Fig 2) will solve two fundamental shortcomings of laboratory experiments: laboratory experiments struggle to reproduce (i) the complexity of the real stratospheric system adequately (realism), and (ii) the evolution of ASAIMs over weeks to months. Achieving the realism and timescale requires innovative hardware that combines (i) a novel method of ageing particles in the real stratosphere without any particle release with (ii) offline aerosol analysis techniques regularly used in the [redacted]. The solution, not available with any other

approach, is a series of stratospheric balloon flights of increasing duration from hours to months with candidate ASAIMs permanently adhered to grids for offline analysis in a low-weight, sealable vessel equipped with temperature, humidity, pressure and UV radiation sensors, as well as communications. Once in the stratosphere this vessel exposes particles to the full stratospheric environment (UV, temperature, pressure, and chemistry) before sealed descent (preventing tropospheric contamination) and recovery. Substrates coated with particles and no exposure and blanks will provide insights into particle ageing. We will also collect and characterise background aerosols, ensuring accurate representation of the nascent stratospheric environment. Offline nanochemical/imaging analysis techniques, which we regularly apply to background stratospheric aerosol collected on electron microscopy and other grids, will measure the evolution of the chemical, physical and radiative properties of ASAIMs as a function of exposure time. These data are needed in **WP3** for accurate numerical modelling to quantify the risks of ASAIMs to stratospheric composition, circulation, and human health.

WP1A Preparation for stratospheric balloon flights: characterise unaged materials not included in our existing laboratory grant (Simons); completion of design, fabrication of existing prototype vessel; selecting and adhering ASAIMs on grids; thermal vacuum tests of complete system analogous to tests of existing stratospheric instrumentation; conduct short duration balloon engineering test flight building on system developed by Sandia National Labs (shared with us); complete ARIA governance framework compliance (product is material mounting and vessel functional and for stratospheric conditions).

WP1B Initial short duration science flights: 2 short (~4 hr) duration science flights; 2nd flight only if iteration needed; deliverable is 3 science ready systems and publication of technical approach.

WP1C Series of short duration balloon flights to 10 hours; offline characterization of all materials; deliverable is scientific publication and readiness for WP1D.

WP1D Preparing and conducting 3-week stratospheric balloon flight: integration with Aerostar's Thunderhead leverages experience in integration complex payloads into stratospheric balloon and aircraft platforms; 3 vessels with ASAIMs and controls exposed 4 d, 10 d, 3 week; characterization of retrieved aerosols; deliverable is publication of first scientific results on realistic ageing of ASAIMs providing input for WP1E, WP2 and WP3.

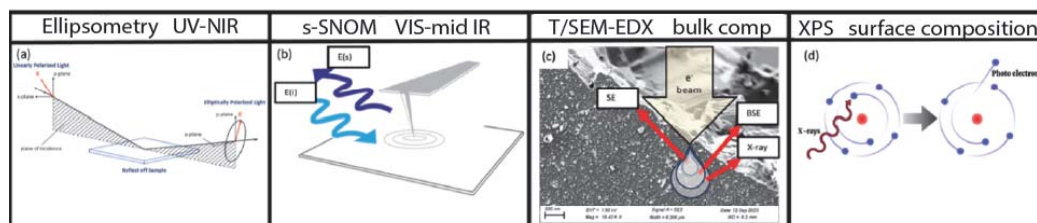


Figure 3. Some employed spectroscopic and imaging techniques. (a) Ellipsometry: UV-NIR refractive index (b) s-SNOM: nanoscale spatially resolved VIS-mid IR absorption and reflectivity; shape, size, morphology and surface roughness (c) T/SEM-EDS: high resolution imaging of topography/morphology and bulk elemental composition, morphology (d) XPS: surface elemental composition/chemical bonding.

WP1E 5-Week stratospheric balloon flight; material choice guided by WP1D; offline characterization of all materials; deliverable is additional scientific publication on 5-week exposure of ASAIMs to stratospheric conditions.

Characterization of fresh and exposed ASAIMs WP1A-E: Changes of ASAIM morphology, bulk and surface composition, and optical properties over stratospherically relevant lifetimes will be determined via established nanoanalysis techniques. SEM/AFM will determine morphology/size. Optical properties of individual particles will be quantified in Mid-IR to VIS via scattering-scanning near field optical microscopy (s-SNOM) as well as electron energy loss spectroscopy (EELS) at Harvard. Optical properties will also be determined for differently mounted samples via ellipsometry and FTIR-ATR at Harvard. Chemical bulk composition will be determined via SEM/TEM-EDS, STXM (including NEXAFS) and XPS for surface composition. We have been partnering extensively with PNNL-EMSL, e.g., on the STXM-NEXAFS cc-SEM-EDS and others. These methods have been applied by the [REDACTED] for stratospheric background aerosol collected with an impactor as well as some unaged commercial ASAIMs. Unreactive ASAIMs, such as alumina, are expected to have little bulk chemical change but the UV environment could result in optical changes as can coatings of sulphuric acid or surface roughness changes. Reactive ASAIMs, such as calcite, magnesite, dolomite and others are expected to have extensive surface and even bulk chemical changes from reaction with sulphuric acid, HCl, HF and HNO₃, also affecting optical properties. In addition, changes in surface roughness / topography are important to explore as it affects light scattering directionality and efficiency, ice and mixed phase cloud formation and agglomeration/coagulation. We will also extend previous laboratory contact angle measurements for sulphuric acid and bulk ASAIMs to see if sulphuric acid forms lenses or envelops ASAIMs. The complex refractive index and surface chemical analyses provide important input for WP3 and the global SOCOL-AER v4 model in our group that will be used for improved prediction of impacts of different ASAIMs, e.g., stratospheric ozone and dynamics as well as radiative forcing.

Milestones

M1: Publication of all technical developments including custom vessel design

M2: Determination of contact angle measurements for sulfuric acid for fresh and lab-aged surfaces

M3: First detailed characterization of evolution of ASAIMs in real environment (morphology, bulk/surface composition, complex refractive index UV to mid-IR) representing key parameters for radiative and chemical impacts of ASAIMs

M4a,b: Input for WP2 from two long duration balloon flights (in terms of identifying target ASAIMs for assessment of deliverability), WP3 (modelling), as well as global climate models currently used for SAI modelling which will reduce uncertainties in impacts of ASAIMs

1.3.2 Work Package 2 (WP2): Dispersal and deliverability of aerosols.

WP2 addresses the dispersal and deliverability of alternative aerosols. Solid particles tend to agglomerate due to surface effects, such as van der Waals forces and electric charges,⁴⁵⁻⁴⁶ making their separation from the bulk state into a desired Particle Size Distribution (PSD) a considerable challenge on a stratospheric platform. Coagulation of particles is undesirable because gravitational sedimentation decreases particle lifetime and may reduce the optical scattering efficiency per unit mass. An efficient dispersal system is needed to release particles at controlled sizes and rates to ensure a consistent and controlled global distribution both at the point of release and beyond. Cambridge University will modify their “spray tunnel” laboratory facility to test potential dispersal systems, measuring particle size distribution using methods including optical and scanning mobility particle sizers. This work will determine options for stratospheric dispersal and provide insights into optimal dispersion of ASAIMs.

WP2A will determine a range of potential candidate particles to assess, taking input from WP1. It is envisaged that an initial set of candidate particles may be some of those previously identified in the SPICE project⁵⁷. Important properties are size, shape, surface properties, chemical composition and refractive index as well as lifetime of the particle in the stratosphere, effects on human health and supply/manufacture/handling issues.

WP2B will explore the surface properties of the various particles and review the specific needs for dispersion and anti-clogging agents for different materials. The surface chemistry and structure of small



Figure 4. electron microscope image of a TiO₂ nanoparticle

particles is complicated as in Fig 4, which shows that tiny particles agglomerate to form bigger clusters; the properties of a cluster differ from those of individual particles.

WP2C will use laboratory experiments to investigate how the agglomeration properties of particles are affected by being immersed in a fluid in the form of a slurry. We will seek to determine whether a scheme can be devised which creates a homogeneous stream of particles from the nozzle. One of the potential devices we will investigate is a micronizer, which is a jet mill that uses a fluid stream to grind clusters of particles to a sub-micron size. It is used in the paint industry to create accurately-tinted pigments. We will also investigate different potential nozzle designs. Once we have a slurry which carries a well-defined set of particles it will be necessary to expel the flow into the atmosphere. It is likely that a choked-flow device will be required, typically comprising a “converging-diverging nozzle”. Such devices are commonplace but for abrasive flows it will be necessary to minimise the boundary layer content of particles in order to avoid excessive abrasive wear. We will design such a nozzle.

WP2D will investigate the electrostatics of the plume, gravitational sedimentation, thermal effects and other mechanisms that might cause the plume to disperse unevenly and perhaps to subsequently coagulate. There may be circumstances when the plume ends up being denser than the surrounding air and if it falls to earth then the benefit of high-altitude injection of the plume will have been lost. It is noted that the timescale for assessment of the plume in the laboratory is limited by the length of the wind tunnel facility, but facilities are being investigated to extend the current ~6m tunnel to up to ~30m.

WP2E involves measurement of the particle size distribution. It is impossible to photograph these sub-micron particles and in the stratosphere it may also be extremely challenging to sample the particles as they exit the nozzle. We will examine closely the size distribution of particles in the plume in the laboratory using a number of particle measurement systems such as an SMPS and DMS500.

The rest of WP2 will investigate different potential delivery methods of manufactured aerosols into the stratosphere. A useful feature of novel materials is that a variety of delivery methods can be explored. The most researched method of delivery is via aircraft⁵⁸ but other delivery options may be rendered viable with ASAIMs, such as tethered balloons, and these have the potential to reduce the costs associated with SAI.⁴⁷ SO₂ cannot be easily delivered by tethered balloons as the gas becomes a solid at the pressures which would need to be used. However, solid particles can be transported as a mixed phase slurry, for example using nitrogen gas as the transport medium. **WP2F-WP2I** will focus on engineering aspects of various delivery methods.

WP2F will evaluate the supercritical properties of the transport media (particles and fluid as a slurry).

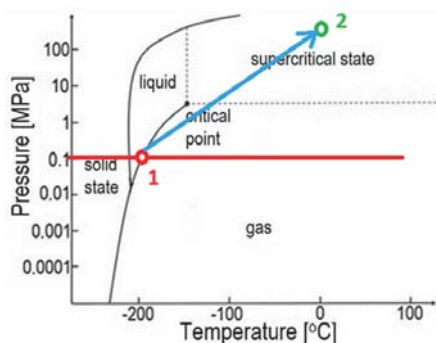


Figure 5. Phase diagram for nitrogen

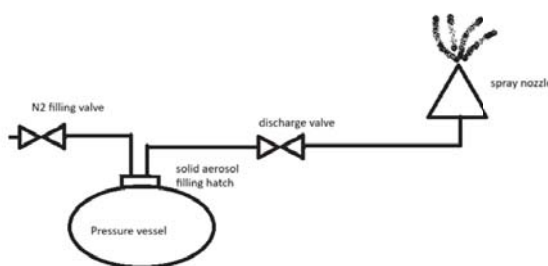


Figure 6. Example pressure vessel

Nitrogen and Argon are abundant in the atmosphere and they may be well suited for slurry transport, and at high pressures and low temperatures neither become solid. However, their properties may be “supercritical”

at pressure of ~2000 bar (see Figure 5) and the transport characteristics of supercritical fluids can be unusual. We will seek to identify the potential fluid carriers which could be used for non-aircraft delivery schemes.

WP2G will involve the construction of a pressure vessel for cold-room-temperature pressurisation (e.g. Figure 6). The testing proposed will be in a laboratory with a vessel of capacity less than one litre, linked via a set of control valves to a delivery system over a length of pipe of ~25mm diameter and 10 metres long. The design and fabrication of the system will be undertaken by the University of Cambridge design engineers and fabrication technicians.

WP2H will experiment with delivery of a powder as a slurry using the vessel developed in WP2G. The target slurr(ies) will be those identified in WP2C-WP2E. The investigation will focus on examination of particle segregation, bridging, slugging, pipe flow and other issues common in mixed-phase flow. The Department of Chemical Engineering in Cambridge University has historical expertise in dealing with fluidized beds, and [REDACTED] will provide guidance on this aspect of the work. In this work package we will investigate pumping both horizontally and at inclined angles as these will have different segregation characteristics.

WP2I will investigate phasing of multiple vessels to give continuous flow. With a single pressure vessel it will be necessary to stop the flow while the vessel is refilled with liquid nitrogen (or other carrier fluid) and hence if multiple vessels are used then filling of the vessels can be phased and interleaved. The energy involved in the charging of the pressure vessels will be calculated with modelling and compared with electrical usage in the experiments as part of the assessment of the overall potential energy savings which a non-aircraft delivery scheme may provide.

Milestones

M5a: design of a dispersal system to deliver particles with narrow size distribution and without clumping

M5b: Manufacture and testing of the dispersal system.

M6a: Design of a multi-phase (slurry) high-pressure pumping system.

M6b: Manufacture and testing of the pumping system.

1.3.3 Work Package 3 (WP3): Climate impact of non-sulphate aerosols

WP3 is targeted at investigating the climate impacts of ASAIMs: *what is the impact of using ASAIMs on the climate, and how do they differ from use of sulphur dioxide as a precursor?*

WP3 provides the necessary context for WP1 and WP2 by evaluating how their findings change the

overall efficacy of SAI using ASAIMs. Through regular assessments, it also provides feedback to the other WPs, indicating which ASAIMs have the greatest promise in producing a global negative radiative forcing (i.e. a climate cooling effect). The work is split into four subpackages: WP3A (plume dynamics), WP3B (efficient plume representation), WP3C (ambient condition estimation), and WP3D (simulating plume effects at global scale). Connections between subpackages and to external information or other WPs are

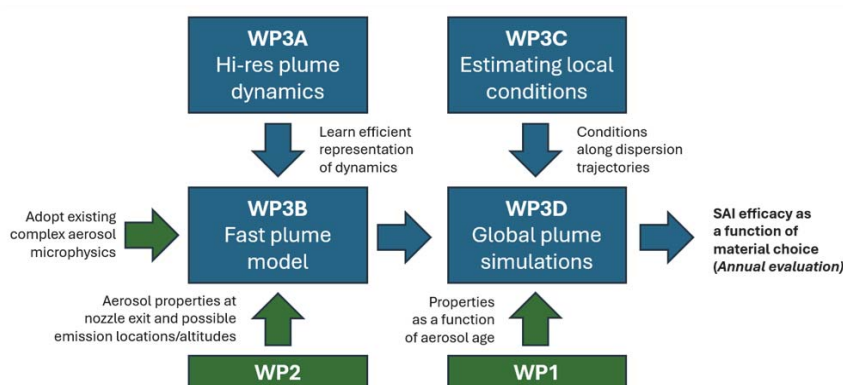


Figure 7. Schematic of the internal relationship between WP3 subpackages and external connections to other work packages.

shown in Figure 7.

WP3A will focus on the early stages of evolution from the delivery scale (metres) to the tens of km scale represented in WP3B. The turbulent flow encountered immediately after delivery will produce a relatively well-mixed but highly localised plume in which aerosol concentrations are relatively large. This plume will then be mixed into the stratospheric environment by the ambient flow. This flow is a complex combination of large-scale wind fields associated with stratospheric ‘weather systems’, smaller scale wave motions, and intermittent turbulence (clear air turbulence). The key information required to predict aerosol evolution and radiative effects are the rate at which the envelope of the plume grows and the rate at which internal heterogeneity within the plume, controlling maximum concentrations (and therefore aerosol coagulation rates), is systematically reduced. The approach taken will be detailed numerical simulations of a family of flows which contain these ingredients, designed to cover a useful range of characteristics of the ambient flow, capturing, for example, effects of geographical and seasonal variation, informed by early results from WP3C. This approach will build on expertise gained in recent studies.⁴⁸⁻⁴⁹ Initial simulations will represent the aerosol as an inert tracer. Diagnostics of the spatial structure of the evolving tracer field will be used to assess the implication for aerosol evolution. Later

simulations, which will be designed and prioritised according to the results obtained, will include more complex tracers that capture effects such as sedimentation, size evolution and aggregation. The results of the detailed numerical simulations will be combined with statistical models of tracer structure in stratospheric flows⁵⁰ to provide a probabilistic representation of the aerosol structure that can be evolved further in time using the methodology of WP3B.

This work will be initiated immediately and conducted over months 1-30. This will inform WP1 by providing information on the requirements for the injection material, and inform WP2 by providing information on which materials should be the focus of feasibility investigation. In both cases progress on other work packages isn't dependent on this activity, but will be enhanced by it.

In **WP3B**, we will develop a flexible, low-cost model of plume evolution designed to simulate many (>100,000) evolving Lagrangian air masses travelling through an atmosphere with prescribed reacting chemicals and wind fields. Each individual air mass will represent a discrete quantity of SAI material, emitted either from an aircraft or from a stratospheric balloon and subsequently carried by stratospheric air currents as it disperses. This new model of plume evolution will be designed to evaluate how quickly aerosols coagulate in the plumes, given the evolution of the properties of the trial materials over time and (from WP3A) the degree of spreading and internal inhomogeneity of the early plume.

This model will use two phases. The early plume will be simulated using a simplified representation of internal mixing based on the results from WP3A, but will embed a detailed representation of solid and liquid aerosol microphysics.^{e.g.,²⁰} The structure used to represent the plume itself will be statistical, representing the probability distribution of different aerosol mass densities across the plume cross section (in kg per m³ of air) as a function of time from the results of WP3A. This is expected to yield a much more efficient simulation than an explicit cross-section resolving model as was previously used for the early plume.⁵¹ Once the plume reaches scales of tens of kilometres and is no longer represented by the work from WP3A, a simplified plume representation would be used to support simultaneous simulation of a large number of plumes.⁵¹⁻⁵² **This work will be initiated immediately and will be conducted over months 1-30.**

In **WP3C**, the necessary dynamical and chemical fields will be determined to provide boundary conditions to the plume model. Background chemical and wind shear fields will be calculated using global simulations with the UKCA model,⁵³ and the NAME Lagrangian Particle Dispersion model⁵⁴ will be applied to determine the trajectories that injected plumes will take through said field. This way we will be able to provide full chemistry-environment data to the newly developed plume model in **WP3A**, including the levels of background aerosols. UKCA is the chemistry and aerosols component of the UK Earth System Model, a leading model in the field of stratospheric geoengineering research.^{e.g.,⁵⁵} The atmospheric chemistry performance of UKCA was reviewed, and improved performance found when run using atmospheric nudging to meteorological reanalysis data.⁵³ We will follow this approach in the work here, nudging the model to the latest meteorological reanalysis available through ECMWFs ERA5 product. NAME can be run on the native output data of UKCA and we will use NAME to calculate back trajectories from the base of the tropopause to 25 km (mid stratosphere) going backwards 10 days in time. We will calculate these back trajectories under conditions of weakly disturbed polar vortex, strongly disturbed polar vortex, different QBO phases and different seasons. The nudged simulations will focus on the recent period (late 20th Century) but we also plan to re-run the 2050s and 2100s (decadal averages) for three SSP-RCP scenarios from the IPCC database (SSP1-2.6, SSP2-4.5 and SSP3-7.0) so that we can also run the plume model under a range of future climate change scenarios. In total we anticipate calculating on the order of 1 million trajectories, using code to cluster these based on the history of meteorological conditions and chemistry along the trajectory path.⁵⁶ This will allow WP3A simulations to determine the rate at which aerosols become dispersed in the atmosphere, and subsequently inform WP3D to quantify the significance of observed changes in aerosol microphysics. **This work will be initiated immediately and will be conducted over months 1-12.** This would provide WP1 with additional information on which key sensitivities and uncertainties in modelling most need to be addressed through experimentation. WP1 is not dependent on this work but will benefit from it.

Finally, in **WP3D** we will incorporate calculation of aerosol optical properties into the plume model from WP3B which will then be used with the trajectory data from WP3C, enabling an estimate of how SAI efficacy varies between candidate materials and the potential for local heating as well as impacts on chemical compositions, in particular ozone. WP3D synthesises results from across the project but also can be used to provide feedback to the other WPs; as such, we also plan to perform preliminary evaluations during months 12 (integrating chemical information along trajectories from WP3C) and 24

(using the prototype WP3B model) which can help inform the prioritisation of materials for WP1 and WP2. **The bulk of this work would be conducted over months 25-36, with preliminary evaluations performed in months 12 and 24.** The final year work depends fundamentally on aerosol data; both optical properties and in particular chemical composition from WP1, and dispersion data from WP2. This stage is complex as the ageing of particle properties from WP1 will have to be included, which is critical for evaluating both the efficacy and unintended impacts on the stratosphere.

Milestones

M7a: Characterization of plume-scale mixing for stratospheric plumes

M7b: Finalized plume-scale mixing model

M8a: Global Lagrangian model of air mass transport

M8b: Incorporation of plume model

M9: Quantification of chemical conditions along trajectories

M10a/b/c: Annual simulations of ASAIM efficacy

1.4 Work Plan

		Project Year & Quarter											
WP	Stage	Y1Q1	Y1Q2	Y1Q3	Y1Q4	Y2Q1	Y2Q2	Y2Q3	Y2Q4	Y3Q1	Y3Q2	Y3Q3	Y3Q4
1	A												
	B				M1,2								
	C								M3				
	D												
	E								M4a				M4b
2	A												
	B						M5a						
	C												
	D												
	E												M5b
	F												
	G											M6a	
	H												
	I												M6b
3	A						M7a		M7b				
	B						M8a				M8b		
	C				M9								
	D				M10a				M10b				M10c

The three WPs come together as a single cohesive project by virtue of covering the breadth of issues relevant to ASAIMs. Chemical and radiative impacts modeled in WP3 depend on input of the evolution of ASAIMs from WP1 and also the dispersion characteristics in WP2. Also the three Work Packages collectively evaluate various attributes of aerosols and if the three WPs deliver GREEN LIGHTS for a particular aerosol then a non-sulphate SAI methodology has been arrived at. If any one of the WPs comes up with a RED LIGHT then that particular aerosol must be ruled out.

We plan four project-wide meetings: the first an inception meeting (online hence no costs currently included) followed by three in-person meetings in the UK – Review Meeting 1 in project Y2Q1 (£7500 + inflation costed), Review Meeting 2 in project Y3Q1 (£7500 + inflation costed) and a Final Meeting in project Y3Q4 (£15000 + inflation costed). Greater cost for the Final Meeting is included to either: widen scope, e.g., inviting relevant stakeholders as a route to impact; or repurpose cost of this meeting as a contribution to a Final Conference, co-organised with the other projects funded through this call.

1.5 Identification and Mitigation of Risks

1. Foreign material introduced to the stratosphere.

WP1 uses very small amounts of natural materials and contains very low environmental risk based on existing protocol and there is no release of material. There is no technical risk as methods are all well established in the [REDACTED]. Functionality (technical risk) of the vessel under stratospheric conditions is very low risk based on prototype design and thermal vacuum testing. Our communication system allows evaluation of system performance in flight enabling adjustments.

2. Failure of balloon.

Even though the risks are very low, we will review each balloon flight and cancel subsequent ones if sufficient data is already collected, thereby reducing the overall risk. We will also follow standard procedures for balloon launches which are established to minimise risk.

3. Unable to secure formal permits or negative publicity prevents outdoor experiments.

Non-release experiments will make the application of necessary formal permits easier. We will engage extremely closely with the ARIA ethics and governance team for support on engagement with necessary stakeholders, since this work will need to be viewed in the context of the overall ARIA programme and cannot be considered in isolation. We will align our project with ARIA's governance framework for full transparency, compliance, and oversight. By month 6 we will have completed ARIA governance framework compliance and finalise experimental protocols.

4. Accidents in WP2 laboratory experiments.

Only materials which are considered non-hazardous will be investigated. Risk assessments and guidance provided by the University of Cambridge Department of Engineering will be followed.

1.6 Conclusion

SAI represents one of the most significant opportunities for affecting the climate in the near term. This project will advance the field considerably by expanding our knowledge of different candidate particles, and the combination of outdoor experiments, laboratory work, and modelling represents a unique strategy for determining which materials will be effective at radiative forcing while reducing risks to stratospheric composition and dynamics compared to SO₂.

Section 2: The Team

[REDACTED]

[REDACTED]

[REDACTED]

References

1. Kleinschmitt, C., Boucher, O., and Platt, U. Sensitivity of the radiative forcing by stratospheric sulfur geoengineering to the amount and strategy of the SO₂ injection studied with the LMDZ-S3A model. *Atmospheric Chemistry and Physics* **18**, 2769–2786 (2018).
2. Kravitz, B. *et al.* The geoengineering model intercomparison project (geomip). *Atmos. Sci. Lett.* **12**, 162–167 (2011).
3. Kravitz, B. *et al.* Climate model response from the Geoengineering Model Intercomparison Project (GeoMIP). *J. Geophys. Res. Atmos.* **118**, 8320–8332 (2013).
4. Kravitz, B. *et al.* First simulations of designing stratospheric sulfate aerosol geoengineering to meet multiple simultaneous climate objectives. *J. Geophys. Res. Atmos.* **122**, (2017).
5. Kravitz, B. *et al.* Comparing surface and stratospheric impacts of geoengineering with different so₂ injection strategies. *J. Geophys. Res.* **124**, 7900–7918 (2019).
6. Crutzen, P. J. Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma? *Climatic Change* **77**, 211–220 (2006).
7. McCormick, M. P., Thomason, L. W., and Trepte, C. R. Atmospheric effects of the Mt Pinatubo eruption. *Nature* **373**, 399–404 (1995).
8. Soden, B. J., Wetherald, R. T., Stenchikov, G. L., and Robock, A. Global cooling after the eruption of Mount Pinatubo: a test of climate feedback by water vapor. *Science* **296**, 727–730 (2002).
9. Hansen, J., Lacis, A., Ruedy, R., and Sato, M. Potential climate impact of Mount Pinatubo eruption. *Geophys. Res. Lett.* **19**, 215–218 (1992).
10. MacMartin, D. G., Ricke, K. L., and Keith, D. W. Solar geoengineering as part of an overall strategy for meeting the 1.5°C Paris target. *Philos. Transact. A Math. Phys. Eng. Sci.* **376**, (2018).
11. Tilmes, S. *et al.* Reaching 1.5 and 2.0 °C global surface temperature targets using stratospheric aerosol geoengineering. *Earth Syst. Dynam.* **11**, 579–601 (2020).
12. Aquila, V., Garfinkel, C. I., Newman, P. A., Oman, L. D., and Waugh, D. W. Modifications of the quasi-biennial oscillation by a geoengineering perturbation of the stratospheric aerosol layer. *Geophys. Res. Lett.* **41**, 1738–1744 (2014).
13. Visioni, D. *et al.* Reduced poleward transport due to stratospheric heating under stratospheric aerosols geoengineering. *Geophys. Res. Lett.* **47**, (2020).
14. Haywood, J. M., Jones, A., Johnson, B. T., and McFarlane Smith, W. Assessing the consequences of including aerosol absorption in potential stratospheric aerosol injection climate intervention strategies. *Atmospheric Chemistry and Physics* **22**, 6135–6150 (2022).
15. Banerjee, A. *et al.* Robust winter warming over Eurasia under stratospheric sulfate geoengineering – the role of stratospheric dynamics. *Atmospheric Chemistry and Physics* **21**, 6985–6997 (2021).
16. Simpson, I. R. *et al.* The regional hydroclimate response to stratospheric sulfate geoengineering and the role of stratospheric heating. *J. Geophys. Res. Atmos.* (2019) doi:10.1029/2019JD031093.
17. Wunderlin, E. *et al.* Side effects of sulfur-based geoengineering due to absorptivity of sulfate aerosols. *Geophys. Res. Lett.* **51**, (2024).
18. Heckendorn, P. *et al.* The impact of geoengineering aerosols on stratospheric temperature and ozone. *Environmental Research Letters* **4**, 045108 (2009).
19. Vattioni, S. *et al.* Microphysical Interactions Determine the Effectiveness of Solar Radiation Modification via Stratospheric Solid Particle Injection. *Geophys. Res. Lett.* **51**, e2024GL110575 (2024) doi:10.1029/2024GL110575.
20. Vattioni, S. *et al.* A fully coupled solid-particle microphysics scheme for stratospheric aerosol injections within the aerosol–chemistry–climate model SOCOL-AERv2. *Geosci. Model Dev.* **17**, 7767–7793 (2024) doi:10.5194/gmd-17-7767-2024.
21. Vattioni, S. *et al.* Chemical Impact of Stratospheric Alumina Particle Injection for Solar Radiation Modification and Related Uncertainties. *Geophys. Res. Lett.* **50**, e2023GL105889 (2023) doi:10.1029/2023GL105889.
22. Labitzke, K. *et al.* Stratospheric temperature increases due to Pinatubo aerosols. *Geophys. Res. Lett.*, **19**(2), 207–210 (1992).
23. Labitzke, K. Stratospheric temperature changes after the Pinatubo eruption. *J. Atmos. Terr. Phys.*, **56**(9), 1027–1034 (1994).
24. Visioni, D. *et al.* Sulfate geoengineering impact on methane transport and lifetime: results from the Geoengineering Model Intercomparison Project (GeoMIP). *Atmos. Chem. Phys.*, **17**, 11,209–11,226 (2017) doi:10.5194/acp-17-11209-2017.

25. McGrory, M. R. *et al.* Mie scattering from optically levitated mixed sulfuric acid-silica core-shell aerosols: observation of core-shell morphology for atmospheric science. *Phys. Chem. Chem. Phys.* **24**, 5813–5822 (2022).
26. Pope, F. D. *et al.* Stratospheric aerosol particles and solar-radiation management. *Nat. Clim. Chang.* **2**, 713–719 (2012).
27. World Meteorological Organization (WMO). Scientific Assessment of Ozone Depletion: 2022, GAW Report No. 278, 509 pp.; WMO: Geneva (2022) <https://ozone.unep.org/sites/default/files/2023-02/Scientific-Assessment-of-Ozone-Depletion-2022.pdf>.
28. Keith, D. W., Weisenstein, D. K., Dykema, J. A., and Keutsch, F. N. Stratospheric solar geoengineering without ozone loss. *Proc. Natl. Acad. Sci. USA* **113**, 14910–14914 (2016).
29. Ferraro, A. J., Highwood, E. J., and Charlton-Perez, A. J. Stratospheric heating by potential geoengineering aerosols. *Geophys. Res. Lett.* **38**, n/a-n/a (2011).
30. Ferraro, A. J., Charlton-Perez, A. J., and Highwood, E. J. Stratospheric dynamics and midlatitude jets under geoengineering with space mirrors and sulfate and titania aerosols. *J. Geophys. Res. Atmos.* **120**, 414–429 (2015).
31. Dykema, J. A., Keith, D. W., and Keutsch, F. N. Improved aerosol radiative properties as a foundation for solar geoengineering risk assessment. *Geophys. Res. Lett.* **43**, 7758–7766 (2016).
32. Jones, A. C., Haywood, J. M., and Jones, A. Climatic impacts of stratospheric geoengineering with sulfate, black carbon and titania injection. *Atmos. Chem. Phys.* **16**, 2843–2862 (2016).
33. Weisenstein, D. K., Keith, D. W., and Dykema, J. A. Solar geoengineering using solid aerosol in the stratosphere. *Atmos. Chem. Phys.* **15**, 11835–11859 (2015).
34. Vattioni, S. *et al.* Chemical impact of stratospheric alumina particle injection for solar radiation modification and related uncertainties. *Geophys. Res. Lett.* **50**, (2023).
35. Vattioni, S. *et al.* A fully coupled solid particle microphysics scheme for stratospheric aerosol injections within the aerosol-chemistry-climate-model SOCOL-AERv2, *EGUsphere* [preprint] (2024) doi:10.5194/egusphere-2024-444.
36. Tang, M. J. *et al.* Heterogeneous reaction of N₂O₅ with airborne TiO₂ particles and its implication for stratospheric particle injection. *Atmos. Chem. Phys.* **14**, 6035–6048 (2014).
37. Molina, M. J., Molina, L. T., Zhang, R., Meads, R. F., and Spencer, D. D. The reaction of ClONO₂ with HCl on aluminum oxide. *Geophys. Res. Lett.* **24**, 1619–1622 (1997).
38. Dai, Z., Weisenstein, D. K., Keutsch, F. N., and Keith, D. W. Experimental reaction rates constrain estimates of ozone response to calcium carbonate geoengineering. *Commun. Earth Environ.* **1**, 63 (2020).
39. Moon, D. R. *et al.* Heterogeneous reaction of HO₂ with airborne TiO₂ particles and its implication for climate change mitigation strategies. *Atmos. Chem. Phys.* **18**, 327–338 (2018).
40. Huynh, H. N., and McNeill, V. F. Heterogeneous reactivity of HCl on CaCO₃ aerosols at stratospheric temperature. *ACS Earth Space Chem.* **5**, 1896–1901 (2021).
41. Huynh, H. N., and McNeill, V. F. Heterogeneous Chemistry of CaCO₃ Aerosols with HNO₃ and HCl. *J. Phys. Chem. A* **124**, 3886–3895 (2020).
42. Cziczo, D. J., Wolf, M. J., Gasparini, B., Münch, S., and Lohmann, U. Unanticipated side effects of stratospheric albedo modification proposals due to aerosol composition and phase. *Sci. Rep.* **9**, 18825 (2019).
43. Tang, M. *et al.* Heterogeneous reaction of ClONO₂ with TiO₂ and SiO₂ aerosol particles: implications for stratospheric particle injection for climate engineering. *Atmos. Chem. Phys.* **16**, 15397–15412 (2016).
44. Eastham, S.D. *et al.* Quantifying the impact of sulfate geoengineering on mortality from air quality and UV-B exposure. *Atmos. Environ.* **187**, 424–434 (2018) doi:10.1016/j.atmosenv.2018.05.047.
45. Neukermans, A., Cooper, G., Foster, J., Galbraith, L., and Jain, S. Methods for dispersal of precipitated calcium carbonate for stratospheric aerosol injection. *J. Atmos. Oceanic Technol.* (2021) doi:10.1175/JTECH-D-20-0205.1.
46. Fuchs, N. A., and Sutugin, A. G. Coagulation rate of highly dispersed aerosols. *J. Colloid Sci.* **20**, 492–500 (1965).
47. Davidson, P., Burgoyne, C., Hunt, H., and Causier, M. Lifting options for stratospheric aerosol geoengineering: advantages of tethered balloon systems. *Philos. Transact. A Math. Phys. Eng. Sci.* **370**, 4263–4300 (2012).
48. Penney, J., Morel, Y., Haynes, P., Auclair, F., and Nguyen, C. Diapycnal mixing of passive tracers by Kelvin-Helmholtz instabilities. *J. Fluid Mech.* **900** (2020) doi:10.1017/jfm.2020.483.

49. Powell, C. W., Haynes, P. H., and Taylor, J. R. Diagnosing tracer transport in convective penetration of a stably stratified layer. *J. Fluid Mech.* **997** (2024) doi:10.1017/jfm.2024.662.
50. Balluch, M. G., and Haynes, P. H. Quantification of lower stratospheric mixing processes using aircraft data. *J. Geophys. Res.* **102**, 23487-23504 (1997).
51. Sun, H. *et al.* Developing a Plume-in-Grid Model for Plume Evolution in the Stratosphere. *J. Adv. Mode. Earth Sys.* **14**, 4 (2022) doi:10.1029/2021MS002816.
52. Fritz, T. M. *et al.* The role of plume-scale processes in long-term impacts of aircraft emissions. *Atmos. Chem. Phys.* **20**,9 (2020).
53. Archibald, A. T. *et al.* Description and evaluation of the UKCA stratosphere–troposphere chemistry scheme (StratTrop vn 1.0) implemented in UKESM1. *Geosci. Mod. Dev.* **13**, 3, 1223-1266 (2020).
54. Jones A. R. *et al.* The U.K. Met Office's next-generation atmospheric dispersion model, NAME III', in Borrego C. and Norman A.-L. (Eds) Air Pollution Modeling and its Application XVII (Proceedings of the 27th NATO/CCMS International Technical Meeting on Air Pollution Modelling and its Application), Springer, 580-589 (2007).
55. Henry, M. *et al.* Comparison of UKESM1 and CESM2 simulations using the same multi-target stratospheric aerosol injection strategy. *Atmos. Chem. Phys.* **23**, 13369–13385 (2023) doi:10.5194/acp-23-13369-2023.
56. Jorba, O. *et al.* Cluster analysis of 4-day back trajectories arriving in the Barcelona area, Spain, from 1997 to 2002. *J. Appl. Met. Clim.* **43**(6), 887-901 (2004).
57. SPICE Project: <http://spice.ac.uk/project/evaluating-candidate-particles/>
58. Smith W. and Wagner G. Stratospheric aerosol injection tactics and costs in the first 15 years of deployment. *Environ. Res. Lett.* **13** 124001 (2018).

BRIGHTSPARK: CLOUD BRIGHTENING WITH ELECTRIC CHARGE

SECTION 1 - PROGRAMME AND TECHNICAL

Introduction

Changing the planetary albedo via the reflectivity of marine layer clouds is well-established as a geoengineering suggestion, but practical methods for achieving it remain in their infancy. We propose a new approach, inspired by conversations with the originator of cloud brightening, John Latham¹, by release of electric charge into marine stratus. Establishing the method's effectiveness and practicality offers a possible new route to achieving planetary cooling, without the use of environmentally unfriendly materials.

Background

Electric charge is present on most atmospheric particles and droplets. It is enhanced in some natural circumstances (e.g. at layer cloud edges, in dust clouds or by release of radioactivity) and can be directly artificially augmented using charge emitters. We have shown that charge influences droplet behaviour², including lengthening small droplet lifetimes by reducing their evaporation rate³, and through the disintegration of strongly charged drops into smaller droplets by the Rayleigh instability⁴. By injecting charge, a cloud's reflectivity can be increased by shifting the drop size distribution to more numerous smaller droplets, through a combination of evaporation reduction and/or Rayleigh mechanisms.

We have demonstrated the effectiveness of this approach in real world experiments, which showed an increase in fog reflectivity following charge release from an overflying aircraft⁵. (Fig 1a shows our aircraft pre-flight, and fig 1b the same aircraft programmed to fly over an instrumented mast.) These proof-of-concept experiments showed changes in fog properties occurred with either positive or negative charge emission, but not with both polarities emitted simultaneously, indicating that the effects were associated with unipolar charging. We have also proven several methods for the release of atmospheric charge through ion emission, including using uncrewed⁶ and crewed aircraft^{7,8}.

Proposal concept

In this proposal, we aim to fully evaluate this method for modifying a natural droplet system, as an essential step in preparing the technology for scaled-up deployment in marine clouds. An important aspect of the electrical approach to cloud brightening is that only lightweight payloads are required for the charge releasing platforms employed, allowing a swarm of small airborne vehicles to be used, and without generating environmentally harmful residues. This brings an additional and environmentally friendly route to achieving the climate cooling sought by the programme.



Figure 1. (a) Catapult-launched Skywalker X8, modified for charge release and droplet monitoring in a valley fog. (b) Skywalker X8 viewed in flight from above, over a measurement site. (c) "Shooting star" display event using a swarm of 330g microdrones.

Through this project we propose to scale up the technology developed for fog reflectivity enhancement to make it suitable for the marine cloud brightening application, by using a swarm of microdrones, similar to those typically used for visual display purposes (fig 1c). This would raise the technology readiness level (TRL) of our methodology from TRL5 (reduced scale verification) to TRL6/7 (full scale/operational). The microdrone as a carrier technology is highly suited to this, as the charge emitters can be made lightweight, and they consume negligible power compared with that already available for propulsion. In addition, the relatively low cloud base height of marine stratus is readily accessible to modest sizes of microdrone. Methods for controlling microdrone swarms continue to evolve – hundreds operating simultaneously in

flight have already been demonstrated¹. Ultimately, we envisage a system of myriad microdrones all equipped with charge emission technology, flying and recharging from marine platforms 24/7 to provide targeted release of charge into the stratiform cloud above.

Methodology

The work in this proposal provides a critical first step in developing a deployable technology and is intended to establish the practicality and scalability required for the final marine stratus application. Because the basic charge release methodology has already been demonstrated in the real world, proof-of-concept laboratory experiments are not needed. In any case, experiments in laboratory chambers are poorly suited to this science area, as their representativeness is significantly limited by electrostatically enhanced wall deposition. Extensive real-world experiments in natural fogs are therefore proposed, building on our existing track record with such experiments, and to overcome the problem of representativity. Fogs are useful for this as they provide an accessible alternative to stratiform clouds, and, although different droplet processes are active due to the droplet size distribution tending to smaller sizes, the electrically induced change in behaviour of the smallest droplets is comparable with that expected in marine stratocumulus clouds which are important for the short-wave reflectivity properties.

A range of sites will be assessed for suitability, but operating in shallow fog, for example at the valley scale, is envisaged, ideally at a remote site to minimise inconvenience and simplify permissions. We expect to operate field experiments across two winters of a three-year project, responding to suitable weather conditions likely to provide a persistent period of fog. Experience indicates that maintaining multiple experimental opportunities are necessary to mitigate the variability associated with fog, and the associated anticyclones generating persistent foggy conditions.

Our field experiments (fig 2) will employ instrumented microdrones to provide multiple point charge emission, to test and understand their use in swarms for influencing more extensive regions of natural fog than our initial single point emission previous experiments.

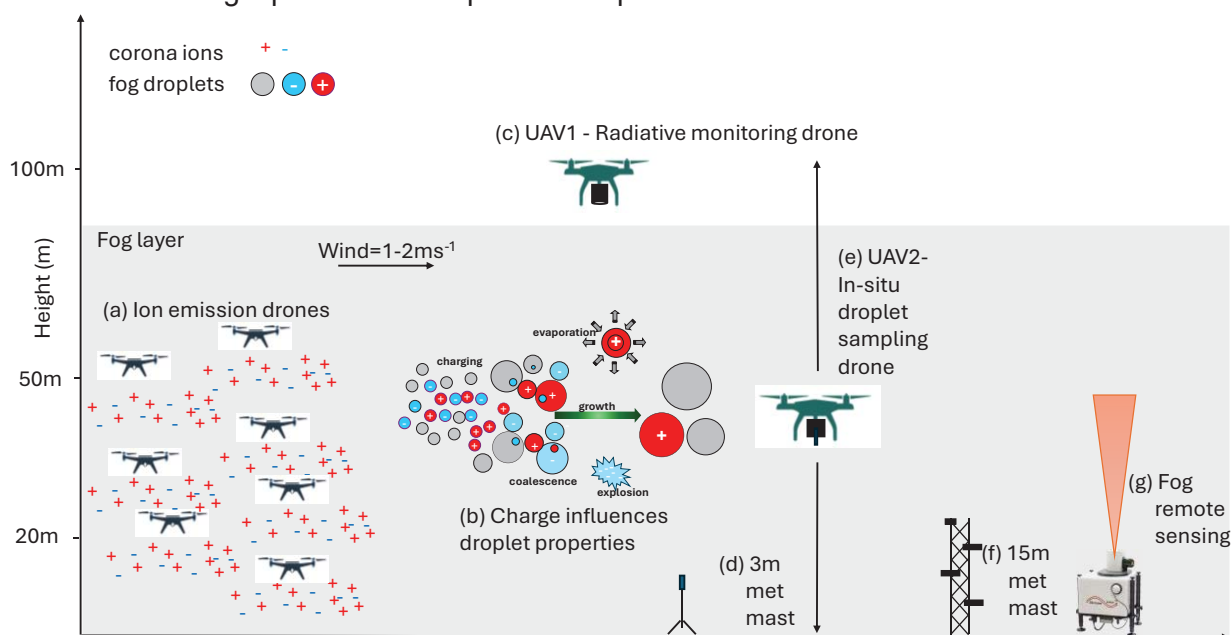


Figure 2. Schematic diagram of experimental campaign setup. (a) Up to 20 ion emission drones (Celestial) will emit bipolar ions into a fog layer, whose droplet properties are expected to change according to processes shown by (b). Changes in fog properties will be monitored by (c) an instrumented drone UAV1 (Menapia) carrying a radiometer and hovering above the fog layer, (d) a vertical profiling drone UAV2 carrying a cloud droplet sensor, and temperature and humidity sensors (Menapia), (e) (f) surface meteorological masts at 3 and 15m respectively, (instrumented with temperature, humidity, visibility, turbulence, cloud droplet sensors, and an electric field sensor) and (g) fog remote sensing instruments such as a doppler lidar and microwave radiometer.

¹ <https://www.forbes.com/sites/grrlscientist/2020/06/30/drone-light-shows-way-cooler-than-fireworks/>

We will progress this in collaboration with a commercial UK partner (Celestial) who are world-leading in drone display work, in designing and operating a dense array of controllable charge emitting microdrones. The physical responses in the droplets following charge release will be monitored using instrumented mast systems able to monitor the electrical environment and droplet properties, and by using an instrumented aircraft flying above the microdrones – fig 1b was obtained in this manner. A further instrumented aircraft will be deployed to sample vertical profiles of droplet properties within the fog, including electrostatic sensors used previously in studying the electrical properties of stratus clouds⁹. Both these monitoring systems will be developed in collaboration with a second commercial UK partner, Menapia, a specialist Uncrewed Aerial Vehicle (UAV) measurements company.

As the ionisation released is dissipated naturally within minutes, there are no ongoing consequences after each experiment. Acoustic nuisance would be equally brief. Nevertheless, from experience of international media interest – and associated poor or fabricated reporting - we will collaborate on communication and providing context with a science philosophy/ethics academic, experienced in the specific questions of meteorology. However, whilst effective communication with the broader community is clearly necessary it is likely not to be sufficient in convincing people of the value and need of the work. Consequently, we will work with the [REDACTED] consultancy on establishing best practice for undertaking novel experimental field work in the environment, with the intention of contributing to developing the necessary decision-making tools and ethical standards ultimately needed for international marine stratus modification.

As well as the direct in situ monitoring, the effectiveness of the charge release will be evaluated by comparison with the natural variability expected, as quantified by high resolution atmospheric modelling of fogs and clouds with the additional charge-induced changes represented.

Description of work proposed

This three-year project consists of multiple workstreams addressing theoretical and experimental aspects, summarised in the Table below. The project will principally employ two PDRAs to carry out the experimental (PDRA1) and modelling (PDRA2) science aspects, and a senior PGRA support scientist to coordinate the fieldwork and instrumentation development. A further part-time PDRA (PDRA3) will work with external consultants on engagement activities, explaining and communicating the work.

Workstream	Scope	Purpose
WS1	Charge delivery systems	Optimising size and efficiency of ion emitters for microdrones
WS2	UAV instrumentation integration	Integration and testing of cloud and reflectivity sensors with monitoring drones
WS3	Site identification and engagement	Assessment and prioritising of experimental sites, and engagement with stakeholders
WS4	Swarm technology	Develop control and deployment systems for the microdrones. Legislative submissions for field experiment and other permissions
WS5	Charge microphysics modelling	Representing charge microphysics in high resolution models and Met Office NERC Cloud Model to derive albedo. Model runs with “extreme effect” scenarios on albedo: derive optimal intervention strategies and bounding adverse effects
WS6	Site instrumentation	Constructing surface measurement and monitoring systems
WS7	Field experiments	Range of experiments to test the microdrone swarm in clear and foggy air
WS8	Field experiment modelling	Ensembles of high-resolution model runs to assess natural variability in reflectivity. Evaluate if interventions lie outside the control ensemble
WS9	Marine stratus scoping	Evaluating marine platforms for a microdrone system, considering naval deployment options
WS10	Reporting and data archiving	Ongoing throughout project through international conferences and peer-reviewed publications. Data archiving activities also.

Detailed workstream (WS) descriptions:

WS1 Charge delivery systems (PDRA1, PGRA)

Charge emission using corona discharge requires an emitter operated at a high voltage, (~3 kV). Only a small (μA) emission current is required, hence the electronic system can be compact. For our experimental fieldwork, optimisation of the ion emission efficiency is sought, together with quantifying the emission current. In this WP, our novel system for isolated current measurement¹⁰ would be combined with a high voltage source, to provide a lightweight and compact device. The electrode design would also be optimised for maximum charge delivery into the surrounding air, and ideally durability against micro-corrosion which can reduce the efficiency. WS1 is a precursor to the fieldwork (WS7); the charge delivery systems would be designed to work with the carrier microdrone to provide active control and monitoring of the actual charge release.

WS2 UAV instrumentation (PDRA1, Menapia)

Monitoring the region of charge release is essential to evaluating and quantifying the effectiveness of the technique. For this, two multirotor UAV aircraft will be instrumented in collaboration with engineers working at Menapia, to carry sensors providing droplet size information in one case, and short-wave reflectivity in the other. One aircraft (UAV1) will fly above the fog test region (performing both hovers and overpasses), carrying solar and terrestrial radiation sensors (Apogee SN-500) to evaluate the change in radiation. The other (UAV2) will be used to vertically sample the droplet properties within the fog, downwind of the charge emission drones, and perform vertical profiles from near the surface to the clear air above. Establishing this capability is necessary prior to the fieldwork (WS7). This aircraft will also be instrumented with the standard suite of meteorological sensors (including temperature and relative humidity) routinely flown by Menapia. The droplet sensor used is anticipated to be the LOAC sensor from Meteomodem (which has previously been deployed on drones by¹¹ and ¹²), but this is an emerging area and Menapia is currently evaluating other available small aerosol/cloud droplet sensors for use on UAVs such as the Alphasense N3 OPC and the UCASS¹³. The UCASS itself is planned to be further developed by another ARIA proposal SUA-MCB, who we intend to work with if both proposals are funded: these may be used instead if their scientific capabilities are found better than the LOAC.

WS3 Site identification and engagement (PDRA2, PDRA3, ██████████)

Evaluation of possible sites for the experiments in WS7 will be based on fog statistics, accessibility to the site for the different parties involved, and the acquisition of flight permissions and safety cases. If possible, this will be carried out in collaboration with ██████████ potentially also engaging with relevant local stakeholders as necessary. It will form the basis for engagement activities. A combination of two or more sites which typically experience very different weather conditions will also be considered, to mitigate the negative effects of persistent unsatisfactory conditions at a single site. This workstream will also engage with the University of Reading press office, who have experience, not least through our previous work, in handling sensitive media topics.

WS4 Swarm technology (PDRA1, PGRA, Celestial)

This workstream is to test and implement the deployment of multiple microdrone devices. The standard microdrones used by Celestial in their displays can operate as close as 1m to each other. For our experiments, a charge emission equipment package will be added to their standard microdrone, to be controlled remotely. This is an important aspect, as switching of the emitters in a defined sequence is a method we have found very effectively previously, as it provides a defined signal to be sought in the fog data as a reliable indication of cause and effect. We would also establish that the emitter payload did not influence the flight performance, and design experimental protocols compatible with the microdrones' flight endurance. The effectiveness of the charge release would be tested from individual microdrones in a controlled environment, flying above an electric field sensor (mounted on a 3m mast) corroborated with satellite location data (GNSS) which each microdrone routinely provides.

WS5 Charge microphysics modelling (PDRA2)

Existing fog and cloud models do not include charged microphysics, and the droplet interactions are assumed to be solely thermodynamic and ballistic. This WS will develop charge microphysics parameterisations to investigate the electrical modification of droplet properties to be evaluated. It will allow evaluation of cloud and fog evolution with and without charge. The parameterisations will be designed to be included in existing community weather forecasting models after selection for suitability, such as WRF

and the MetOffice-NERC cloud model. Representation of the droplet physics for this modelling work will consider evaporation, growth by condensation, coalescence efficiency and Rayleigh disruption, for droplets charged to a prescribed extent.

WS6 Site instrumentation (PDRA1, PGRA, Menapia)

The surface instrumentation to be deployed will be procured and assembled in this WS, to provide two monitoring masts for use in WS7. A combination of sonic anemometer, electric fieldmill, visibility sensor and Light Optical Aerosol Counter (LOAC) to determine the droplet size distribution near the surface (using 3 m masts and a vehicle-borne 15 m tilt-over mast) will be constructed, with dataloggers based on RPi and Arduino single-board computers as used previously. The field mill is a critical piece of equipment as it responds directly to the charge emitted, for verifying that the release systems are operating. We will also apply to deploy the NCAS Doppler lidar and HATPRO microwave radiometer from their Atmospheric Measurement Facility (AMF), to provide detailed high temporal and spatial information on the fog droplets present.

WS7 Field experiments (PDRA1, PDRA2, Menapia, Celestial)

Deployment of the equipment for the fieldwork is envisaged to be of a week's duration, approximately twice per winter in the second and third years of the project. The fieldwork will be conducted in shallow fogs, into which the controlled swarm of the charge-emitting microdrones will be flown at heights of tens of metres, using a prescribed pattern of charge release. An overview of the arrangements for the field experiments is shown in fig 2. The microdrone separation will be varied to evaluate the relative effects of direct turbulent disturbance of the fog and effects from charge release. Individual microdrone position information will be captured together with the charge emission performance. During the microdrone swarm activation, a UAV1 overpass will be arranged to measure the reflectivity from above, integrating across charge release area. Further, UAV2 will obtain vertical profiles of the droplet properties and meteorological parameters (temperature and relative humidity). Although horizontal wind speeds in fog are typically very small (1 to 2 ms^{-1}), to mitigate unwanted effects from this, the microdrone swarm will be situated upwind of the vertical profiling UAV (UAV2), measurement masts and doppler lidar, to maximise detection of fog droplet changes.

WS8 Field experiment modelling (PDRA2)

The circumstances of the field experiments carried out will be simulated, and the sensitivity to the charge released obtained using the representation of droplet behaviour obtained in WS5. This will also allow the expected charge effects to be constrained against natural variability, using an ensemble of runs. Testing for the apparent effects observed against the variability generated in this way offers a more promising methodology than simply comparing predictions with observations, as is sometimes previously used, e.g. in evaluating cloud seeding. These simulations would be undertaken at high spatial resolution to allow the local reflectivity effects to be evaluated by averaging over the domain in the same way as the measurements of UAV1.

WS9 Marine stratus scoping (PDRA2)

The ultimate application of this project work is to the marine stratus brightening problem, which brings additional scaling and deployment issues well beyond those of the evaluation experiments. The modelling capabilities developed and validated throughout this project will be applied to this problem and the reflectivity changes estimated for a feasible microdrone fleet. Knowledge of the microdrone separation appropriate for the charge emission possible will be new and essential information with which a marine deployment can be planned, and the effectiveness of the charge emission approach evaluated. Sustaining airborne microdrones of specified endurance will allow the effective area able to be influenced to be estimated and the necessary resources required to be calculated. With this information, ship-based deployment of this system at practical scales will be evaluated.

WS10 Reporting and data archiving (PDRA2, PDRA1, PGRA)

Throughout the project one national and one international conference annually will be sought to report the progress of the different aspects of the work. Our previous experience of related work is that many publications in peer reviewed journals are extremely likely to be produced. High quality international journals will be sought, as previously, for example *Geophys Res Lett*, *J. Atmos&OceanTech*, and *AIP Advances*. Encouraging a journal special issue (or issues) for related work through other ARIA-supported projects may provide an additional route to proceed, through our presence on different journal editorial boards. Data management and archiving will also be achieved through this workstream.

Project plan

Across the three years of the project, the expected phasing of the workstream activities is given in the Gantt chart below, with the field experiments scheduled for the winters of project years 2 and 3, assuming a project start in April 2025.

Workstreams	Year 1				Year 2				Year 3			
	1	2	3	4	5	6	7	8	9	10	11	12
WS1 Charge delivery systems												
WS2 UAV instrumentation												
WS3 Site identification and engagement												
WS4 Swarm technology												
WS5 Charge microphysics modelling												
WS6 Site instrumentation												
WS7 Field experiments												
WS8 Field experiment modelling												
WS9 Marine stratus scoping												
WS10 Reporting and data archiving												
Legend												

The key milestones in the technical progress project will be:

Milestone	Objective	Audit point (quarter years)
1	Identify scientifically suitable field experiment sites	End of Q2
2	Demonstrate charge delivery systems for microdrones	End of Q4
3	Establish UAV1 and UAV2 monitoring capability	End of Q6
4	Demonstrate charge microphysics modelling capability for layer cloud properties	End of Q7
5	Provide marine stratus scaling plan	End of Q9
6	Complete a successful field experiment	End of Q11
7	Complete data archiving	End of Q11
8	Simulate scientific results from field experiments	End of Q12

Unknowns and risk mitigation

Our previous fieldwork experience will be brought to this project, including approaches for successful outcomes whilst adapting and responding to weather conditions and strategies for safely mobilising and rapidly deploying a science team at a site in poor weather. We are familiar with the extensive safety cases needed to the CAA, but this is unlikely to be needed for fog experiments. The charge emitters are an established technology, which, due to electronic component supply shortages arising from the pandemic, have previously been specifically designed to be robust to fluctuations in electronic component availability. However, small commercial USB negative ionisers are widely available which would provide an alternative to developing new emitter designs, but with reduced efficiency and no ionisation output monitoring: we have assessed and deployed these previously, and established how they can be modified to meet our science requirements. Working with two expert subcontractors in related areas of drone deployment will also bring some redundancy in obtaining permissions and offer routes to mitigating hardware problems. It has already been demonstrated that a simple photodiode¹⁴ can provide reflectivity information, for which there are other platforms available (e.g. our existing Skywalker X8 of fig 1a), should the improved

quantification expected from more extensive radiative sensors prove unreliable, and other pilots are available from within the Department of Meteorology at Reading. An existing Windsonde balloon system could be deployed for thermodynamic profiles should UAV2 be inadequate.

Staffing and resources justification

The estimated cost for this project is £1.9M, arising from staffing and equipment. Resources are sought to employ two post-doctoral scientists – one for the experimental aspects (PDRA1) and the other (PDRA2) for the theoretical aspects, able to work independently. An experienced PGRA is also requested, to operate as a support scientist and coordinator [REDACTED]. Further admin support is also requested [REDACTED], from existing staff. Support for a science engagement PDRA is requested [REDACTED] who will design an engagement programme, and collaborate with the [REDACTED] consultancy too [REDACTED], or, if the [REDACTED] proposal is not funded, progress the development of our own decision-making tools as an in-house project. [REDACTED] will provide the microdrone display system and deploy it for the science experiments [REDACTED]. [REDACTED] will jointly develop instrumented drones for operating charge emitters in fog, [REDACTED]. Funding is also requested for international conferences ([REDACTED] and fieldwork travel [REDACTED] in total. Supercomputer, facilities and equipment time support, and each of the staff members recruited will require standard desktop PC and network access is sought ([REDACTED]), and the equipment items required are summarised below. External financial auditing costs are also sought ([REDACTED]). Publication costs for dissemination of the work are requested too (4 papers x [REDACTED]).

For workstreams requiring specific items of equipment and instrumentation, the costs are identified below:

Workstream	Scope	Equipment	Total
WS1	Charge delivery systems	Electronic consumables for multiple charge emitters (50 x £500)	£25k
WS2	UAV instrumentation development	Radiometer (Apogee SN-500) (£3.5k x 2) LOAC droplet counter (£5k)	£12k
WS6	Site instrumentation	Biral SWS-050 visibility sensor (2 x £3.6k, total £7.2k inc VAT) Electric field mill, Vaisala (2 x £17k inc VAT), £34k total Windmaster sonic anemometer (2x £3.6k) £7.2k total inc VAT LOAC droplet counter (2x £5k), £10k total RPI and Arduino computers (10 x £50) £500 total inc VAT Mast hardware (2 x £1.2l), £2.4k total inc VAT Electronic consumables and weather-proof enclosures, £2k Campbell CCFC field camera (£1k)	£61.3k
WS7	Field experiments	AMF Doppler Lidar and HATPRO Radiometer (£41K for 3 month deployment)	£41k

SECTION 2 - THE TEAM

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Celestial (<https://celestial.show/our-story/>) are an international drone display company, with offices in the south-west of the UK. They are specifically interested in bringing their existing technology and expertise to the new application we have proposed. The experience of atmospheric measurements using drones we bring to this potential partnership, forged through experiments conducted in the south-west, offers highly promising synergies.

As explained in the technical work programme, the project consists of a series of workstreams. The project will be led by [REDACTED] (WS3, and overall), [REDACTED] (WS1,2,4,6,7), and [REDACTED] (WS5,8,9), through weekly meetings with the staff employed and by maintaining active contact with the external companies providing support activities. This will be through site and company visits, and online meetings. The PGRA support scientist will lead in the scientific and logistical coordination and apparatus provision, with some additional involvement in the scientific aspects for staff development. Associated admin support will be provided to help this.

The research staff employed on this project will be allowed autonomy in how their work is organised, within the project requirements. All the project staff will collaborate on disseminating the results through papers and conference presentations, throughout the three-year life of the project. The PDRAs will have full access to courses run by the University of Reading's Centre for Staff Training and Development, with career development encouraged. Significant support is available to PDRAs through the local implementation of the Concordat, which is a national agreement between funders and employers of researchers: it articulates key principles for the support and management of research careers.

Page 99

References

-
- ¹ C.P.R. Saunders, R.G. Harrison, Obituary: John Latham (1937-2021) *Weather* 76, 9, 297. <http://doi.org/10.1002/wea.4025>
- ² M.H.P. Ambaum, T. Auerswald, R. Eaves, R.G. Harrison, Enhanced attraction between drops carrying fluctuating charge distributions *Proc Roy Soc Lond A* 478, 2257, <https://doi.org/10.1098/rspa.2021.0714>, 2022
- ³ R.G. Harrison, G.J. Marlton, M.H.P. Ambaum, K.A. Nicoll, Modifying natural droplet systems by charge injection. *Phys Rev Res* 4, L022050. doi: 10.1103/PhysRevResearch.4.L022050
- ⁴ M.W. Airey, R.G. Harrison, K.L. Aplin, C. Pfrang, B. McGinness, Electrical effects on droplet behaviour, *J.Phys.: Conf. Ser.* 2702 012015 (2024) doi:10.1088/1742-6596/2702/1/012015
- ⁵ R. Giles Harrison, Keri A. Nicoll, Graeme J. Marlton, Douglas J. Tilley, Pejman Iravani Ionic charge emission into fog from a remotely piloted aircraft *Geophys Res Lett* 49, <https://doi.org/10.1029/2022GL099827> (2022).
- ⁶ R. Giles Harrison, Keri A. Nicoll, Douglas J. Tilley, Graeme J. Marlton, Stefan Chindea, Gavin P. Dingley, Pejman Iravani, David J. Cleaver, Jonathan L. du Bois, David Brus, Demonstration of a remotely piloted atmospheric measurement and charge release platform for geoengineering *J.Atmos Oceanic Tech*, 38, 1, 63-75 (2021)
- ⁷ K.A. Nicoll, V. Escobar-Ruiz, R.G. Harrison, M.H.P. Ambaum, A.A. Alkamali, A charge emitter for use in evaluating aircraft rainfall enhancement, *J. Phys.: Conf. Ser.* 2702 012005 (2024) doi: 10.1088/1742-6596/2702/1/012005
- ⁸ R. Giles Harrison, Ahmad A. Alkamali, Veronica Escobar-Ruiz, Keri A. Nicoll, Maarten H.P. Ambaum, Providing charge emission for cloud seeding aircraft *AIP Advances* 14, 9, (2024) <https://doi.org/10.1063/5.0227533>
- ⁹ K.A. Nicoll and R.G. Harrison, Stratiform cloud electrification: comparison of theory with multiple in-cloud measurements *Quart Jour Roy Meteorol Soc* 142, 2679–2691 (2016) 10.1002/qj.2858
- ¹⁰ R. Giles Harrison, Veronica Escobar-Ruiz, Keri A. Nicoll, Maarten H.P. Ambaum, Isolated corona current monitoring using a compensated light-emitting diode as an unpowered sensor, *Rev Sci Instrum* 94, 094504 (2023) <https://doi.org/10.1063/5.0170176>
- ¹¹ J.B. Renard, Dulac, F., Berthet, G., Lurton, T., et al. LOAC: a small aerosol optical counter/sizer for ground-based and balloon measurements of the size distribution and nature of atmospheric particles—Part 2: First results from balloon and unmanned aerial vehicle flights. *Atmospheric Measurement Techniques*, 9(8), 3673-3686 (2016).
- ¹² M.F.G. Vera, Reyna, M.A., Sammaritano, M.A., Griffouliere, et al. Studies for the Integration of a Light Optical Aerosol Counter in an Unmanned Aerial Vehicle (Flying Wing): Tropospheric Environment Research Observatory (TERO Project). In *2019 XVIII Workshop on Information Processing and Control (RPIC)* (pp. 88-92). IEEE (2019, September).
- ¹³ H.R. Smith, Ulanowski, Z., Kaye, P.H., Hirst, E., et al. The Universal Cloud and Aerosol Sounding System (UCASS): a low-cost miniature optical particle counter for use in dropsonde or balloon-borne sounding systems. *Atmospheric Measurement Techniques*, 12(12), 6579-6599 (2019).
- ¹⁴ K.A. Nicoll and R.G. Harrison, Balloon-borne disposable radiometer *Rev Sci Instrum* 83, 025111 (2012) doi: 10.1063/1.3685252

Full Proposal: Ethics and governance of solar geoengineering research: from concepts to implementation

Section 1: Program and Technical

1. Programme alignment.

The ARIA 2024 Call on climate cooling seeks to fund projects exploring “ethical, governance, law, and geopolitical dimensions” of climate interventions (ARIA, 2024a). Our team has previous experience working on the ethics and governance of solar geoengineering (SG)¹.

We apply a “Fundamental Questions” methodology (Box 2) to allow for a seamless transition from “conceptual engineering” (Chalmers 2020) to the implementation of responsible participatory governance (Reynolds 2019), making our project intentionally incorporable with other ARIA proposals. We focus our approach on small outdoor SG research and small non-validated deployment instances (e.g. Make Sunsets), the intended scale of the call (p. 3 ARIA, 2024a). We will build a research team across Latin America and the Caribbean (LAC) and the UK to address the ethics and governance of this international, disruptive technology.

2. Description of research and methodology.

2.1 General aims. The project has two interrelated general aims: (i) contribute to ARIA’s mission of enhancing responsible governance of R&D and eventual deployment of SG for the common good (Rayner et al 2013, ARIA 2024b); (ii) build a research team across Argentina and further afield in Latin America and the Caribbean (LAC), alongside collaborators in the UK; (iii) protect global society from destabilisation and negative social tipping points associated with irresponsible use of SG (Spaiser et al 2024). Here, we understand responsibility from a common good, interspecies, and intergenerational justice perspective (London 2022, COMEST 2023).

2.2 Specific objectives. There are three specific objectives: (i) provide an enhanced theoretical framework for proper governance of SG research that serves UK ARIA projects, (ii) build global south research capacity around SG by hiring new researchers, research assistants (PhD and/or postdoc), and advisors tailored to the novel work packages (WP) & research questions, (iii) build inclusive, participatory governance for LAC that emphasises centralised public engagement.

2.3 Methodological approach

The overall approach of our project is to provide a conceptual foundation (via “conceptual engineering”) leading seamlessly to a governance framework. Importantly, our approach is agnostic to—and can be therefore be applied broadly to—different climate cooling strategies, including but not limited to stratospheric aerosol injection (SAI), marine cloud brightening (MCB), and contrail management, or hybrid interventions. Box 1 focuses on the applicability of our reasoning to marine cloud brightening. The idea of the movement from concepts to implementation is that the conceptual categories offered are not just normative (to distinguish right from wrong action), but also analytical (if certain actions are (not) undertaken, then certain consequences may be more likely to occur), exemplified in Box 1.

Box 1. Climate experiments require public participation: the case of marine cloud brightening

The University of Washington's Marine Cloud Brightening (MCB) experiment may be free of legal flaws, negative environmental impacts and public health risks (1). However, if the climate science community does not foster public participation through sustained interaction and clear societal objectives, it is likely to create conflict (2). As seen in this and other cases (3), inappropriate public participation can lead to outdoor experiments being delayed, stopped or even banned. Moreover, a loss of public trust can affect not only individual projects, but the climate science community as a whole (4).

¹ Our application is enriched by three recent funded projects (see Box 2) on ethics & governance of SG: 1) enhancing definitions of experimentation, research, & deployment (Degrees 1: 06.24-08.26, 45K USD); 2) public engagement of SG research and experimentation in Argentina and comparative research with Brazil (Degrees 2: 10.24-12.26, 35K USD); 3) public health & geoengineering in the Global South (WHO: 09.24-08.25 in collaboration with the Alliance for Just Deliberation on Solar Geoengineering (DSG), 50K USD).

References (see Box 1 references).

- 1) It distinguishes between SG research and deployment
- 2) It applies to interventions with an insufficient level of evidence for regular use
- 3) It is neutral to scale, mechanisms of action, outcome, and ethical status.

A responsible participatory governance for LAC should emphasise centralised public engagement and standard procedures for SG small outdoor research (Jasanoff, 2003;Jinnah et al. 2024), social equity, diversity, and political representation (Fischer, 2012) to mitigate threats of SG research governance backlash both international (Gupta et al 2024, Biermann and Gupta 2024) and local (Biermann 2023), with negative rhetoric and misinformation (Ribeiro 2024).

- 1) An aims-based glossary
- 2) Principles of governance
- 3) Guidelines for policymakers

2.5 Fundamental questions methodology (Box 2). The “ethics and governance of SG” is a “multidimensional overlapping landscape” (Reynolds 2019). Our model (see Box 2) breaks down this unclear concept with a logically interrelated and practically oriented set of fundamental questions developed for biomedical innovation (Mastroleo & Holzer 2020) and applied to SG (Degrees 1 & 2, WHO).

3. Workflow overview: delivery of four Work Packages (WPs) over a 2-year period (extendable to 5)

3.1.WP1. Clarifying SG as a socio-technical intervention to reduce misunderstanding

Aim. Explain the meaning of SG as a transformable “socio-technical intervention” to understand small-scale perturbation field or outdoor trials as part of the larger research pathway of climate engineering on SG interventions (Lenferna et al 2017).

Working hypotheses.

WH1: Good technical performance is not sufficient for an intervention to provide overall benefit. SG is usefully understood as an “intervention ensemble” (Kimmelman 2012) emphasising the relationship between technical materials and the information required to use them to a given end (Kimmelman & London 2015). A socio-technical understanding of an intervention ensemble underlines the need for harmony between “people, processes, and environment” for successful implementation of interventions (McCradden et al. 2023).

WH2: Small outdoor research on SG requires increased research governance (socio-technical co-interventions, e.g. independent oversight and monitoring by a research ethics committee (REC), national system of accreditation of RECs) to function within an acceptable level of risk-benefit balance for a just global society (Jinnah et al 2024, Parson et al 2024, London 2022).

Box 2. Ethics and governance of SG research: a fundamental questions model

	Objectives	Product	Project
Part 1. Conceptual engineering	Clarifying concepts. What does the claim “SG is a socio-technical intervention” mean?	WP1*	ARIA
	Defining activities. What is SG experimentation (research and/or deployment)?	-	Degrees 1
	Debating reasonableness. What is a reasonable disagreement on SG research?	WP2	ARIA
	Justifying ethical status. Is SG research forbidden, permissible and/or mandatory?	WP3	ARIA
Part 2. Ethics and governance of SG small outdoor research	Reconstructing Standard operating Procedures principles of Responsible Research. If SG research is ethically permissible or mandatory, what principles should guide responsible instances of SG research?	-	Degrees 1 & 2 (focus on public engagement principle)
	Designing institutional mechanisms. If SG research is ethically permissible or mandatory, what institutional mechanisms or regulations can help to implement responsible SG research?	-	WHO
	Implementing regional governance. What is an appropriate model of ethics and governance of SG in LAC?	WP4	ARIA (focus on Mexico). Degrees 2 (focus in Argentina and Brazil)

*WP: Work package.

WH3: Improving understanding about SG as a socio-technical intervention minimises unreasonable disagreements in SG (Clark 2023) and may protect global society from destabilisation and reaching negative social tipping points because of irresponsible SG research and deployment (Spaiser et al 2024). Formalising the concept of socio-technical interventions provides the conceptual tools to capture basic dimensions in non-formalised analysis, including types or pathway activities (e.g. exploratory vs. confirmatory research vs. deployment), the intent or main aim of an intervention, scales, evidence thresholds, etc. (Lenferna et al 2017, MacMartin et al 2019) in regimented and consistent language, fostering better understanding of socio-technical interventions in general and SG in particular. For an example of this tool see SCoPEX small scale outdoor experiment analysis in figure 1 below and its comparison with other SG interventions.

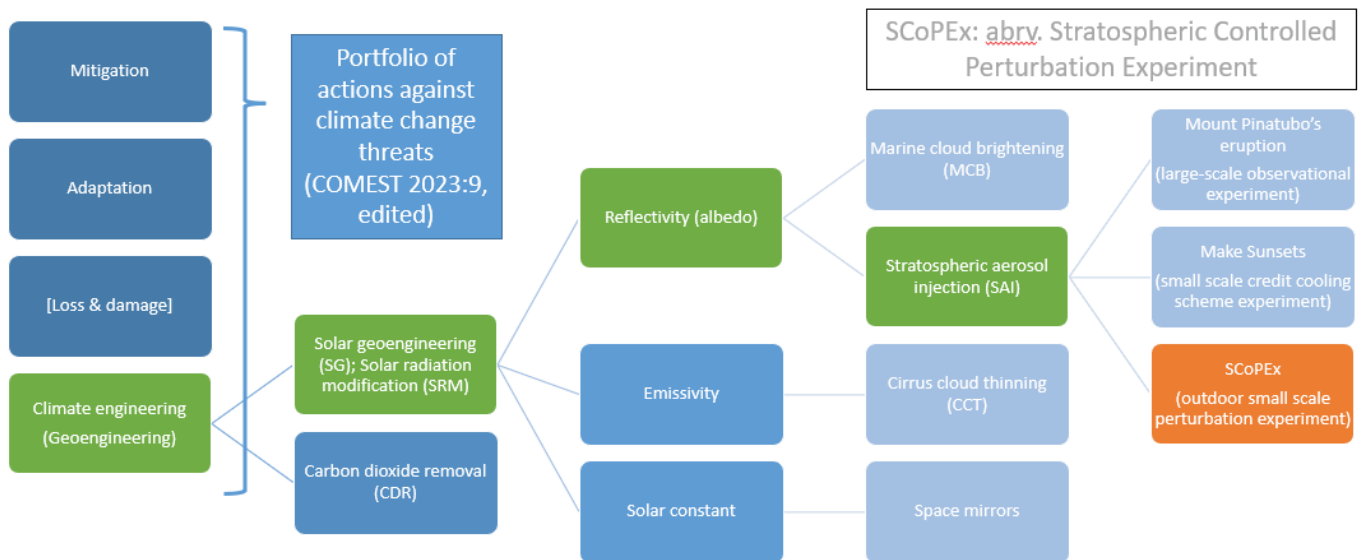


Figure 1. Analysis of SCoPEX experiment: SG SAI climate intervention of small scale outdoor research

3.2.WP2. Defining reasonable agreements in SG research using analogies

Aim. Map a multi-agent continuum of rejection-hesitancy-acceptance of SG research based on analogs from bioethic research.

Working hypothesis. **WH1:** This continuum works similarly to other forms of planetary technology, e.g. experimental COVID-19 vaccination research (Mastroleo 2024).

WH2: Two experts may disagree on a particular SG intervention belonging to the borderline cases of permissible SG interventions. One may example e.g., that large scale SG research may not be ethically permissible (Lenferna et al 2017)–, while the other may think it is ethically mandatory (e.g. Make Sunsets, Gelles & Bates 2024) (for the concepts of clear and borderline cases, see Fine, 1975; Williamson, 1994; Cobrerros and Tranchini, 2019).

WH3: The difference in these reasonings is based on a theory about different formal and material cross-commitments involving doxastic attitudes of accepting, rejecting and suspending judgement (withholding, hesitation) about theories and claims (Sturgeon et al., 2010; Friedman, 2013). There are different forms of suspension of judgment, some grounded and other underground (Ferrari and Incurvati 2021). Rational forms of disagreement involving suspension of judgment are only of the first kind. This theory, then, can be used to distinguish between reasonable and unreasonable disagreements in SG small outdoor research.

3.3.WP3. Justifying the ethical status of SG research as prohibited, permissible or mandatory

Aim. Dealing with the research question of justification of SG small outdoor research.

Working hypothesis: **WH1:** An analytical difference exists between the justification of SG research as an activity and the principles of responsible SG research. For instance, the first of the Oxford Principles impliesthat only SG research, development and eventual deployment of SG interventions for the common good (including SG small outdoor research) is ethically permissible(Rayner et al 2013) wich forbids other

uses such as SG for war. Moreover, others consider that SG research is not only ethically permissible but that SG research may be ethically mandatory (Lawrence & Crutzen 2017).

WH2: Reasons for opposing SG research at the extremes of the rejection-hesitancy-acceptance continuum of possible SG deployment (see ARIA WP 2) are inadequate, insofar as they are based on unexamined assumptions (see as examples, “moral hazard” (Biermann et al 2022, as interpreted by Parsons et al 2024); “cooling credit schemes” as an alternative to the traditional scientific research pathway (see ARIA WP1) and there is sufficient evidence of favourable risk-benefit balance given the current level of climate change-related disasters, harms, and risks (Gelles and Bates 2024).

WH3: Mapping this basic discussion clarifies the ethics and governance of SG research and leads to further refined specific fundamental questions related to our governance model including: If ethically permissible, do potential host communities (e.g. LMICs) have ethical and prudential general reasons to host (e.g. cooperation) or to refuse to host (e.g. unpreparedness, exploitation) SG small outdoor research? (Camilloni 2024, personal communication).

WH4: To answer this important question foundational models of research ethics and political philosophy can be extended, e.g. London’s (2003, 2022) general interests model of the common good can be partly used to understand what a moral imperative or ethical duty to research means in the case of SG research, or using Gilabert’s (2018) model based on the concept of dignity to explain the global south rights and duties of potential host countries from the LMICs (e.g. if national authorities are planning to or foresee the potential use of SG at a national, regional or global scale they have a duty to research to protect basic interests or dignity of their citizens).

3.4. WP4. Building models for implementing good and fair governance based on North-South Collaborations

Aim. Learn from the Mexican government’s intention to ban experimentation on SG following the Make Sunsets small-scale experimental deployment and put forward a participatory governance model.

Working hypotheses. **WH1.** In Latin America and The Caribbean region (LAC) and elsewhere, SG is not yet a priority in the climate change portfolio of mitigation and adaptation strategies nor a topic on the radar of LAC governments.

WH2. Any appropriate, just, fair and equity global governance model must take into account significant cultural and ethnic diversity (ARIA 2024b) and build its principles in climate justice. Building good participatory governance requires mapping the sparse SG landscape in the LAC region and explore new ways of North-South early collaboration to strengthen Global South capabilities. Including boundary organisations (such as the Interamerican Institute for Global Change Research (IAI), Economic Commission for Latin America and the Caribbean (ECLAC) and regional stakeholders, policymakers, scientists, Indigenous communities, and greater civil society throughout the process of knowledge co-production will strengthen the legitimacy, relevance and saliency of research and experimentation (Jasanoff, 2004; Carabajal & Hidalgo, 2021)

WH3. The Mexican intention to ban SRM “experimentation” (following the Make Sunsets episode) may increase public resistance and discourage Global South governments, experts, and civil society from participating in international discussions and undermining responsible climate intervention research and practice (e.g., at UNEA 2025).

WH4: Increased access to science-based information for Global South countries and strengthening North-South collaborations will improve international participation, informed decision-making and build effective, fair and legitimate governance frameworks to advance research and practice or SRM.

3.5. Common deliverables. All WPs are expected to produce one conceptual (WP1-3) or empirical paper (WP4) with the research assistant as first author within 24 months, and it is expected to be part of their thesis (students) or research program (post-docs).

3.6. WP Methods. WP1-3 will draw on standard conceptual research methods of philosophical analysis and conceptual engineering (Chalmers 2020) guided by scoping literature review and consultation with experts in the field. WP4 will use standard empirical research methods from anthropology and qualitative methods, including interviews, focus groups if necessary, mapping of actors and discourse and media analysis.

3.7. Timeline, activities and milestones

Period	Workflow objectives	Capacity-building objectives
Q1-Q2.25	.Establish monthly whole-project reading group with UK advisors. .Finish WP1 with a multi-authored theoretical paper (logic branch, see 4.): “Solar geoengineering as a socio-technical intervention ensemble”	. Identify research assistants (1 MA student for each WP) and enrol them in suitable institutional research projects (e.g. MA programs). . Train research assistants and researchers in conceptual analysis.
Q3-Q4.25	.WP4: Contact regional boundary organisations such as IAI, ECLAC, and other social and institutional actors for roundtable (Q4.26)	. Train research assistants and researchers in qualitative methods and dialogical skills to reach out to actors from different backgrounds: academics, politicians and international organisations members.
Q1-Q2.26	.WPs 2-3: Edit a bilingual special issue on ethics and governance of SG small outdoor research (e.g. National Autonomous University of Mexico Bioethics Journal).	. Foster ethical thinking and argumentation on the governance of small-scale SG research among researchers assistants. . Strengthen their academic writing skills.
Q3-Q4.26	. WP4: Organise a North-South workshop in Buenos Aires with UK advisors and different local, regional and international organisations (such as IAI, ECLAC) and different stakeholders - indigenous groups and civil society on SG research.	. Public-facing presentation of work . Train research assistants and researchers in the organisation of large-scale academic events involving academics, members of international organisations and civil society actors. In particular, to train them in the development of cultural competences.

Graphical representation of the two-year project.

Ethics and governance of solar geoengineering research: from concepts to implementation



Section 2: The Team



- [REDACTED]

Advisors:

- [REDACTED]

Roles and Responsibilities

Principal investigators responsibilities:

- Lead the current project and collaborate with other researchers to realize the achievementment of the current application.
- Attend international conferences to promote the project.

Academic coordinators responsibilities

Academic coordinators are academic colleagues who work on the project as collaborators and have the following coordination roles:

- Contribute to publications as academics on at least one work package.
- Prepare monthly LAC-UK reading group
- Organise the in-person meeting
- Co-author publication of the LAC-UK report

Students and fellows' responsibilities:

- Collaborate with PI's and AC's in writing grants and articles based on the current project
- Collaborate with PI's and AC's in presenting partial results in academic meetings.
- Develop a dissertation (students) or similar project (postdoc fellows) within a suitable research program (e.g. PhD in Philosophy, PhD in Anthropology or Social Sciences)

Advisors responsibilities

- Follow the students' research
- Propose bibliography for the monthly journal club
- Collaborate on the LAC-UK report

References

Numbered References for Box 1.

1. Flavelle, C. (2024, mayo 23). A Test of Cloud-Brightening Machines Poses No Health Risk, Officials Say. *The New York Times*. <https://www.nytimes.com/2024/05/23/climate/cloud-brightening-geoengineering.html>
2. Karlamangla, S. (2024, junio 5). Alameda City Council Votes to Stop Cloud Brightening Test. *The New York Times*. <https://www.nytimes.com/2024/06/05/us/alameda-cloud-brightening-climate-change.html>
3. Temple, J. (2024, marzo 18). Harvard has halted its long-planned atmospheric geoengineering experiment. MIT Technology Review. <https://www.technologyreview.com/2024/03/18/1089879/harvard-halts-its-long-planned-atmospheric-geoengineering-experiment/>
4. Holzer, F. S. (2017). Defending the social value of knowledge as a safeguard for public trust. *Bioethics*, 31(7), 559-567. <https://doi.org/10.1111/bioe.12364>
5. Rayner, S., Heyward, C., Kruger, T., Pidgeon, N., Redgwell, C., & Savulescu, J. (2013). The Oxford Principles. *Climatic Change*, 121(3), 499-512. <https://doi.org/10.1007/s10584-012-0675-2>
6. Harrison, D. P. (2023, octubre 16). Could 'marine cloud brightening' reduce coral bleaching on the Great Barrier Reef? The Conversation. <http://theconversation.com/could-marine-cloud-brightening-reduce-coral-bleaching-on-the-great-barrier-reef-214308>

Main text references.

- ARIA. (2024a). Exploring Climate Cooling: Call for proposals. <https://www.aria.org.uk/wp-content/uploads/2024/09/Exploring-Climate-Cooling-Call-for-Proposals.pdf>.
- ARIA. (2024b). Exploring Climate Cooling: Programme oversight and governance. <https://www.aria.org.uk/wp-content/uploads/2024/09/Exploring-Climate-Cooling-Programme-Oversight-and-Governance.pdf>.
- Biermann, F. (2023, January 30). *Mexico Bans Solar Geoengineering Experiments*. Frank Biermann. <https://www.frankbiermann.org/post/mexico-bans-solar-geoengineering-experiments>
- Biermann, F., & Gupta, A. (2024). A paradigm shift? African countries call for the non-use of solar geoengineering at UN Environment Assembly. *PLOS Climate*, 3(5), e0000413. <https://doi.org/10.1371/journal.pclm.0000413>
- Biermann, F., Oomen, J., Gupta, A., Ali, S. H., Conca, K., Hajer, M. A., Kashwan, P., Kotzé, L. J., Leach, M., Messner, D., Okereke, C., Persson, Å., Potočník, J., Schlosberg, D., Scobie, M., & VanDeveer, S. D. (2022). Solar geoengineering: The case for an international non-use agreement. *WIREs Climate Change*, 13(3), e754. <https://doi.org/10.1002/wcc.754>
- Carabajal, M. e Hidalgo C. (2021). "Making Sense of Climate Science: From Climate Knowledge to Decision Making" In *The Anthropocene of Weather and Climate: Ethnographic Contributions to the Climate Change Debate*. Ed. Sillitoe Paul. Berghahn Books. Oxford.
- Chalmers, D. J. (2020). What is conceptual engineering and what should it be? *Inquiry*, 1-18. <https://doi.org/10.1080/0020174X.2020.1817141>
- Clark, B. (2023). How to Argue about Solar Geoengineering. *Journal of Applied Philosophy*, 40(3), 505-520. <https://doi.org/10.1111/japp.12643>
- Cobrerros, P. and Tranchini, L., 2019, "Supervaluationism, Subvaluationism and the Sorites Paradox", in Elia Zardini and Sergi Oms (eds.), *The Sorites Paradox*. Cambridge, 38–62.

- Commission on the Ethics of Scientific Knowledge and Technology (COMEST). (2023). Report of the World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) on the ethics of climate engineering (SHS/COMEST-13/2023/1 REV.). <https://unesdoc.unesco.org/ark:/48223/pf0000386677>
- Ferrari, F. and Incurvati, L., The varieties of agnosticism. *Philosophical Quarterly* **72**, 2, 365–380 (2021). 10.1093/pq/pqab038
- Fine, K., 1975, “Vagueness, truth and logic”, *Synthese*, 54: 235–259.
- Fischer, F. (2012). Participatory governance: From theory to practice. Oxford University Press.
- Friedman, J. Suspended judgment. *Philos Stud* **162**, 165–181 (2013). <https://doi.org/10.1007/s11098-011-9753-y>
- Gelles, D., & Bates, I. C. (2024, September 25). Silicon Valley Renegades Pollute the Sky to Save the Planet. *The NY Times*. <https://www.nytimes.com/2024/09/25/climate/rogue-solar-geoengineering.html>
- Gilbert, P. (2018). Human dignity and human rights. Oxford University Press. DOI: <https://doi.org/10.1093/oso/9780198827221.001.0001>
- Gupta, A., Biermann, F., Driel, E. van, Bernaz, N., Jayaram, D., Kim, R. E., Kotzé, L. J., Ruddigkeit, D., VanDeveer, S. D., & Wewerinke-Singh, M. (2024). Towards a Non-Use Regime on Solar Geoengineering: Lessons from International Law and Governance. *Transnational Environmental Law*, 1–32. <https://doi.org/10.1017/S2047102524000050>
- Jasanoff, Sheila (2003). Technologies of humility: citizen participation in governing science. *Minerva* 41 (3):223–244.
- Jasanoff, S. (2004). States of Knowledge: the co-production of science and the social order. London: Routledge.
- Jinnah, S., Talati, S., Bedsworth, L., Gerrard, M., Kleeman, M., Lempert, R., Mach, K., Nurse, L., Patrick, H. O., & Sugiyama, M. (2024). Do small outdoor geoengineering experiments require governance? *Science*, 385(6709), 600-603. <https://doi.org/10.1126/science.adn2853>
- Kimmelman, J. (2012). A theoretical framework for early human studies: Uncertainty, intervention ensembles, and boundaries. *Trials*, 13(1), 173. <https://doi.org/10.1186/1745-6215-13-173>
- Kimmelman, J., & London, A. J. (2015). The Structure of Clinical Translation: Efficiency, Information, and Ethics. *Hastings Center Report*, 45(2), 27-39. <https://doi.org/10.1002/hast.433>
- Lawrence, M. G., & Crutzen, P. J. (2017). Was breaking the taboo on research on climate engineering via albedo modification a moral hazard, or a moral imperative? *Earth's Future*, 5(2), 136–143. <https://doi.org/10.1002/2016EF000463>
- Lenferna, G. A., Russotto, R. D., Tan, A., Gardiner, S. M., & Ackerman, T. P. (2017). Relevant climate response tests for stratospheric aerosol injection: A combined ethical and scientific analysis. *Earth's Future*, 5(6), 577-591. <https://doi.org/10.1002/2016EF000504>
- London, A. J. (2003). Threats to the Common Good: Biochemical Weapons and Human Subjects Research. *Hastings Center Report*, 33(5), 17–25. <https://doi.org/10.2307/3528632>
- London, A. (2022). *For the Common Good: Philosophical Foundations of Research Ethics*. Oxford University Press. <https://www.cmu.edu/dietrich/philosophy/docs/london/london-for-the-common-good.pdf>
- Mastroleo, I. (2024). Use of experimental vaccines is ethically permissible during public health emergencies. *Vaccine*. <https://doi.org/10.1016/j.vaccine.2024.04.065>
- Mastroleo, I., & Holzer, F. (2020). New non-validated practice: An enhanced definition of innovative practice for medicine. *Law, Innovation and Technology*, 12(2), 318–346. <https://doi.org/10.1080/17579961.2020.1815405>

- MacMartin, D. G., & Kravitz, B. (2019). Mission-driven research for stratospheric aerosol geoengineering. *Proceedings of the National Academy of Sciences*, 116(4), 1089-1094. <https://doi.org/10.1073/pnas.1811022116>
- McCradden, M. D., Joshi, S., Anderson, J. A., & London, A. J. (2023). A normative framework for artificial intelligence as a sociotechnical system in healthcare. *Patterns* (New York, N.Y.), 4(11), 100864. <https://doi.org/10.1016/j.patter.2023.100864>
- National Research Council (NRC), Division on Earth, Life Studies, Ocean Studies Board, Board on Atmospheric Sciences, Committee on Geoengineering Climate, Technical Evaluation, & Discussion of Impacts. (2015). *Climate intervention: Reflecting sunlight to cool earth*. National Academies Press.
- Parson, E. A., Buck, H. J., Jinnah, S., Moreno-Cruz, J., & Nicholson, S. (2024). Toward an evidence-informed, responsible, and inclusive debate on solar geoengineering: A response to the proposed non-use agreement. *WIREs Climate Change*, e903. <https://doi.org/10.1002/wcc.903>
- Rayner, S., Heyward, C., Kruger, T., Pidgeon, N., Redgwell, C., & Savulescu, J. (2013). The Oxford Principles. *Climatic Change*, 121(3), 499-512. <https://doi.org/10.1007/s10584-012-0675-2>
- Ribeiro, S. (2024, August 21). Resistencia logra clausura de proyecto de geingeniería. Desinformémonos. <https://desinformemonos.org/resistencia-logra-clausura-de-proyecto-de-geingenieria/>
- Spaiser, V., Juhola, S., Constantino, S. M., Guo, W., Watson, T., Sillmann, J., Craparo, A., Basel, A., Bruun, J. T., Krishnamurthy, K., Scheffran, J., Pinho, P., Okpara, U. T., Donges, J. F., Bhowmik, A., Yasseri, T., Safra de Campos, R., Cumming, G. S., Chenet, H., ... Spears, B. M. (2024). Negative social tipping dynamics resulting from and reinforcing Earth system destabilization. *Earth System Dynamics*, 15(5), 1179-1206. <https://doi.org/10.5194/esd-15-1179-2024>
- Sturgeon, S., Gendler, T. S., and Hawthorne, J. (2010). Confidence and coarse-grained attitudes. In *Oxford studies in Epistemology* (Vol. 3). Oxford: Oxford University Press, 126-149.
- Williamson, T., 1994, *Vagueness*, London: Routledge.
- Wong, P.-H., Douglas, T., & Savulescu, J. (2014). Compensation for Geoengineering Harms and No-Fault Climate Change Compensation. In *The Climate Geoengineering Governance Working Papers* (pp. 1–23). <https://philarchive.org/rec/WONCFG>

How to speak about climate cooling?: co-creating a climate engineering engagement toolkit in the Arctic and the UK (previously “Entangled Futures: Geoengineering, Youth, and Indigenous Futures in the Arctic”)

Section 1: Programme & Technical Overview

1. Background:

Public engagement is an essential and as of yet underdeveloped part across all scales of climate engineering research.¹ On a project specific scale, the examples of the cancellations of SCoPEX² and the University of Washington’s experiments with Marine Cloud Brightening³ show that adequate community engagement is a prerequisite for conducting field experiments. Not only is engagement valuable for informed collective decision making, but in the absence of formal governance on climate engineering research, some authors argue that “*co-producing research could serve as a de facto form of governance*”⁴. Yet, although several research projects have made such engagement an essential part of their research design, with the recently published AGU Ethical Framework⁵ setting out some general guidelines, broadly applicable studies on useful engagement strategies are lacking. On the larger national or international scales, public engagement studies have recently proliferated. These have, however, so far mainly been limited to the scoping of opinions and stances towards research or future deployment⁶. Whilst such efforts have provided valuable snapshots of public opinion and provided important insights into contextual specificity and complexity in opinions, these studies fundamentally leave two critical gaps in our understanding.

First, these studies have failed to capture the process through which participants form, refine or change their views when exposed to new information or perspectives on climate engineering. Second, many of these approaches have not focused on key climate actors – especially individuals whose concerns will be impactful for governance – environmental and social justice advocates, indigenous communities, community organisations and other engaged citizens⁷.

¹ We use climate engineering, climate cooling, and climate interventions as synonyms throughout this application to refer to large-scale interventions to artificially intervene in (parts of) the climate system in order to mitigate some of the effects of global warming.

²<https://www.saamicouncil.net/news-archive/saami-councils-statement-to-the-harvard-decision-to-halt-the-scopex-project>

³ <https://www.sfchronicle.com/climate/article/geoengineering-alameda-study-stopped-19453924.php>

⁴ Ilona Mettiäinen et al., “‘Bog Here, Marshland There’: Tensions in Co-Producing Scientific Knowledge on Solar Geoengineering in the Arctic,” *Environmental Research Letters* 17, no. 4 (March 9, 2022): 045001, <https://doi.org/10.1088/1748-9326/ac5715>.

⁵ <https://www.agu.org/learn-about-agu/about-agu/ethics/ethical-framework-for-climate-intervention>

⁶ i.e. Brutschin, E., Baum, C.M., Fritz, L., Low, S., Sovacool, B.K. and Riahi, K., 2024. Drivers and attitudes of public support for technological solutions to climate change in 30 countries. *Environmental Research Letters*, 19(11), p.114098.; Contzen, N., Perlaviciute, G., Steg, L., Reckels, S.C., Alves, S., Bidwell, D., Böhm, G., Bonaiuto, M., Chou, L.F., Corral-Verdugo, V. and Dessi, F., 2024. Public opinion about solar radiation management: A cross-cultural study in 20 countries around the world. *Climatic Change*, 177(4), p.65.;

Sugiyama, M., Asayama, S., Kosugi, T., Ishii, A. and Watanabe, S., 2024. Public attitude toward solar radiation modification: results of a two-scenario online survey on perception in four Asia-Pacific countries. *Sustainability Science*, pp.1-16.

⁷ Sapinski, J. P., Holly Jean Buck, and Andreas Malm. 2021. *Has it come to this?: The promises and perils of geoengineering on the Brink*. New Brunswick, NJ: Rutgers University Press.

Understanding how people form, refine or change their views on climate interventions is as important as the opinion they ultimately express⁸. Focusing on this process will provide insights into the journey of engagement – the way individuals grapple with climate engineering information, confront their assumptions and adapt to new knowledge. This matters because opinions are not static⁹ – they emerge from ongoing dialogue, shaped by responses of those involved. By focusing on the process of engagement, we gain both a clearer picture of public opinion and of what drives public trust or skepticism towards climate engineering research.

Our proposal seeks to address these gaps by adopting a dual-stream framework that goes beyond static opinion measurement towards the co-creation of a climate engineering engagement process. Fundamentally, we seek to explore how participants in the UK and Arctic¹⁰ communities think conversations around climate engineering could and should take place. While our project also seeks to understand what different communities think about climate engineering, it primarily focuses on the process of engagement – its design, inclusivity and desirability for participants.

2. Programme Alignment and Project Overview

According to the funding guidelines, this project is of direct relevance regarding the “...consideration of public perception, potential legal, ethical, regulatory and governance frameworks, ethics, community engagement, and the economic impact of those approaches”. Because ARIA is a cutting-edge organisation at the forefront of innovative research, it is uniquely positioned to lead in setting new standards of public engagement for emerging tech. This makes ARIA both the ideal place to create and to implement engagement frameworks to guide the responsible development of high-impact, transformative technologies.

Specifically, we propose to use this funding for two workstreams. The first work stream will focus on co-creative workshops with engaged citizens and communities in the Arctic, especially those who are often left out of other similar climate engineering engagement endeavours. The second phase will involve conducting citizen assembly engagements in the UK with members of the public across multiple locations (London, East Cambridgeshire, and Glasgow/Aberdeen).

Aspect	WP1: Arctic Communities (section 2.1)	WP2: UK citizen assemblies (section 2.2)
Focus	Inclusivity and Indigenous perspectives	Iterative learning and opinion shifts
Participants	3 assemblies of up to 25 participants	3 assemblies of up to 25 participants
Engagement format	Two-day workshops across three Arctic sites	Repeated two-days assemblies across three UK locations

⁸ Dennis Chong and James N. Druckman, “Dynamic Public Opinion: Communication Effects over Time,” *American Political Science Review* 104, no. 4 (November 2010): 663–80, <https://doi.org/10.1017/s0003055410000493>.

⁹ Ibid.

¹⁰ We use the term “Arctic” throughout this proposal, even while our field sites will likely be primarily located in the Arctic regions of the Nordic countries, but do not suggest that our toolkit will encompass or be directly relatable to the entire Arctic region. However, given the developed inter-Arctic indigenous networks, the possibility of expanding into other Northern regions, and many climate intervention proposals refer to the Arctic, we found the Arctic to be the best term.

Outputs	Academic articles, engagement toolkit.

2.1 Work package 1 - Engaging Arctic Communities

Overview:

The Arctic is often considered as a potential location for climate engineering field tests and potential future deployment. To many living in the region, especially indigenous peoples, the controversies around such experiments resonate strongly with past and ongoing colonialist projects like the construction of wind farms and hydroelectric dams, while the Arctic has also been long constructed as an empty frontier or laboratory perfect for such experimentation¹¹. There are several climate engineering research projects that conduct their own outreach¹² and there is at least one general engagement project in the Arctic conducted by the Alliance for Just Deliberation on Solar Geoengineering (SDG)¹³. While very worthwhile, the research-first projects only focus on a specific technique and location, and the SDG project is limited in scope and means, not intending to be methodologically innovative or broadly generalisable.

Objectives:

1. Explore forms of learning, deliberation, and knowledge exchange that incorporate the role, value, and norms of multiple forms of learning and knowing, such as those present among Indigenous Peoples and local community organizations in the Arctic.
2. Discuss how participants perceive the inclusivity of discussions around the issues and complexities linked to climate engineering research projects, and their subsequent willingness to take part in citizen assemblies.

Methods and Rationale:

The assemblies will consist of 3 groups of around 25 participants each who will participate in co-creative discussions/assemblies around climate engineering engagement for two full days or one weekend. Methodologically, the project combines pre- and post-session Q-sort exercises, qualitative analysis of facilitated discussions, and reflective exercises to capture the co-creative and collaborative engagement of participants. Data collection includes summaries of discussions, plans produced by participants detailing their ideas for such engagement processes, Q-sort responses, and participants' reflective journals. The combination of quantitative Q-sort and qualitative methods will help us better understand our participant's collective and individual views towards climate engineering, as well as their reasons for holding these views or how they track with other opinions (participants' view towards climate change and technology more generally, for example).

Participants will not be required to have prior experience with climate engineering, and will ideally include a mix of Indigenous and non-Indigenous participants to see how to integrate Indigenous Traditional and Local Ecological Knowledge and non-Indigenous knowledge together. Recruitment will occur through our local contacts and collaborators—many of whom are either Sámi themselves or have experience working with Sámi communities (such as Operaatio

¹¹ Cooper, A. M. 2023. "FPIC and Geoengineering in the Future of Scandinavia". In *Arctic Justice*. Bristol, UK: Bristol University Press. Retrieved Oct 6, 2024, from <https://doi.org/10.51952/9781529224832.ch010>

¹² See for example the GRISCO project: <https://www.arcticcentre.org/EN/grisco/background> or reports by *Real Ice*: <https://www.realice.eco/cambay-comm-eng-factsheet>

¹³ <https://sgdeliberation.org/activities/youth-engagement-program/>

Arktis) and/or climate engineering topics. Specifically, these sites will likely be places with dense Indigenous Populations (taking into account seasonal reindeer herding and other events), sites of past or proposed, climate engineering experiments, and other locations with engaged citizen communities that we have contacts in, such as: Reykjavik (climate engineering experiments have already been explored in Iceland under the auspices of the Bright Ice Initiative), Kiruna (the proposed site of the 2021 ScopeX tests), Inari (home to the Sámi Parliament), Rovaniemi (home to the University of Lapland, the seat of the UArctic Thematic Network on the Frozen Arctic focused on Climate Intervention), Helsinki (home to Operaatio Arktis), and Kautokeino (a center of Sámi culture in Norway), while other sites with significant Sámi populations such as Tromsø, Oulu, Mannndalensjøbuer, Enontekiö, Karasjok, Utsjoki, Arvidsjaur, Jokkmokk, and Gällivare are also possibilities depending on who has the interest and capacity to work with us.

Output of WP 1:

Evidence based framework for engagement on controversial technology: out of the collaborative engagement processes, we would be able to combine participants' perspectives about how discussions concerning controversial technologies can be structured, and whether participants perceive these engagements as worthwhile or meaningful. In addition to the toolkits, the outputs of WP 1 will be a series of academic articles reporting on the challenges and opportunities of co-creating engagement processes around controversial techniques like climate engineering.

2.2 Work package 2 - Co creation of a climate engineering engagement framework in the UK

Overview of research design: This work package explores how iterative exposure to SRM knowledge supports public understanding and deliberation over time.

Objectives:

1. Identify forms of learning, deliberation and knowledge exchange that best support participants in refining their views on SRM/Climate engineering over time.
2. Explore how participants' opinions about SRM/Climate engineering evolve over time and through iterative exposure to SRM knowledge

Methodology and rationale: The research questions for this work package are: *how do participants' opinions about SRM evolve over time and through iterative exposure to SRM knowledge, and what forms of learning, deliberation and knowledge exchange best support participants in refining their views on SRM over time?* The research design involves a pilot citizen assembly model where approximately 25 participants, representing a diverse cross-section of the population, convene annually over three years for two-day sessions. This frequency allows for sustained engagement, providing the time necessary for participants to process complex information, deliberate collaboratively, and refine their views over time. Other, non-SRM interventions are less likely to be directly applicable to the UK context.

Methodologically, the project combines pre- and post-session Q-sort exercises, qualitative analysis of facilitated discussions, and reflective exercises to capture the evolution of participants' knowledge and opinions. Data collection includes transcripts of discussions, Q-sort responses, and participants' reflective journals. The longitudinal structure is critical to the robustness of the methodology, as it allows for the observation of opinion shifts over an extended period rather than relying on static, one-time snapshots.

We propose selecting 25 participants, selected to reflect a representative and diverse cross-section of three locations: East Cambridgeshire, London, and Glasgow/Aberdeen. This assembly would convene for two full days or weekends each year over the course of two years, allowing for sustained engagement, iterative learning, and longitudinal data collection.

East Cambridgeshire has been selected as a site because: (1) of the region's proximity to academic and scientific hubs (including the University of Cambridge where one of the co-authors is based), which increases the likelihood of future SRM field experiments being planned or debated locally, (2) it offers a mix of rural and semi-urban settings, providing perspectives underrepresented in discussions dominated by urban populations, and (3) the region is famously low lying and would be strongly impacted by future sea level rise.

London has been selected as a site because of its relatively underprivileged and ethnically diverse population (1), it's being part of the UK's capital and major political centre (2), and for the number of universities establishing its status as a knowledge hub (outside of Oxbridge). We have not decided on the precise Borough or neighborhood yet, but neighborhoods like Brixton (which is known for its large Caribbean population) or x are very likely

For a more Northern perspective, Aberdeen is our preferred option due to its unique connection to the fossil fuel industry that might provide an interesting perspective alongside the more engaged community groups that we will be engaging. Another option would be Glasgow for a more diverse population and spread of perspectives, as well as its climate connections through the hosting of COP26, but this will depend on the place in London we decide on.

Output of WP2: Evidence based framework for engagement on controversial technology: out of the continuous engagement, we would be able to combine participants' perspectives about how engaging discussions about controversial technologies can be structured. This aims to be directly applicable to ARIA's broader mission of engaging with cutting edge research.

Output of both projects:

The combined long term engagement and Arctic focused work packages will produce unique insights with the strengths of contextual, and in-depth/long term methodologies embracing multiple forms of knowledge, compared to other climate engineering engagement studies. For example, AGU's Ethical Framework for Climate Intervention is "A code of conduct to guide the research, experimentation and deployment of climate intervention measures"¹⁴ by consulting experts and advisors, while the EU Co-Create stakeholder forums¹⁵ are focused on governance and decision making, not on the process of public engagement itself. Currently existing frameworks like post-normal science¹⁶ or other citizen science frameworks are also helpful guides, but are not designed specifically with the challenges of climate engineering in mind. While most relevant to projects taking place in the UK funded by ARIA, our toolkit may be useful to add to or fuse with engagement work done by other project proposals from the CCCR, University of Manchester, and Aker Solutions¹⁷ which are due to take place in the Arctic/Antarctic. Even though many regions could be suited for expanding the contextual focus of the toolkit, and might indeed be included in the future, the Arctic is the most accessible and

¹⁴ <https://www.agu.org/learn-about-agu/about-agu/ethics/ethical-framework-for-climate-intervention>

¹⁵ <https://co-create-project.eu/>

¹⁶ Silvio O. Funtowicz and Jerome R. Ravetz, "Science for the Post-Normal Age," *Futures* 25, no. 7 (September 1993): 739–55, [https://doi.org/10.1016/0016-3287\(93\)90022-I](https://doi.org/10.1016/0016-3287(93)90022-I).

¹⁷ As per Aria recommendations, we contacted these organizations who expressed interest in our project.

relevant region. Additionally, restraining the scope to the UK and the Arctic will allow us to focus on technologies relevant to these regions, thus not stretching our expertise, time, or participants' patience. The expertise and connections of Albert and Cody will help ensure that the engagements are scientifically informed and not extractive, while helpful for raising awareness around how the Arctic is being affected by climate change.

2.3 Project management

Risks and dependencies to the project

Type	Name	Description	Mitigation strategy
Risk	Recruitment challenges (WP1&2)	Difficulty recruiting diverse participants in the Arctic and UK communities.	Leverage local networks from the start, and offer flexible timelines.
Risk	Scheduling conflicts (WP1&2)	Delays due to the participants availability	The Gantt chart has been built with this in mind incorporating buffers between the different assemblies.
Risk	Cross-cultural barrier (WP1)	Miscommunication between researchers and local communities.	Co-design workshop with local partners and following guidelines for conducting research and engagement
Risk	Longitudinal drop-off (WP2)	Participants dropping out of UK assemblies over time, reducing discussion quality.	Maintain regular communication, provide participants incentives to come (minimum wage) and recognition of contribution.
Risk	Ethical concerns (WP1&2)	Criticism regarding the ethics of climate engineering discussions with marginalised groups.	Go through the internal Oxford, ARIA and Arctic organisation ethics approval processes, as well as allowing participants to go off record when desired.
Risk	Political backlash (WP1&2)	Controversy over climate engineering could affect participants or attract negative media.	From the beginning, engage the participants, transparently, on controversies.
Dependencies	Local partnership (WP1&2)	Collaboration with Arctic organisation for recruitment and workshop design.	Build early partnership with trusted organisations and co-develop engagement methods.

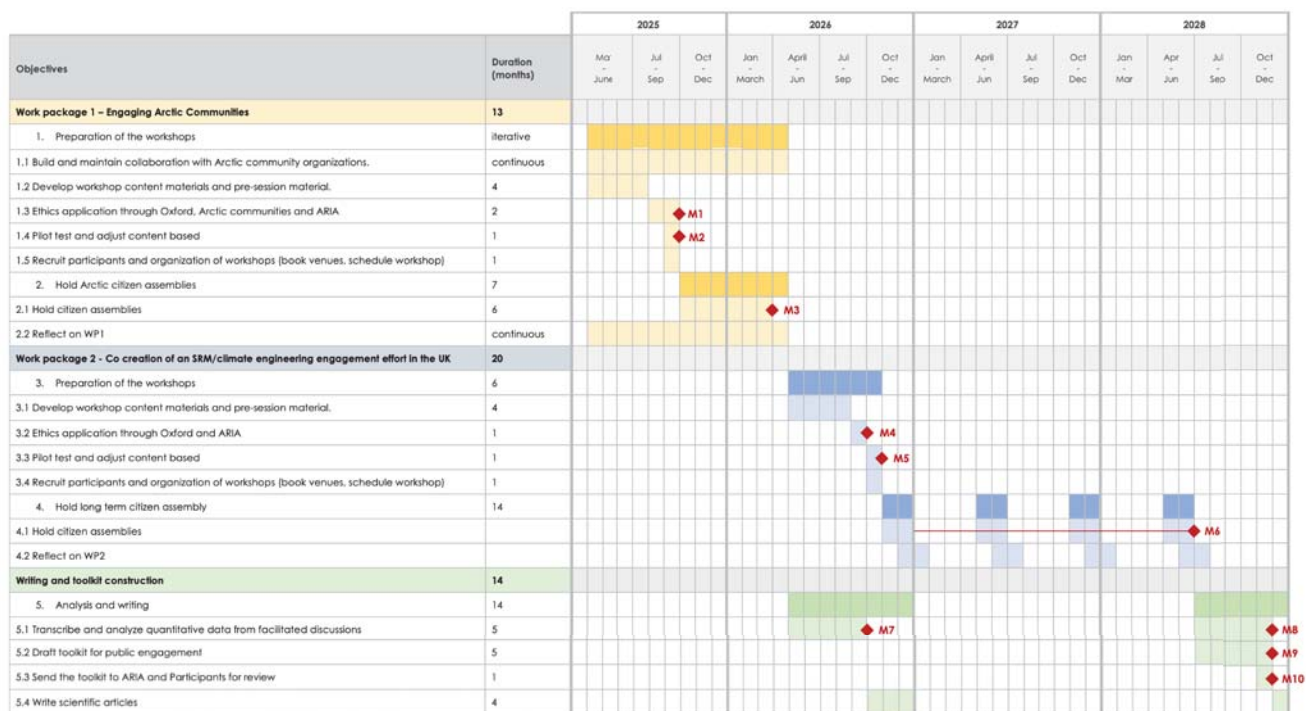
Timeline

We have identified 10 milestones over the course of this project lasting from March 2025 to Dec 2028. For each milestone in this project, we are committed to maintaining clear and consistent communication with stakeholders, whether it is providing updates on progress, sharing

emerging insights, or gathering feedback to refine our approach. This ensures that the process remains transparent, collaborative, and responsive to the needs and expectations of those involved.

- M1 & M4: finished ethics applications we would co-create with Arctic organisations for WP1, and seek approval with the Oxford Ethic committee as well as ARIA (WP1&2).
- M2&M5L completed pilot workshops which will be held with partnered organisations to validate the methodology and the future content of the workshop (WP1&2).
- M3&M6: completed all workshops (WP1&2)
- M7&M8: completed the summary and the analysis of all material (WP1&2).
- M9: drafted the toolkit based on empirical analysis and literature review (WP1&2).
- M10: approval and integrated the feedback from participants and stakeholders within the toolkit (WP1&2).

Gantt chart showing timeline and key milestones of project (larger version available, or use zoom function to read more clearly).



[REDACTED]

[REDACTED]

[REDACTED]

What makes us a team?

As a team, we represent a rare merging of disciplines - anthropology, engineering, humanities, environmental sciences and public policy. This diversity does not just add variety to our perspectives; it enhances our capacity to think creatively and critically. In our PhDs, interdisciplinarity has meant approaching the complexities of climate engineering engagement with depth, balance, and an openness to alternative perspectives, ensuring that every voice finds its place in the conversation. This commitment extends beyond disciplines and perspectives to the core of procedural justice: whose voices are heard, and whose are too often overlooked. This has come as a foundation of our commitment to engagement that is both inclusive and meaningful. In that sense, our commitment to public engagement has not been theoretical - it is grounded in practice. Each of us has worked directly with communities, from facilitating dialogues with Arctic Indigenous groups to collaborating with youth activists on climate interventions and bridging conversations between scientists and policymakers. These experiences have taught us how to design and guide processes that foster trust, encourage dialogue, and empower participants. We know how to engage meaningfully and create space for marginalised voices.

What brought us together on this project was a shared vision, driven not by disciplinary boundaries but by the belief that science should serve society with transparency, inclusivity, and fairness. As early-career researchers, we bring fresh perspectives. For us, this project is more than a toolkit: it is a chance to set a new precedent for how emerging technologies like geoengineering can be explored, putting people and justice at the center.

Re-thickening Arctic Sea Ice

1. Proposed Idea/Solution

The Arctic is currently warming 3-4 times faster than the global average¹. While rapidly decarbonizing the global economy is crucial, implementing methods to specifically cool the Arctic region could significantly extend the time needed to avoid temperature-induced climate tipping points. To explore the feasibility of purposefully cooling the Arctic, we propose investigating whether sea ice re-thickening could offer a viable solution. Ice re-thickening is primarily achieved by drawing seawater onto existing sea ice to increase its thickness. By enhancing ice thickness, sea ice can endure longer during warmer seasons, thereby enhancing the reflectivity of a geographic area compared to seawater. This would reduce not only solar warming of the region but also global temperatures. Alongside direct re-thickening, we will explore how thickening key portions of sea ice can be used to help limit sea ice export out of the Arctic Ocean..

In line with ARIA's programme thesis, we propose a 3.5-year research programme to develop the essential knowledge, technology and impact assessments required for sea ice thickening to mitigate the significant loss of sea ice coverage in the Arctic Ocean^{2,3}.

We will integrate large-scale climate and sea ice modelling validated by field and laboratory tests to assess:

- The large-scale *Regional Application of Arctic Ice Thickening*.
- A targeted approach involving *Ice Arch Strengthening*, so as to limit the export of Arctic sea ice.

Alongside each of these approaches, we will also address the scalability of developed technologies.

The applications used in this project will utilise natural materials (i.e. sea water) in a reversible manner which mimics natural processes. Throughout the project, we shall assess and engage with relevant bodies to determine whether there are any adverse impacts upon local ecology, climate, and communities with whom we plan to engage and involve in local fieldwork.

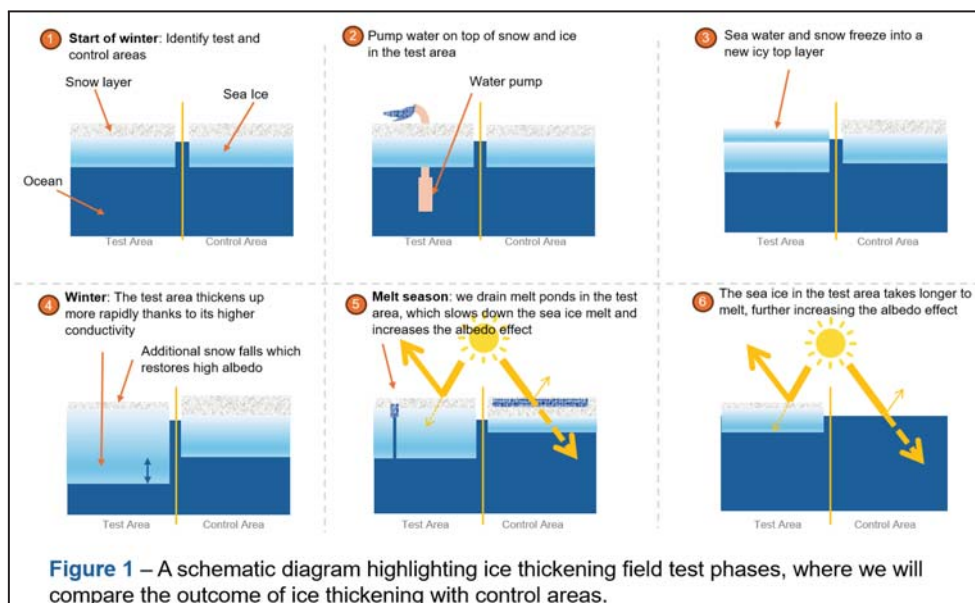
This proposal brings together a motivated, diverse and expert team uniquely positioned to address the aforementioned challenges. The project is both highly ambitious and novel, with the potential for significant climatic rewards and minimal risk. The project team is exceptionally suited to deliver this goal-focused proposal, having extensive experience in implementing high risk/reward science in extreme environments⁴, as well as in-depth knowledge of multi-scale modelling of sea ice rheology^{5,6} and sea ice growth^{7,8}.

a. *Regional Application of Arctic Ice Thickening*

The concept of increasing sea ice thickness on a regional scale is drawn from previous work by team members, including [REDACTED] and [REDACTED] found that pumping 140 cm of seawater onto existing sea ice results in an additional 100 cm of ice thickness. Similarly, [REDACTED]

[REDACTED] showed that flooding a 20 cm layer of snow on top of sea ice can increase sea ice thickness by 70 cm. In this study, we seek to build upon this research by testing and validating the effectiveness of these ice thickening strategies. We also will examine the effectiveness of draining melt water pools on existing sea ice to prolong the life of the sea ice during the summer months. This will be undertaken by drilling small holes in the sea ice during the spring season.

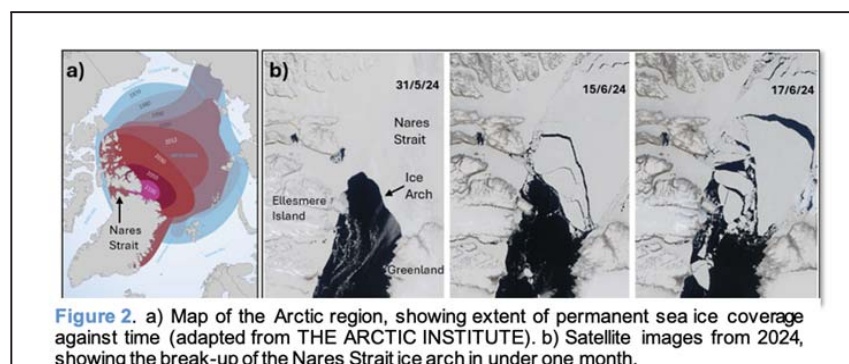
Throughout the project, results from our field tests will



continually be used to feedback and inform the modelling exercise, thereby enhancing the accuracy and certainty of parameters. Recent work by project applicants has already laid the groundwork for this research^{7,8}. Over the past 2 years, project applicants have conducted field tests in Nome, Alaska (Real Ice, 2023), Cambridge Bay, Nunavut ([Real Ice, University of Cambridge, Arctic Reflections, 2024](#)) and [Svalbard](#)

b. Ice Arch Strengthening

In order to limit the export and subsequent loss of sea ice from the Arctic Ocean, we will explore the targeted use of ice re-thickening to strengthen certain ice arches of the Arctic region, so that they are structurally stable for additional weeks during the summer months. The end-goal of this targeted approach



is the same as the regional ice thickening intervention (Arctic albedo improvement), but the key difference is that the strength of the arch post-thickening needs to withstand significant lateral forces, to inhibit the export of sea ice¹⁰.

Perhaps the best known ice arch is that of the Nares Strait, which is a 530 km x 35 km channel between Canada and Greenland (see Fig. 2). Typically, an ice arch forms annually at both ends of the channel, which has the natural effect of blocking the export of Arctic sea ice southwards, which would otherwise occur due to strong currents and the forces in the ice pack (Fig. 2b).

When formed, the ice arch in the Nares Strait typically lasts for around six months¹¹ before breaking apart, allowing the withheld sea ice to flush south. Approximately 95,000 km² of the Arctic Ocean's sea ice is lost through

the Nares Strait during the annual open period, accounting for some ~11% of the ocean's total sea ice export¹². The southern arch, or "ice bridge" plays a crucial role in maintaining the open water of the NOW Polynya (or Pikialasorsuaq), one of the richest ecosystems in the Arctic and vital sources of life. This area is essential for local indigenous communities, who have formed a Commission and recently published a report on the importance of the ice arch¹³. However, the Nares Strait ice arch has been forming less frequently and lasting for shorter durations in recent decades¹⁴. Before 2007, the arch lasted an average 177 days per year, but since then the average duration has decreased to 128 days per year¹⁵. Thinner ice arch thicknesses, resulting from less favorable formation and maintenance conditions¹⁶, are less effective at holding back the surrounding glaciers¹⁷ and the Arctic Ocean's sea ice¹⁸.

The weakened state of the Nares Strait accelerates the depletion of sea ice within the Arctic Ocean. This depletion is further amplified by the Arctic Ocean's disastrous sea ice feedback loop, which includes effects such as increased open water causing larger waves, which breaks up even more ice¹⁹. In this study, it is anticipated that the maximum thickening required to stabilise an arch will be up to a few metres tall; this is much thicker than that needed for the regional application, but in line with previous ice island construction by oil companies²⁰. This study will develop all the necessary components to determine if and how successful intervention in the detrimental ice arch feedback loop (Fig. 3b) can be achieved.

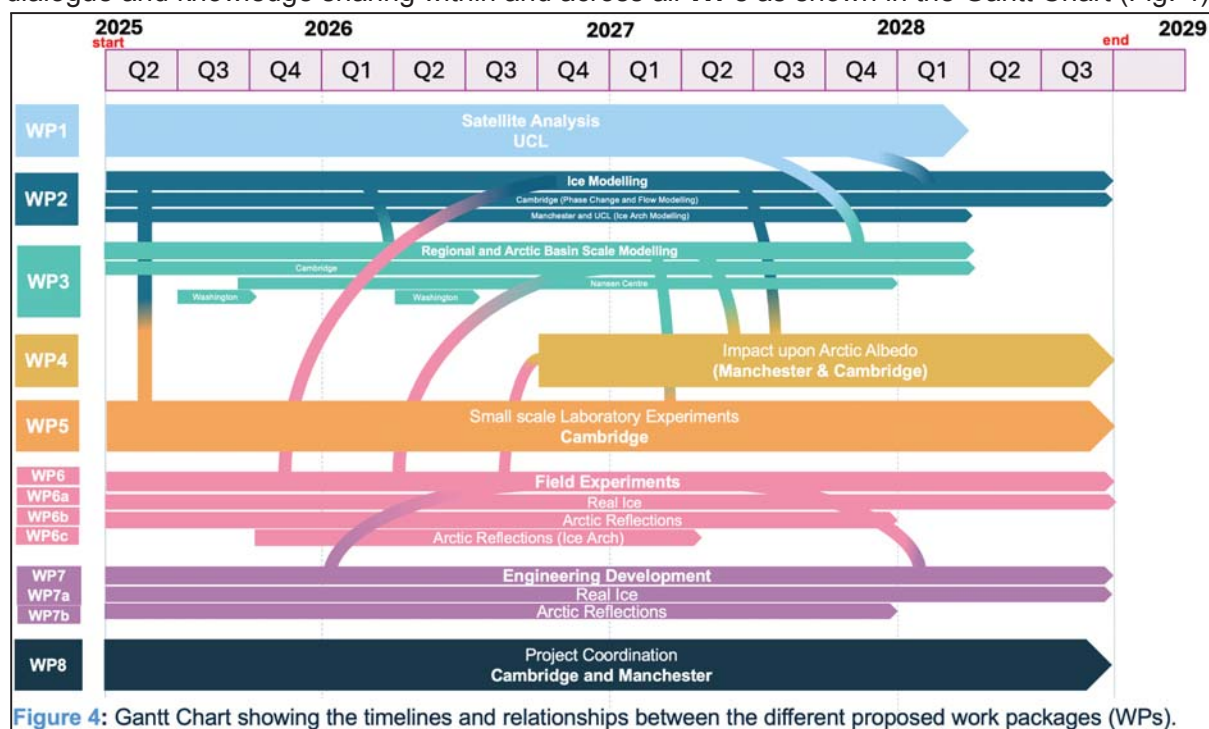
Scalability studies

In parallel to the above studies, we will investigate two methods to scale ice thickening techniques to large areas. One method will explore the use of underwater drones to automatically distribute a solution under the ice. The other method will seek to distribute water over larger ice areas from movable pumping platforms using high flow rate pumps.

2. Proposed activity of work (key metrics and milestones, dependencies and assumptions)

The project will comprise eight interlinked thematic work packages (WPs). Within each thematic WP, sub-packages will be led by the named institution. These sub-packages will support research into regional

scale sea ice thickening and the targeted approach of ice arch strengthening. There will be significant dialogue and knowledge sharing within and across all **WPs** as shown in the Gantt Chart (Fig. 4).



WP1 - Satellite Analysis: This WP aims to identify the most vulnerable areas of ice thinning that would benefit from ice thickening, providing crucial input for the modelling work. **UCL** will combine up to 30 years of sea ice thickness data from airborne and satellite measurements with sea ice drift data to calculate ice fluxes in both area extent and ice volume. This analysis will focus on regions such as the Canadian Archipelago and the Nares Strait, where ice arches form. We will use high-resolution satellite imagery to monitor the timing and location of ice arch formation and disintegration. Additionally, we will review data to identify areas in the Arctic, away from the ice arches, that are experiencing annual ice loss. This will help determine regions that could benefit most from winter sea ice thickening. The outputs from **WP1** will be shared as they become available to support the modelling work outlined in **WP2** and **WP3**.

*Milestone/deliverable Month 9 (M9) – report on sea ice characteristics for input to regional model in **WP3***

Milestone/deliverable (M36) – report highlighting target areas for Ice Thickening (Ice Arches and Regional)

WP2 - Ice modelling: **Cambridge** will use a suite of analytical and numerical models to enhance our understanding of how sea ice grows and strengthens when seawater is pumped onto its surface. This work will provide crucial input for the larger-scale modelling efforts of **WP3**. Building on initial modelling of ice growth⁷ from water flow across the ice surface, Cambridge will develop models for water flow through snow. These models will help establish the areal extent of water coverage required based on snow depth, temperature, flow rate, and ice surface morphology. By developing end-member models of channel and radial flow, we aim to better predict the physical characteristics of sea ice that grows faster through seawater pumping. Informed by these findings, **UCL and Manchester** will use state-of-the-art finite element (FDEM) and mathematical modelling (utilising both discrete/granular and continuous properties) to better understand the structural integrity of ice arches as they are vertically thickened, and how this varies across different horizontal scales. This will be compared to satellite and in-situ observations from **WP1**. The output models from **WP2** will support and be informed by laboratory experiments in **WP5**, and the regional and basin-scale modeling in **WP3**.

Milestone/deliverable (M12) – report on initial modelling for Ice Thickening processes

Milestone/deliverable (M24) – report on sea ice mechanics from discrete/continuous FDEM model

Milestone/deliverable (M42) – report on modelling for Ice Thickening and structural integrity of ice arches

WP3 - Regional and Arctic basin scale modelling: This work package will determine the ultimate potential for ice thickening. Modelling the large-scale effects of Arctic ice thickening within climate models involves dealing with grid resolutions much larger than the scale of typical individual interventions. It also requires incorporating realistic operational scenarios and parameters. Therefore, we will use the outputs of our detailed ice modelling undertaken (**WP2**) in conjunction with the results from the small-scale laboratory

experiments (**WP5**), and field tests (**WP6**) to inform the regional and Arctic basin model parameters. **Washington and Cambridge** will model the impact of re-icing using two fully-coupled climate models: the Community Earth System Model version 2 (CESM2) and the UK Earth Systems Model (UKESM). They will simulate sea ice flooding over specific locations and periods to assess its impact on sea ice and climate. This will include evaluating different scales of flooding (10,000 km² to 500,000 km²), optimal timing, and the effects of geographically variable flooding (e.g. starting further north early in the freeze-up season and moving southward over time). They will also quantify the impact on coastal sea ice, which is important to Arctic communities' livelihoods and coastal erosion. CESM2's sea ice component has been modified by the University of Washington team for sea ice flooding, following the CESM model used in [REDACTED] which flooded sea ice everywhere. Additionally, the impact of adding snow in spring as a potential sea ice restoration engineering technique will be modelled. The sea ice parameterization in UKESM is undergoing rapid improvements as part of the 5-year UKRI program in Climate Change in the Arctic-North Atlantic Region (<https://canari.ac.uk/>). This will allow for the incorporation of complex physics of sea ice and underlying water stratification to assess sea ice thickening impacts. Complementing this work, **Nansen** will seek to understand the overall impact and risks upon the Arctic Ocean of blocking Nares Strait for a longer period than currently observed. They will use the neXtSIM sea-ice model to simulate the impact on sea ice distribution across the Arctic basin. This task requires a much higher resolution than the fully coupled climate models can deliver and will benefit greatly from the advanced sea-ice dynamics of neXtSIM^{6,19}. The modelling will provide crucial information on the dynamics of ice flow on a regional scale and how this may change in a warming climate. It will also allow us to identify the impact of blocking the Nares Strait in a warmer climate and understand how the ice flows further north. This will be key to determining the overall impact and benefits of the targeted approach.

Milestone/deliverable (M12) – report on initial modelling of Regional- and Basin-scale ice thickening

Milestone/deliverable (M24) – report on the evaluation of modelling ice flow through Nares Strait

Milestone/deliverable (M36) – final report on modelling of Regional- and Basin-scale ice thickening

Milestone/deliverable (M42) – report on modelling ice flow and Arctic ice state with a blocked Nares Strait

WP4 - Impact upon Arctic Albedo: Initial benefits of ice thickening in terms of albedo have been observed²⁷. However, more work is needed to quantify the potential under differing conditions. Using the results of **WP2**, **WP3** and observations planned in **WP6**, we will calculate the potential change in Arctic albedo (and therefore global warming contribution) for a range of climate scenarios. In addition to the overall impact on areal extent of ice cover, we will assess the different levels of albedo of normal sea ice, flooded sea ice, and snow covered sea ice. This will help inform potential strategies, such as the best timing for pumping seawater onto sea ice to maximize climate benefits. **Cambridge** will oversee the impact of large scale intervention and **Manchester** will focus on ice arches.

Milestone/deliverable (M42) – report on impact of albedo of Re-Thickening of Arctic Sea Ice

WP5 - Laboratory Experiments: Initially **Cambridge** will conduct laboratory tests to validate the models developed in **WP2**. This will be critical for building our understanding of the evolution of the ice. We will then conduct a series of non-flow experiments to investigate the freezing of saltwater on top of fresh ice and the subsequent migration of brine. We will compare the evolving ice thickness and temperature profiles with theoretical predictions. These experiments will enable us to understand how the rate of ice accumulation from the underside of an overlying ice layer is affected by the introduction of artificial snow, and snow which has been flooded. Our final suite of laboratory experiments will investigate the flow of water through a snow layer on top of ice. The different processes of melting/freezing/dissolution will be investigated so that we can determine how to optimise the snow flooding process. The set up of the experiments will be informed by **WP2** and the results from this work package will feed back into the development of models in **WP2**.

Milestone/deliverable (M12) – Initial report on laboratory experiments

Milestone/deliverable (M42) – Final report on laboratory experiments

WP6 - Field Experiments: In order to get a better understanding of the behaviour of ice growth and melting beyond that which is possible by modelling and small scale laboratory experiments alone, field experiments will be undertaken. The experiments are designed to be as large as necessary to investigate issues such as fracturing of sheets of thickened sea ice, but as small as possible, using knowledge from previous field work. We propose two field test programs running in parallel, each lasting at most three winters (2025/26 to 2027/28), operating in different locations in the Arctic. This will mitigate the risk of disruption by local weather conditions, and increase the likelihood of successfully completing the field work, potentially even just after two winters. **Real Ice**, supported by **Arizona State University**, are proposing to undertake field experiments at Cambridge Bay (**WP6a**). **Arctic Reflections** will conduct work in the

Inuvialuit Settlement Region (**WP6b**) on general ice thickening, and on Svalbard (**WP6c**) on ice arch strengthening. These experiments will be informed by and inform our modelling work on ice growth (**WP2**). They will also help inform our larger scale modelling (**WP3**), our assessment of the impact on albedo (**WP4**), and our work on scalability (**WP7**).

In **WP6a** and **WP6b**, we aim to cover up to 1 km² in the first year, adapting in subsequent years. To observe results by the next melt season, the area re-iced must be large enough to minimise boundary effects which depend on local conditions. Further adjustments in the following year will be made based on the outcome of the results in the first year. In each location, we will measure net ice growth, melting, and the effect of salinity and snow, by pumping water on various test areas, using different methods, and comparing these rigorously with control areas (Fig. 1). We plan to learn, adjust and refine the ice thickening methods annually, so that the most effective ones can be given more focus. Furthermore, we will use a combination of manual and automated measurements during and after the tests. Measurements will include ice and snow thickness, salinity, density and temperature profiles. The automated tools will include six Ice Mass Balance buoys (for temperature profile and ice thickness) as well as tools for net radiation measurements and visual monitoring. For **WP6c**, determining how the thickened ice arch postpones its break-up is the key outcome.

Necessary permits will be obtained annually, including the required environmental impact assessments, to ensure up-to-date detailed plans are shared with relevant national, regional, and local institutions. Permissions have already been granted for the 2024/25 winter season in Cambridge Bay, which will offer a useful baseline for the subsequent winter seasons. In the other regions, contacts have been made, and the permit process has been initiated. To ensure a model of shared ownership with the local community, we will conduct community engagement activities that prioritise transparency, safety, and collaboration throughout the project. These will include outreach initiatives with Indigenous organisations, workshops, seminars, engineering demonstrations, and participation in community events.

We are committed to actively involving local representatives by offering roles such as guides, polar bear guard, and ice-thickening operators, to foster local employment and engagement throughout the project. For the ice arch strengthening work, a community outreach programme will be conducted in two phases, separate from field testing. This will help us understand the importance of ice arches, like those in the Nares Strait, to local communities and gather their perspectives on the advantages and risks to ice arch strengthening. In the first phase, we will build on initial contacts and conduct local interviews to build relationships and understand local concerns. In the second phase, we will implement a more extensive engagement programme. During this phase, we will also subcontract an ecological (desk based) research study to better understand the positive and negative effects of ice arch strengthening. The travel budget proposed for the project will support not only the team members conducting the experiments but also the visits and time spent developing and maintaining relationships with the local communities.

Milestone/funding stage-gate(M6) – Permits & local support obtained in each location for 2025/26 winter

Milestone/funding stage-gate (M18) – No barriers identified in previous winter, and permits & local support obtained in each location for 2026/27 winter

WP7 - Engineering Development: In parallel to **WP6**, engineering work will be undertaken by **Real Ice** and **Arctic Reflections**. They will investigate two different technological approaches and their potential for scaling up ice thickening to areas of approximately 1 million square kilometers. The technological approaches will build on a base of existing technologies, such as ice roads, but will differ from other commercial or emerging technologies due to the unique logistical challenges of the Arctic region, and the need to scale across a large area. Additionally, some components in standard designs will need to be modified to withstand the harsher conditions of the Arctic. Real Ice (**WP7a**) will focus on developing methods using a distributed solution which moves under the ice with underwater drones that automatically performs ice thickening operations. In Year 1 they will develop individual drone functions (such as underwater locomotion, ice perforation, and water pumping) and test these in the laboratory. In Years 2 and 3, up to four drones will be deployed in the Arctic to test scalability and robustness in real-world conditions. These tests will showcase increasingly sophisticated communication, navigation, and collaboration features, enabling the drones to autonomously perform ice thickening operations over larger areas. The drone prototypes will be developed in collaboration with **The Interdisciplinary Center on Sustainability and Climate**. Arctic Reflections (**WP7b**) will focus on developing methods to distribute water across a larger area of ice from larger pumping sites using higher flow rate pumps. They will also develop a method to move these simple, floatable pumping platforms safely and autonomously over the ice. Initially, movement will be achieved with amphibious vehicles. In subsequent years, a semi-autonomous hub & spoke model will be developed, with a centralised, sustainable energy supply hub, supporting and powering multiple mobile pumping platforms around it. Real Ice and Arctic Reflections will liaise with local

communities and institutions to gather views on the different approaches and obtain guidance on potential business and deployment models that would be of interest or acceptable. By pursuing two strategies within this work package, the chances of successfully validating the feasibility of scaling up within the project timeframe are materially improved. This work will be informed by the experience gained from the field experiments (WP6).

Milestone/funding stagegate (M12) – Successful completion of design, delivery and testing/operation of first underwater drone before funding for manufacture of subsequent test drones (WP7a)

Milestone/deliverable (M36) – Successful design, manufacturing and operational test in Arctic conditions of the hub & spoke model, and a full feasibility study detailing a realistic pathway to scaleup, including the relevant operational parameters and required number of units for the ultimate ambition (WP7b)

WP8 - Project Management, Coordination and Synthesis: This project involves a number of teams in different locations. Project management and coordination of the project activities and deliverables across the different work packages will be led by [REDACTED]. One of the more challenging aspects of the project will be the fieldwork. Consequently, Real Ice and Arctic Reflections will meet regularly with [REDACTED] to review progress and proactively identify potential challenges before they arise, ensuring they can be effectively mitigated. The Advisory Group, already part established by the Centre for Climate Repair, will have regular meetings with the fieldwork teams to provide oversight and guidance. All team members will coordinate and agree on the broader engagement and communication of the project and its results. We will hold annual all-team in-person workshops in addition to regular project control meetings.

Milestone/deliverable (M3, M15, M27) – In person meetings of the whole team

3. Technical and non-technical risks/unknowns, and mitigations

The risks and mitigations noted below are key dependencies for the work packages.

1. Pumping of sea water onto sea ice doesn't lead to net increased thickness of ice.

To mitigate, pumping will only be undertaken when air temperatures are sufficiently low and experiments will be monitored in real-time to ascertain growth or reduction during both freezing and melting seasons. The rate of pumping and timescales of relaxation in pumping activity will be factors investigated in order to ensure overall ice growth. The Team already has first-hand experience in successfully conducting ice-thickening experiments on Arctic ice, which were conducted in Nome (Alaska) in winter 2022/23 and in Cambridge Bay (Nunavut) and Svalbard in winter 2023/24 led by Real Ice and Arctic Reflections. Initial observations indicate increased thickness on the surface. However, overall *net* ice growth over the winter (especially in presence of snow) is not yet fully validated and quantified.

2. Artificially introducing material to the surface of existing sea ice could change the ecological and chemical environment of the surface, affect biogeochemistry, and impact carbon pump. Increase in ice thickness could also reduce the amount of sunlight that reaches the base of the ice thereby causing reduction in growth of microalgae.

We will only utilise natural materials (seawater) present in the area to thicken the ice, significantly reducing environmental risks. We will collaborate with [REDACTED] regarding possible ecological and biogeochemical impacts of introducing new material to the ice surface and how timing, pumping rate and depth from which water is pumped could be designed to minimise risk. Ice will likely only be thickened by max 30% and any effect will last less than a season.

3. Export of ice is diverted rather than reduced through increased strength of ice arches.

The impact of strengthened ice arches on the ice extent north of the Nares Strait will be a key aspect being investigated by the modelling work. During our field work, experiments will be focused to limited areas in a much narrower inlet or strait. The risk from our experimental intervention will be minimal.

4. Technical challenges within a given location, unfavourable weather, and a local authority might decide not to support field work in a given winter.

The team is going to use multiple locations for the field work. These are supported by national technical and scientific bases and this will reduce the risks of technical, meteorological and logistical problems. We will incorporate time contingency into field work to help alleviate any issues arising from hold-ups. The use of locations in different regions also reduces the risk of societal challenges preventing any field work.

5. Local communities not supporting execution of field work in areas they own and control.

The teams already have established ongoing relationships with the communities at the sites selected, which greatly helps increase the support for the work – one of the Real Ice team is now living in Northern Canada to aid with relationship building and planning. There is a formal permitting process which has been followed in the past and will be used in the future, to ensure work commences with local communities approval. These steps are to minimise the legal, regulatory and ethical risks associated with the field experiments. The project team already has an Ethics and Governance Advisory Group (see climaterepair.cam.ac.uk) including some indigenous people and social science experts to help guide the team in its work. We plan to expand this depending on advice from the current Advisory Group. Finally, we will continue to invest in community engagement, and also liaise with the ARIA team to coordinate with other funded projects.

6. Health/safety risks in the field (accidents due to extreme weather, wildlife, ice breakup, etc.).

Prior to any staff working overseas, the project leadership will ensure staff have the following: have completed the appropriate training for the work they are undertaking; have all necessary PPE, H&S equipment; completed the appropriate risk assessments and methods statements to carry out their projects; health care assessment; any necessary vaccinations and/or medications; have met all institution/University travel office requirements (particularly regarding Covid-19, visa's and insurance).

7. Technology for Re-thickening Arctic Sea Ice found not to be scalable.

Different technologies for re-thickening Arctic Sea Ice will be developed in parallel (see **WP7**).

4. The Team: The Team possesses a vast breadth of relevant knowledge and experience, with scientific discussions and collaborations among members having existed for a substantial length of time. All team members are passionate about *Re-thickening Arctic Sea Ice* and highly driven by the potential impact this project could have on mitigating the significant loss of sea ice coverage in the Arctic Ocean^{2,3}. While most of the work will be UK-based, the team's international composition provides a valuable skill set. Its diversity allows for the inclusion of geographically varied perspectives, better reflecting the global nature of finding cutting-edge solutions to the climate problem. Further members and advisors will be continually sought to optimise the project's progress. Project lead [REDACTED] and deputy lead [REDACTED] are committing 40% of their time to the project. Key team members from Real Ice and Arctic Reflections are providing 100% of their time to the field trial aspects of the project. All postdoctoral researchers and PhD students involved are 100% allocated to this. Other university Co-Investigators will be providing between 5% and 15% commitment to the project.

(i) **The Interdisciplinary Center on Sustainability and Climate:** The group at Sant'Anna School of Advanced Studies has expertise in biorobotics and bionics, including the development of autonomous underwater systems, as well as smart systems inspired by the living world, and focuses its research in innovative solutions to issues related to sustainability and climate change. <https://www.santannapisa.it/en/institute/biorobotics>.

5. Conclusion This project proposal presents a now-or-never opportunity to help alleviate climate change. It provides the vital step towards determining the feasibility of large-scale sea ice re-thickening, offering a potential targeted, high-impact, low-risk climate intervention. We will address fundamental scientific questions, establish essential partnerships with local communities, and test innovative engineering technologies for re-thickening Arctic sea ice. Our fieldwork will be conducted in a small-scale, reversible manner, and will mimic existing natural processes, adhering to ARIA's oversight and governance principles. Depending on the success of the field, laboratory experiments, and modelling, the project aims to position the teams for scaling up seawater pumping for re-thickening of the Arctic's sea ice. This will include development of respective business plans, and raising of funds to make deployment a reality.

Bibliography

1. Key, J. R., Wang, X., Stoeve, J. C. & Fowler, C. Estimating the cloudy-sky albedo of sea ice and snow from space. *Journal of Geophysical Research: Atmospheres* (2001).
2. Pauling, A. G. & Bitz, C. M. Arctic sea ice response to flooding of the snow layer in future warming scenarios. *Earth's Future* **9**, (2021).
3. Desch, S. J. *et al.* Arctic ice management. *Earth's Future* **5**, 107–127 (2017).
4. Joy, K. H. *et al.* Overview of the Lost Meteorites of Antarctica field campaigns. *Meteorit. Planet. Sci.* **59**, 245–259 (2024).
5. Tsamados, M., Feltham, D. L. & Wilchinsky, A. V. Impact of a new anisotropic rheology on simulations of Arctic sea ice. *J. Geophys. Res. Oceans* **118**, 91–107 (2013).
6. Ólason, E. *et al.* A new brittle rheology and numerical framework for large-scale sea-ice models. *J. Adv. Model. Earth Syst.* **14**, (2022).
7. Pantling, J., Cartlidge, K., Worster, M. G. & Fitzgerald, S. D. Modelling the response of an ice surface to a water flow in the context of ice thickening. *International Journal of Thermal Sciences* **204**, 109232 (2024).
8. van Dijke, L. The implementation of Arctic ice management. (2022).
9. Research Summary Report of Svalbard field test 2024 | Arctic Reflections.
<https://arcticreflections.earth/news/research-summary-report-of-svalbard-field-test/>.
10. Howell, S. E. L. & Brady, M. The dynamic response of sea ice to warming in the canadian arctic archipelago. *Geophys. Res. Lett.* **46**, 13119–13125 (2019).
11. Kirillov, S. *et al.* On the physical settings of ice bridge formation in nares strait. *J. Geophys. Res. Oceans* **126**, (2021).
12. Howell, S. E. L. *et al.* A comparison of arctic ocean sea ice export between nares strait and the canadian arctic archipelago. *J. Geophys. Res. Oceans* **128**, (2023).
13. People of the Ice Bridge: the future of the Pikialasorsuaq.
<https://repository.oceanbestpractices.org/handle/11329/1826?show=full> (2017).
14. Moore, G. W. K., Howell, S. E. L. & Brady, M. Evolving relationship of Nares Strait ice arches on sea ice along the Strait and the North Water, the Arctic's most productive polynya. *Sci. Rep.* **13**, 9809 (2023).
15. Vincent, R. F. A Study of the North Water Polynya Ice Arch using Four Decades of Satellite Data. *Sci. Rep.* **9**, 20278 (2019).
16. Moore, G. W. K., Howell, S., Ballinger, T., McNeil, K. & Brady, M. Contribution of ice dynamics along Nares Strait to the stability of ice arches. *Res. Sq.* (2024) doi:10.21203/rs.3.rs-3976407/v1.
17. Prakash, A., Zhou, Q., Hattermann, T. & Kirchner, N. Impact of the Nares Strait sea ice arches on the long-term stability of the Petermann Glacier Ice Shelf. (2023) doi:10.5194/egusphere-2023-73.
18. Moore, G. W. K., Howell, S. E. L., Brady, M., Xu, X. & McNeil, K. Anomalous collapses of Nares Strait ice arches leads to enhanced export of Arctic sea ice. *Nat. Commun.* **12**, 1 (2021).
19. Rheinländer, J. W. *et al.* Driving mechanisms of an extreme winter sea ice breakup event in the beaufort sea. *Geophys. Res. Lett.* **49**, (2022).
20. Ice Island Study Final Report MMS Project #468.
Accessible: https://www.boem.gov/sites/default/files/boem-newsroom/Library/Publications/2005/c_core_468.pdf. (2005).
21. Fitzgerald, S. D. & Woods, A. W. The instability of a vaporization front in hot porous rock. *Nature* **367**, 450–453 (1994).
22. Evatt, G. W. *et al.* Glacial melt under a porous debris layer. *JoG* **61**, 825–836 (2015).
23. Smedley, A. R. D., Evatt, G. W., Mallinson, A. & Harvey, E. Solar radiative transfer in Antarctic blue ice: spectral considerations, subsurface enhancement, inclusions, and meteorites. *The Cryosphere* **14**, 789–809 (2020).
24. Tsamados, M. *et al.* Impact of variable atmospheric and oceanic form drag on simulations of arctic sea ice*. *J. Phys. Oceanogr.* **44**, 1329–1353 (2014).
25. Nicolaus, M. *et al.* Overview of the MOSAiC expedition: Snow and sea ice. *Elem. Sci. Anth.* **10**, (2022).
26. Hammer, T. C. *et al.* Data from Field Experiments on Sea Ice Restoration by Artificial Flooding. *4TU.ResearchData* (2024) doi:10.4121/dae61d9b-d079-4959-868e-591b7de1b7f6.
27. Hammer, T. C. *et al.* Field data on sea ice restoration by artificial flooding. *Data Brief* **57**, 111117 (2024).

StratoGuard - Global Monitoring of Geoengineering using Micro High-Altitude Balloons.

What do we want to do? Ultra-persistent, solar powered, micro-High-Altitude Balloons (mHABs), stationed primarily in the stratosphere, present a scientific and technological breakthrough in monitoring climate cooling mechanisms, over large scales, at high resolution and for long durations, whilst offering an extremely low regulatory barrier to world-wide operation and adoption. Many potential climate cooling technologies, such as stratospheric aerosols injection or marine cloud brightening, have a poor network of monitoring solutions; satellites lack the spatial, vertical and temporal resolution (e.g. estimations of SO₂ in the stratosphere have a resolution of +/-2km and revisit time of 2 per day¹) to adequately measure the impact of any small-scale interventions in remote equatorial regions where interventions will likely be deployed². Large scale measurements of stratospheric composition using the NASA ER-2 are extremely expensive (\$3500/h)³ and impractical over remote regions. Without a better baseline monitoring system, any active cooling interventions would have to be large scale, politically contentious and potentially risky⁴ before their effects could be detected using current sensing systems.

Voltitude would like to use existing and intermittently occurring phenomena, such as volcanic activity, aircraft contrails, marine traffic, pollution and meteorological events (such as Saharan dust clouds) as pseudo sources of climate cooling technologies, as an ethically sensible stepping stone to future wider scale demonstrations of similar technologies, without meeting the same fate as other climate intervention programmes⁵. We cannot deploy geoengineering techniques until we can adequately monitor and

model their effectiveness. There are already anthropometric and naturally occurring activities that alter the radiation flux of the world; volcanic activity⁶ can present a similar cooling effect to a stratospheric veil and releases the same sulphur dioxide and potential subsequent damage to ozone. Equally marine and aviation traffic has been shown to affect the formation of clouds⁷ to a similar effect as would be instigated by marine cloud brightening⁸. Monitoring of these effects in the short term allows development of technology while meeting the requirements for outside experiments as detailed in the thesis.

Voltitude would like to develop a novel low cost, light weight category (<4kg under the balloon), long endurance micro (<5m diameter) super pressure high altitude balloon capable of navigating for up to 30 days over an altitude range of 55-75kft. The [Super-Pressure \(SP\) mHAB platform](#) is presented in Figure 1 and Figure 2 alongside our existing Zero Pressure (ZP) mHAB. The platform will be capable of carrying a wide range of remote sensing, in-situ and dispensable payloads in the sub 2kg SWaP range. This project will deploy the University of Hertfordshire's Universal Cloud and Aerosol Sounding System (UCASS)⁹ for in-situ measurement of aerosols targeting the Junge Layer (Stratospheric Aerosol Layer)¹⁰ and Voltitude will combine our micro dropsonde with the UoH micro-optical particle sensor to produce a full column data of aerosols all the way to sea level, all in remote regions inaccessible to current sensing systems. Voltitude has also had extensive discussions with the proposed project 'INPUT:ACCESS' team, an airborne particle collector and research ARIA proposal by NOAA Chemical Sciences Laboratory. This is the same research team coordinating the Balloon Baseline Stratospheric Aerosol Profiles (B²SAP) project, which is NOAA's

'Earth's radiation budget initiative' project. The B²SAP project uses other payloads which, if combined with Voltitude's long endurance SP mHAB, could offer new research opportunities by collecting observation data from regions they cannot currently access on their existing B²SAP short duration balloon systems. These include variants of the B²SAP Frost Point Hygrometer (FPH) water vapour; Electrochemical Concentration Cell (ECC) ozone; and Portable Optical Particle Spectrometer (POPS) payloads.

The SP mHAB, combined with our current 5-day endurance ZP mHAB (a type of latex balloon), enables a low cost mHAB network of sensing platforms, offering a range of endurances

and profiling capabilities. For example, our ZP mHAB latex balloon can drift at constant height to remote regions before profiling to sea level, over durations <5days, and our SP mHAB will be able to profile the stratosphere and dispense micro sensors before transiting back for recovery and reuse.

The proposed mission will be to launch from the UK during summer months and demonstrate navigation to the west coast of Africa using each navigation manoeuvre to profile the lower stratosphere with in-situ sensors, measuring aerosol concentration through the 'Junge Layer'. Once over the region of interest, micro-optical particle sensors will be dispensed to profile the lower atmosphere and measure particulates entering the Atlantic from the Saharan dessert. This will be joined in the region by our short duration ZP mHAB system, which we operate out of Cabo Verde, to attempt aggressive profiling manoeuvres from high altitude to sea level, and back, using the ballast budget for profiling instead of navigation. This mission will demonstrate navigation to remote regions over long endurance while gathering stratospheric profile data from different volumes of air. The low-cost, long endurance mHAB system concept will unlock a 'cube sat' style capability in the stratosphere for the scientific community, using networks of mHABs which can be readily deployed from the UK for various measurements of geoengineering. We believe this could also act as a global warning system to detect and highlight rogue scenarios¹¹ from other countries – hence 'StratoGaurd'.

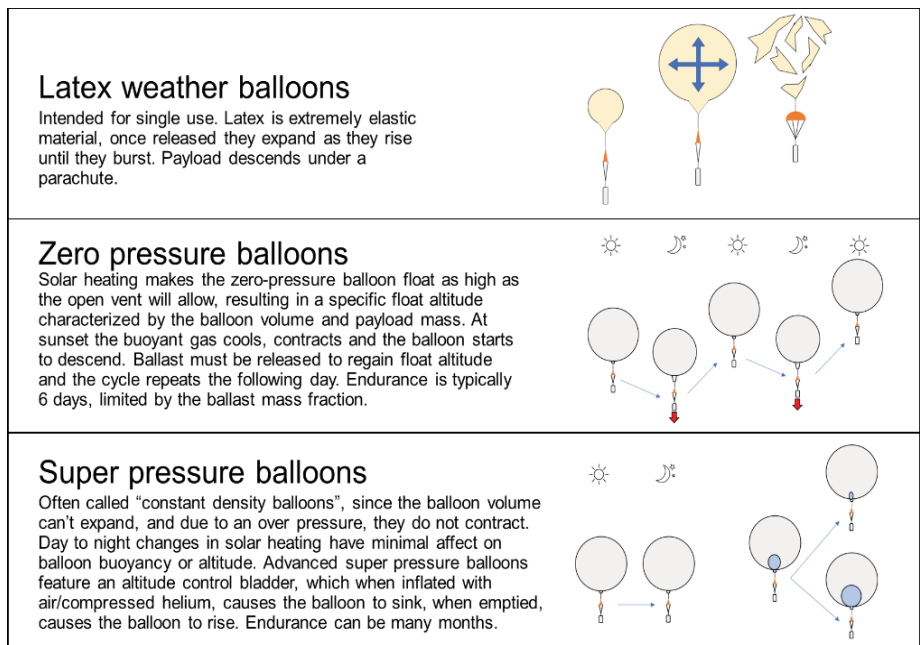
Why is it important? The world is striving towards net zero, however current forecasts by the IPCC¹², make grim reading. 1.1°C of global temperature rise has already occurred, with climate effects directly attributed to this change. Limiting global increases to 1.5°C is possible, however an overshoot is likely which will still impact the climate in ways that may be irreversible including activating climate tipping points. As we become more aware of predicting these events, it is inevitable that an engineering solution may be grasped if these limits are exceeded, and climate change begins to affect the global order. The question is whether that reaction be last minute and 'knee jerk' (as is likely once political realities are applied) or should society prepare for this eventuality, if it is needed. The most credible, both in terms of technical feasibility, political ability, and implementable in a time span to be effective, will be a form of aerosol injection into the tropical tropopause¹³. It is vitally important that were this scenario¹⁴ to play out an adequate method of monitoring the effects and measuring impacts relative to long term fiducial reference measurements¹⁵ would be needed. mHABs are



Figure 3: Example heavy category HAB, after launch (left), fully inflated in the stratosphere (middle), and example station-keeping performance over many days (right).

the only solution that can be implemented within the current International Civil Aviation Organization (ICAO) regulations, and allow global reach at low through-life cost.

Balloon Technology Background: With advancements in the miniaturisation of electronics and improvements in electrical power efficiency, for many missions, there now exist lightweight payloads which do not require the lift capability of heavy category balloons, for example the Aerostar Thunderhead system in Figure 3 and Figure 6. Large HABs can offer extreme endurance, > 200 days has been demonstrated. Modern SP balloons have fine altitude control by pumping air into a ballonnet, permitting the selection of specific wind layers to drift in. By changing altitude to hunt for desired wind drift directions, they can achieve accurate station keeping through an integrated drift vector which aims to remain below a desired station



keeping radius. Common types of balloon systems and how they work are presented in Figure 4. This project will complete development of a small variant of a SP mHAB system which can mimic the amazing navigation and endurance capability of much larger, heavy category, SP HAB systems, and achieve through life cost 100x lower. SP mHAB have fine altitude control, accurate navigation and extremely long endurance. However, their dynamic range in altitude is limited to about 20kft in the stratosphere, i.e. 65kft $\pm$ 10kft. ZP balloons offer multi-day endurance – these systems have more coarse altitude control and navigation is not as accurate, but

Figure 4: Common types of balloons and how they work.

they display extremely large dynamic range in altitude. Project StratoGuard will use a complementary network of SP and ZP mHAB to profile both the entire troposphere and lower stratosphere over remote regions using OPCs and dropsonde sensors. This will be in support of demonstrating climate cooling technology and monitoring methods, including the impact of stratospheric veils and marine cloud brightening.

Navigation and In-Situ Profiling

Balloons that can navigate between 55-75kft are able to access a diversity of wind tracks to allow year-round navigation in equatorial regions, with similar results over higher latitudes in summer months. This allows navigation to extreme remote areas, such as launching in the UK to transit to the west coast of Africa. Altitude changes require energy and in the case of a zero-pressure balloon this means using ballast or venting gas. As these are finite resources this limits endurance on top of the daily heating / cooling cycle so a choice must be made between endurance and profiling / navigation. The balloon navigation concept is presented in Figure

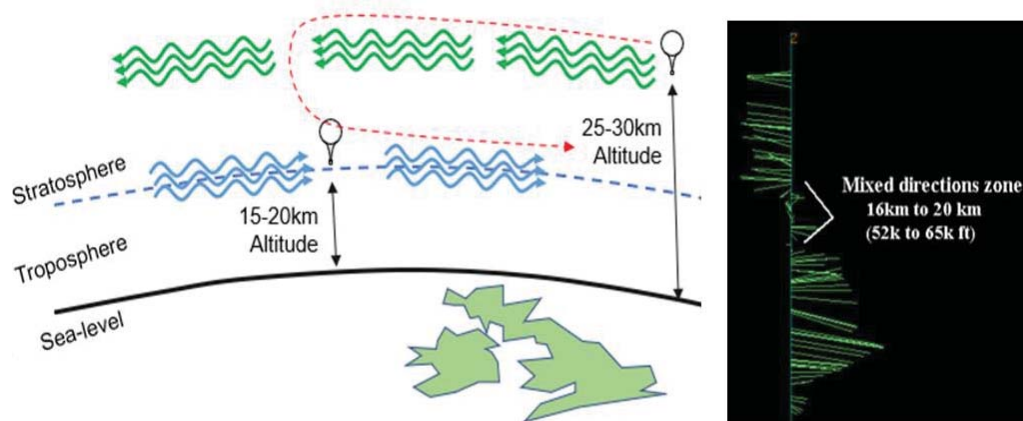
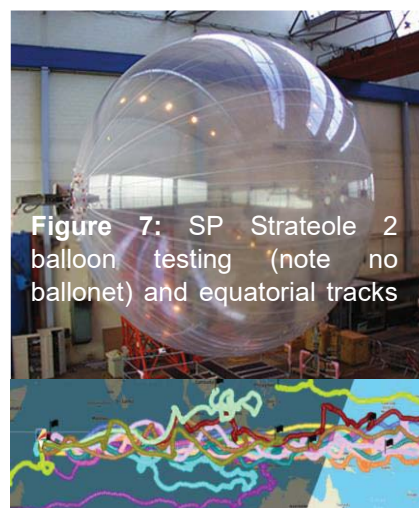
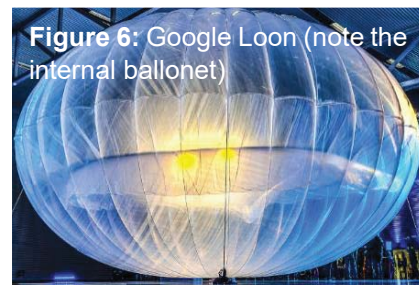


Figure 5: Navigation concept, in the light and variable winds of the lower stratosphere, just above the tropopause, a diversity of wind headings that rapidly change with small changes in altitude, can be selected by altitude controlling balloons to control drift direction and provide navigation.

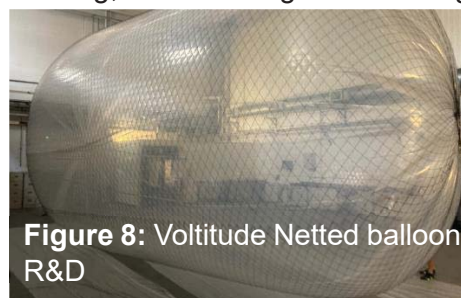
Changing altitude ensures that balloon-borne in-situ sensors measure different air masses and move to new regions and new airmass.

Why hasn't it been done yet? High altitude long endurance navigable super pressure balloons are not new technology; however, the system trade space analysis shows that larger balloons are 'easier' to design, requiring lower material specification and battery/solar array performance while maximising payload mass fraction. The negative is that the envelopes become increasingly complex and expensive. These large balloons are produced on 100ft+ tables with intricate gore designs and quality control processes to maintain sufficient pressure without leaks to overcome the day to nighttime cooling without losing volume and descending (hence 'super pressure'). The Google Loon¹⁶ project (Figure 6) successfully deployed a fleet of these balloons in equatorial regions with endurances above 250 days, with payload capacities of 25kg. However, the unit cost of these systems was in the order of \$500k-\$1m per balloon. Ultimately it was not commercially viable, and these systems now live on only in a military capacity¹⁷ as the Aerostar Thunderhead system.



Other scientific projects such as Strateole 2 have been extremely successful in deploying heavy category constant height super pressure balloons around the equator. These balloons, while successful, can only stay at a constant height. Not only does this mean sampling the same air mass over and over again with in-situ sensors, but there is no ability to move to new altitudes or control locations of overflight. They are also made with high performance biaxially tensioned materials (the skin takes the hoop stress directly as a monocoque as per Figure 7) and require a very high-quality threshold, a small defect will lead to an explosive failure. In contrast, a Google Loon balloon in Figure 6, uses a more puncture-resistant polyethene with shaped 'gores' where defects manifest as slow leaks rather than explosive failure.

All long-duration SP balloons are typically 'heavy category' (>6kg payload) and as such follow a much more stringent approval system, requiring authorisation from each country to enter its airspace. Conversely a light category balloon (<4kg under the envelope) used exclusively for meteorology is authorised to cross state boundaries¹⁸ without prior approval other than the launch state (as per a normal radiosonde launch). Up until now it has not been possible to produce a small super pressure navigable balloon which meets this regulatory category. With advances in battery/array technology, micro-electronics, low SWaP payloads and a novel approach of combining high performance envelopes and commercial netting, Voltitude's ground testing supports progressing this disruptive new technology to operation. No one has tried to make such a small navigable super pressure balloon. There are challenges in realising long endurance self-navigating mHAB within the light regulatory category. The opportunity is a low-cost system which can operate globally, without barriers. A global network would help accurately calibrate prediction models, and better understand the consequences using naturally occurring events¹⁹, opening the door to large scale interventions with much higher confidence levels and provide UK institutions with an unprecedented data set and capability for further modelling. Furthermore, mHAB are more sustainable than heavy category HAB, and accurate navigation presents opportunities for recovery for responsible disposal of balloon envelop and payload reuse.



Envelope: Optimal mHAB envelope performance is the primary risk. Polythene envelopes used for zero-pressure mHABs are readily available at low-cost but cannot maintain any overpressure. This is traditionally overcome (as in the case of Google Loon) via a complex gore pattern and load wires to reduce hoop stress on the material and transfer it to the base. Voltitude have invented a novel combination of using a readily available zero-pressure balloon, and commercial Dyneema netting to produce a low-cost super-pressure balloon. The production of netting used to contain the hoop-stress of the super-pressure balloon "over-pressure" is an established commercial process (primarily from the fishing/sport industry). However there are

[REDACTED]

Effusion: Even ‘air-tight’ balloons lose gas through a process of effusion, compounded due to the small size of hydrogen molecules or helium atoms. In the stratosphere, effusion loss rate is slowed by extremely low ambient temperature, however, it is also proportional to the thickness of the skin material. There is a risk that the thin materials required to make an mHAB viable will not provide sufficient endurance due to the pressure being lost due to effusion. This is mitigated by early testing of candidate balloons and constant altitude flight testing in year 1. [REDACTED]

[REDACTED]

Micro-Compressor and Energy Budget: A compressor is required to fill the ballonets with air and allow multiple navigation manoeuvres or ‘profiles’ for in-situ measurements. Voltitude are experts in regenerative power systems having worked on the power systems for multiple high altitude solar powered aircraft and have extended this knowledge into high altitude ballooning to produce the highest energy density power system possible today. We have a longstanding relationship with [REDACTED] and the ability to manufacture our own custom battery packs within our facilities. A high energy power source still requires an optimised efficient compressor to work in the rarified air in the stratosphere. Voltitude has already prototyped and tested a micro-compressor candidate (Figure 9), although further optimisation is necessary. No commercial off the shelf compressor exists for this use case and at low enough SWaP.

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Micro OPC: The micro OPC technology is the only candidate for including on a micro dropsonde. H [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

StratoGuard Project Plan - All our projects follow project management best practice: we conduct weekly all staff stand up meetings, and each project has a bi-monthly progress review where sub-system managers and delivery channels are reviewed, with actions recorded and tracked and technical / commercial risk registers reviewed. When working with external collaborators our default is fortnightly progress reviews. This way our collaborators are involved, informed, motivated and have strong influential voices into our projects.

The proposed 24-month project plan supports rapid prototyping and integration efforts to take advantage of early summer flight testing, all within the first 9 months of the project. This will support and inform a design optimisation process which will culminate in a demonstration in the second summer flight testing window. The summary project plan (Figure 10) highlights the modular programme with measurable key milestones.

This plan is reflected in a detailed task/resource breakdown under each work package with key interdependencies fully defined. Critical to each year within the programme is following a system engineering “V-cycle” approach to manage the design life cycle, leading to a yearly field trial campaign of the technical activities and allow the programme to pivot as the ARIA opportunity space develops. This approach allows balloon flights to be exploited in other projects, permitting flexibility in mission requirements and can accommodate alternative payloads from sister programmes. Management of technical risk is through early rapid prototyping and real-world test and evaluation, including stratospheric flights on pre-existing high-altitude balloons to inform decisions at engineering gate reviews.

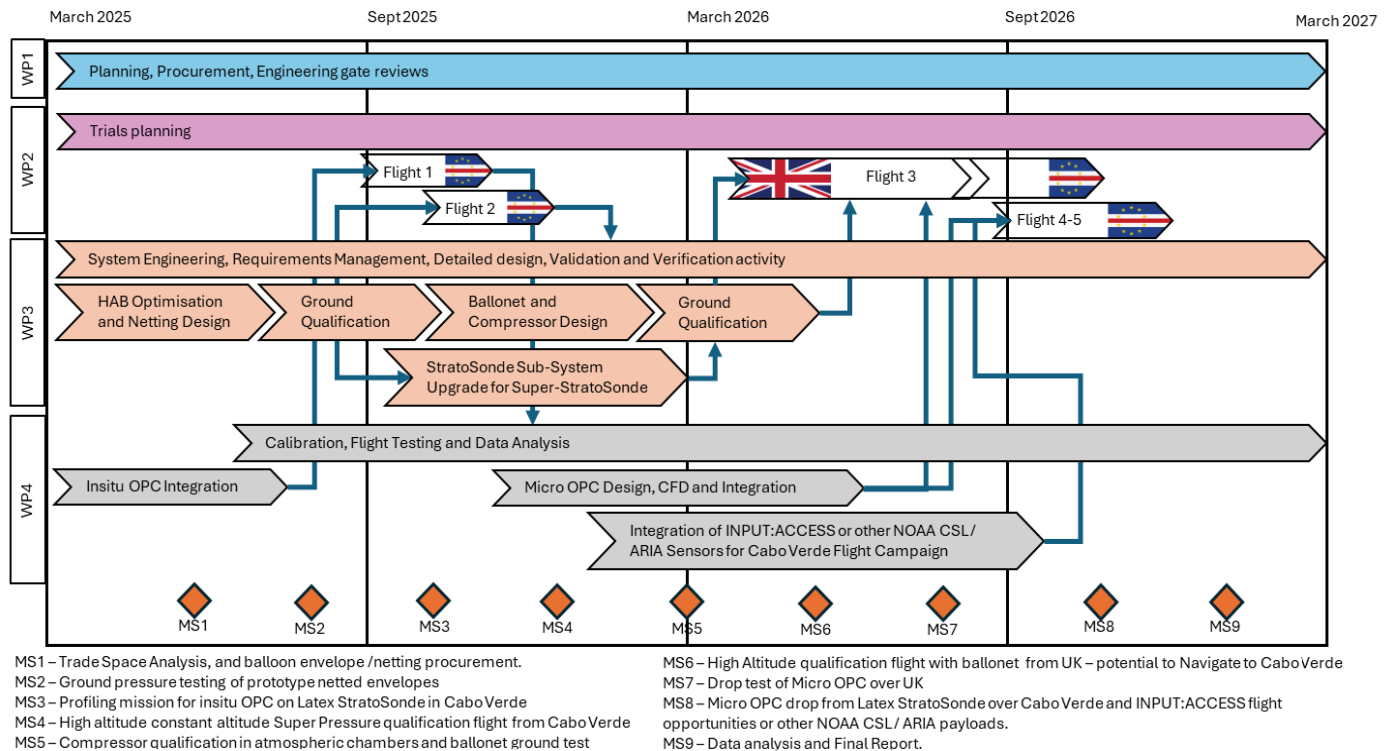


Figure 10: StratoGuard project plan and milestones

The project is delivered through the following work packages:

- WP1 Project / Engineering Management** led by Steve Doughty (Project Manager and Voltitude COO)
- WP2 Field Trials, Logistics and Data Dissemination** led by Jonny King (Delivery Manager and Trails Lead)
- WP3 Platform Development** led by Richard Nash (overall Technical Manager)
- WP4 Payload(s) Development and Integration** (New Hire supported by System Integrator Andy Corrigan)

Year 1: Aim to demonstrate a long duration super-pressure envelope, perform atmospheric profiling mission with in-situ mHAB mounted sensor and qualify sub-systems.

Managed through WP1, early system requirements review, and preliminary design review will establish the specifications and configurations to be tested in this year’s field trials. The specifications will come out of the SP mHAB optimisation and netting design in WP3, culminating in MS1. After completing ground testing to the full over-pressure requirement, MS2, and after a critical design review, flight prototypes of the novel netted balloon envelope will be manufactured and prepared for flight testing the in the stratosphere from Cabo Verde (CV), MS4. The Y1 flight tests, coordinated though WP2, will be without ballonet and compressor. These sub-systems will continue to be developed and optimised and undergo qualification testing in vacuum chambers, MS5, in preparation for integration with the netted mHAB envelope in Y2.

In parallel to the SP mHAB envelope and sub-systems testing, WP4 focuses on integration of the in-situ OPC sensor for mounting on Voltitude’s standard latex StratoSonde balloons. This will permit early testing and calibration of the OPC over the range of ascent and descent speeds expected of ZP mHAB performing full profiles of the entire troposphere and lower stratosphere. WP4 will also perform design, prototyping and ground-based calibration testing of the micro-OPC for integration with Voltitude’s micro-dropsonde, this will be started in Y1 and include iterative optimisation of the sensor air intake through CFD analysis in preparation

for constructing flight test prototypes in Y2. WP4 will also evaluate the feasibility of integrating other ARIA programme payloads from different projects ready for flight-testing in Y2.

Year 2: Aim to demonstrate a long duration navigable super pressure mHAB envelope, featuring balloonnet and demonstrate novel micro-OPC dropsonde and support flights of other ARIA payloads

The Y2 cycle starts with a re-review of system requirements and design reviews to establish inclusion of lessons learnt and design improvements from Y1 into the configuration and specifications to be tested in Y2 field trials. This will include critical design review of the integration of the balloonnet and micro-compressor into the [REDACTED] envelope, prior to assembly of a complete system prototype with OPC payload and dropsondes for the system's qualification test flight from the UK, MS6. This flight will attempt to navigate from the UK to CV, supporting a payload of balloon-mounted in-situ OPC and standard dropsondes.

Integration of the micro-OPC into dropsondes will continue under WP4 and will feature repeat real-world tests from standard latex StratoSonde systems over the UK, MS7, with validation data collected using the balloon-mounted OPC sensor for comparison. WP4 will also complete the integration of other ARIA programme payloads and ensure these are ready for field trials from CV under WP2, culminating in micro-OPC dropsonde and balloon mounted in-situ OPC comparison test flights from CV over the tropical Atlantic, MS8. The end of Y2 should have completed flight test qualification of the SP mHAB system including evaluation of its in-situ balloon-mounted OPC and micro-OPC dropsondes, with comparison test profiles provided by OPC sensors mounted on latex StratoSonde balloon systems. The legacy of project StratoGuard will be to have demonstrated the services available to other research projects of using low-cost SP and ZP mHAB systems in support of climate cooling experiments through the publication and sharing of the analysis and OPC sensor data in the project final report MS9. This might include the flight testing of other ARIA programme payloads.

Why we are the right team: The team at Voltitude have an outstanding track record for innovation and delivery. We are the design team behind the amazing Zephyr solar electric stratospheric aircraft, which is owned and operated by Airbus AALTO. Voltitude is exclusively owned by its employees, and is managed by Paul Stevens, former Zephyr Head-of-Design, and Steve Tate, former Zephyr Architect. We are joined in Voltitude by our most trusted team of design engineers who collectively have over 120 years of HAPS design, manufacturing and operational experience. Formed during the pandemic, Voltitude has grown to 12 full-time members of staff with a turnover ~£1 million/yr. Voltitude has created an environment of innovation where we are tackling the challenges facing the stratospheric industry.

As a team we are all passionate about working to address climate change and finding ways that mHABs can be used for scientific missions. As part of this journey, we invented the StratoSonde® long endurance mHAB balloon and micro-dropsonde system to provide weather data over Atlantic hurricanes (Figure 11).

[REDACTED] While we have the passion and drive of a startup, our team is experienced in managing complex projects and following industry best practices. We are a very experienced multi-disciplinary team covering all engineering competency areas with support from our key collaborators. Geoengineering is something that, in our view, will be inevitable within the coming decades. Our current passion was providing mitigation to the effects of climate change through better weather forecasting of extreme events; however, we are excited to be a potential cornerstone of deploying real intervention strategies and provide the monitoring assurance that it is being done ethically, scientifically and responsibly.

ARIA funding for project StratoGuard will be hugely impactful for Voltitude, allowing us to commit to an accelerated growth plan, focusing on opportunities to train new

scientists and engineers in mHAB design. To achieve this, we are seeking to employ talented people of diverse backgrounds and at varying points in their careers, including continuing and extending our year-in-industry (YIN) student programmes. Our industry has a gross under-representation of women and people of diverse or minority backgrounds which we see reflected in the demographics of students and graduates applying to work with us. We currently fund 2x YIN students each year, boosting our workforce by 20% and providing early engagement of diverse talent as students complete their education. We regularly work and collaborate with research institutions, f [REDACTED]. We are the innovative bridge to ensure silos are broken down to deliver exceptional in-field demonstrations.

Team Bios: Our key team members and collaborators are:

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Consultants (sub-contractors) within project StratoGuard:

NOAA Chemical Sciences Laboratory: Expertise in ice nucleation and cirrus modelling. We will consult with NOAA CSL to gather requirements for monitoring of the Junge Layer and will share all data.

U [REDACTED]

[REDACTED]

Aerostar International Inc, Manufacturer of balloon envelopes and operators of Thunderhead balloons (ex Google Loon team). Voltitude collaborates closely with Aerostar due to their position as the leader in long endurance balloon design and construction.

References

- ¹ Yaowei Li et al, 'In situ measurements of perturbations to stratospheric aerosol and modeled ozone and radiative impacts following the 2021 La Soufrière eruption', 2023
- ² Irvine, P and Keith, D, 'Halving warming with stratospheric aerosol geoengineering moderates policy-relevant climate hazards', 2020
- ³ https://airbornescience.nasa.gov/content/Costing_Support
- ⁴ Bala, G and Caldeira, K, 'Geoengineering Earth's radiation balance to mitigate CO2-induced climate change', 2000
- ⁵ Harvard, (SCoPEX) Stratospheric controlled perturbation experiment to understand the risks of solar geoengineering
- ⁶ McCormick, et al, 'Atmospheric Effects of the Mount Pinatubo Eruption', 1995
- ⁷ Grysperdt, E, 'The impact of Ship Emission Controls Recorded by Cloud Properties', 2019
- ⁸ Bala, Govindasamy et al, 'Albedo enhancement of marine clouds to counteract global warming: Impacts on the hydrological cycle', 2011
- ⁹ <https://amt.copernicus.org/articles/12/6579/2019/>
- ¹⁰ Aloyan, A.E., Arutyunyan, V.O. & Ermakov, A.N. Modeling the Junge Layer Formation in Northern Latitudes: Spatiotemporal Structure and Particle Composition. Russ. Meteorol. Hydrol. 44, 311–316 (2019). <https://doi.org/10.3103/S1068373919050017>
- ¹¹ Weitzman, M, 'A Voting Architecture for the Governance of Free-Driver Externalities, with Application to Geoengineering', 2015
- ¹² Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report (AR6)
- ¹³ Morton, O, 'The Planetary Remade', 2015
- ¹⁴ Keith, D, and MacMartin D, 'A Temporary, Moderate and Responsive Scenario for Solar Geoengineering', 2015
- ¹⁵ Ruddick, K.G et al, 'Protocols for Fiducial Reference Measurements of Downwelling Irradiance', 2019
- ¹⁶ <https://x.company/projects/loon/>
- ¹⁷ <https://thedefensepost.com/2023/12/08/us-army-spy-balloon/>
- ¹⁸ ICAO, Rules of the Air, Annex 2 to the Convention on International Civil Aviation
- ¹⁹ PJ Crutzen, 'Albedo enhancement by stratospheric sulphur injections a contribution to resolve policy dilemma', 2006

21

Towards Robust and Unbiased Validation of SAI Simulations (TRUSS): Advancing Ensemble Calibration for Reliable Geoengineering Impact Analysis

SECTION 1: Programme and Technical

Programme Alignment

This project aligns with ARIA's *Exploring Climate Cooling* programme by addressing a critical gap in the validation of Stratospheric Aerosol Injection (SAI) ensemble simulations. Many existing studies focus on ensemble means but often overlook the variability and uncertainties inherent in the data—key factors for evaluating the robustness of SAI models, especially at regional scales. Our research addresses this by applying advanced calibration methods, including Bayesian and machine learning techniques, to enhance ensemble reliability. By reducing uncertainty and improving model accuracy, we aim to provide more precise climate projections and assessments of both regional and global geoengineering impacts.

This approach directly supports ARIA's objective of advancing the predictability and effectiveness of climate cooling technologies, contributing to more informed climate policies and practical geoengineering implementations. The benefits of this project extend beyond academic research: by producing calibrated and validated SAI ensemble outputs, we equip policymakers with tools to better evaluate the viability and risks of geoengineering strategies. Our methodology presents robust, uncertainty-aware climate impact projections that reduce the risk of overconfidence in model outputs, fostering more cautious and effective climate policy planning. Ultimately, this makes our research an invaluable asset for future climate policy and global response strategies.

Description of Research and Methodology

Our project seeks to address the critical challenge of improving the reliability and interpretability of Stratospheric Aerosol Injection (SAI) ensemble simulations. The research aligns with ARIA's objective of advancing innovative approaches to mitigate climate change by refining climate intervention models, specifically focusing on improving the accuracy of SAI simulations. The project aims to develop a robust validation framework for SAI simulations through advanced post-processing techniques such as Bayesian ensemble calibration and machine learning-based corrections. By enhancing the reliability of ensemble outputs from established simulations, the project contributes to more informed and accurate assessments of SAI's potential as a geoengineering solution.

Ensemble simulations, such as those produced by the ARISE¹ and GLENS² projects, are critical in understanding the potential outcomes of SAI interventions. These ensembles provide multiple climate model runs that attempt to capture the range of possible outcomes given uncertainties in initial conditions, better sampling the long-term changes in oceanic conditions to provide a better constraint over the forced signal by more easily separating it from natural climate variability, thereby making attribution easier. However, much of the current research has focused on ensemble means^{3,4,5}, potentially underestimating the variability and uncertainty inherent in the results. This can mask important differences between individual ensemble members, leading to overconfident predictions about the efficacy or risks associated with SAI, especially at the regional scale. By exploring the degree of agreement between ensemble members and calibrating these outputs, we aim to improve the reliability and robustness of conclusions drawn from SAI simulations. This approach will not only enhance the validation process but will also provide more accurate assessments of the localized and regional impacts of SAI interventions, as well as allowing for more robust analysis of other SAI simulations with smaller ensembles (such as those under the GeoMIP^{6,7} project, which normally only have 1 or 2 model runs) where the variability is undersampled, and of potential future SAI ensembles that include Perturbed Physics Ensembles (PPEs).

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Supporting Data

We will utilize data from the ARISE and GLENS SAI simulations to support our research, with additional observational data from satellite and climate monitoring networks for validation purposes. Previous published studies have demonstrated the effectiveness of Bayesian post-processing and ensemble correction methods in improving the reliability of weather forecasts^{8,9,10,11}. This evidence underlines the scientific foundation of our proposed approach and provides a strong basis for improving SAI ensemble simulation accuracy.

Risk Mitigation Strategies

Technical Risks

Cross-Validation and Sensitivity Testing: To address the risk of inconsistent or unreliable outputs, comprehensive cross-validation and sensitivity analyses will be conducted for all calibration models. These practices will ensure robustness and applicability across various scenarios and datasets, minimizing the potential for model failures or biases in the results.

Non-Technical Risks

Stakeholder Engagement and Communication: A proactive strategy will be employed to engage policymakers and relevant stakeholders, ensuring that research findings are communicated in a clear and transparent manner. This approach includes providing evidence-based explanations of scientific assumptions, potential limitations, and the broader implications of the research. These efforts aim to build trust and encourage the practical adoption of findings, facilitating informed decision-making.

Overview of the Proposed Activity

This project focuses on enhancing the reliability of SAI simulations by addressing variability and uncertainty within ensemble outputs. The main research objectives (ROs) are:

- **(RO1)** Quantify and reduce uncertainty in ensemble outputs from SAI simulations (e.g., ARISE, GLENS).
- **(RO2)** Develop advanced calibration techniques to improve the predictive power and reliability of ensemble simulations, making these techniques available for future ensembles.

- **(RO3)** Validate the developed calibration techniques by comparing calibrated outputs with observational data and alternative simulations.
- **(RO4)** Utilize calibrated ensemble outputs for regional and local SAI impact analysis, simplifying the process by enabling teams to focus on aggregated outputs and their variability.

These objectives are covered through the following work packages:

WP1: Uncertainty Quantification and Calibration (Addresses RO1 and RO2)

This work package focuses on quantifying and reducing uncertainty in SAI ensemble outputs and developing calibration methods. We will perform detailed statistical analyses to understand the variability among ensemble members and quantify the spread and agreement within large ensemble simulations. Moreover, we will create and apply advanced Bayesian calibration and machine learning-based methods to refine ensemble outputs. This step ensures that ensemble data more accurately reflects real-world climate variability and conditions. The deliverable for WP1 is the production of calibrated ensemble simulations output with quantified uncertainty and reduced bias, forming a reliable basis for validation and impact analysis.

WP2: Validation (Addresses RO3)

This package is dedicated to validating the accuracy and reliability of the calibration techniques developed in WP1. We will validate calibrated outputs using historical climate data to ensure models align with observed trends and frequency of extreme events, as well as test the robustness of calibration methods by comparing calibrated outputs with other SAI simulation datasets. Furthermore, we will conduct sensitivity tests to evaluate how reliable the calibration techniques are under various conditions. This working package targets outputs in the form of reliable and validated calibration methods supported by observational data comparisons and sensitivity analyses. The deliverable for WP2 is a comprehensive publication detailing the reliability of pre- and post-calibration ensembles based on historical data.

WP3: Impact Analysis (Addresses RO4)

This work package focuses on using validated ensemble outputs for regional and local impact analysis. We will apply the calibrated ensemble data to understand potential future SAI impacts on specific regions (with a specific focus on Southeast Asia), identifying critical trends and outcomes relevant for policymaking and adaptation strategies. We will also assess and report on the variability within the calibrated ensembles to simplify interpretation for stakeholders. The key deliverables for WP3 are a set of comprehensive regional impact assessments that include quantified variability and support informed decision-making. Furthermore, we will generate detailed reports that present findings clearly, providing actionable insights for policymakers and researchers.

Key Metrics

- *Ensemble Variability Analysis*: Quantification of the variability among ensemble members using statistical measures (e.g., variance, agreement metrics). *Success Metric*: Reduced variability in calibrated outputs.
- *Calibration Accuracy*: Enhancement in predictive accuracy post-calibration using Bayesian and machine learning techniques. *Success Metric*: Significant reduction in prediction error rates compared to uncalibrated models.
- *Validation and Testing*: Comparison of calibration outputs with observational datasets (e.g., temperature) and alternative SAI simulations. *Success Metric*: Demonstrated accuracy and reliability of calibrated outputs, supported by cross-validation results against real-world data.
- *SAI Impact Analysis*: Delivery of robust and reliable results assessing the effectiveness of SAI in moderating climate change impacts. *Success Metric*: Consistent and reliable findings regarding the efficacy of SAI interventions.

The results of our project will be made available publicly through the release of code and results through open-access platforms such as GitHub.

Estimated Timelines and Key Milestones

The project is set to run for 36 months to comprehensively address the outlined research questions. The key milestones and specific activities are detailed in Figure 2.

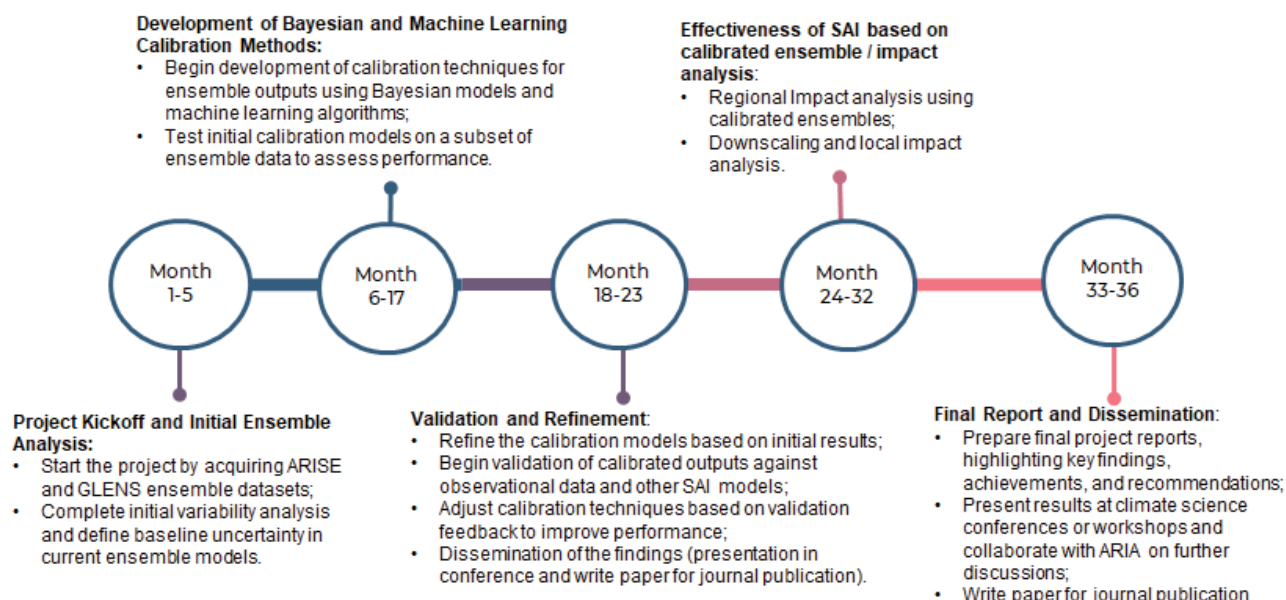


Figure 2. Estimated timelines and project milestone

Dependencies and Assumptions

The project relies on the availability of ensemble simulation data from the ARISE and GLENS projects. It is assumed that these datasets will remain accessible throughout the project timeline without significant delays in acquisition. This will be ensured by the project partners [REDACTED] who have reliable access to the datasets.

Successful execution of the project requires substantial computational resources to run machine learning and Bayesian models on large ensemble datasets, due to the complexity and scale of the analyses. Support from Institut Teknologi Sepuluh Nopember (ITS) has been secured, ensuring access to high-performance computing (HPC) facilities.

Mitigation Strategies

Recognizing the importance of uninterrupted data access and computational capacity, the team has developed proactive plans to address potential risks:

- **Early Data Acquisition:** Data collection will be prioritized at the project's outset to minimize any delays. Backup datasets from alternative climate data repositories will also be secured to mitigate potential disruptions.
- **HPC Resource Management:** Access to ITS's HPC facilities, including the NVIDIA DGX A100 system, will be organized with pre-planned usage schedules and contingency workflows. This approach will ensure continuous analysis, even in the event of unexpected challenges.

These measures are designed to safeguard the project's progress and maintain consistent analytical capabilities throughout the research period.

Ethical and Legal Compliance

This project adheres to all applicable legal frameworks and ethical standards for climate intervention research, ensuring transparency, safety, and global collaboration. The key aspects of our approach include:

1. **Compliance with International and Domestic Laws:**
All research activities will comply with domestic regulations in the countries where data collection, analysis, or project activities occur. Specifically, we will ensure adherence to climate-related research policies, intellectual property laws, and data sharing agreements. The project respects international frameworks such as the Paris Agreement and UN Conventions on Climate Change, ensuring that the research aligns with globally accepted norms for climate intervention and geoengineering practices.
2. **Data Use and Privacy:**
The project will utilize datasets from ARISE and GLENS, ensuring that access complies with licensing agreements and intellectual property rights. Data storage and processing will follow institutional policies for cybersecurity and privacy, safeguarding sensitive information.
3. **Ethical Risk Assessment:**
The potential societal and ecological impacts of SAI simulations will be critically evaluated, with a focus on minimizing harm. For example, we will transparently communicate the scientific basis, assumptions, and limitations of the project to prevent misuse or misinterpretation of results.
4. **Stakeholder Consultation and Public Engagement:**
The project will engage with policymakers, scientific communities, and relevant stakeholders to ensure alignment with societal values and needs. Open forums and workshops will be conducted to gather input and address concerns from the public and key decision-makers. Results, including negative findings, will be made available in an open-access format to foster transparency and informed debate.

Section 2. The team

The proposed project team brings together a multidisciplinary group of experts with deep experience in Stratospheric Aerosol Injection (SAI) simulations, ensemble calibration, and advanced statistical techniques, and computer science.

- [REDACTED]
- [REDACTED]
- [REDACTED]
- [REDACTED]

[REDACTED]

Collaboration: Throughout the project, we will maintain active collaboration and discussions with leading scientists specializing in SRM experiments and ensemble calibration, particularly those cited in this proposal. This collaborative approach will ensure that our methodologies remain cutting-edge and aligned with the latest scientific advancements. We expect our results to be of great use for the validation of future ensembles, as well as downscaled products that might be produce in the next years.

Team Coordination: The project will use a collaborative platform to maintain regular communication among team members and ensure seamless integration of data analysis and model development. Regular bi-weekly meetings will be held to track progress, address challenges, and coordinate tasks. Collaborations with Exeter University and Cornell University will be managed through joint workshops and regular video conferencing.

Motivation and Suitability Our motivation stems from a collective commitment to advancing geoengineering research that accounts for both uncertainty and variability in model predictions. The team's combined expertise in geoengineering, machine learning, and statistical analysis positions them to tackle the unique challenges of SAI ensemble calibration. The PI's proven track record in handling large climate data sets and the collaborative experience of the team members ensures the project's success.

Section 3: Administrative Response

Regulatory, Legal, and Ethical Risks: The project involves handling large-scale climate data, which poses minimal regulatory risk. Data agreements will be secured to comply with privacy and data-sharing regulations. Ethical considerations include ensuring transparency in our calibration methods and results dissemination to policymakers and the public.

Intellectual Property (IP): The proposed methods will not depend on proprietary IP. Any developed tools or software will be shared as open-source to benefit the wider climate research community.

Budget: The project budget will cover personnel costs, HPC access, travel for conferences, and publication fees. A breakdown of costs includes:

- Personnel : PI, co-PI, postdoc, and research assistants.
- Materials : Laptops, cloud-based resources, etc.
- Equipment : Lab admin, maintenance, access to HPC, etc.
- Travel : Conferences and collaborative meetings.
- Others : Publication of paper in journals

References

1. Richter, J. H., D. Vioni, D. G. MacMartin, D. A. Bailey, N. Rosenbloom, B. Dobbins, W. R. Lee, M. Tye, J. -F. Lamarque (2022): Assessing Responses and Impacts of Solar climate intervention on the Earth system with stratospheric aerosol injection (ARISE-SAI): protocol and initial results from the first simulations. *Geosci. Model Dev.*, 15, 8221–8243.
2. Tilmes, S., Richter, J. H., Kravitz, B., MacMartin, D. G., Mills, M. J., Simpson, I. R., Glanville, A. S., Fasullo, J. T., Phillips, A. S., Lamarque, J.-F., Tribbia, J., Edwards, J., Mickelson, S., and Ghosh, S. (2018). CESM1(WACCM) Stratospheric Aerosol Geoengineering Large Ensemble Project, *B. Am. Meteorol. Soc.*, 99, 2361–2371.
3. **H. Kuswanto**, B. Kravitz, B. Mifathurrohman, F. Fauzi, A. Sopaheluwaken, J. Moore (2022). Impact of Solar Geoengineering of Temperatures over the Indonesian Maritime Continent. *International Journal of Climatology* 42(5), 2795-2814. <https://doi.org/10.1002/joc.7391>.
4. Pinto, I., Jack, C., Lennard, C., Tilmes, S. and Odoulami, R.C. (2020). Africa's Climate Response to Solar Radiation Management with Stratospheric Aerosol. *Geophysical Research Letters*, p.e60122
5. Tilmes, S., MacMartin, D. G., Lenaerts, J. T. M., van Kampenhout, L., Muntjewerf, L., Xia, L., Harrison, C. S., Krumhardt, K. M., Mills, M. J., Kravitz, B., and Robock, A.: Reaching 1.5 and 2.0 °C global surface temperature targets using stratospheric aerosol geoengineering. *Earth Syst. Dynam.*, 11, 579–601, <https://doi.org/10.5194/esd-11-579-2020>, 2020.
6. Kravitz, B., A. Robock, O. Boucher, H. Schmidt, K. E. Taylor, G. Stenchikov, and M. Schulz (2011), The Geoengineering Model Intercomparison Project (GeoMIP), *Atmospheric Science Letters*, 12, 162-167, doi:10.1002/asl.316.
7. Vioni, D., Robock, A., Haywood, J., Henry, M., Tilmes, S., MacMartin, D. G., Kravitz, B., Doherty, S. J., Moore, J., Lennard, C., Watanabe, S., Muri, H., Niemeier, U., Boucher, O., Syed, A., Egbebiyi, T. S., Séférián, R., and Quaglia, I. (2024). G6-1.5K-SAI: a new Geoengineering Model Intercomparison Project (GeoMIP) experiment integrating recent advances in solar radiation modification studies, *Geosci. Model Dev.*, 17, 2583–2596, <https://doi.org/10.5194/gmd-17-2583-2024>.
8. Marty, R, Fortin, V., **Kuswanto, H.**, Favre and Parent, E. (2015). Combining the Bayesian Processor of Output with Bayesian Model Averaging for reliable ensemble forecasting. *Journal of Royal Statistical Society C: Applied Statistics*, Vol 64 (1).75-92.
9. Wilks, D. (2017). On assessing calibration of multivariate ensemble forecasts. *Quarterly Journal of the Royal Meteorological Society*, 143 (702): 164-172
10. Raftery, A.E., Gneiting, T., Balabdaoui, F. and Polakowski, M. (2005). Using Bayesian Model Averaging to Calibrate Forecast Ensembles. *Monthly Weather Review*, 133, 1155-1174.
11. Faidah, Y., **Kuswanto, H.**, Sutikno (2022). Improving the Accuracy of Rainfall Prediction Using Bias-Corrected NMME Outputs: A Case Study of Surabaya City, Indonesia. *The Scientific World Journal*, 2022.
12. Lu et al. (2020). Accelerating Gradient Boosting Machines. *Proceedings of the 23rd International Conference on Artificial Intelligence and Statistics (AISTATS) 2020*, Palermo, Italy. PMLR: Volume 108.

Global to Local Impacts of SRM Project (GLISP)

Advancing data accessibility and policy-relevant research

1. Programme and Technical

A. Concept

For the world to make evidence-based and equitable decisions about climate intervention, it must accelerate SRM (solar radiation modification) evaluation in the world's most climate vulnerable regions. Access to high-quality and relevant climate data is prerequisite for the evaluation of SRM and its impacts in the Global South. Data provision is currently underwritten by the goodwill and volunteerism of experts in the Global North, but this approach is reaching its limits. The proposed project would fill this gap by initially performing global statistical downscaling on relevant climate data sets and then creating an accessible data repository housed at the University of Cape Town (UCT). The repository of downscaled data would constitute a public good that would enable much more accessible SRM analysis across the Global South.

The proposed project would then demonstrate the potential of the repository and the downscaled data. It would convene a consortium of SRM experts from Asia, Africa, the Americas and Europe to conduct two global modelling pilot studies on a key global and regional climate impacts, with particular attention to potential regional tipping elements. Having single, authoritative, global studies on the impacts of SRM on key processes and sectors would be invaluable for developing the necessary evidence base to inform policy processes.

This project is proposed by a coalition that is uniquely capable of delivering such an ambitious programme of work. The Degrees Initiative (UK) has singularly transformed the global SRM research environment, and the Degrees Modelling Fund is the largest SRM research programme in the world, supporting 26 SRM research projects in 22 developing countries and emerging economies. Project data provision and downscaling would be managed by leading SRM scientists from the University of Cape Town (South Africa) and Cornell University (USA), and the data repository would be managed at the University of Cape Town, which is already well set up to do this.

B. Barriers, risks, and mitigation

Technical challenges in this project include building and supporting the required computational infrastructure. This requires (1) the computational hardware and related facilities and (2) software support for the storage architecture, modelling software and a user-friendly platform to make the data easily accessible. Both require engineers to support the data centre.

The existing infrastructure and expertise at the Climate Systems Analysis Group (CSAG) at UCT mitigates this challenge. Experienced software and hardware engineers already support a local data centre. Additionally, UCT has an efficient and user-friendly policy to accommodate additional data storage and provide access to the data downscale dataset.

A challenge in any modelling study is mitigating potential inaccuracies in the underlying climate models. Random biases, which often arise from the inherent unpredictability and complexity of the climate system, can vary from one simulation to another due to the sensitivity of the model to initial conditions and small perturbations. Systematic biases, typically due to the simplifications and assumptions made in the structure and parameterisations of Global Climate Models (GCMs), are consistent and repeatable errors that occur in the same way across multiple simulations. While random biases may not be removed by downscaling or bias correction, systematic bias can be reduced or removed using bias correction methods. To address this, we plan to include bias correction with our downscaling.

Non-technical challenges primarily revolve around the climate modelling and selection and validation of downscaling methods for climate data. Scientific decisions are needed to determine the most appropriate experiment design, including downscaling methods, especially for precipitation data, which will require validation using local observed data including rain gauge and satellite-derived data. Furthermore, the selection of specific agricultural and other impact models will require an understanding of available downscaled data and its temporal and spatial resolution. Although any advancement over current large-scale modelling will be beneficial, some variables, such as surface ozone and surface UV, might still rely on raw model output if challenges arise with downscaling these particular datasets.

To mitigate this, UCT has the capacity for both statistical and dynamical downscaling. Collaborations with the Coordinated Regional Downscaling Experiment (CORDEX), facilitated by [REDACTED] have connected the UCT team with a global network of downscaling experts.

It would be beneficial if the data repository remained accessible to researchers from the Global South following the three-year duration of this project. To facilitate this, Degrees will aim to explore external avenues for future funding from the 2nd year of the project onwards to help continue funding the post-doctoral researcher and the technical support expert costs at the University of Cape Town from year 4 onwards. Subsequently, most climate change modelling efforts would then transition to the CMIP7 cycle.

C. Proposed activity of work

We propose a project in three related work packages (WPs), all coordinated by the Degrees Initiative with partners from the USA and across the Global South. The first two WPs would conduct statistical downscaling and bias correction of key global SRM modelling datasets and create a repository for SRM research output. Together, these WPs would improve global access to regional-scale data, provide a foundation for modelling SRM impacts and reduce barriers to research, especially in the Global South. Scientists would be empowered to more easily and accurately understand how SRM might impact their regions which would act as an “output multiplier” for more and better SRM research around the world.

The third WP would convene a pair of global consortia of scientists for two studies modelling the effects of SRM on key policy-relevant climate impacts, such as health, agriculture or water availability, with additional attention to potential tipping elements. These would demonstrate the potential of downscaled data while producing new, policy-relevant science.

WP 1 – SRM information repository

We propose to create a repository of SRM research data and research output housed at the University of Cape Town and managed by a dedicated data technician. This repository will serve as an online, remote data analysis tool that does not require the user to download the data locally, e.g. a Jupyter Hub; a catalogue of all SRM research papers to provide access to a knowledge base often unavailable to researchers at institutions unable to pay article costs; and provide a structured platform to support the broader SRM community. Establishing the hub would represent a public good that acts as an “output multiplier” for SRM evaluation, enabling better and more accessible SRM research worldwide. One post-doctoral researcher will be employed at UCT over years 2 and 3 to support the creation of a repository of SRM research data, and to carry out the technical work in WP3.

WP 2 - Centralised global downscaling and bias correction

This work package will complete a statistical downscaling and bias correction of global climate data using a range of methodologies that have already been employed for future projections of climate change, and that will make the evaluation of the local impacts of SRM more reliable, robust and accessible in conjunction with WP1. The downscaling and bias correction methodologies include Ensemble Generalised Analog Regression Downscaling (En-GARD), bias-correction spatial disaggregation (BCSD, as used in the ISIMIP and NASA-NEX-GDDP-CMIP6 projects) and Multivariate Adapted Constructed Analogs (MACA). Most SD methods downscale only rainfall and temperature. However, this proposal will improve existing downscaled products, such as wind, humidity, and incoming solar radiation, which are required by many impact models, including those for agriculture, health, and renewable energy.

It will leverage current climate model outputs, including the new GeoMIP simulations, which are part of CMIP7 and the ARISE and GAUSS ensembles. The team will employ two post-doctoral researchers, one at UCT who will assist with the downscaling and the other at Cornell University to perform the downscaling based on GeoMIP data. Additionally, the project will provide funding for workshops to educate scientists about the use and limitations of downscaled outputs. The repository mentioned in WP1 will be used to share these outputs globally. The constant engagement with the Degrees Initiative's community will ensure that the downscaled and bias-corrected data can be validated in the regions that matter most, providing a “reality-check” that will allow for a robust, trustworthy product.

WP 3 - Global impacts studies

Degrees will convene a pair of global scientific consortia, each with members from Africa, Asia, and South and Central America to conduct two modelling studies on important impacts of global warming. Possible initial impact studies would include agriculture and food security, water security, extreme heat and heat exposure, health (climate-borne diseases and heat exposure) and biodiversity with additional attention to

potential tipping elements. Such impact studies are reliant on downscaled and bias-corrected climate data, as opposed to the large-scale direct GCM output, to better capture the regionalised and local impacts of changes in temperature and hydrology that are context-dependent (i.e. they might depend on orography in a way that is not captured at the global scale), and therefore will greatly benefit from the output of WP2, which will provide a communal framework for worldwide impact assessments. These studies would represent a significant advancement in global SRM evaluation, offering an unprecedented level of granularity because of the downscaling and bias correction conducted in this project. The same post-doctoral researcher that was mentioned in WP1 will be employed at UCT to conduct the research for years 2 and 3 of the project, as the downscaled data will be produced during year 1. Having demonstrated what is possible and its impact on SRM evaluation, we would then seek further funding from other sources to continue studies on additional impacts. As such, any ARIA funding would leverage additional external funding.

D. Project timeline

Year 1 - Laying foundations and establishing infrastructure

1. Establish a data analysis hub at UCT/CSAG (Months 1 - 6)
 - a. Procure computational hardware for the Climate Systems Analysis Group at the University of Cape Town.
 - b. Install and configure hardware to create a high-performance hub for data analysis, processing and hosting.
 - c. Recruit a qualified technician to support the CSAG analysis hub.
 - d. Hire one post-doctoral research fellow specialising in statistical downscaling and data accessibility.
 - e. Begin the downscaling and secure transfer of relevant datasets to UCT.
2. Begin statistical downscaling (Months 6 - 12):
 - a. Complete statistical downscaling of relevant data sets.
 - b. Testing and validation of initial results.

Year 2: Data processing and regional output development

1. Complete statistical downscaling (Months 1-4):
 - a. Finalise downscaling of datasets and validate outputs for accuracy and reliability using bias-correction.
2. Enhance data accessibility (Months 1-12):
 - a. Ensure the centre maintains high quality downscaled data for key regions including Southeast Asia, Latin America and the Caribbean, South Asia, and Africa.
 - b. Ensuring the centre's data, including the research repository, is easily accessible.
3. Global pilot study (Months 1-12):
 - a. Design and execute a pilot study focusing on a specific climate variable (e.g., precipitation trends or temperature variability) or sector (e.g. agriculture, health, water availability).
4. Create impact study repository (Months 6-12):
 - a. Collect and curate 50 impact studies to begin building the SRM research repository.
5. Data access and usage analytics (Months 3-12):
 - a. Establish tracking systems to monitor data access and usage.
6. Added value study (Months 6-12):
 - a. Begin the analysis to quantify added value the downscaling brings over the raw GCM-scale data. Work closely with CORDEX in this study as they have similar questions.

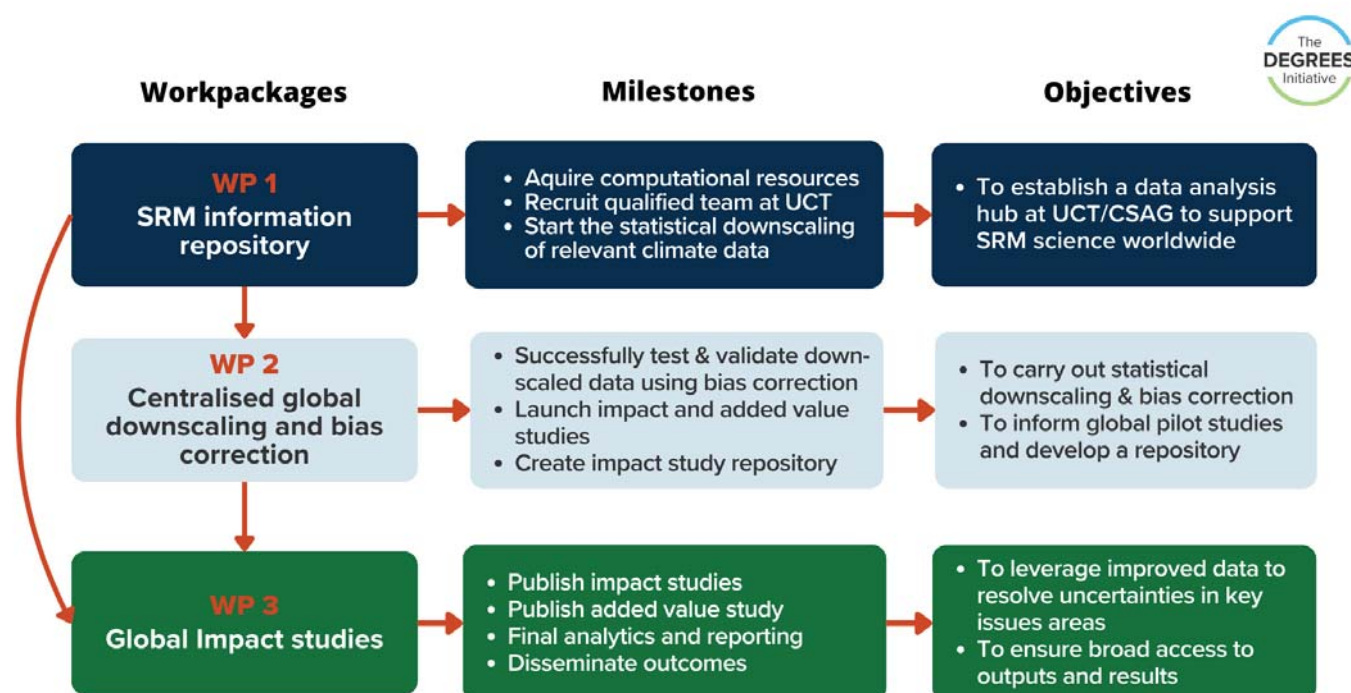
Year 3: Expansion, validation, and delivery

1. Maintain high-quality regional datasets (Months 1-12):
 - a. Ensure datasets are continually updated, refined, and validated for priority regions.
 - b. Collaborate with international partners to address emerging research needs.
2. Complete impact study repository (Months 1-8):

- a. Expand the repository to contain 100 rigorously reviewed impact studies, accessible via the research hub.
3. Complete global impact studies (Months 8-12):
 - a. Complete analysis on chosen impact studies for write up in an international journal.
4. Complete added value study (Months 6-12):
 - a. Complete analysis of added value for write up in an international journal.
5. Final analytics and reporting (Months 8-12):
 - a. Analyse and report on data usage, identifying trends and areas for improvement.
 - b. Develop a comprehensive project report summarising achievements, lessons learned, and recommendations for future initiatives.
6. Dissemination and stakeholder engagement (Months 6-12):
 - a. Host workshops and webinars to share project findings and outputs.
 - b. Engage with stakeholders to identify future collaborative opportunities and funding sources.

Metrics and milestones

Dependencies and milestones diagram



E. Regulatory, legal and ethical risks

To mitigate regulatory, legal, and ethical risks, we will adhere to the AGU (American Geophysical Union) [Ethical Framework for Climate Intervention](#), ensuring that our practices align with the best available internationally recognised standards on SRM. These guidelines will serve as a benchmark for all our project activities, providing a clear framework for ethical conduct and decision-making.

To mitigate regulatory, legal, and ethical risks, UCT has several robust frameworks. These include obtaining legal certificates of compliance to ensure adherence to local and international regulations (<https://uct.ac.za/about-uct-finance/compliance-certificates-and-bank-accounts>). The Research Contracts and Innovation Department supports the navigation of legal complexities and securing necessary agreements and permissions (<https://uct.ac.za/rci>). Additionally, UCT's Office for Research Integrity oversees the ethical aspects of research, ensuring that all projects adhere to high ethical standards (<https://uct.ac.za/research-support-hub/research-integrity>).

2. The Team

F. The project team

[REDACTED]

Programme Director

[REDACTED], *to be hired, 0.2 FTE*

Responsible for defining and shaping the overall project strategies, including establishing clear objectives, priorities, and deliverables that align with the overarching project plan. This role entails ensuring that the project vision is effectively translated into actionable plans and outcomes. Key responsibilities include overseeing the performance and progress of the staff scientist, providing guidance and support to ensure their work aligns with project goals, and serving as the primary point of coordination among various sub-contractors.

Staff Scientist - Project Manager

[REDACTED] *to be hired, 0.5 FTE*

The Staff Scientist will work closely with the Programmes Director to help deliver the project. Responsibilities include helping to coordinate the research between the universities, support the delivery of the workshops, as well as facilitating access to data and to cutting-edge techniques such as statistical downscaling.

[REDACTED]

[REDACTED]

Technical support expert - Information Repository Technician

[REDACTED] *to be hired, 1.0 FTE*

The Climate System Analysis Group at UCT has over the last 15 years built and administered a data centre, developing the expertise to support both the hardware and software components. However, this project will add an additional responsibility for the data centre with respect to technical support, particularly

in the hosting of a cloud-type environment for researchers to conduct analyses on the downscaled data, e.g. a Jupyter-hub. This requires access control and security, set up and administration of the hub environment, user support and developing online training materials on working on the hub. These responsibilities sit beyond those of the current technical support staff and would require a full-time technician able to support the new hardware and software infrastructure around the analysis hub environment.

Post-doctoral researchers - Downscaling Technicians

[REDACTED] *to be hired, 2.0 FTE*

Two post-doctoral researchers will be hired. One will be a 3-year hire to assist with the downscaling and bias correction in WP2 as well as address questions of added value. Added value could be assessed around climate metrics (e.g. extreme events), impact metrics (e.g. health, agriculture), tipping elements (e.g. West African Monsoon or glacier loss) or quantitative metrics (e.g. added value or fractional skill score metrics). The second post-doc will be a 2-year hire to conduct the global impact analysis of the downscaled data (WP3). This analysis will focus on impacts to various sectors and communities, for example agriculture, health, energy and water availability.

[REDACTED]

Post-doctoral researcher

[REDACTED] *to be hired, 1.0 FTE*

A post-doctoral associate will be hired for at least 2 years to perform the downscaling based on GeoMIP data, by firstly testing different downscaling and bias-correction methodologies for temperature and precipitation in collaboration with the other groups in the project and then performing and validating the downscaled data at the global scale.

Additional team members

The project suggests flexible work execution in two ways. First, contracting external support for downscaling may be beneficial. Project leads are currently discussing this with Carbon Plan, a US nonprofit providing climate data services.

Second, the selection of WP3 consortia members will depend on the chosen impacts. Where feasible, we will involve grantees and research collaborators from the Degrees Modelling Fund. They have expertise in with key climate impacts, including agriculture and food security, water security, extreme heat and heat exposure, health and biodiversity.

Potential members could include:

[REDACTED]

G. Participating organisations

The Degrees Initiative

The Degrees Initiative is an NGO committed to placing the Global South at the centre of the conversation on Solar Radiation Modification (SRM). Our vision is a future where experts from every region of the Global South play a central role in SRM evaluation and governance. We work to transform the global landscape by building the capacity of developing countries through outreach workshops, research funding, and community-building activities that foster expertise and collaboration. Neutral on SRM, we focus on inclusiveness, academic excellence, and a commitment to mitigation, advocating for a more informed and equitable global dialogue on SRM.

Climate System Analysis Group, University of Cape Town

The Climate System Analysis Group is a climate research centre at the University of Cape Town. CSAG is a leading hub for climate research in Africa, with a strong emphasis on climate modelling and regional downscaling. It specialises in the development and application of advanced climate models to understand atmospheric, oceanic, and terrestrial processes. CSAG leverages state-of-the-art computational tools and datasets to generate high-resolution climate projections, which are critical for assessing climate variability and change at regional and local scales. CSAG is internationally recognised for its expertise in regional climate modelling and is involved in initiatives like CORDEX (Coordinated Regional Downscaling Experiment). Additionally, CSAG is concerned with generating robust, relevant regional climate change information while advancing understanding of the dynamics and processes driving the coupled climate system.

Cornell University

Cornell University is globally recognised for its research in climate science and expertise in climate modelling, downscaling, and SRM. With a robust track record of interdisciplinary research and innovation, Cornell combines advanced computational techniques with deep domain knowledge to address complex climate challenges. The university's researchers have pioneered scalable downscaling methods that bridge global models with local climate impacts, enabling actionable insights for policy and planning.

Additional organisations

As noted above, we will bring in additional organisations as appropriate into WP2 and especially WP3. Among these are Carbon Plan and the host institutions of the Degrees Modelling Fund grantees and research collaborators. This would demonstrate the value added of access to data, including downscaled, across the Global South.

H. Coordination and management

The Degrees Initiative would be the coordinator of the overall project, leveraging its extensive experience in transforming the global SRM research environment. UCT will lead WPs 1 and 2, focusing on the creation of an SRM information repository and the centralised global downscaling of climate data. The senior staff responsible for these efforts include [REDACTED] and the to be hired programme director at the Degrees Initiative, who will oversee the coordination between the participating organisations, and [REDACTED] and [REDACTED] who will lead the respective work packages. The leadership of WP3 will be determined later based on the topic chosen and the researchers recruited.

Additionally, we will coordinate with Degrees Modelling Fund teams, including those receiving funding through ARIA, to ensure they have access to the data and that we are informed of their research questions and requirements. For example, ARIA brought to our attention the concept note of [REDACTED] [REDACTED], who proposes to research the impacts of SRM on the variability and dynamics of the West African Monsoon—precisely the sort of work that could benefit from the data that we wish to provide. Furthermore, this would provide the opportunity to compare dynamical and statistically downscaled data over the region, a task the UCT postdoctoral researcher could undertake.

I. Gaps in competency

The hiring of the data and analysis hub technician is crucial to the overall goals of the project. This skillset is not yet present at CSAG and would require a thorough hiring process including an interview and competence testing.

J. Motivation

This design of this proposal is informed by over a decade of engagement work on SRM in the Global South, plus extensive experience managing the Degrees Modelling Fund. It is shaped by the advice of Degrees' network of SRM experts in Global North and South in particular at a dedicated three-day convening at the Rockefeller Foundation Bellagio Centerⁱ. Last year, Degrees began a process of regionalisation, transferring coordination capacity to regional hubs across the Global South so that they can set their priorities and collaborate^{iiiv}. These workshops brought together Degrees SRM modelling teams from across Africa, Southeast Asia and Latin America & the Caribbean to discuss what useful regional SRM research might look like in each context. At each of these meetings, scientists outlined key obstacles to advancing regional SRM research. Lack of access to data, and particularly downscaled local climate data, was one of the top concerns across the three meetings.

This view, shared by our network, is also echoed by cutting-edge scientific organisations. In 2021, a committee of the US National Academies called for, among other things, a system for data sharing and an international registry of SRM research^v. Similarly, a committee formed by the UN Environment Programme (UNEP) recommended the promotion of reporting, transparency, inclusiveness and data-sharing^{vi}. Finally, the leadership of the Geoengineering Model Intercomparison Project (GeoMIP) have regularly outlined the need for improved access to data for effective SRM impact modelling, particularly in the Global South^{vii}.

3. Budget narrative

Degrees expects the 3-year proposal to cost £2,180,693 in line with the full cost summary template, including the ARIA calculation for indirect costs. As advised, with Degrees leading the bid, the costs for the University of Cape Town, Cornell University, and the costs for bringing in international expertise in workpackage 3 all constitute sub-contracted costs. Across each year the breakdown of costs is expected to be as follows:

Year 1	£694,523
Year 2	£863,835
Year 3	£622,335
TOTAL	£2,180,693

Given year 1 of the programme will commence with a significant outlay of hardware costs (£250,000) a prudent request would be for these committed costs to be repaid early in the project, or ideally in advance as it would significantly assist with cash flow. The situation will be similar for the hardware costs in year 2 (£100,000). The rest of the costs can be reimbursed through regular invoicing at the time period most convenient to ARIA. We have assumed quarterly stage gates in arrears for the rest of the costs. As such, the expected tranches of funding are as follows:

Initial payment	3 months	6 months	9 months	12 months	15 months	18 months	21 months	24 months	27 months	30 months	33 months	36 months	TOTAL
£ 250,000	£111,131	£111,131	£111,131	£211,131	£ 190,959	£190,959	£190,959	£190,959	£155,584	£155,584	£155,584	£155,584	£2,180,693

ⁱ The Rockefeller Foundation, *Bellagio Center Opens Applications for 2025 Convenings*, <https://www.rockefellerfoundation.org/insights/perspective/bellagio-center-opens-applications-for-2025-convenings/> [accessed 04 Oct 2024].

ⁱⁱ The Degrees Initiative, *Degrees holds workshop on regionalising SRM research in Southeast Asia*, <https://www.degrees.ngo/degrees-holds-workshop-on-regionalising-srm-research-in-southeast-asia/> [accessed 04 Oct 2024].

ⁱⁱⁱ The Degrees Initiative, *African scientists gather in Cape Town to develop collaborative SRM research*, <https://www.degrees.ngo/african-scientists-gather-in-cape-town-to-develop-collaborative-srm-research/> [accessed 04 Oct 2024].

^{iv} The Degrees Initiative, *Degrees holds research planning and regionalisation workshop in Latin America and the Caribbean*, <https://www.degrees.ngo/degrees-holds-research-planning-and-regionalisation-workshop-in-lac/> [accessed 04 Oct 2024].

^v NASEM. Reflecting Sunlight: Recommendations for Solar Geoengineering Research and Research Governance. National Academies Press; 2021, pp. 174, 183. <https://doi.org/10.17226/25762>

^{vi} United Nations Environment Programme (2023). p. 22 [One Atmosphere: An independent expert review on Solar Radiation Modification research and deployment](#). Kenya, Nairobi.

^{vii} Visoni, D., Robock, A., Haywood, J., Henry, M., & Wells, A. (2023). A New Era for the Geoengineering Model Intercomparison Project (GeoMIP). *Bulletin of the American Meteorological Society*, 104(11), E1950-E1955. <https://doi.org/10.1175/BAMS-D-23-0232.1>

^{viii} Visioni, D., Kravitz, B., Robock, A., Tilmes, S., Haywood, J. M., Boucher, O., & Muri, H. (2022). Opinion: The scientific and community-building roles of the Geoengineering Model Intercomparison Project (GeoMIP)-past, present, and future. *Atmospheric chemistry and physics Discussions*, 2022, 1-44. <https://doi.org/10.5194/acp-23-5149-2023>

Section 1: Programme & Technical

1.1 Background & how this work is novel The use of geoengineering as a tool to actively cool the Earth is seen as a potential approach to “buy time” to allow for global decarbonisation. ***Eco-GAP will provide an assessment of the ecological impact of proposed polar geoengineering experiments using an independent, robustly empirical, risk assessment framework.*** There are several reviews on the potential efficacy of geoengineering interventions targeting, for example, solar^{1,2}, aerosol^{3,4}, and ice building^{5,6}. There are also acknowledged challenges linked with the complex geopolitical issues associated with proposed interventions⁷⁻⁹. And, of course, concerns over the potential environmental impact on fragile polar ecosystems¹⁰. However, with perhaps the exception of iron-fertilisation^{11,12}, very few geoengineering concepts have included both modelling and experimental approaches to evaluate impacts and risks to the ecosystem; this is where Eco-GaP is unique and important. Additionally, recognising that the geoengineering space will likely continue to grow, Eco-GaP will develop an ecological risk assessment framework that can be utilised by funding bodies, governing bodies, environmental conservation organisations or geoengineering groups themselves to evaluate future proposed projects.

1.2 Objectives

- Obj1.** Design an Evaluation Framework (EF), with the necessary metrics, from which a robust and thorough assessment of potential ecological impacts due to geoengineering interventions can be established.
- Obj2.** Determine the physical changes that will occur in the ocean, sea-ice and atmosphere, and disentangle the geoengineering intervention impacts from the background and climate driven change.
- Obj3.** Using the outputs from Obj2; identify, test, model and predict shifts in biogeochemical parameters due to physical changes at both large and small spatiotemporal scales.
- Obj4.** Using outputs of Obj2 and Obj3; identify, test, model and predict shifts in the pelagic ecosystem due to physical and biogeochemical changes at both large and small spatiotemporal scales.
- Obj5.** Undertake a comprehensive Ecological Risk Assessment (ERA) of proposed geoengineering interventions to evaluate the scale, timeframe, scope and intensity of the potential ecological impact.

1.3 The challenges We aim to identify and assess the ecological impacts of the polar and marine related geoengineering interventions ARIA have selected for funding. This is a challenging task to fulfil: ideally, the parameters and interactions investigated would be well understood, constrained, and persist at a predictable steady state in polar ecosystems. In reality, many physical and ecosystem processes are not yet well observed or modelled, thus leading to major investigative programmes¹³⁻¹⁷ and are in a state of stress and flux due to global climate change¹⁸⁻²¹. Consequently, identifying changes due exclusively to geoengineering interventions versus its confounding impact with global climate change, even at local scales, is complex. Thus, developing a holistic understanding of the ecological impact risk at multiple spatiotemporal scales and trophic levels is critical. We aim to elucidate and disentangle localised and global impacts of geoengineering interventions from climate change through highly advanced modelling and careful experimental design.

1.4 Project Management The project management structure of Eco-GaP is comparable to those utilised by similar-sized projects. This structure has proven to be effective in integrating scientific objectives with stakeholder involvement to produce results that break systemic barriers, enhance collaborations and interdisciplinary syntheses, and lead to high-profile publications and breakthroughs. It provides exceptional multi-sectoral penetration and decision-maker dialogue opportunities, and significant networking and training opportunities for Early Career Researchers (ECR). To promote equality, diversity and inclusion, Eco-Gap have united professionals from various sectors, backgrounds and stages of career development. Importantly, we have ECR representation at all levels of our project, including co-leadership roles for all WPs, and we strive for gender balance within the project. Project governance is based around a multi-layer, hierarchical, organisational structure, with clear responsibilities assigned to each layer. This robust management process achieves a seamless integration of the project's objectives along with enhanced dialogue – for project partners and stakeholders alike – with the expected transparency and equity. Scientific and managerial decision-making revolves around the Project Management Team (PMT), which consists of the Project Lead (A. Burson), WP co-leads, and the British Antarctic Survey's (BAS) in-house Research Development and Support Team (ReDs). Within ReDs, Eco-GaP will have a dedicated Project Manager who will assist in management tasks including keeping track of deliverables, milestones and maintenance of a risk register. The PMT will oversee communication with the collaborators, organise the annual project meetings as well as facilitate quarterly updates on project activities and deliverables, dissemination priorities, ethics, and other reporting requirements to ARIA. Additionally, Eco-GaP has dedicated resources with BAS's in-house communications team for support with project communications and outreach activities, including social media, website, and the stakeholder conference and summer school organisation. To ensure synergy between deliverables, WP and Task leads will organise team meetings as and when needed. Our annual project meetings (APM) will be in a hybrid format to ensure that all participants can equitably participate. In the spirit of inclusiveness, stakeholder groups and other ARIA projects will be invited to our APM.

1.5 Data Management Given the importance of our results to many stakeholder groups, the necessity for transparency, and the need for others to be able to replicate our findings, we will develop a comprehensive Data Management Plan (DMP) within the first 6 months of the project (WP5, M5.1). We have accounted for dedicated project time with the UK's Polar Data Centre (PDC), which will assist with DMP development. The DMP will ensure we adhere to international standards and best practices for collection, management, access and dissemination of our data. Data products generated will be publicly available in interoperable easy-to-access format. Data will be archived at the PDC (located at BAS) or Centre for Environmental Data Analysis (CEDA; for large volumes of model data, with archiving costs included), and there will be no limitations on sharing, reusing, or re-distributing our data products. A group workspace on the data analysis facility JASMIN will be used to share model data within Eco-GaP, and access will be granted to key outside collaborators. We abide by the TRUST (Transparency, Responsibility, User Focus, Sustainability, Technology), FAIR (findable, accessible, interoperable, and reusable) and CARE (collective benefit, authority to control, responsibility, and ethics) principles for data governance. To this end we will share modified model codes with public access coding platform GitHub.

1.6 Methodology and Work Package Description A diverse range of geoengineering interventions have

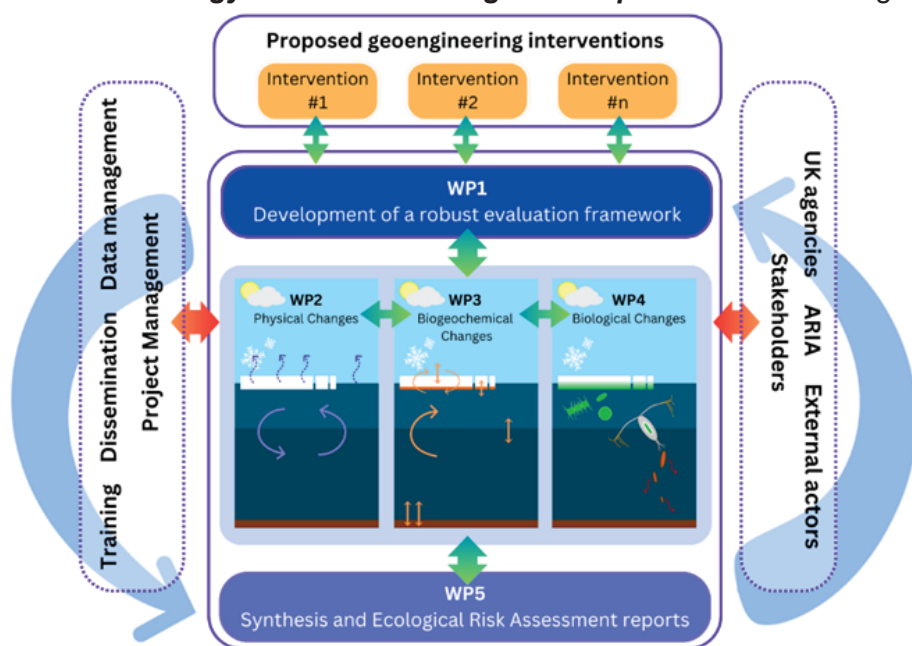


Figure 1: Schematic of WP interconnectivity and links to inputs and outputs

been proposed as potential methods to mitigate climate change by cooling the Earth²². Polar regions have a disproportionate influence on the global climate¹⁸, thus geoengineering projects there have the potential for far reaching impacts. It is important that effects and unintended consequences on the polar ecosystem (and particularly the polar marine ecosystem, where ARIA's proposed interventions are mainly based) are anticipated, understood, and quantified. We have designed five interdisciplinary, iterative, and self-reinforcing Work Packages (WP) with interlinked objectives, and milestones (see Fig. 1). At the top of Fig.1 sit the proposed geoengineering interventions. To constrain our empirical and modelling studies, we will first discuss with the ARIA-funded geoengineering teams the parameters of their proposed interventions in **WP1**. This is a critical step in ascertaining the necessary information to perform our assessment studies and develop a robust Evaluation Framework (EF) (**Obj1**). During the development of the EF we will incorporate standard methodology for the development of monitoring systems for the marine environment by embracing best practice documents for evaluating Marine Protected Areas (MPAs), as well as international guidelines for biodiversity monitoring. Once a draft EF is completed it will be evaluated by an Independent Board of Advisors (IBoA) comprised of experts within key organisations (e.g. Scientific Committee on Antarctic Research, International Arctic Science Committee (IASC), Convention for the Conservation of Antarctic Marine Living Resources (CCMLAR), World Wide Fund for Nature) (**Obj1**). Output of this evaluation will help facilitate WP1 in finalising the EF (WP1: dark blue box Fig 1.). The acceptance of the EF by key stakeholders, via WP5, is a crucial milestone for Eco-GaP, as well as for its use in the evaluation of future geoengineered interventions. The main programme of research is performed in WP2 to WP4, guided by the EF, which will quantify the ecological consequences of the proposed interventions in terms of physical, biogeochemical, and biological changes. **WP2** will assess physical changes in the environment caused by geoengineering interventions, directed by the EF. Within WP2, the physical changes will be contextualised from the perspective of the subsequent changes in the ocean, sea ice and atmospheric environs (**Obj2**). The induced changes will be modelled at multiple scales, using several model platforms (e.g., UK Earth System Modelling (UKESM) at regional and fine scale modelling, ensembles, etc.). The outputs of this will be used to (i) direct the assessment of the associated changes in the biogeochemical environment and subsequently the biological response, (ii) provide physical and climatological impact risk information for the scientific synthesis report, and (iii) be an independent assessment of the efficacy of interventions, giving credence to our subsequent ecological assessments. **WP3** and **WP4** will respectively assess the biogeochemical and biological response of the projected physical changes predicted in WP2 models, both *experimentally*, using sea ice-growth tanks and controlled chemostat culturing facilities and *theoretically* using biogeochemical and pelagic ecosystem

models (**Obj3 & Obj4**). Results of the experimental and modelling exercises performed in WP2-4 will be supplied to **WP5** (light blue box in Fig 1.) and synthesised. This synthesis will inform an Ecological Risk Assessment (ERA) report, that will draw on established methodology^{e.g. 23,24}, to evaluate the potential ecological impacts of the proposed geoengineering interventions and convey these in terms of risk (**Obj5**).

WP1 Development of a robust evaluation framework (Objective 1)	
Inputs: Other ARIA projects, all WPs, IBoA	Outputs: WP2, WP3, WP4, WP5
Co-Leads: ██████████ (*Indicates an Early Career Researcher)	
Participants/CO-I: PDRA2*, co-leads from all WPs	
Overview: WP1 will develop a robust, science-based Evaluation Framework that underpins an independent evaluation of the physical and cascading ecological impacts on the polar marine environment associated with each ARIA-selected geoengineering intervention. A recognised method for quantifying the effects of outside impacts on a marine ecosystem, such as a geoengineering intervention, is through the establishment of an Evaluation Framework (EF). A well-designed, scientifically robust EF allows for definitive conclusions (with quantified uncertainties) to be drawn on the cascading ecological impact across different trophic levels. The main objective of the EF is 1) identify key ecological components and associated environmental parameters that are most likely to be impacted by the intervention and 2) design observational experiments and modelling studies to quantify the ecological consequences of the proposed intervention. WP1.1 Round Table assessment To initiate the drafting of the EF a series of round-table meetings will be held with the proponents of each assessed intervention. The aim of these meetings is to obtain a more complete understanding of (i) the intervention and its spatiotemporal domain, (ii) its expected environmental impacts and (iii) the magnitude of the intended perturbation and how it varies under different Shared Socioeconomic Pathways (SSPs). Co-leads of WP2 to WP4 will participate in the round tables to ensure their modelling and laboratory experiments can be better linked to each intervention. (M1.1) WP1.2 Production of Evaluation Framework Using the outputs of WP1.1 we will co-design (with WP5.1) a step-by-step EF from which an interlinked and comprehensive understanding of physical changes (WP2), biogeochemical changes (WP3) and biological changes (WP4) caused by the intervention can be derived. The EF will include (i) defining clear and achievable objectives, (ii) determining the threshold and boundaries, as well as spatiotemporal limitations of the analysis, (iii) robustly selecting the ecological, environmental and pressure indicators to evaluate^{i.e 25}, and (iv) to identify/compile a baseline (control) dataset from which an assessment of the spatiotemporal impacts of the intervention can be assessed. Data availability, reliability and knowledge gaps will be key considerations when developing the EF. Once the draft EF has been completed it will be delivered to WP5.1 for evaluation by an Independent Board of Advisors (IBoA). This peer-review process is aimed at strengthening the EF, as well as ensuring the framework is flexible enough to be used for future assessments (beyond ARIA). Whilst the EF will remain consistent for the evaluation of selected ARIA-funded geoengineering interventions, the practicalities must be developed on a case-by-case basis. (M1.2) Milestones M1.1 (month 6): Report on round table meetings for each intervention to be assessed. M1.2 (Draft: month 8, Peer-Reviewed: month 12): Delivery of the peer-reviewed Evaluation Framework.	
WP2: The Global and Regional Physical Changes Associated with Geoengineering (Objective 2)	
Inputs: WP1, EF	Outputs: WP3, WP4, & WP5
Co-Leads: ██████████	
Participants/CO-I: ██████████ PDRAs 3,4, & 5*, ESM Engineer, PhD_Oxford*	
Overview: WP2 focuses on diagnosing the physical changes associated with geoengineering interventions by implementing scenarios in global earth system models alongside high-resolution regional ocean-only models to isolate their impacts on sea-ice, oceans and climate. It will assess the physical impact of interventions, quantify their uncertainty, describe the mechanisms responsible and attribute the contribution of feedback processes. This diagnosis and assessment of impacts, uncertainties, and feedbacks supports the WP5 synthesis (M2.4), and provides the physical forcing (boundary conditions) and mechanistic understanding required for the subsequent modelling and analysis of biogeochemical (WP3) and biological (WP4) impacts. WP2.1 Implement Geoengineering Scenarios in UKESM and Regional Ocean models Driven by the WP1 prioritisation, WP2.1 will implement the WP1 geoengineering scenarios using ensembles of UKESM (United Kingdom's Earth System Model)^{26,27} and high-resolution ocean-only regional simulations (M2.1). It will ensure thorough testing of the impact of boundary conditions, model resolution and parameterisation, and other model set-up choices. WP2.2 Track Global and Regional Geoengineering Impacts Across Earth System Components The UKESM is uniquely equipped with BAS developed water tracers^{26,27}. This will allow for a detailed assessment and quantification of the water and climate impacts that are critical to understanding the	

changes and dynamics central to the proposed interventions^{28,29}. As well as using this capability to trace directly where thickened sea ice, precipitation changes, and the oceanic freshwater goes, WP2.2 will also use a BAS developed water mass dynamic framework³⁰ to assess ocean circulation and property distribution changes in response to geoengineering scenarios. These approaches will quantify the responses of essential climate variables, including heat, sea ice and CO₂^{e.g.31} to support WP5 reports. Additionally, an established high-resolution ocean model ACCESS-OM2-01³² will be used to assess the impact of fine-scale processes (e.g. eddies, topography) unresolved in the UKESM, and feedbacks between climate components that may act to compensate geoengineering interventions **(M2.2)**.

WP2.3 Attribute Simulated Changes to Geoengineering Interventions vs. Projected Climate Change

Ensemble simulations of future climate projection(s) and the associated geoengineering simulations will enable robust estimation of causal processes, pathways of changes **(M2.3)** and attribution to intervention versus climate change^{33,34}. Both storyline and probabilistic approach to attribution will be used^{35,36} to establish causality information flow and infer crucial mechanisms³⁷.

Milestones **M2.1 (month 24)**: Initial small ensembles of UKESM and high-resolution/ocean-only simulations to assess how geoengineering interventions affect the physical world and provide (global scale) data required for subsequent risk assessments and physical context for WP3 and WP4. **M2.2 (month 36)**: Track and assess the impact of feedbacks between climate components that may act to compensate geoengineering interventions. **M2.3 (month 36)**: Multi-method attribution and causality analysis for each intervention. **M2.4 (quarterly; final inputs month 42)**: Provide a synthesis report summarising the potential physical changes associated with geoengineering actions.

WP3: Modelling the biogeochemical implications (Objective 3)

Inputs: WP1, WP2

Outputs: WP4, & WP5

Co-Leads: [REDACTED]

Participants/CO-I: [REDACTED] PDRA6*

Overview: WP3 will investigate the sensitivity of biogeochemical cycling to geoengineering implementation in the polar regions¹⁰. The polar regions are important regions for driving global productivity and carbon cycling, both by direct supply of nutrients to the polar surface ocean, and by setting the nutrient signature of global-scale ocean circulation^{38,39}. Using the outputs of WP1 and informed by the quantified outputs of WP2, WP3 will assess the biogeochemical impacts of geoengineering methods using experimental approaches, to determine the key drivers of biogeochemical change, and use observations to quantify changes relative to a baseline. Using established modelling frameworks, this work-package will quantify the sensitivity of biogeochemical variables such as nutrients and alkalinity, to geoengineered changes in an idealised system, e.g. fjord or two-basin ocean. WP3 will then provide a biogeochemical framework that will feed into WP4, identifying key potential bottom-up drivers of ecological impacts of geoengineering interventions **(M3.3)**.

WP3.1. Physical modelling of biogeochemical impacts of different scenarios. Use outputs from WP1 and WP2 to design and execute scaled laboratory-based physical models, either using seawater and/or sea ice incubations to reproduce resultant conditions following geoengineering implementation **(M3.1)**. For example, to reproduce sea ice thickening/albedo geoengineering methods and assess the changes to important drivers of biological production and inorganic carbon cycling, such as the flow of nutrients and alkalinity^{e.g. 40,41}. Laboratory analyses will be carried out in BAS laboratories to calculate the distribution and fluxes of macronutrients, alkalinity and dissolved inorganic carbon (DIC).

WP3.2. Idealised modelling of biogeochemical impacts of geoengineering interventions. Idealised models are well-suited to this purpose because they allow for simple perturbations to key parameters/forcing of interest (i.e. phosphate, alkalinity and DIC) and efficiently allow for large numbers of model experiments. The MIT general circulation model (MITgcm)⁴² presents a flexible and portable modelling framework and includes a range of state-of-the-art numerical schemes. We will investigate the implications for marine biogeochemical processes of two geoengineering scenarios: **i)** We will address biogeochemical impacts of physical changes in upwelling and mixing driven by benthic curtains using an ISOMIP-like (Ice Shelf Ocean Model Intercomparison Project)^{e.g. 43} model with added carbon cycle model⁴⁴. WP2 models will provide far-field conditions to drive the circulation and a simple carbon cycle model and far-field biogeochemical conditions will allow for quantification of the role of benthic curtains in modifying, e.g., surface nutrient supply and changes in productivity. Results will be calibrated against existing datasets to determine the geoengineering-driven anomaly. **ii)** A two-basin sector model of the Atlantic and Pacific with sea ice⁴⁵ and biogeochemical factors^{e.g.46}, designed as part of the BIOPOLE National Capability programme, will be used to consider the biogeochemical impact of sea ice interventions driven by stratification changes. We will use WP2 models to design the sea ice model parameter perturbations required to force geoengineering scenarios and guide the individual experiments. The computational efficiency of this configuration allows for the consideration of even longer (>100 years) timescales. **(M3.2)**

Milestones M3.1 (month 24): Develop capability for, and carry out, a set of sea ice thickening experiments, resolving fundamental nutrient exchange between ice and seawater during sea ice growth and loss. **M3.2 (month 36):** Deliver 3D idealised models with key biogeochemical tracers that can test the sensitivity of carbon and nutrients to proposed geoengineering methods. **M3.3 (quarterly; final inputs month 42):** Provide a synthesis report on the potential changes to nutrient cycles following geoengineering method implementation, and disseminate research.

WP4 Understanding the Biological Change (Objective 4)

Inputs: WP1, WP2, WP3

Outputs: WP5

Co-Leads: [REDACTED]

Participants/CO-I: PDRA7*, [REDACTED]

Overview: WP4 will evaluate the potential impact of geoengineering interventions on the composition, functioning and resilience of pelagic polar ecosystems. We will focus on the plankton component, which underpins the biological carbon pump and is the base of the wider food web^{47,48}. We will assess the individual and combined impacts of these interventions, including additive-synergistic and cascading effects. Using outputs from WP1-3, we will identify potential direct (i.e. habitat loss or degradation, species mortality or displacement) and indirect (i.e. altered food webs or predator-prey dynamics) impacts on community structure and biologically mediated carbon export. We will perform simulation experiments (using a combination of mesocosm incubation and modelling) where organisms will be exposed to environmental conditions reflecting pre- and post-geoengineering intervention scenarios. Findings will be relayed to WP5 and disseminated through scientific publications (**M4.3**).

WP4.1 Laboratory mesocosm simulation of biological impacts. Key marine plankton species will be cultivated-incubated and exposed to environmental stressors (**M4.1**) using multifactorial mesocosm experiments capable of supporting multivariable parameters and treatments under different environmental conditions (i.e. control versus geoengineering-intervention induced stressors such as changed light or nutrient conditions)⁴⁹⁻⁵³. Disturbances such as chemical pollution and physical barriers generated by the geoengineering interventions will also be addressed. Mesocosm experiments will be carried out in BAS climate-controlled laboratories.

WP4.2 Modelling biological impacts. Models informed by WP4.1 outputs will be used to evaluate ecosystem impacts over larger spatial and temporal scales and to further explore the effects of individual and combined stressors⁵⁴ (**M4.2**). The 2D ecosystem models will represent the spatiotemporal dynamics and food web structure of marine plankton under current and changed environmental conditions and will be used to assess impacts on biomass across trophic levels, species composition, network structure, predator-prey dynamics and their implications for ecological resilience and carbon export.

Milestones: M4.1 (month 30) Perform experiments to investigate impact on and resilience of plankton community structure. **M4.2 (month 40)** Deliver a model-based analysis of the impacts of geoengineering interventions on plankton community structure, dynamics, resilience and carbon export. **M4.3 (quarterly; final inputs month 42)** Provide a synthesis report on the potential changes to plankton community and carbon export following geoengineering intervention.

WP5 Synthesis and Ecological Risk Assessment reports (Objective 5)

Inputs: WP1-4, IBoA, select BAS scientific experts

Outputs: WP1, ARIA, UK policy agencies

Co-Leads: [REDACTED] and PDRA2*

Participants/Co-I: [REDACTED] Independent expert Board of Advisors (IBoA), all WP co-leads

Overview: WP5 will work with WP1 to ensure that the design of the Evaluation Framework (EF), is suitable for the delivery of an Ecological Risk Assessment (ERA), synthesise the modelling and experimental results from WP2-4, and produce an ERA report of the proposed geoengineering interventions. Leads will ensure Eco-GaP addresses the three main phases of ecological risk⁵⁵, 1. problem formulation (Obj1), 2. analysis of exposure and effects (Obj2-4) and 3. risk characterisation with considerations of uncertainty (Obj5).

WP5.1 Support development of Evaluation Framework. Once provided with an overview of the proposed geoengineering interventions, WP5 will consult with the IBoA, via roundtable discussion, to inform the development of the EF. The precise composition will depend on the proposed geoengineering intervention, but could include, for example, expertise on benthic communities, higher marine predators (such as birds and marine mammals), fisheries, and invasive species, as well as management and policy experts. The environmental /ecological issues raised during the roundtable discussion will be collated and used to inform the EF design (**M5.2**). WP5 will also work with the ReDs and the PDC to develop the DMP (**M5.1**).

WP5.2 Scientific synthesis of Eco-GaP programme. The results from WP2-4 will be collated, interpreted and summarised to provide a scientific synthesis report for each geoengineering intervention (**M5.3**). Importantly, the synthesis report will also identify uncertainties in analysis and results. The scientific

synthesis report will be shared with the IBoA, as well as an expanded network of experts, if deemed necessary. Additional IBoA roundtable discussions will be held to incorporate input from a broad range of experts to yield a final scientific synthesis of the ecological impact which will ultimately inform the ERA. WP5 co-leads will meet regularly (minimum quarterly) with WP2-4 research teams to receive a steady input of modelling and experimental results allowing a progressive development of the scientific synthesis report, and associated sections of the ERA, with a consolidated effort in the final months.

WP5.3 Ecological Risk Assessment report. Utilising the scientific synthesis report and the input from the IBoA roundtable discussions, an ERA will be undertaken to evaluate the level of ecological risk associated with the proposed geoengineering interventions. This will include evaluation of the (i) likelihood (probability of impact occurring), (ii) magnitude (severity of the impact), (ii) duration (temporary, long-term, or permanent effects), (iv) reversibility (potential for recovery/restoration), and (v) significance (ecological importance). We will provide scaling metrics for these evaluation criteria and ultimately provide a final assessment of the ecological risk associated with geoengineering interventions to be weighed against the theoretical climatological benefit. The structuring of the ERA will begin immediately following the development of the EF and progress in stages as new scientific results are documented during regular meetings with WP2-4 research teams. Upon completion, the ERA report will be disseminated to ARIA, the geoengineering teams and relevant stakeholders as well as presented at the end of project stakeholders conference. The Polar Regions Department (Foreign and Commonwealth and Development Office) is well-placed to share WP5 outputs with international policymakers through the Antarctic Treaty Consultative Meeting (ATCM) and Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), thereby informing international thinking regarding potential issues with geoengineering solutions under the Antarctic Treaty System governance framework and associate environmental impact assessment system. Programme Advisor Hughes and Co-lead Cavanagh work closely with the Polar Regions Department as members of the UK delegations to the ATCM and CCAMLR. Project Lead Burson works closely with IASC and the UK Arctic Office (located within BAS) for dissemination to Arctic stakeholders (**M5.4**)

Milestones: **M5.1 (month 6):** Develop data management plan with PDC and ReDs support. **M5.2 (month 12):** Hold IBoA roundtable discussions to support development of the EF with WP1. **M5.3 (initial structuring from month 9, final conscripting month 40-45):** Scientific synthesis report of modelling and experimental outputs of WP2-4 **M5.4 (initial structuring month 9, final conscripting 45-48):** Development and completion of ERA report. Dissemination of ERA to relevant bodies.

1.7 Project Plan

Work Package	Month of Project																Objectives
WP 1.1			M1.1														1
WP 1.2				M1.2													1
WP 2.1						M2.1											2
WP 2.2													M2.2				2
WP 2.3														M2.3			2
Scientific Synthesis WP2															M2.4		2&5
WP 3.1								M3.1									3
WP 3.2														M3.2			3
Scientific Synthesis WP3																M3.3	3&5
WP 4.1														M4.1			4
WP 4.2															M4.2		4
Scientific Synthesis WP4																M4.3	4&5
WP 5.1			M5.1														1
WP 5.1				M5.2													5
WP 5.2																M5.3	5
WP 5.3																M5.4	5
Annual Project Meeting (APM)					APM1				APM2					APM3			All
Ethics Board Meeting (EBM)					EBM				EBM					EBM			All
Stakeholder Conference (SC)																SC	All
Outreach: ECR exchange																	All
Outreach: Summer school													SS				All

1.6 Managing and mitigating risks

Non-technical risks: Due to the cascading and interconnective nature of this programme, the down-chain risks to later WPs should early WPs be delayed is significant. As much of the modelling and experimental design of WP-2-4 depends on development of an effective EF in WP1, access and willingness of participation with geoengineering project teams is paramount. To mitigate this risk, we will work closely with ARIA to ensure the geoengineering project teams are informed regarding the added value that ecological assessment of their proposals provides not only to them but also to ARIA. **Technical risks:** Other potential risks to early WPs include access interruptions of the NERC HPC platforms. As WP2 output will also inform the specific experimental questions evaluated in WP3 and 4, ensuring efficiency in the modelling stages is important. Should this occur, we would seek to utilise non-NERC HPC platforms as well as perform smaller scale computations within BAS. However, additional resources and modelling time may be required should the

interruptions in access prove to be substantial. **Regulatory, legal & ethical:** Due to the sensitivity of geoengineering projects and potential ethical considerations they involve (e.g. local community and Indigenous community impacts), Eco-GaP, with the assistance of BAS's Communications and Research Development offices, will establish an "ethics board" who will identify, alert, and suggest mitigation strategies for, possible areas of concern. Because we are not proposing any field-based experimentation we do not anticipate regulatory or legal issues, but if any should arise BAS is well equipped with support staff to assist.

Section 2: The Team

[REDACTED]

[REDACTED]

Publications

1. Duffey, A., Irvine, P., Tsamados, M., & Stroeve, J. (2023). Solar geoengineering in the polar regions: A review. *Earth's Future*, 11(6), e2023EF003679. <https://doi.org/10.1029/2023EF003679>
2. Sutter, J., Jones, A., Frölicher, T. L., Wirths, C., & Stocker, T. F. (2023). Climate intervention on a high-emissions pathway could delay but not prevent West Antarctic Ice Sheet demise. *Nature Climate Change*, 13(9), 951-960. <https://doi.org/10.1038/s41558-023-01738-w>
3. Chen, Y., Liu, A., & Moore, J. C. (2020). Mitigation of Arctic permafrost carbon loss through stratospheric aerosol geoengineering. *Nature communications*, 11(1), 2430. <https://doi.org/10.1038/s41467-020-16357-8>
4. Jiang, J., Xia, Y., Cao, L., Kravitz, B., MacMartin, D. G., Fu, J., & Jiang, G. (2024). Different strategies of stratospheric aerosol injection would significantly affect climate extreme mitigation. *Earth's Future*, 12(6), e2023EF004364. <https://doi.org/10.1029/2023EF004364>
5. Minunno, R., Andersson, N., & Morrison, G. M. (2023). A systematic literature review considering the implementation of planetary geoengineering techniques for the mitigation of sea-level rise. *Earth-Science Reviews*, 241, 104431. <https://doi.org/10.1016/j.earscirev.2023.104431>
6. Chakraborty, S., Kambekar, A. R., & Sarma, A. (2023). A Contemporary Review on Geo-engineering Techniques for Mitigation of Accelerated Rise in Global Sea Level in the Past Eight Hottest Years. *Int. J. Environ. Clim. Change*, 13(8), 553-561. <https://doi.org/10.9734/ijec/2023/v13i81983>
7. Versen, J., Mnatsakanyan, Z., & Urpelainen, J. (2022). Concerns of climate intervention: understanding geoengineering security concerns in the Arctic and beyond. *Climatic Change*, 171(3), 27. <https://doi.org/10.1007/s10584-022-03345-8>
8. Flamm, P., & Shibata, A. (2024). 'Ice sheet conservation' and international discord: governing (potential) glacial geoengineering in Antarctica. *International Affairs*, iiae281. <https://doi.org/10.1093/ia/iae281>
9. Kornbech, N., Corry, O., & McLaren, D. (2024). Securing the 'great white shield'? Climate change, Arctic security and the geopolitics of solar geoengineering. *Cooperation and Conflict*, 00108367241269629. <https://doi.org/10.1177/00108367241269629>
10. Siegert, M., Sevestre, H., Bentley, M., Brigham-Grette, J., Burgess, H.,...**Hendry, K...**Truffer, M. (submitted) Safeguarding the polar regions from dangerous geoengineering. <https://doi.org/10.13140/RG.2.2.13179.94246>
11. Fowles, V. (2020). Sea-questration: the effects of marine iron fertilization on phytoplankton carbon uptake in the Southern Ocean.
12. Jiang, H. B., Hutchins, D. A., Zhang, H. R., Feng, Y. Y., Zhang, R. F., Sun, W. W., ... & Chai, F. (2024). Complexities of regulating climate by promoting marine primary production with ocean iron fertilization. *Earth-Science Reviews*, 104675. <https://doi.org/10.1016/j.earscirev.2024.104675>
13. BIOPOLE, <https://biopole.ac.uk/>
14. MOSAIC, <https://www.awi.de/en/focus/mosaic-expedition.html>
15. iCUPE, <https://www.atm.helsinki.fi/icupe/>
16. OCEAN:ICE, <https://ocean-ice.eu/>
17. ArcticPASSION, <https://arcticpassion.eu/>
18. Meredith, M., et al. (2019). Polar regions. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. Retrieved from <https://www.ipcc.ch/srocc/>
19. Otosaka, I. N., Shepherd, A., Ivins, E. R., Schlegel, N. J., Amory, C., van den Broeke, M., ... & Wouters, B. (2022). Mass balance of the Greenland and Antarctic ice sheets from 1992 to 2020. *Earth System Science Data Discussions*, 2022, 1-33. <https://doi.org/10.5194/essd-15-1597-2023>
20. Casado, M., Hébert, R., Faranda, D., & Landais, A. (2023). The quandary of detecting the signature of climate change in Antarctica. *Nature Climate Change*, 13(10), 1082-1088. <https://doi.org/10.1038/s41558-023-01791-5>
21. Meier, W. N., Hovelsrud, G. K., Van Oort, B. E., Key, J. R., Kovacs, K. M., Michel, C., ... & Reist, J. D. (2014). Arctic sea ice in transformation: A review of recent observed changes and impacts on biology and human activity. *Reviews of Geophysics*, 52(3), 185-217. <https://doi.org/10.1002/2013RG000431>
22. ARIA, <https://www.aria.org.uk/exploring-climate-cooling/>
23. Hobday, A. J., Smith, A. D. M., Stobutzki, I. C., Bulman, C., Daley, R., Dambacher, J. M., ... & Zhou, S. (2011). Ecological risk assessment for the effects of fishing. *Fisheries Research*, 108(2-3), 372-384. <https://doi.org/10.1016/j.fishres.2011.01.013>
24. Burgman, M.A., 2005. Risks and Decisions for Conservation and Environmental Management. Cambridge University Press, Cambridge, UK.
25. Noble-James, T., Jesus, A. & McBreen, F. (2018) Monitoring guidance for marine benthic habitats (Revised June 2018), JNCC Report 598, ISSN 0963-8091
26. McLaren, A. J., **Sime, L. C.**, Wilson, S., Ridley, J., Gao, Q., Gorguner, M., Line, G., Werner, M., & Valdes, P. (submitted). Implementation of water tracers in the Met Office Unified Model. Geoscientific Model

Development.

27. McLaren, A. J., **Sime, L. C.**, Gorguner, M., Valdes, P., Wilson, S., Ridley, J., & Gao, Q. (2024). Report on the software implementation of new ice core and marine core relevant code in UKESM1 to enable testing against water isotope measurements (Version 1). Zenodo. <https://doi.org/10.5281/zenodo.10634391>
28. Fiorella, R. P., Siler, N., Nusbaumer, J., & Noone, D. C. (2021). Enhancing understanding of the hydrological cycle via pairing of process-oriented and isotope ratio tracers. *Journal of Advances in Modeling Earth Systems*, 13(10), e2021MS002648. <https://doi.org/10.1029/2021MS002648>
29. Gao, Q., **Sime, L. C.**, McLaren, A. J., Bracegirdle, T. J., Capron, E., Rhodes, R. H., Steen-Larsen, H. C., Shi, X., & Werner, M. (2024). Evaporative controls on Antarctic precipitation: An ECHAM6 model study using innovative water tracer diagnostics. *The Cryosphere*, 18(2), 683–703. <https://doi.org/10.5194/tc-18-683-2024>
30. Sallée, J. B., Shuckburgh, E., Bruneau, N., Meijers, A. J., Bracegirdle, T. J., Wang, Z., & Roy, T. (2013). Assessment of Southern Ocean water mass circulation and characteristics in CMIP5 models: Historical bias and forcing response. *Journal of Geophysical Research: Oceans*, 118(4), 1830–1844. <https://doi.org/10.1002/jgrc.20135>
31. Williams, R. G., Meijers, A. J., Roussenov, V. M., Katavouta, A., Ceppi, P., Rosser, J. P., & Salvi, P. (2024). Asymmetries in the Southern Ocean contribution to global heat and carbon uptake. *Nature Climate Change*, 14(8), 823–831. <https://doi.org/10.1038/s41558-024-02066-3>
32. Kiss, A. E., Hogg, A. M., Hannah, N., Boeira Dias, F., Brassington, G. B., Chamberlain, M. A., ... & Zhang, X. (2020). ACCESS-OM2 v1. 0: a global ocean–sea ice model at three resolutions. *Geoscientific Model Development*, 13(2), 401–442. <https://doi.org/10.5194/gmd-13-401-2020>
33. Stott, P. A., Christidis, N., Otto, F. E., Sun, Y., Vanderlinden, J. P., van Oldenborgh, G. J., ... & Zwiers, F. W. (2016). Attribution of extreme weather and climate-related events. *Wiley Interdisciplinary Reviews: Climate Change*, 7(1), 23–41. <https://doi.org/10.1002/wcc.380>
34. Perkins-Kirkpatrick, S. E., Alexander, L. V., King, A. D., Kew, S. F., Philip, S. Y., Barnes, C., ... & Zscheischler, J. (2024). Frontiers in attributing climate extremes and associated impacts. *Frontiers in Climate*, 6, 1455023. <https://doi.org/10.3389/fclim.2024.1455023>
35. National Academies of Sciences, Division on Earth, Life Studies, Board on Atmospheric Sciences, Committee on Extreme Weather Events, & Climate Change Attribution. (2016). *Attribution of extreme weather events in the context of climate change*. National Academies Press.
36. Shepherd, T. G. (2016). A common framework for approaches to extreme event attribution. *Current Climate Change Reports*, 2, 28–38. <https://doi.org/10.1007/s40641-016-0033-y>
37. Camps-Valls, G., Gerhardus, A., Ninad, U., Varando, G., Martius, G., Balaguer-Ballester, E., ... & Runge, J. (2023). Discovering causal relations and equations from data. *Physics Reports*, 1044, 1–68. <https://doi.org/10.1016/j.physrep.2023.10.005>
38. Tuerena, R. E., Mahaffey, C., Henley, S. F., De La Vega, C., Norman, L., Brand, T., ... & März, C. (2022). Nutrient pathways and their susceptibility to past and future change in the Eurasian Arctic Ocean. *Ambio*, 51, 355–369. <https://doi.org/10.1007/s13280-021-01673-0>
39. Henley, S. F., Cavan, E. L., Fawcett, S. E., Kerr, R., Monteiro, T., Sherrell, R. M., ... & Smith, S. (2020). Changing biogeochemistry of the Southern Ocean and its ecosystem implications. *Frontiers in marine science*, 7, 581. <https://doi.org/10.3389/fmars.2020.00581>
40. Kanna, N., Toyota, T., & Nishioka, J. (2014). Iron and macro-nutrient concentrations in sea ice and their impact on the nutritional status of surface waters in the southern Okhotsk Sea. *Progress in Oceanography*, 126, 44–57. <https://doi.org/10.1016/j.pocean.2014.04.012>
41. Henley, S. F., Cozzi, S., Fripiat, F., Lannuzel, D., Nomura, D., Thomas, D. N., ... & Delille, B. (2023). Macronutrient biogeochemistry in Antarctic land-fast sea ice: Insights from a circumpolar data compilation. *Marine Chemistry*, 257, 104324. <https://doi.org/10.1016/j.marchem.2023.104324>
42. Marshall, J., Adcroft, A., Hill, C., Perelman, L., & Heisey, C. (1997). A finite-volume, incompressible Navier Stokes model for studies of the ocean on parallel computers. *Journal of Geophysical Research: Oceans*, 102(C3), 5753–5766. <https://doi.org/10.1029/96JC02775>
43. Holland, P. R. (2017). The transient response of ice shelf melting to ocean change. *Journal of Physical Oceanography*, 47(8), 2101–2114. <https://doi.org/10.1175/JPO-D-17-0071.1>
44. Dunne, J. P., Bociu, I., Bronselaer, B., Guo, H., John, J. G., Krasting, J. P., ... & Zadeh, N. (2020). Simple global ocean Biogeochemistry with Light, Iron, Nutrients and Gas version 2 (BLINGv2): Model description and simulation characteristics in GFDL's CM4. 0. *Journal of Advances in Modeling Earth Systems*, 12(10), e2019MS002008. <https://doi.org/10.1029/2019MS002008>
45. Zhang, J., & Hibler III, W. D. (1997). On an efficient numerical method for modeling sea ice dynamics. *Journal of Geophysical Research: Oceans*, 102(C4), 8691–8702. <https://doi.org/10.1029/96JC03744>

46. **Munday, D. R.**, Johnson, H. L., & Marshall, D. P. (2014). Impacts and effects of mesoscale ocean eddies on ocean carbon storage and atmospheric pCO₂. *Global Biogeochemical Cycles*, 28(8), 877-896. <https://doi.org/10.1002/2014GB004836>
47. Hunt Jr, G. L., Stabeno, P., Walters, G., Sinclair, E., Brodeur, R. D., Napp, J. M., & Bond, N. A. (2002). Climate change and control of the southeastern Bering Sea pelagic ecosystem. *Deep Sea Research Part II: Topical Studies in Oceanography*, 49(26), 5821-5853. [https://doi.org/10.1016/S0967-0645\(02\)00321-1](https://doi.org/10.1016/S0967-0645(02)00321-1)
48. Steinberg, D. K., & Landry, M. R. (2017). Zooplankton and the ocean carbon cycle. *Annual review of marine science*, 9(1), 413-444. <https://doi.org/10.1146/annurev-marine-010814-015924>
49. Huisman, J., Matthijs, H. C., Visser, P. M., Balke, H., Sigon, C. A., Passarge, J., ... & Mur, L. R. (2002). Principles of the light-limited chemostat: theory and ecological applications. *Antonie van Leeuwenhoek*, 81, 117-133. <https://doi.org/10.1023/A:1020537928216>
50. Jensen, L. K., Carroll, J., Pedersen, G., Hylland, K., Dahle, S., & Bakke, T. (2006). A multi-generation *Calanus finmarchicus* culturing system for use in long-term oil exposure experiments. *Journal of experimental marine biology and ecology*, 333(1), 71-78. <https://doi.org/10.1016/j.jembe.2005.12.001>
51. Stewart, R. I., Dossena, M., Bohan, D. A., Jeppesen, E., Kordas, R. L., Ledger, M. E., ... & Woodward, G. (2013). Mesocosm experiments as a tool for ecological climate-change research. *Advances in ecological research*, 48, 71-181. <https://doi.org/10.1016/B978-0-12-417199-2.00002-1>
52. **Burson, A.**, Stomp, M., Greenwell, E., Grosse, J., & Huisman, J. (2018). Competition for nutrients and light: testing advances in resource competition with a natural phytoplankton community. *Ecology*, 99(5), 1108-1118. <https://doi.org/10.1002/ecy.2187>
53. **Burson, A.**, Stomp, M., Mekkes, L., & Huisman, J. (2019). Stable coexistence of equivalent nutrient competitors through niche differentiation in the light spectrum. *Ecology*, 100(12), e02873. <https://doi.org/10.1002/ecy.2873>
54. D'Alelio, D., Libralato, S., Wyatt, T., & Ribera d'Alcalà, M. (2016). Ecological-network models link diversity, structure and function in the plankton food-web. *Scientific Reports*, 6(1), 21806. <https://doi.org/10.1038/srep21806>
55. Hope, B. K. (2006). An examination of ecological risk assessment and management practices. *Environment International*, 32(8), 983-995. <https://doi.org/10.1016/j.envint.2006.06.005>
56. **Cavanagh, R. D.**, Melbourne-Thomas, J., Grant, S. M., Barnes, D. K., Hughes, K. A., Halfter, S., ... & **Hill, S. L.** (2021). Future risk for Southern Ocean ecosystem services under climate change. *Frontiers in Marine Science*, 7, 615214. <https://doi.org/10.3389/fmars.2020.615214>
57. **Sime, L. C.**, Hopcroft, P. O., & Rhodes, R. H. (2019). Impact of abrupt sea ice loss on Greenland water isotopes during the last glacial period. *Proceedings of the National Academy of Sciences*, 116(10), 4099-4104. doi: 10.1073/pnas.1807261116.
58. Guarino, M. V., **Sime, L. C.**, Diamond, R., Ridley, J., & Schroeder, D. (2023). The coupled system response to 250 years of freshwater forcing: Last Interglacial CMIP6–PMIP4 HadGEM3 simulations. *Climate of the Past*, 19(4), 865-881. <https://doi.org/10.5194/cp-19-865-2023>
59. Roberts, M. J., Reed, K. A., Bao, Q., Barsugli, J. J., Camargo, S. J., Caron, L.-P., Chang, P., Chen, C.-T., Christensen, H. M., Danabasoglu, G., Frenger, I., **Fučkar, N.S.**, et al. (submitted). High Resolution Model Intercomparison Project phase 2 (HighResMIP2) towards CMIP7, *EGUsphere*, egusphere-2024-2582, <https://doi.org/10.5194/egusphere-2024-2582>
60. Notz, D., Dörr, J., Bailey, D., Blockley, E., Bushuk, M., Debernard, J., Dekker, E., DeRepentigny, P., Docquier, D., **Fučkar, N.S.**, et al. (2020) Arctic Sea Ice in CMIP6, *Geophys. Res. Lett.*, <https://doi.org/10.1029/2019GL086749>
61. Uotila, P., Goosse, H., Barthelemy, A., Bricaud, C., Carton, J., **Fučkar, N.S.**, et al. (2019) An assessment of ten ocean reanalyses in the polar regions, *Clim. Dyn.*, 52: 1613. <https://doi.org/10.1007/s00382-018-4242-z>
62. Haarsma, R. J., Roberts, M., Vidale, P. L., Senior, C. A., Bellucci, A., Bao, Q., Chang, P., Corti, S., **Fučkar, N.S.**, et al. (2016) High Resolution Model Intercomparison Project (HighResMIP v1.0) for CMIP6, 2016, *Geosci. Model Dev.*, 9, 4185-4208. <http://dx.doi.org/10.5194/gmd-9-4185-2016>
63. **Fučkar, N. S.**, Massonnet, F., Guemas, V., García-Serrano, J., Bellprat, O., Doblas-Reyes, F. J., & Acosta, M. (2016). 27. Record low northern hemisphere sea ice extent in March 2015. *Bulletin of the American Meteorological Society*, 97(12), S136-S140. <https://doi.org/10.1175/BAMS-D-16-0153.1>
64. **Manno, C.**, Carlig, E., Falco, P. P., Castagno, P., & Budillon, G. (2024). Life strategy of Antarctic silverfish promote large carbon export in Terra Nova Bay, Ross Sea. *Communications Biology*, 7(1), 450. <https://doi.org/10.1038/s42003-024-06122-8>
65. Johnston, L. W., Bergami, E., Rowlands, E., & **Manno, C.** (2023). Organic or junk food? Microplastic contamination in Antarctic krill and salps. *Royal Society Open Science*, 10(3). <https://doi.org/10.1098/rsos.221421>

66. **Manno, C.**, Fielding, S., Stowasser, G., Murphy, E. J., Thorpe, S. E., & Tarling, G. A. (2020). Continuous moulting by Antarctic krill drives major pulses of carbon export in the north Scotia Sea, Southern Ocean. *Nature communications*, 11(1), 6051. <https://doi.org/10.1038/s41467-020-19956-7>
67. **Manno, C.**, Giglio, F., Stowasser, G., Fielding, S., Enderlein, P., & Tarling, G. A. (2018). Threatened species drive the strength of the carbonate pump in the northern Scotia Sea. *Nature communications*, 9(1), 4592. doi: 10.1038/s41467-018-07088-y
68. **Manno, C.**, Peck, V. L., & Tarling, G. A. (2016). Pteropod eggs released at high pCO₂ lack resilience to ocean acidification. *Scientific Reports*, 6(1), 25752. <https://doi.org/10.1038/srep25752>
69. **Meijers, A. J. S.** (2014). The Southern Ocean in the coupled model intercomparison project phase 5. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 372(2019), 20130296. doi: 10.1098/rsta.2013.0296
70. Williams, R. G., **Meijers, A. J.**, Roussenov, V. M., Katavouta, A., Ceppi, P., Rosser, J. P., & Salvi, P. (2024). Asymmetries in the Southern Ocean contribution to global heat and carbon uptake. *Nature Climate Change*, 14(8), 823-831. <https://doi.org/10.1038/s41558-024-02066-3>
71. Zhou, S., **Meijers, A. J.**, Meredith, M. P., Abrahamsen, E. P., Holland, P. R., Silvano, A., ... & Østerhus, S. (2023). Slowdown of Antarctic Bottom Water export driven by climatic wind and sea-ice changes. *Nature climate change*, 13(7), 701-709. <https://doi.org/10.1038/s41558-023-01695-4>
72. Josey, S., **Meijers, A. J. S.**, Blaker, A. T., Grist, J. P., Mecking, J., and Ayres, H. C. (In press) Record Low Antarctic Sea-Ice in 2023 Increased Ocean Heat Loss and Storms. *Nature*.
73. **Meijers, A. J.**, Le Quéré, C., Monteiro, P. M., & Sallée, J. B. (2023). Heat and carbon uptake in the Southern Ocean: the state of the art and future priorities. *Philosophical Transactions of the Royal Society A*, 381(2249), 20220071. <https://doi.org/10.1098/rsta.2022.0071>
74. Ng, H. C., **Hendry, K. R.**, Ward, R., Woodward, E. M. S., Leng, M. J., Pickering, R. A., & Krause, J. W. (2024). Detrital input sustains diatom production off a glaciated Arctic coast. *Geophysical Research Letters*, 51(12), e2024GL108324. <https://doi.org/10.1029/2024GL108324>
75. März, C., Freitas, F. S., Faust, J. C., Godbold, J. A., Henley, S. F., Tessin, A. C., ... **Hendry, K.R.**... & Widdicombe, S. (2022). Biogeochemical consequences of a changing Arctic shelf seafloor ecosystem. *Ambio*, 51, 370-382. <https://doi.org/10.1007/s13280-021-01638-3>
76. Ng, H. C., Cassarino, L., Pickering, R. A., Woodward, E. M. S., Hammond, S. J., & **Hendry, K. R.** (2020). Sediment efflux of silicon on the Greenland margin and implications for the marine silicon cycle. *Earth and Planetary Science Letters*, 529, 115877. <https://doi.org/10.1016/j.epsl.2019.115877>
77. **Hendry, K. R.**, Huvenne, V. A., Robinson, L. F., Annett, A., Badger, M., Jacobel, A. W., ... & Woodward, E. M. S. (2019). The biogeochemical impact of glacial meltwater from Southwest Greenland. *Progress in oceanography*, 176, 102126. <https://doi.org/10.1016/j.pocean.2019.102126>
78. Hawkings, J. R., Wadham, J. L., Benning, L. G., **Hendry, K. R.**, Tranter, M., Tedstone, A., ... & Raiswell, R. (2017). Ice sheets as a missing source of silica to the polar oceans. *Nature communications*, 8(1), 14198. <https://doi.org/10.1038/ncomms14198>
79. **Atherden, F.**, Slomska, A., & Manno, C. (2024). Sediment trap illustrates taxon-specific seasonal signals in Southern Ocean zooplankton. *Marine Biology*, 171(9), 173. <https://doi.org/10.1007/s00227-024-04487-2>
80. Jenkins, H. E., **Atherden, F.**, Cook, K. B., Anderson, T. R., Thornton, B., Mitchell, E., ... & Mayor, D. J. (2022). Grazing, egg production and carbon budgets for *Calanus finmarchicus* across the Fram Strait. *Frontiers in Marine Science*, 9, 981461. <https://doi.org/10.3389/fmars.2022.981461>
81. Mayor, D. J., Cook, K. B., Thornton, B., **Atherden, F.**, Tarling, G. A., & Anderson, T. R. (2022). Biomass turnover rates in metabolically active and inactive marine calanoid copepods. *Frontiers in Marine Science*, 9, 907290. <https://doi.org/10.3389/fmars.2022.907290>
82. Stroeve, J. C., Veyssiere, G., Nab, C., Light, B., Perovich, D., Laliberté, J., ... & **Wilkinson, J.** (2024). Mapping potential timing of ice algal blooms from satellite. *Geophysical Research Letters*, 51(8), e2023GL106486. <https://doi.org/10.1029/2023GL106486>
83. Flores, H., Veyssière, G., Castellani, G., **Wilkinson, J.**, Hoppmann, M., Karcher, M., ... & Stroeve, J. (2023). Sea-ice decline could keep zooplankton deeper for longer. *Nature Climate Change*, 13(10), 1122-1130. <https://doi.org/10.1038/s41558-023-01779-1>
84. Jena, B., Kshitija, S., Bajish, C. C., Turner, J., Holmes, C., **Wilkinson, J.**, et al. (2024). Evolution of Antarctic sea ice ahead of the record low annual maximum extent in September 2023. *Geophysical Research Letters*, 51, e2023GL107561. <https://doi.org/10.1029/2023GL107561>
85. Siegert, M. J., Bentley, M. J., Atkinson, A., Bracegirdle, T. J., Convey, P., Davies, B., ... & **Wilkinson, J.** (2023). Antarctic extreme events. *Frontiers in Environmental Science*, 11, 1229283. <https://doi.org/10.3389/fenvs.2023.1229283>
86. Veyssière, G., Castellani, G., **Wilkinson, J.**, Karcher, M., Hayward, A., Stroeve, J. C., ... & Jung, J. (2022). Under-ice light field in the Western Arctic Ocean during late summer. *Frontiers in Earth*

- Science*, 9, 643737. <https://doi.org/10.3389/feart.2021.643737>
87. Bronselaer, B., Zanna, L., **Munday, D. R.**, and Lowe, J. (2018). Southern Ocean carbon-wind stress feedback. *Clim. Dyn.*, 51:2743–2757. <https://doi.org/10.1007/s00382-017-4041-y>
 88. Klocker, A., **Munday, D.**, Gayen, B., Roquet, F., and LaCasce, J. H. (2023). Deep-reaching global ocean overturning circulation generated by surface buoyancy forcing. *Tellus*, 75:392–409, doi:10.16993/tellusa.3231.
 89. Meredith, M. P., Inall, M. E., Brearley, J. A., Ehmen, T., Sheen, K., **Munday, D.**, Cook, A., Retallick, K., Van Landeghem, K., Gerrish, L., Annet, A., Carvalho, F., **Jones, R.**, Naveira Garabato, A. C., Bull, C. Y. S., Wallis, B. J., Hogg, A. E., and Scourse, J. (2022). Internal tsunamigenesis and ocean mixing driven by glacier calving in Antarctica. *Sci. Adv.*, 8:eadd0720, doi:10.1126/sciadv.add0720.
 90. **Munday, D. R.**, Zhai, X., Harle, J., Coward, A. C., and Nurser, A. J. G. (2021). Relative vs. absolute wind stress in a circumpolar model of the Southern Ocean. *Ocean Model.*, 168:101891, doi:10.1016/j.ocemod.2021.101891.
 91. **Munday, D. R.**, Johnson, H. L., and Marshall, D. P. (2014). Impacts and effects of mesoscale ocean eddies on ocean carbon storage and atmospheric pCO₂. *Global Biogeochem. Cycles*, 28:877–896, doi:10.1002/2014GB004836.
 92. **Jones, R. L.**, Meredith, M. P., Lohan, M. C., Woodward, E. M. S., Van Landeghem, K., Retallick, K., ... & Annett, A. L. (2023). Continued glacial retreat linked to changing macronutrient supply along the West Antarctic Peninsula. *Marine Chemistry*, 251, 104230. <https://doi.org/10.1016/j.marchem.2023.104230>
 93. Constable, A.J., Melbourne-Thomas, J., Muelbert, M.M.C., McCormack, S., Brasier, M., Caccavo, J.A., **Cavanagh, R.D.**, Grant, S.M., Griffiths, H.J., Gutt, J., Henley, S.F., Höfer, J., Hollowed, A.B., Johnston, N.M., Morley, S.A., Murphy, E.J., Pinkerton, M.H., Schloss, I.R., Swadling, K.M., van de Putte, A.P.. (2023) Marine Ecosystem Assessment for the Southern Ocean: Summary for Policymakers. Online, SCAR, SCOR and IMBeR, 74 pp. (.) 10.5281/zenodo.8359585
 94. **Cavanagh, R. D.**, Trathan, P. N., **Hill, S. L.**, Melbourne-Thomas, J., Meredith, M. P., Hollyman, P., ... & Grant, S. M. (2021). Utilising IPCC assessments to support the ecosystem approach to fisheries management within a warming Southern Ocean. *Marine policy*, 131, 104589. <https://doi.org/10.1016/j.marpol.2021.104589>
 95. Tittensor, D. P., Beger, M., Boerder, K., Boyce, D. G., **Cavanagh, R. D.**, Cosandey-Godin, A., ... & Worm, B. (2019). Integrating climate adaptation and biodiversity conservation in the global ocean. *Science Advances*, 5(11), eaay9969. DOI: 10.1126/sciadv.aay996
 96. **Cavanagh, R. D.**, **Hill, S. L.**, Knowland, C. A., & Grant, S. M. (2016). Stakeholder perspectives on ecosystem-based management of the Antarctic krill fishery. *Marine Policy*, 68, 205–211. <https://doi.org/10.1016/j.marpol.2016.03.006>
 97. Eskuche-Keith, P., **Hill, S. L.**, Hollyman, P., Taylor, M. L., & O’Gorman, E. J. (2023). Trophic structuring of modularity alters energy flow through marine food webs. *Frontiers in Marine Science*, 9, 1046150. Doi:10.3389/fmars.2022.1046150
 98. Cavan, E.L. & **Hill, S.L.** (2022) Commercial fishery disturbance of the global ocean biological carbon sink. *Global Change Biology*. 28 (4) 1212-1221 Doi:10.1111/gcb.16019
 99. **Hill, S. L.**, Pinkerton, M. H., Ballerini, T., Cavan, E. L., Gurney, L. J., Martins, I. & Xavier J. C. (2021) Robust model-based indicators of regional differences in food-web structure in the Southern Ocean. *Journal of Marine Systems* 220: 103556. Doi: 10.1016/j.jmarsys.2021.103556
 100. **Hill, S.L.**, Keeble, K., Atkinson, A. and Murphy, E.J., (2012). A foodweb model to explore uncertainties in the South Georgia shelf pelagic ecosystem. *Deep Sea Research Part II: Topical Studies in Oceanography*, 59, pp.237-252. Doi:10.1016/j.dsr2.2011.09.001
 101. **Burson, A.**, Stomp, M., Akil, L., Brussaard, C. P., & Huisman, J. (2016). Unbalanced reduction of nutrient loads has created an offshore gradient from phosphorus to nitrogen limitation in the North Sea. *Limnology and Oceanography*, 61(3), 869–888. <https://doi.org/10.1002/lno.10257>
 102. **Burson, A.**, Matthijs, H. C., de Bruijne, W., Talens, R., Hoogenboom, R., Gerssen, A., ... & Huisman, J. (2014). Termination of a toxic *Alexandrium* bloom with hydrogen peroxide. *Harmful Algae*, 31, 125–135. <https://doi.org/10.1016/j.hal.2013.10.017>
 103. Grosse, J., **Burson, A.**, Stomp, M., Huisman, J., & Boschker, H. T. (2017). From ecological stoichiometry to biochemical composition: variation in N and P supply alters key biosynthetic rates in marine phytoplankton. *Frontiers in Microbiology*, 8, 1299. <https://doi.org/10.3389/fmicb.2017.01299>
 104. Tarling, G. A., Thorpe, S. E., Henley, S. F., **Burson, A.**, Liszka, C. M., **Manno, C.**, ... & Abrahamsen, E. P. (2024). Collapse of a giant iceberg in a dynamic Southern Ocean marine ecosystem: in situ observations of A-68A at South Georgia. *Progress in Oceanography*, 103297. <https://doi.org/10.1016/j.pocean.2024.103297>

Grants

- G1. EU project – Past to future: Towards Paleo-informed future climate projections (P2F). EU framework programme for research and innovation, Horizon Europe (commencing in March 2025) (**Sime institute & WP lead**)
- G2. EU project – Tipping points in the Earth System (TiPES). EU framework programme for research and innovation, Horizon Europe, under grant agreement number 820970 (2019-2024) (**Sime WP & institute lead**).
- G3. EU project – Research and training network on understanding Deep ice corE Proxies to Infer past antarctic climate dynamics (DEEPICE). EU framework programme for research and innovation, Horizon Europe, under grant agreement number 955750 (call: 2021-2024) (**Sime institute lead**).
- G4. NERC Directed (**Co-I Sime**) 2024-29: Assessing ocean-forced, marine-terminating glacier change in Greenland during climatic warm periods and its impact on marine productivity: KANG-GLAC.
- G5. NERC National Capability Single Science (**Co-I Sime**) 2024-28: UK Polar Research Expertise for Science and Society: PRESCIENT
- G6. EU project – Marie Skłodowska-Curie Actions IF (**PI Fučkar**) Attribution of dynamic and thermodynamic components in extreme weather and climate events (2020-2023)
- G7. EPSRC Impact Acceleration Account Fund (**PI Fučkar**) User-oriented information on tropical cyclones and water cycle extremes for the climate and disaster risk management (2023-2024)
- G8. NIHR Research and Innovation for Global Health Transformation Call 5 (**Co-I Fučkar**) The Hospital Risk Insurance System for Kenya (2023-2027)
- G9. Wellcome Trust (**Co-I Fučkar**) Climate Change Impacts on Early Childhood Health and Development: From Evidence to Action (2025-2027)
- G10. NERC Addressing environmental challenges - highlight topic (**Co-I Fučkar**) Drivers and Impacts of Extreme Weather Events in Antarctica: ExtAnt (2024-28)
- G11. CUPIDO II-RENEWAL, UKRI-FLF grant, (**PI, Manno**) 2024-2027: Calculating the strength of the Plastic pump in counteracting the Deep export of Oceanic carbon (CUPIDO) £0.55M
- G12. NERC Directed (**WP Co-lead, Manno**) 2024-29: Assessing ocean-forced, marine-terminating glacier change in Greenland during climatic warm periods and its impact on marine productivity: KANG-GLAC £1.5M.
- G13. UKRI Grant (**Co-I Manno**) BIOPOLE, Biogeochemical processes and ecosystem function in changing polar systems and their global impacts
- G14. CUPIDO, UKRI-FLF grant, (**PI, Manno, £1.2M**) 2020-2024: Calculating the strength of the Plastic pump in counteracting the Deep export of Oceanic carbon (CUPIDO)
- G15. Canada-Inuit Nunangat-UK Arctic Research Programme (CINUK) Inuit Qaujisarnirmut Pilirijjuitit on Arctic Shipping Risks in Inuit Nunangat 2022-2025 (**Co-I Manno**)
- G16. NERC grant 2017-2027 (**WP Co-lead, approx £350K to BAS**), PICCOLO, Processes Influencing Carbon Cycling: Observations of the Lower limb of the Antarctic Overturning
- G17. PRESCIENT (NC-SS2), UK Polar Research Expertise for Science and Society, 2024-2029 (**Manno, WP leader**)
- G18. Horizon Europe – OCEAN:ICE Ocean-Cryosphere Exchanges in Antarctica: Impacts on Climate and the Earth System. (Nov 2022-2026) (**PI Meijers**)
- G19. NERC LTSM2 – BIOPOLE Biogeochemical processes and ecosystem function in changing polar systems and their global impacts (April 2022-2027) (**WP Lead Meijers**)
- G20. Horizon 2020 – SO-CHIC Southern Ocean Carbon and Heat Impact on Climate, (Nov 2019-2024) (**WP & institute lead Meijers**)
- G21. NERC LTSM1 – ORCHESTRA Ocean Regulation of Climate by Heat and Carbon Sequestration and Transports (2016-2021) (**PI Meijers**)
- G22. NERC LTSM1.5 – ENCORE ENCORE is the National Capability Orchestra Extension (2021-2023) (**PI Meijers**)
- G23. NERC Large Grant “POLOMINTS: Polar Ocean Mixing by Internal Tsunamis” (2025-, £3.7M). (**Co-I Hendry**).
- G24. NERC Pushing the Frontiers Grant (2024-2027, £1M) “Silicon Cycling IN Glaciated environments (SiCLING)”. (**PI Hendry**)
- G25. ERC Starter Grant (2016-2021, €2M) “ICY-LAB: Isotope Cycling in the Labrador Sea”. (**PI Hendry**)
- G26. NERC-Conicyt Grant (2016-2019, approx. £680k) “PISCES: Patagonian Ice field Shrinkage impacts on Coastal and fjord Ecosystems”. (**Co-I Hendry**)
- G27. ERC H2020 Consortium Grant (2016-2019, in the theme “Blue Growth: Unlocking the Potential of Seas and Oceans”; approx. £91k to Bristol) “SpongGES: Deep-sea Sponge Grounds Ecosystems of the North Atlantic”. (**Co-I Hendry**).
- G28. Royal Society University Research Fellowship (2013-2021, £450k). (**PI Hendry**).

- G29. NERC Changing Arctic Ocean Strategic Science Grant (2017-2021, approx. £600k to Bristol) “The Changing Arctic Ocean Seafloor (ChAOS)”. **(Co-I Hendry)**.
- G30. NERC Pushing the Frontiers Grant (2024-2027, £1M) “Silicon CycLing IN Glaciated environments (SiCLING)”. **(PDRA Jones)**
- G31. RaCE:TRaX: Radium in Changing Environments: A Novel Tracer of Iron Fluxes at Ocean Margins. **(PhD Jones)**
- G32. Diamond Light MG30572, MG32502 "Determining the composition and lability of glacially-derived iron-rich material from the West Antarctic Peninsula". **(Lead Jones)**
- G33. Diamond Light MG36740 - “The composition and lability of iron-rich sediments from the West Antarctic Peninsula and East Greenland shelf”. **(Lead Jones)**
- G34. KANG-GLAC (2024-29, £1.5M): Assessing ocean-forced, marine-terminating glacier change in Greenland during climatic warm periods and its impact on marine productivity. **(PDRA Atherden)**
- G35. PICCOLO (2017-2027, £330K) Processes Influencing Carbon Cycling: Observations of the Lower limb of the Antarctic Overturning. **(PDRA Atherden)**
- G36. DIAPOD (2017-2022, £701K): Mechanistic understanding of the role of diatoms in the success of the Arctic Calanus complex and implications for a warmer Arctic. **(PhD Atherden)**
- G37. SPITFIRE Placement (2021, 5k). Using sediment traps to monitor the Southern Ocean zooplankton community. **(Lead Atherden)**
- G38. DEFIANT: (NERC: ~£5 million): Drivers and Effects of Fluctuations in sea Ice in the ANTArctic (active) **(Coordinator Wilkinson)**
- G39. PRESCIENT:(NERC: ~£11 million) UK Polar Research Expertise for Science and Society (active) **(Co-I Wilkinson)**
- G40. TRaNSMIT:(EPSRC: £500k) A towable RF system for non-invasive sensing and measurement of Arctic sea ice thickness (active) **(Co-PI Wilkinson)**
- G41. MOSAiC: (NERC: ~£300k): Seasonal evolution of Ku and Ka band backscattering horizon over snow on first-year and multiyear sea ice (completed) **(Co-PI Wilkinson)**
- G42. Arctic PASSION: ~€15 million): Pan-Arctic observing System of Systems: Implementing Observations for societal Needs (active) **(Lead team Wilkinson)**
- G43. EU PolarNet 2: (~€3 million): EU Polar Network 2 (active) **(Co-I Wilkinson)**
- G44. KEPLER: (~€3 million): Key Environmental monitoring for Polar Latitudes and European Readiness (completed) **(Co-I Wilkinson)**
- G45. ICE-ARC: (~€12 million): Ice, Climate, Economics – Arctic Research on Change. (completed) **(Coordinator Wilkinson)**
- G46. EU PolarNet:(~€2 million): EU Polar Network (completed) **(Co-I Wilkinson)**
- G47. Eco-Light: PI (NERC/BMBF: ~£1 million): Ecosystem functions controlled by sea ice and light in a changing Arctic (Eco-Light) (completed) **(PI Wilkinson)**
- G48. MIZ:(ONR: ~\$10 million): Emerging Dynamics of the Marginal Ice ZoneDRI (completed) **(PI Wilkinson)**
- G49. SODA: PI (ONR: ~\$10 million): Stratified Ocean Dynamics in the Arctic (completed) **(PI Wilkinson)**
- G50. CARB-SEA (NERC global partnership seedcorn fund, £80k), **(project Co-lead and BAS lead Munday)**.
- G51. POLOMINTS (NERC large grant, ~£3.7 million), **(Co-I and modelling contributor Munday)**
- G52. C-Streams (NERC large grant ~£3 million), **(Co-I and BAS lead Munday)**
- G53. NERC Highlight Topic Award. Drivers and Impacts of Extreme Weather Events in Antarctica. (2024-28). £3 million. British Antarctic Survey with Birmingham, Cardiff, Leeds, Reading and St Andrews Universities. **(Co-I Cavanagh)**
- G54. UK Government Darwin Plus Funding Award. Evaluating climate change risks to Patagonian and Antarctic toothfish. (2023-26). £240,000. **(PI Cavanagh)**
- G55. NERC Antarctic Logistics & Infrastructure. Research, Conservation and Leadership in Southern Ocean Ecosystems (CONSEC) (2023-33). British Antarctic Survey. **(WP Co-Lead Cavanagh)**
- G56. PhytoFA:Phytoplankton in a Freshening Arctic, Rubicon Fellowship Dutch Research Council, (€200k) **(PI Burson)**
- G57. NERC National Environmental Isotope Facility grant £20k **(Co-I Burson)**
- G58. Natural Environment Research Council (NERC) International Opportunities Fund: Coordinating International Research on Southern Ocean Ecosystems: Implementation of the ICED Programme. NERC International Opportunities Fund (IOF). £300,000 (completed). **(PI Cavanagh)**
- G59. NERC National Capability Science Multicentre. BIOPOLE: How nutrients in polar waters drive the global carbon cycle and primary productivity (2022-2027). **(Co-I Hill)**
- G60. NERC Pushing the Frontiers. KRILLGUARD: Safeguarding the future of the Southern Ocean (2024-2027). **(Co-I, institute lead, WP co-lead Hill)**

G61. NERC Antarctic Logistics & Infrastructure. CONSEC: Research, Conservation and Leadership in Southern Ocean Ecosystems (2023-2033). (Co-I, WP lead Hill)

Impact (I)

- I1. Record low Antarctic sea ice 'extremely unlikely' without climate change Press Release 20 May 2024 **(Sime)**
- I2. Team heads for Antarctica to study global warming effects Press Release 8 November, 2023 **(Sime)**
- I3. Past evidence supports complete loss of Arctic sea-ice by 2035 Press Release 10 August 2020 **(Sime)**
- I4. Arctic sea ice loss in past linked to abrupt climate events Press Release 12 February, 2019 **(Sime)**
- I5. Lee, J.J., Francisna Fernando, F., Desjonquieres, C., Gorgulu, N., Knudsen, C., Mealy, P., Shariq, A., Wu, J., **Fučkar, N.S.**, et al., 2024, Rising to the Challenge: Success Stories and Strategies for Achieving Climate Adaptation and Resilience, World Bank report
<https://www.worldbank.org/en/publication/rising-to-the-challenge-climate-adaptation-resilience>
- I6. The Telegraph, 25 July 2024, Everything you need to know about La Niña, the climate phenomenon behind this year's extreme weather, <https://www.telegraph.co.uk/global-health/climate-and-people/what-you-need-to-know-about-climate-phenomenon-la-nina/> **(Fučkar)**
- I7. **Fučkar, N.S.**, 17 May 2024, Extreme heatwaves in south and south-east Asia are a sign of things to come, The Conversation, <https://theconversation.com/extreme-heatwaves-in-south-and-south-east-asia-are-a-sign-of-things-to-come-229832>
- I8. **Fučkar, N.S.**, 9 February 2024, Weather v climate: how to make sense of an unusual cold snap while the world is hotter than ever, United Nations Office for Disaster Risk Reduction, PreventionWeb, <https://www.preventionweb.net/news/weather-v-climate-how-make-sense-unusual-cold-snap-while-world-hotter-ever>
- I9. Macintyre, H.L., Murage, P., **Fučkar, N.S.**, Hajat, S., Heaviside, C., Vardoulakis, S., Cordiner, R., Health Effects of Climate Change in the UK: 2023 Report, Chapter 2. Temperature effects on mortality in a changing climate, UK Health Security Agency, <https://www.gov.uk/government/publications/climate-change-health-effects-in-the-uk>
- I10. Plastic reduces how krill remove carbon into deep ocean, Press Release 20 November, 2024 **(Manno)**
- I11. Sea butterfly life cycle threatened by climate change Press Release 15 May 2023 **(Manno)**
- I12. Microplastic found in Antarctic krill and salps Press Release 29 March 2023 **(Manno)**
- I13. New kit enables study of microplastics in the ocean, 8 September 2022 **(Manno)**
- I14. Universities Network: COP26 Images of Innovation Exhibition, 19 October 2021 **(Manno)**
- I15. Plastic pollution and ocean acidification reduce Antarctic krill development 4 August 2021 **(Manno)**
- I16. Krill provide a highway for ocean carbon storage 27 November 2020 **(Manno)**
- I17. Krill swarms responsible for 'hidden' carbon storage 21 February 2019 **(Manno)**
- I18. Sea butterflies repair shell damage from ocean acidification 25 January 2018 **(Manno)**
- I19. EU policy briefing: The Changing Poles: how Antarctic and Arctic science helps to inform and prepare the EU for changes in sea level rise and the global climate (Brussels, Feb 2024) **(Meijers)**
- I20. The Conversation article: Slowing deep Southern Ocean current may be linked to natural climate cycle – but that's no reason to stop worrying about melting Antarctic ice (June 2023) **(Meijers)**
- I21. Is the climate crisis finally catching up with Antarctica? Finding the answer has never been more pressing – Guardian invited opinion article (Aug 2023) **(Meijers)**
- I22. Changes in Atlantic currents may have dire climate implications for the next century – Guardian Invited opinion article (Feb 2021) **(Meijers)**
- I23. Live interview BBC news: A23a iceberg encounter (Dec 2023) **(Meijers)**
- I24. "Southern Ocean monitoring needed to predict climate change", invited interview on ABC Radio National Breakfast. (Aug 2023) **(Meijers)**
- I25. Speaker at Cheltenham Science Festival 2024 **(Hendry)**
- I26. Expert witness for cross-Whitehall round table discussion on UK Arctic policy (2022) **(Hendry)**
- I27. Attendance at Arctic Circle Assembly, Reykjavik, invited speaker in 2021 & 2023 **(Hendry)**
- I28. Lead author of IES environmental SCIENTIST article "Where warming land meets warming sea" (2021) **(Hendry)**
- I29. Co-author of ECOMagazine article "New nutrient sensors provide icy insights" (2020) **(Hendry)**
- I30. Co-author Grantham Institute briefing note "The Arctic and the UK: climate, research and engagement" (2020) **(Hendry)**
- I31. Interview for BBC News on Arctic policy and climate change (2020) **(Hendry)**
- I32. UN Ocean Decade Early Career Ocean Professionals International Workshop co-convenor (2022) **(Jones)**

- I33. UK Arctic Expert: G7 FSOI (2023-2024) **(Wilkinson)**
- I34. Policy Brief European Parliament OCEAN:ICE and Arctic PASSION (2024) **(Wilkinson)**
- I35. Invited speaker: Future Collaboration by Research Vessels and Icebreakers, Japan (2023) **(Wilkinson)**
- I36. Invited speaker: Arctic Circle Japan Forum, (2023) **(Wilkinson)**
- I37. Various press releases associated with NERC:DEFIANT and EU:Arctic PASSION (2023-2024) **(Wilkinson)**
- I38. Marine Working Group Fellow International Arctic Science Council (2020-2023) **(Burson)**
- I39. Invited speaker *Author spotlight: recent high -impact authors from the Association for Sciences in Limnology and Oceanography journals* at 2019 meeting Puerto Rico **(Burson)**
- I40. Imbalance in Phosphorus and Nitrogen Levels in the North Sea Caused by Environmental Policy 27 January 2016 Press Release **(Burson)**
- I41. Member of the Scientific Committee on Antarctic Research (SCAR) Standing Committee on the Antarctic Treaty System (SCATS) (2024-28) **(Cavanagh)**
- I42. Scientific Advisor on the UK delegation to the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), leading on climate change issues (2021-ongoing) **(Cavanagh)**
- I43. Invited speaker and panellist: UK Government Bluebelt Symposium, February 2024 **(Cavanagh)**
- I44. Co-author of climate change “report card” for the coastal and marine environment around the Polar UK Overseas Territories (2021) 10.14465/2021.orc02.pol **(Cavanagh)**
- I45. Leading scientists warn of global impacts as Antarctic nears tipping points Press Release 15 June, 2021 <https://www.bas.ac.uk/media-post/leading-scientists-warn-of-global-impacts-as-antarctic-nears-tipping-points> **(Cavanagh)**
- I46. Studies highlight fragility of Antarctic ecosystems 29 November, 2019 Press Release **(Cavanagh)**
- I47. Krill from Space. Livestreamed presentation at COP29 15 November 2024 **(Hill)**
- I48. Antarctic krill can lock away similar levels of carbon as seagrass and mangroves. Press Release 19 September 2024 **(Hill)**
- I49. Enabling sustainable fisheries management in the Southern Ocean. Commended Entry, NERC Impact Awards, 2023. 11 April 2024 **(Hill)**
- I50. Q&A: How might fishing be impacting the carbon cycle? Interview 26 January 2022 **(Hill)**
- I51. Antarctic krill: Key food source moves south. Interview, BBC News, 21 January 2019 **(Hill)**

Responsible Research

- R1. Earth System Modelling summer school lecturer: <https://deepice.cnrs.fr/deepice-events/> (DEEPICE AWI, Germany, 2023) **(Sime)**
- R2. Winter school lecturer: <https://deepice.cnrs.fr/deepice-events/> (DEEPICE Finse, Norway, 2022) **(Sime)**
- R3. DEEPICE: Network of young researchers to unveil past climate change in Antarctica **News** 13 October, 2021 **(Sime)**
- R4. Glasgow COP26: Invited panel member: Climate Risk & Tipping Points in the Polar Regions (Panel + Q&A, 2021) **(Sime)**
- R5. University of the Arts COP26 event speaker/panellist: Ask a Climate Scientist: COP, Science, Culture and Politics **(Sime)**
- R6. Engagement with multiple artists through ClimArts: <https://www.climarts.org/> **(Fučkar)**
- R7. Two bachelor and seven master students graduated, and supervision of two master and doctoral students, and two PDRAs **(Fučkar)**
- R8. Climate Change and Our Power, Youth Forum, Oxford University Museum of Natural History, 2023 **(Fučkar)**
- R9. Co-chair of the series of Oxford University Climate and Health Forums, 2021 **(Fučkar)**
- R10. Climate Advice Sessions with the Lord Mayor of Oxford, 2019 **(Fučkar)**
- R11. Podcast “Plastic in Antarctica”, Pine Forest Media, <https://podcasts.apple.com/us/podcast/5-plastics-in-antarctica/id1748730442?i=1000660878643> **(Manno)**
- R12. Podcast, “Ask the geographer” Royal Geographical Society Schools <https://soundcloud.com/rgsibg> **(Manno)**
- R13. 2020 Creation of an animated video for general audience focus on the link between microplastic and climate change shared on YouTube <https://www.youtube.com/watch?v=lvn4H3Lpr8A> **(Manno)**
- R14. How Might Plastic Pollution Affect Antarctic Animals?. *Frontiers for Young Minds*. **(Manno)**
- R15. Sea Butterflies Defend Their Homes Against an Acidic Ocean. *Frontiers for Young Minds* **(Manno)**
- R16. Live stream event organized by the German Federal Ministry of Education and Research (BMBF) in partnership with the Intergovernmental Oceanographic Commission to talk about anthropogenic impact on impact the marine ecosystem. **(Manno)**

- R17. COP26 UK Universities' Climate Innovation showcase
<https://www.strath.ac.uk/workwithus/cop26/innovationshowcase/livingonlandsea/zooplanktonplasticcup/> **(Manno)**
- R18. Panellist at the INC-5 Intergovernmental Negotiating Committee on plastic pollution to develop an international legally binding instrument on plastic pollution, South Korea **(Manno)**
- R19. Co-convenor RECOIL workshop: Reconciling Cross-platform Observations of Ice-shelf mELt. (September 2024, Copenhagen). **(Meijers)**
- R20. Southern Ocean summer school convenor (May 2024, Corsica) **(Meijers)**
- R21. Lead convenor Royal Society Discussion Meeting: Heat and carbon uptake in the Southern Ocean: the state of the art and future priorities (May 2022, London) **(Meijers)**
- R22. "Oxygen Thieves". Invited chapter in: "Adventures in Climate Science". Woodslane Pty Ltd. (2023) **(Meijers)**
- R23. Lead convenor: Workshop on Southern Ocean-cryosphere feedbacks (July 2023, Berlin)
- R24. Invited speaker: European Data Week (May 2024, Genoa) **(Meijers)**
- R25. Co-convenor of Arctic Science Summit Week (ASSW) Science Day, Edinburgh, 2024 **(Hendry)**
- R26. Panellist for EDIA session at Challenger150 Meeting, London (September 2023) **(Hendry)**
- R27. Member of Greenland Ice Sheet Ocean Science Network (GRISO) working group (2022-) **(Hendry)**
- R28. Co-chair of Diversity in Polar Science Initiative DiPSI (2021- 2023) **(Hendry)**
- R29. Honorary Secretary of Challenger Society for Marine Science (CSMS) (Sept 2022-) **(Hendry)**
- R30. Net Zero Oceanographic Capability (NZOC) Work Package lead (2020-2021) **(Hendry)**
- R31. Lead author of Ocean Challenge article "Equity at Sea: Gender and inclusivity in UK sea-going marine science" (2020) **(Hendry)**
- R32. Mentoring networks for women in science, including mentoring junior researchers (via: mento International) **(Hendry)**
- R33. Antarctic Science Ltd Board member (2012-); Treasurer (2017-2020); Chair (2020-) **(Hendry)**
- R34. UK Polar Network: International Collaboration Officer: Arctic field training seminar series (2022), Social Media Officer (2022) **(Jones)**
- R35. UK-Russia Arctic collaborations policy brief co-author (2021) **(Jones)**
- R36. Net Zero Marine Planning policy recommendations for 25 % reduction by 2025, co-author (2022) **(Jones)**
- R37. GEOTRACES Early Career Scientist Committee member (2024-) **(Jones)**
- R38. National Oceanography Centre Environmental Advisory Group Postgraduate Representative **(Jones)**
- R39. Creator and current coordinator of Fellows' On-going X-change (FOX), fellows alumni group within the International Arctic Science Council (IASC) (2023-) **(Burson)**
- R40. Lead convenor: Workshop for IASC FOX contribution to International Conference on Arctic Research IV (July 2024) **(Burson)**
- R41. Editor of the British Phycological Society's biannual magazine *The Phycologist* **(Burson)**
- R42. Participant in *Skype a Scientist* programme 2021 **(Burson)**
- R43. Capacity Building Fund Committee, Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) (2023-ongoing) **(Cavanagh)**
- R44. Debate and Spokesperson Climate Change Masterclass, Grantham Institute, Imperial College (2021) **(Cavanagh)**
- R45. COP26 (26th United Nations Climate Change Conference) Engagement Campaign, British Antarctic Survey Ambassador (2021) **(Cavanagh)**
- R46. Cambridge Natural Environment Research Council (NERC) Doctoral Training Partnerships Training Committee, University of Cambridge (2019-ongoing) **(Cavanagh)**
- R47. Leadership Programme for Women (2017) **(Cavanagh)**
- R48. Lead author "The Important but Mysterious Antarctic Krill" - children's journal article 2023. **(Hill)**
- R49. Scientific consultant "Krill: Superheroes of the Southern Ocean" - animated video 2021 **(Hill)**
- R50. Challenge of Science Leadership course 2021 **(Hill)**
- R51. Unconscious Bias Training course 2021 **(Hill)**
- R52. Science Coordinator SCAR Krill Expert Group 2022-2024 **(Hill)**

A Responsible innovation Framework for assessing NOvel Spray Technology Research to examine local AlbeDo changes from Marine brightening and its mUlti-Scale impacts. (NOSTRADAMUS)

Section 1: Programme and Technical

1.1 Programme Alignment: Marine Cloud Brightening (MCB) and Marine Sky Brightening (MSB) are two of the most significant opportunities to increase the average planetary albedo and provide a mechanism for cooling the earth. The biggest technical barriers in any proposed MCB deployment are associated with the ability to produce aerosols at a high enough rate in an energetically efficient way and at the ‘correct’ size in a real world environment. We propose a programme for developing and testing spray technologies to deliver aerosol particles; their application for MCB and MSB; and a robust framework for testing both their effectiveness and wider environmental impacts through a stepwise, consultative and inclusive approach. We will follow responsible research and innovation best practice to deliver a limited area experimental environment to test and optimise the effectiveness of a range of spray technologies in increasing the local planetary albedo. We will use this to inform and challenge a multi-scale modelling prediction system to improve assessment of MCB and MSB schemes and quantify risks and threats of future deployment. We propose a closely coupled programme of laboratory studies, sprayer technology development, testing, and modelling to aid and develop small scale field trials. As identified in a recent review¹, these elements are essential next steps to assess the feasibility and risks of MCB and MSB, and test the veracity of current model predictions of large scale deployment effectiveness and impacts, necessary conditions before implementation is considered.

Field trials of MCB will emerge in the next few years to examine important cloud regimes in key geographical locations around the world. These need to be conducted transparently, objectively, and be acceptable to society. At present only one trial is underway, in a sub-tropical cumulus regime focusing on locally reducing sea surface temperatures around the Great Barrier Reef². It is necessary to also examine other cloud types important for MCB, such as stratocumulus clouds¹. Owing to practical constraints, such experiments are only possible for a limited number of case studies and cloud regimes. A multi-scale model approach is therefore a vital component for interpolation and extrapolating results to the global environment. Our proposed field experimental programme would provide: an independent evaluation environment for MCB and MSB technologies; a globally unique test of mid-latitude stratocumulus response to aerosol perturbations; UK spray developers with a testing location for their devices at modest cost compared to overseas deployments; a UK capability for testing other MCB projects within ARIA and beyond.

1.2 Research Objectives:

- O1:** Develop and test spray technologies capable of delivering sea spray aerosol particles at the necessary size distribution and rate, that can reliably operate in real world environments for extended periods.
- O2:** Conduct laboratory experiments on multiple particle populations to verify model predictions of cloud activation used to optimise spray technology for use in a range of cloud conditions.
- O3:** Deliver a real-world experimental framework to rigorously assess the viability of spray technologies for influencing local albedo change in clear and cloudy conditions, and examine cloud property changes
- O4:** Assess the local, regional mesoscale and climate-scale dynamical responses and impacts of a large-scale implementation of spray technology for MCB and MSB.
- O5:** Evaluate the wider risks and benefits of future development and use.
- O6:** Develop and manage a responsible research and societal engagement framework, building on well-established imperatives for socially desirable science and innovation, undertaken in the public interest.

1.3 Research Description: We envisage a set of coupled work packages (WPs) to address widely recognised research questions (RQs)¹, conducting limited area field trials and determining impacts via **predict-test-monitor-validate** cycles, focusing on new approaches and validating the outcomes (see Fig.1).

Work package A (WPA): Effective Spray Generation of Aerosols (UoC, Archipelago, UoM); (O1, O2)

RQ1: *Can a robust sprayer be designed for use in the marine environment which delivers aerosol particles in an appropriate size range, at the requisite rate (informed by WPC) with reasonable energy use.*

The focus is to research promising novel droplet generation methods for MCB/MSB (Fig. 1) that may prove more optimal than current effervescent spraying technology. We aim to develop at least two of the following emerging spray techniques into efficient field deployable prototypes: 1) superheated atomisation^{3,4}; 2) electrospraying^{5,6}; 3) Rayleigh jets^{5,6,7}; 4) bubble bursting atomisation^{8,9}; 5) Powercloud spray system from inkjet technology developer Archipelago Technology. Only the superheated approach is developed elsewhere, by a close collaborator, Southern Cross University (SCU).

Spray technology development will proceed in three stages. *Stage A1* will develop each of the five methods in parallel at the laboratory scale with single nozzle testing including combinations so that the findings from

one method can be applied to others. The methods that show most promise will progress to *Stage A2* where arrays of nozzles will be tested within wind tunnel facilities at UoC and the Manchester Ice Cloud Chamber (MICC). These experiments will examine whether aerosol particle size distributions change as a result of coagulation before scaling the technology further. *Stage A3* will scale up at least two of the technologies into prototypes for field testing. Prior to a stage gate review at **M32** or any outdoor trials, the prototypes will be tested indoors, in a large controlled environment such as a hangar or warehouse. This is a low risk approach to verify correct and safe operation of the entire spray generation system, including droplet dispersal and filtration before going out into the field.

The progression of each technology is dependent on evaluation against the following metrics: spray

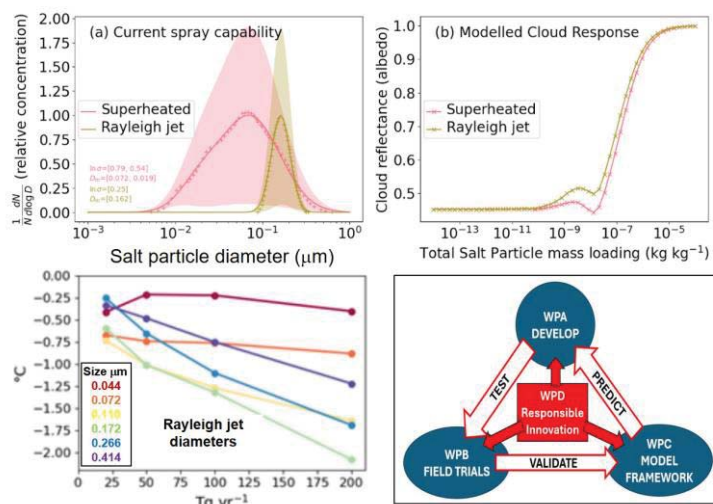


Figure 1. (a) spray number size distribution of two methods developed by UoC, the Rayleigh jet distribution is narrow and represents significant advance, (b) cloud albedo using the UoM parcel model two spray distributions including representative background aerosol populations. The reduction of cloud albedo seen in the superheated spray case is avoided for the Rayleigh Jet, (c) UKESM1 climate model simulations (Haywood et al., 2023) - the Rayleigh jet optimises the global mean cooling for significant injection rates.

generation rate, droplet size range, overall power consumption and unit cost to achieve the target spray rates, filtration requirements, spatial requirements, robustness to marine environments, and manufacturability. The latest results from our chamber experiments and parcel modelling (**RQ2**) will provide metrics to evaluate and improve sprayer performance during laboratory scale development. Technologies that show no improvement over existing spray technology will not progress to the next stage; however, the risk of not producing new applications is low since we are pursuing multiple approaches. Impacts of sprayer performance will be tested in **WPC**.

Methods 1-4 will involve the use of engineering design consultants (UoC currently liaising with a potential

subcontractor) for prototype(s) design. The design scale-up for method 5 will be undertaken by Archipelago and the manufacturing of a prototype for all methods will involve outsourcing to fabrication companies. We are working closely with SCU who have suppliers with relevant experience in engineering for marine environments willing to share knowledge to streamline development. We have already identified suppliers with capacity for manufacturing some of the main components for each technology, including for silicon-based nozzles.

Key outcomes: **KO1:** Single nozzle tests and stage one technology evaluations completed for at least two methods (**M6**) and for three further methods (**M18**); **KO2:** Multi-nozzle tests and stage two technology evaluations completed for at least one technique (**M18**) and for the remaining techniques (**M30**); **KO3:** First field trial capable prototype designed, built and fully tested indoors (**M30**); **KO4:** Second prototype tested indoors (**M36**); **KO5:** Continued testing (indoors) and refinement of prototypes and final design recommendation for full MCB/MSB deployment (**M60**).

RQ2: Do models correctly capture the competition effects between aerosol particles of different sizes and composition during realistic cloud formation experiments?

Whether injecting NaCl particles into the base of marine clouds will give the desired cloud response depends on how aerosol particles of different sizes and compositions compete for water vapour. If too many small particles are generated they may not be capable of growing into cloud droplets, on the other hand, large particles require a lot of water to grow and this can suppress clouds forming on smaller particles, and may also lead to drizzle. Understanding these competition effects is crucial to addressing **RQ1**¹⁰. Single particle experiments or use of cloud condensation nuclei (CCN) counters cannot test process-level models that predict the dynamic competition for water vapour that occurs in a real cloud with a mixed population of particles (e.g. Fig 1a-b). We propose to experimentally test this for the first time by comparing our process models, ACPIM¹¹ and PARSEC¹², to results from the UoM cloud and aerosol chamber. Findings will be directly fed into the multi-scale modelling framework (**WPC**, Fig 2), since PARSEC is embedded in the UK Met Office Unified Model (UM) via UKESM1 (**WPC**).

During the first 6 months we propose necessary upgrades to the MICC by fitting new state-of-the-art probes using customised inlets fabricated at the UoM. We will also build a standalone spray system for aerosol generation, based on known technology (Palas UGF2000) and ultrasonic atomisation that can generate realistic background aerosol size distributions with mode diameters in the range 40 to 250nm. This relatively

low-tech development does not have the same potential for scale-up as the spray technology in **RQ1**, but it can produce variable particle size distributions and allows experiments to commence quickly. We propose to use two simple, single component aerosols for background activation experiments such as $(\text{NH}_4)_2\text{SO}_4$ and fulvic acid, which span observed atmospheric aerosol hygroscopicity. Aerosols will be generated inside the MICC, and we will perform cloud formation experiments, measuring the cloud drops. Experimental data will be used to drive the UoM cloud parcel model, ACPIM¹¹, developed to evaluate competition effects. We will experiment with external mixtures of both background aerosol and NaCl aerosol, evaluating against ACPIM and correcting biases. Findings from the experiments will be transferred to **RQ1** so that the correct droplet sizes and concentrations can be targeted. As the spray systems mature they will be deployed in the MICC to test their performance in competition with a background aerosol population.

Key outcomes: **KO6:** MICC upgrades (**M06**); **KO7:** MICC experiments evaluating single component aerosol ($(\text{NH}_4)_2\text{SO}_4$, organic acid) at 3 different mode sizes compared to ACPIM simulations using approximately 5 cooling rates (**M10**) **KO8:** addition of external mixtures of NaCl particles of different sizes with feedback to spray development (**M18**); **KO9:** external mixture evaluation using new spray technology in MICC (**M24**); **KO10:** refinement of spray technology during MICC tests (**M30**).

Work Package B (WPB): Field Trials (UoM, UoC, UoL) (O3; O4; O5; O6)

RQ3: *How can a UK based experimental test bed for examining spray technology applications for marine atmospheres which is transparent and objective be established and delivered?*

RQ4: *Will different spray technologies perform as expected in an operational environment?*

RQ5: *Can local albedo changes induced by an evolving spray plume be detected, perturbations to microphysical properties be observed, and results correctly predicted in cloud-free and cloudy conditions?*

We propose an experimental test bed that will be used to validate (i) spray performance in real world conditions and (ii) model tools that predict aerosol mixing through the boundary layer, impacts on the surface albedo and responses of the cloud. The WP is deliberately cautiously staged, with a formal stage gate review at **M32** to externally evaluate the effectiveness, safety, and risks before any field experiments are carried out. It will develop in close synergy with our responsible research and innovation¹³ (RRI) framework (**WPD**) and be regularly examined by our management team and key stakeholders (Part 2: Governance). A second stage gate at **M42** is possible to allow re-evaluation after the initial experiment.

Stage B1 (M1-M32): identification of field location, safety and risk management framework development:

Identification of an optimum field location will be made in year 1 based on the likelihood of representative conditions and operational considerations. A coastal, land-based location will: reduce cost; allow ready access to technical support for ease of servicing/modifying; facilitate space and power for sprayers and instrumentation. In the case of the second field experiment, the background CCN concentration should be as close to 100 cm^{-3} as possible to represent clean, marine conditions¹⁴ where cloud albedo response is sensitive¹⁵ and ideally an airfield for small aircraft within range. Initial investigations suggest the Weybourne Atmospheric Observatory (north Norfolk), for example, provides a very promising location for the first stage field trials having sufficient power, space, hard standing, an adjacent grass airstrip for UAVs, and easy access from Cambridge.

A Technical, Safety and Risk Management Framework will be developed synergistically with the RRI Framework (**WPD**), guided by the technical consideration decision tree (Fig 2) and funding approval decision

tree (Fig. 3) in the [ARIA Programme Thesis](#). Our framework will be a living document that, alongside a technical progress report and the RRI Framework (**WPD**), will form the basis of the Stage Gate review (**M32**) and acceptance via the ARIA evaluation process ahead of any field trials. This will include the plans, safety documentation and technical, regulatory and environmental assessments of risk and mitigation plans.

Importantly, Box 1 summarises the size of the particle generation sufficient to examine the

BOX 1: TARGET SPRAY RATES FOR SAFE, CONTROLLED BUT MEASUREABLE

A spray rate of $1 \times 10^{15} \text{ s}^{-1}$ injected into a 1 km deep boundary layer with a mean wind speed of 10 ms^{-1} will yield concentrations of 100 cm^{-3} , equivalent to a marine background only 10 km downwind.

To examine cloud perturbations, distance scales would need to be 30-40 km to allow the plume to mix through the depth of the boundary layer. A spray rate of $5 \times 10^{16} \text{ s}^{-1}$ would lead to 300-500 cm^{-3} at these distances, with plume widths of less than 3-4 km.

effectiveness of the sprayers but not to cause regional impacts and these scales bound the size of our experiments. We will begin with low emission rates ($\sim 10^{14} \text{ s}^{-1}$) lasting only a few minutes, evaluating outcomes and risks at each stage as we scale in a stepwise manner to approach target rates of $\sim 5 \times 10^{16} \text{ s}^{-1}$ lasting up to one hour to examine cloud interactions. Our experiments involve real time monitoring so that they can be

rapidly terminated. Our Framework documentation will include wider safety assessments such as near field exposure, discussions with landowners, and government compliance (eg Environment Agency, SEPA). A risk assessment and Environmental Impact Assessment will be carried out, though we anticipate risks are very low given that the volumes of filtered seawater are of the order of 5-6 l/min or 300-400l over a hour long experiment and spraying will be done in offshore wind conditions. Drafts of the framework will be regularly presented to ARIA, our Advisory Board, and to Key stakeholders (see **WPD**) and recommendations incorporated into the document which will be made publicly available online.

Key outcomes: **KO11:** Locations selected for the two field deployment (**M18**) **KO12:** Technical, Safety and Risk Management Framework developed (**Draft M24; Acceptance Stage Gate M32**)

Stage B2 (M32-M48): Testing Effective Distribution of Spray Aerosols in the Atmospheric Boundary Layer. Generation of large aerosols or near-field coagulation may produce giant CCN that may preferentially activate, suppressing activation of background aerosol¹⁶ and/or initiating drizzle¹⁷. Rapid evaporation of water from the spray may inhibit mixing¹⁸, and although initial experiments¹⁹ and modeling²⁰ suggest this effect may be modest, confirmation via field observations is necessary. Spray generation and mixing will be tested in this first field trial. Field scale spray systems (**WPA**) will be deployed alongside the current SCU spray system for comparison in a 40 day field experiment (**M38**). Atmospheric monitoring of the marine boundary layer will include use of radiosondes, a wind profiler, radiometers and a ceilometer as well as in-situ observations of the background aerosol, temperature and humidity. Operational models (Met Office's Unified Model (UM) and Numerical Atmospheric-dispersion Modelling Environment (NAME) will forecast plume direction, altitude and dispersion width. Plume evolution will be observed by scanning aerosol and Doppler lidars. A UAV mounted aerosol instrument will examine the aerosol size distribution development in the plume (100nm-10µm diameter) and UAV borne radiometers will monitor any resulting changes in the local planetary albedo. These observations will constrain and validate our models of physical and thermodynamical plume evolution, mixing and impact on albedo. Large Eddy Model (LEM) simulations will be used to interpret the observations (**WPC**).

Key Outcomes: **KO13:** Assessment of performance of spray technologies (**WPA**) in real world conditions to inform final stage-gate review (**M42**). **KO14:** Data stored in a publicly available repository (**M42**).

Stage B3 (M42-M60): Determination of Clear Sky Albedo and Cloud Responses to Aerosol Injection into the Boundary Layer. Responses of clouds to changes in aerosol are highly uncertain. Introduction of aerosol into a cloud system may change drizzle, cloud thickness, entrainment and diurnal cycle of cloud, all of which interact with each other in complex ways. LEM and Cloud Resolving Model (CRM) tools have been used to investigate these interactions but critically have yet to be tested against observations of an aerosol injection on a scale large enough to assess cloud responses. The second 40 day field study (**M48**), will seek to investigate cloud responses and test the LEM and CRM cloud simulations (**WPC**). A new Frequency Modulated Continuous Wave (FMCW) mobile cloud radar and micro rain radar will be added to the Stage B2 observations. The FMCW radar is capable of high resolution scanning and retrieval of droplet size distributions and so offers a powerful way of examining the plume interaction with cloud. These observations will deliver the necessary constraints to validate model predictions and target improvements. At the scales envisaged large aircraft fly too fast to adequately resolve the plume features though small, slower aircraft may be deployed.

Key Outcomes: **KO15:** Public report on field trial outcomes (**M60**); **KO16** Publicly available data archive (**M60**).

Work Package C (WPC): Modelling (UoE, FMI) (O4, O5)

RQ6: *How accurately can model predictions of MCB/MSB, optimised using information from sprayers, be represented across a range of scales?*

RQ7: *What are the regional and global impacts of MCB and MSB?*

In WPC we will assess the regional dynamical and climate scale responses and impacts of a large-scale implementation of spray technology for MCB and MSB. An essential part of our **test/monitor/validate** strategy is the use of models to extend the necessarily limited number of observations at local scales (**WPA**, **WPB**) to additional meteorological regimes and to larger spatial scales. This will be achieved through a seamless multiscale-framework (Figure 2). We will utilise:-

i) Parcel models: The UoE cloud parcel model (PARSEC)¹², and the UoM bin microphysics model (ACPI)¹¹ are state-of-the-art size dependent cloud models that serve as the benchmarks for the development of droplet activation parameterisations in climate models. PARSEC is already operational within the UM, and whilst too computationally expensive for decadal simulations, can be used for shorter (up to 1 year) process-orientated UM simulations. PARSEC can track aerosol growth and evaporation for specific bin sizes explicitly in global

climate simulations allowing competition effects to be quantified for regions with different background aerosol and updraft regimes for comparison against idealised chamber experiments (**WPA**).

ii) **LES models:** The Met Office NERC Cloud model (MONC)²¹ multi-moment bulk microphysics model and the UCLA Large-Eddy Simulation (UCLALES) coupled with the Sectional Aerosol module for Large-Scale Applications (SALSA)²² bridge the gap between microphysical processes and larger scale models (Figure 2).
 iii) **Nested models:** The Nested Unified Model with Aerosol and Chemistry (NUMAC)²³ can be used to assess the impact of plume concentrations at surface level, visibility, deposition etc. that cannot be resolved with climate models. iv) **Earth System Models:** UKESM1 is a well-respected climate model that can be used to assess the dynamical impacts of MCB/MSB²⁴.

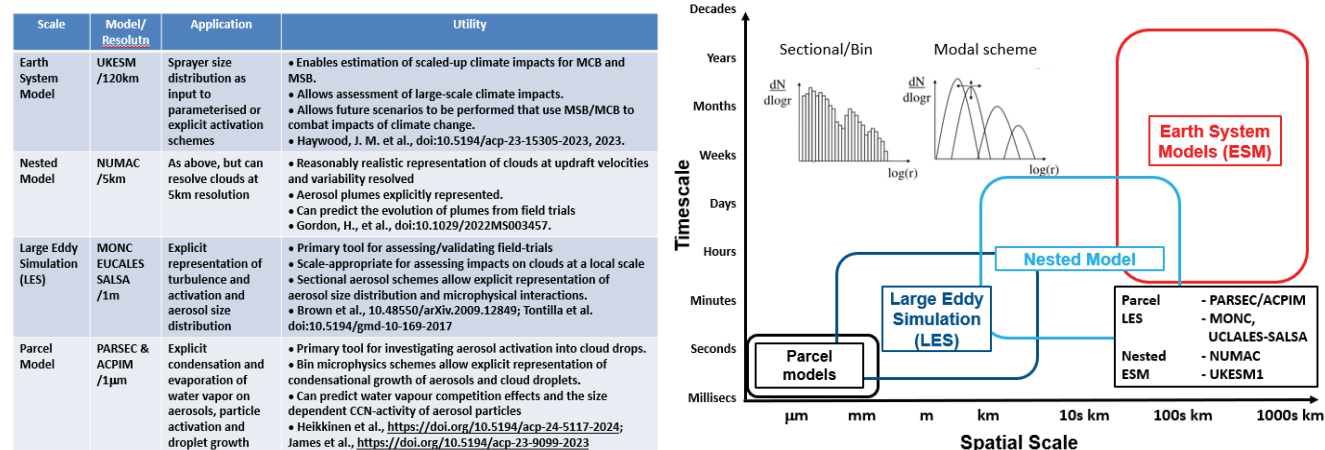


Figure 2. Left Panel): details of the specific models that are proposed. Right Panel): models and their spatial scales and schematic of sectional and modal aerosol size distributions.

MONC and UCLALES simulations will be performed using the observed aerosol size distribution from the sprayers and appropriate meteorological boundary conditions to simulate the aerosol plume and impacts on cloud development, microphysical and radiative properties (see **WPB**). Synergistic NUMAC model simulations and UKESM1 coupled simulations will investigate a number of scaled up deployments. These will include centring the NUMAC grid on i) the UK, ii) the Namibian stratocumulus cloud deck, iii) the Caribbean ocean, iv) the N. Atlantic Ocean, and v) the Indian Ocean. These simulations will use the sprayer-derived aerosol size distribution (**WPA/WPB**) which can be explicitly modelled in terms of emissions (Figure 1c) and will use the standard activation scheme¹⁹ and that developed from emulation of the PARSEC model to facilitate accurate simulation of cloud droplet number response to spray injection on climate timescales.

UKESM1 simulations, which are fully coupled to a dynamical ocean, will allow assessments of dynamical feedbacks, and the local and remote cooling impacts for each of the regions where sea-salt aerosol is applied. This is critical in understanding climate impacts should any deployment be successful in cooling a limited area of the ocean as inhomogeneous spray deployments have been shown to lead to very inhomogeneous climate responses^{24,25}. Particular foci will be on the effectiveness of MCB/MSB in ameliorating climate extremes, tipping points and climate change-induced wildfire, hurricane development, Amazon die-back, sea-ice loss, and changes in the Indian monsoon as appropriate. Other areas may be investigated.

NUMAC simulations are unable to provide climate projections, but the superior resolution provides a realistic and more detailed representation of the impacts on cloud properties and precipitation for any potential deployments. Air-quality (sea-spray contributes to the PM2.5 and PM10 pollution targets adopted by the UK and internationally) will be impacted by extensive sprayer deployments and could lead to some deleterious impacts if deployed around populous regions. Similarly, visibility could be very strongly impacted²⁴. Simulations can adjust deployment strategies to take account of e.g. location, time of year, meteorological conditions etc. Time-slice NUMAC simulations will be run for future scenarios through to the end of the century utilising various future Shared Socioeconomic Pathways (SSP) and GeoMIP scenarios.

Key Outcomes: **KO17:** Spray characteristics embedded into models (**M30; M42**) **KO18:** Simulations of aerosol plume and impacts on cloud evolution and radiative properties (**M32; M48**); **KO19:** Reports on impacts of sprayer deployments if applied to key regions optimised in **WPA** for MCB and MSB on simulations of cloud, visibility, air-quality and further optimisation/improvement (**M32; M48**) **KO20:** impacts of optimised sprayer deployment for MCB and MSB under various future climate scenarios (UKESM1-climate) (**M32; M48**)

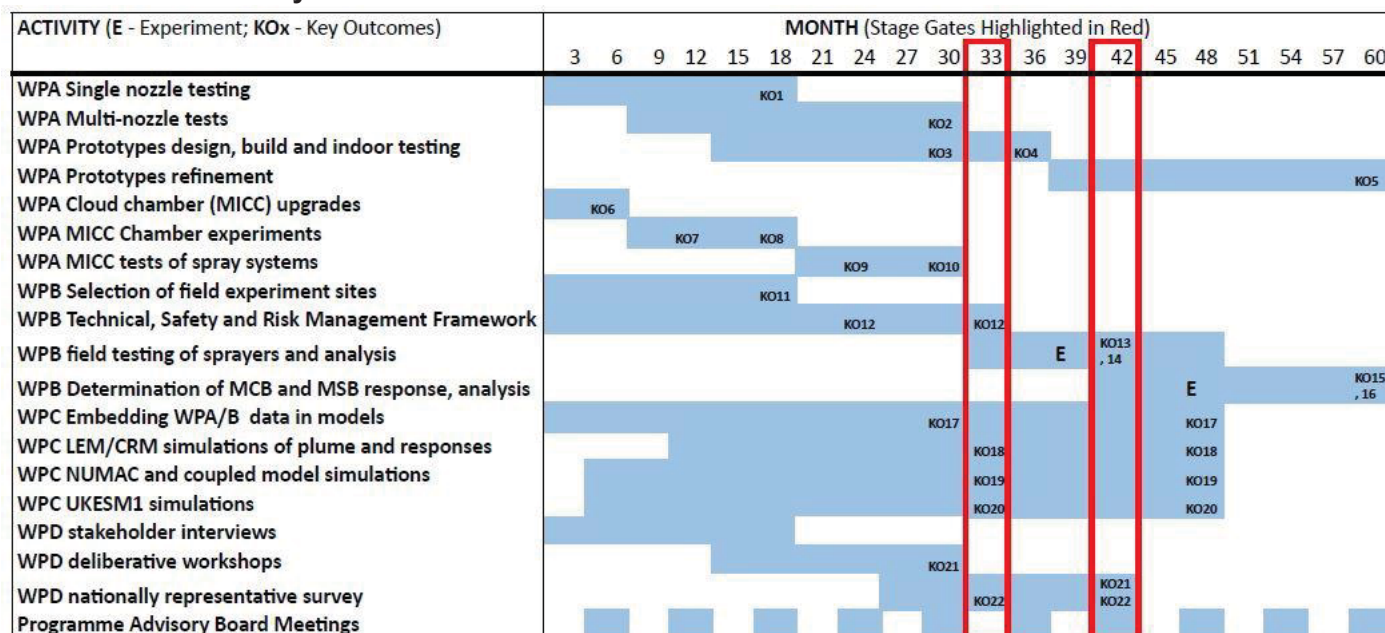
Work Package D (WPD): Responsible Innovation and Societal Engagement (UoM) (O6)

R6: How can MCB/MSB field experiments be conducted responsibly and under what societal pre-conditions?

We build on well-established imperatives for science and innovation that it is socially desirable and undertaken in the public interest, by seeking to (i) “anticipate” the impacts of MCB/MSB field experiments; (ii) “reflect” on the uncertainties and ambiguities of research; (iii) “engage” in meaningful two-way engagement with society; and (iv) “act” on its findings to inform the trajectory of MCB/MSB research and innovation in the project and more broadly^{13,26}. We will facilitate “upstream” societal engagement to address these aspects in advance of significant research activities to help avoid sociotechnical lock-in to undesirable pathways. **WPD** will elicit perceptions of, and preferences for, MCB/MSB experimentation pathways through (1) semi-structured interviews with diverse experts and stakeholders from across academia, government, civil society, and industry (**M1-18**), (2) qualitative deliberative workshops with socio-demographically diverse members of the public²⁷ (**M15-30**), and (3) a quantitative nationally representative survey of the public (**M27-41**). The work will include consideration of key ethical concerns known to pervade SRM research, including ‘moral hazard’ or ‘mitigation deterrence’ (the pursuit of MCB/MSB may distract from efforts to reduce greenhouse gas emissions) and ‘slippery slope’ (research and experimentation may lead to undesirable deployment)²⁸. In tandem with the project’s technical stage-gate process (see **WPB**), **WPD** will develop and apply a social stage-gate process to ensure that responsible innovation is addressed prior to MCB/MSB field experiments taking place (M38, M48). Building on earlier frameworks, this will include consideration of risk management, regulatory compliance, clear communication, impacts review, and stakeholder and public engagement¹³. This forms part of our wider commitment to the ARIA Programme Oversight and Governance measures, which will include regular engagement with the Independent Oversight Committee (IOC) and our own independent oversight and advisory group (IOAG) (see **Management and Governance of the project**). These tasks will be carried out by a dedicated responsible innovation and societal engagement Postdoctoral Research Associate and supported by the work package lead.

Key outcomes: **KO21** Synthesis of the stakeholder interviews and public workshops and survey on the responsible conduct and societal preconditions for MCB/MSB field experiments (**M30**), that are peer reviewed (**M41**); **KO22** a social stage-gate process for ensuring that responsible innovation is addressed prior to MCB/MSB field experiments taking place (**M33**, **M42**).

1.4 Timelines and Key Outcomes



1.5 Synergies: In **WPA**, the work being undertaken by UoC is also costed in the proposal being developed by SCU. If both proposals are funded, there is no need to duplicate the UoC costs. It is planned that use of the sprayers for field experiments will be at different times to save on infrastructure and sprayer costs, and so that practical experiences from different field trials can be shared across the two teams. Where possible, we will use as much of the SCU back-end equipment that has already been demonstrated during their previous field trials (e.g. filtration, pumps, and generators) to provide cost savings, reduce risk, and streamline development. Planned use of the MICC chamber in other proposals is either to test new particle types or work on SAI and there is no overlap with the more comprehensive competition experiments planned here. **WPB:** There is considerable synergy between this proposal and that of SCU. Examination of aerosol injection into the marine boundary layer and its effects on radiation and clouds needs to be carried out at a number of small, experimental scales to test cloud responses under different meteorological and cloud microphysical

regimes. The SCU proposal is very complementary, focusing on subtropical Cu clouds, which will respond very differently. Further, we provide a UK testbed and a legacy capability for the UK. This proposal would benefit from the ARIA proposal led by Girdwood to develop a drone based platform for MCB, but we limit reliance on UAVs in this work to sub-cloud aerosol and can use pre-existing instruments if necessary. A part of **WPC** is complimentary to some NERC proposals submitted to the recent SRM call but the work is not focused on assessing the wider impacts of sprayer development that are at the heart of **WPC**. **WPD** is likely to have synergies with potential cross-programme social science proposals through its wider responsible innovation activities and its expert, stakeholder and public engagement activities in particular. Cross-cutting ethical concerns are likely to arise in other funded technical projects with which we will engage.

1.6 Overall project risk and mitigation: The main risk to the project is that a field location for testing (**WPB**) cannot be found (unlikely) or cannot be developed due to a lack of public acceptance or stakeholder requirements that cannot be addressed. The **M32** stage-gate ensures that we are not committed to large field costs until the field site and associated social acceptance and regulatory compliance is approved by the ARIA process. This alleviates substantial financial risk since the field costs are approximately £4.5M, 40% of the total budget. Even if the field trials cannot be delivered, the project will deliver a large number of successful outcomes since the spray development and optimisation (**WPA**), the impacts of its regional and global implementation (**WPC**), and the development of a technical (**WPC**) and RRI plan (**WPD**) would have all been delivered. We have discussed other specific risks along with their mitigation in the relevant **WPs**.

Section 2: The Team

2.1 Details of Project Team

[illegible]

[REDACTED]

2.2 Third Parties and Sub-Contractors: Nozzle design assembly and manufacturer will need to go to tender. Cambridge Design Partnership has been identified as a potential subcontractor. Initial costings have been provided, but at least two other potential subcontractors will be approached in line with the procurement policy of the University of Cambridge. Contractors may well be used to provide some of the field logistics infrastructure. Archipelago will use two subcontractors, both of whom it has worked with extensively.

2.3 Management and Governance of the project Overall project management will be the responsibility of the project management group (PMG). It will meet quarterly (twice in person; twice online) to review WP progress, budgets, the risk register, engagement with local community groups and other stakeholders, data quality assurance and availability, and communications. Chaired by the PI [REDACTED], it will include the Partner leads, [REDACTED] (RRI lead), the NCAS Communications lead ([REDACTED]) and the Project Manager. The PM will work alongside the PI and will be responsible for operational management, including ensuring that records of all meetings are publicly available and reporting is timely and transparent.

Our data management and stewardship will follow the FAIR Principles. It will be made publicly available promptly and will have clear and full metadata. The atmospheric observations during the field trials will be carried out through the NCAS Atmospheric Measurement and Observation Facility (AMOF). AMOF Data is made available through the Centre for Environmental Data Analysis (CEDA). Laboratory and model data will be made available through host institution servers. All data will be signposted through the project website. Project Governance will be guided by the ARIA Exploring Climate Cooling Programme Oversight and Governance document. The PMG and PM will work closely with the ARIA leadership and its Independent Oversight Committee (IOC), providing regular updates and meeting reporting requirements. We will set up a project specific independent oversight and advisory group (IOAG). It will meet twice yearly to provide critical feedback to the PMG, drawing on the ARIA Governance measures. It will aid the development of the Technical, Safety and Risk Management Framework (WPB). It will appraise the project approach to RRI (WPD), which is guided by the UKRI AREA Responsible Innovation Framework and the Oxford Principles for Geoengineering Governance and examine engagement with the wider public and key stakeholders. [REDACTED] has already agreed to sit on the IOAG and we will advertise for other members. IOAG views will be cascaded to organisations' senior management teams, the ARIA Leadership and the ARIA IOC.

NCAS Communications will work with the communications teams from the partner organisations across the project to build a unified communications strategy; assign roles and responsibilities; coordinate regular meetings; develop a communications calendar and digital content (incl. web design/hosting, campaign branding); evaluate/optimize communications; develop a community-building stream to enable effective KE.

2.4 Motivation We are extremely motivated by this project. Substantial action to reduce carbon emissions is essential and SRM is not an alternative to that primary goal. Equally, we are aware that rapid interventions may help avoid harm until carbon reductions can be ramped up. We believe that MCB is one of the most likely schemes to make a difference on a decadal timescale. We are convinced that small scale field experiments are a necessary next step in developing the knowledge needed to predict how the atmosphere responds to MCB perturbations and wish to ensure that independent assessment of technology is at the core of the approach. The project also provides key team members with a unique opportunity to use their combined skills and knowledge in a broad range of areas which will be incredibly fulfilling.

References

- Feingold G, Ghatte VP, Russell LM, Blossey P, Cantrell W, Christensen MW, Diamond MS, Gettelman A, Glassmeier F, Gryspeerdt E, Haywood J, Hoffmann F, Kaul CM, Lebsock M, McComiskey AC, McCoy DT, Ming Y, Mülmenstädt J, Possner A, Prabhakaran P, Quinn PK, Schmidt KS, Shaw RA, Singer CE, Sorooshian A, Toll V, Wan JS, Wood R, Yang F, Zhang J, Zheng X., (2024), *Sci Adv.* 2024 Mar 22;10(12):eadi8594. doi: [10.1126/sciadv.adi8594](https://doi.org/10.1126/sciadv.adi8594).
- Harrison, D.P., *An Overview of Environmental Engineering Methods for Reducing Coral Bleaching Stress*, in *Oceanographic Processes of Coral Reefs*, E. Wolanski and M. Kingsford, Editors. 2024, CRC Press. p. 484
- Zalkind, V.I. et al 2017 *J. Phys.: Conf. Ser.* 891 012011 <https://doi.org/10.1088/1742-6596/891/1/012011>
- Reardon, E., 2023, Experimental Investigation of Superheated Atomisation for Marine Cloud Brightening [Unpublished manuscript], PhD First Year Report, Cambridge University Engineering Department
- G. Cooper, D. Johnston, J. Foster, L. Galbraith, A. Neukermans, R. Ormond, J. Rush and Q. Wang, "A Review of Some Experimental Spray Methods for Marine Cloud Brightening," *International Journal of Geosciences*, Vol. 4 No. 1, 2013, pp. 78-97. doi: 10.4236/ijg.2013.41009, <http://dx.doi.org/10.4236/ijg.2013.41009>
- Chapman, J., 2024, Experimental Investigation of Electrosprays and Rayleigh Jets for Marine Cloud Brightening [Unpublished manuscript], PhD First Year Report, Cambridge University Engineering Department]
- Salter, S.H.; Stevenson, T.; and Tsiamis A., CHAPTER 6: Engineering Ideas for Brighter Clouds in Geoengineering of the Climate System, <https://doi.org/10.1039/9781782621225-00131https://doi.org/10.1039/9781782621225-00131>
- Mezhericher, M., Ladizhensky, I., and Etlin I., Atomization of liquids by disintegrating thin liquid films using gas jets, *International Journal of Multiphase Flow*, Volume 88, January 2017, Pages 99-115, <https://doi.org/10.1016/j.ijmultiphaseflow.2016.07.015>
- Raj, Y., 2024, Bubble Bursting Atomisation for Marine Cloud Brightening [Unpublished manuscript], PhD First Year Report, Cambridge University Engineering Department];
- Connolly P.J., McFiggans G.B., Wood R. and Tsiamis A., 2014, Factors determining the most efficient spray distribution for marine cloud brightening, *Phil. Trans. R. Soc. A* 372 20140056, <http://doi.org/10.1098/rsta.2014.0056>
- James R.L., Crosier J., and Connolly P.J., 2023, A bin microphysics parcel model investigation of secondary ice formation in an idealised shallow convective cloud, *ACP*, 23, 9099–9121, <https://doi.org/10.5194/acp-23-9099-2023>
- Heikkinen, L., Partridge, D.G., Blichner, S., Huang, W., Ranjan, R., Bowen, P., Tovazzi, E., Petäjä, T., Mohr, C. and Riipinen, I., 2024. Cloud response to co-condensation of water and organic vapors over the boreal forest. *Atmospheric Chemistry and Physics*, 24(8), pp.5117-5147.
- Stilgoe J., Owen R, and Macnaghten P., 2013, Developing a framework for responsible innovation, *Research Policy*, Vol. 42, Issue 9, Pages 1568-1580, <https://doi.org/10.1016/j.respol.2013.05.008>
- Yang, M., Norris, S. J., Bell, T. G., and Brooks, I. M.: Sea spray fluxes from the southwest coast of the United Kingdom – dependence on wind speed and wave height, *Atmos. Chem. Phys.*, 19, 15271–15284, <https://doi.org/10.5194/acp-19-15271-2019>, 2019
- Pringle, K. et al., 2012 <https://acp.copernicus.org/articles/12/11647/2012/acp-12-11647-2012.pdf>
- Wood, R., 2021, Assessing the potential efficacy of marine cloud brightening for cooling Earth using a simple heuristic model, *Atmospheric Chemistry and Physics*, 21(19), 14507–14533. <https://doi.org/10.5194/acp-21-14507-2021>
- Hoffman F. and Feingold G., 2021, Cloud Microphysical Implications for Marine Cloud Brightening: The Importance of the Seeded Particle Size Distribution, *J. Atmos Sci.*, 3247–3262, <https://doi.org/10.1175/JAS-D-21-0077.1>
- Jenkins A.K.L. and Forster P.M., 2013, The inclusion of water with the injected aerosol reduces the simulated effectiveness of marine cloud brightening. *Atmospheric Science Letters*, 14 (3). 164 - 169. ISSN 1530-261X <https://doi.org/10.1002/asl2.434>
- Hernandez-Jaramillo, Harrison L., Kelaher B., Ristovski Z. and Harrison D.P. (2023), 2023, Evaporative Cooling Does Not Prevent Vertical Dispersion of Effervescent Seawater Aerosol for Brightening Clouds, *Environ Sci Technol*, 20559-20570. doi: [10.1021/acs.est.3c04793](https://doi.org/10.1021/acs.est.3c04793).
- Dhandapani C., Kaul C.M., Pressel K.G., et al., 2023, Sensitivities of Large Eddy Simulations of Aerosol Plume Transport and Cloud Response. *ESS Open Archive*, DOI: 10.22541/essoar.170365352.28240067/v1
- Brown N. et al., Software Engineering, <https://doi.org/10.48550/arXiv.2009.12849>
- Tonttila, J., Maalick, Z., Raatikainen, T., Kokkola, H., Kühn, T., and Romakkaniemi, S.: UCLALES–SALSA v1.0: a large-eddy model with interactive sectional microphysics for aerosol, clouds and precipitation, *Geosci. Model Dev.*, 10, 169–188, <https://doi.org/10.5194/gmd-10-169-2017>, 2017.
- Gordon H., Carslaw K.S., Hill A.A., Field P.R., Abraham N.L., Beyersdorf A., Corr-Limoges C., Ghosh P., Hemmings J., Jones A.C., Sanchez C., Wang X., and Wilkinson J. (2023), NUMAC: Description of the Nested Unified Model With Aerosols and Chemistry, and Evaluation With KORUS-AQ Data, *JAMES*, Volume 15, Issue 11, e2022MS003457, <https://doi.org/10.1029/2022MS003457>
- Haywood, J. M., Jones, A., Jones, A. C., Halloran, P., and Rasch, P. J.: Climate intervention using marine cloud brightening (MCB) compared with stratospheric aerosol injection (SAI) in the UKESM1 climate model, *Atmos. Chem. Phys.*, 23, 15305–15324, <https://doi.org/10.5194/acp-23-15305-2023>, 2023

25. Rasch P., Hirasawa H., Wu M., Doherty S., Wood R., Wang H., Jones A., Haywood J., and Singh H., (2024), A protocol for model intercomparison of impacts of Marine Cloud Brightening Climate Intervention, <https://doi.org/10.5194/egusphere-2024-1031>
26. Bellamy, R., Chilvers, J., Vaughan, N. and Lenton, T. (2012): A review of climate geoengineering appraisals. *WIREs Climate Change*, 3, 597 – 615, <https://doi.org/10.1002/wcc.197>
27. Bellamy, R., Lezaun, J. and Palmer, J. (2017): Public perceptions of geoengineering research governance: An experimental deliberative approach. *Global Environmental Change*, 45, 194 – 202, <https://doi.org/10.1016/j.gloenvcha.2017.06.004>.
28. Bellamy, R. and Healey, P. (2018): 'Slippery slope' or 'uphill struggle'? Broadening out expert scenarios of climate engineering research and development. *Environmental Science and Policy*, 83, 1 – 10, <https://doi.org/10.1016/j.envsci.2018.01.021>
29. Wood R, Mechoso C.R., Bretherton C.S., Weller R.A., Huebert B., Straneo F., Albrecht B.A., Coe H., Allen G., Vaughan G., Daum P., Fairall C., Chand D., Gallardo Klenner L., Garreaud R., Grados C., Covert D.S., Bates T.S., Krejci R., Russell L.M.I, de Szoeke S., Brewer A., Yuter S.E., Springston S.R., Chaigneau A., Toniazzo T., Minnis P., Palikonda R., Abel S.J., Brown W.O.J., Williams S., Fochesatto J., Brioude J., and Bower K. N. (2011), The VAMOS Ocean-Cloud-Atmosphere-Land Study Regional Experiment (VOCALS-REx): goals, platforms, and field operations, *ACP Volume 11*, issue 2, 627–654, <https://doi.org/10.5194/acp-11-627-2011>
30. Haywood J.M., Abel S.J., Barrett P.A., Bellouin N., Blyth A.M., Bower K.N., Brooks M., Carslaw K., Che H., Coe H., Cotterell M.I., Crawford I., Cui Z., Davies N., Dingley B., Field P., Formenti P., Gordon H., de Graaf M., Herbert R., Johnson B., Jones A.C., Langridge J.M., Malavelle F., Partridge D.G., Peers F., Redemann J., Stier P., Szpek K., Taylor J.W., Watson-Parris D., Wood R., Wu H., and Zuidema P., (2021), The CLOUD–Aerosol–Radiation Interaction and Forcing: Year 2017 (CLARIFY-2017) measurement campaign, *ACP Volume 21*, issue 2, 1049–1084, <https://doi.org/10.5194/acp-21-1049-2021>
31. Brooks J., Allan J.D., Williams P.I., Liu D., Fox C., Haywood J., Langridge J.M., Highwood E.J., Kompalli S.K., O'Sullivan D., Babu S.S., Satheesh S.K., Turner A.G., and Coe H., (2019), Vertical and horizontal distribution of submicron aerosol chemical composition and physical characteristics across northern India during pre-monsoon and monsoon seasons, *ACP*, Volume 19, issue 8, 5615–5634, <https://doi.org/10.5194/acp-19-5615-2019>
32. Bellamy, R., Chilvers, J. and Vaughan, N. (2016): Deliberative Mapping of options for tackling climate change: Citizens and specialists 'open up' appraisal of geoengineering. *Public Understanding of Science*, 25, 269 – 286, <https://doi.org/10.1177/0963662514548628>
33. Haywood, J. and S. Tilmes (Lead Authors), F. Keutsch, U. Niemeier, A. Schmidt, D. Vioni, and P. Yu, Stratospheric Aerosol Injection and its Potential Effect on the Stratospheric Ozone Layer, Chapter 6 in *Scientific Assessment of Ozone Depletion: 2022*, GAW Report No. 278, 509 pp., WMO, Geneva, 2022, [csl.noaa.gov/assessments/ozone/2022/downloads/Chapter6_2022OzoneAssessment.pdf](https://www.csl.noaa.gov/assessments/ozone/2022/downloads/Chapter6_2022OzoneAssessment.pdf)
34. Vioni, D., Robock, A., Haywood, J., Henry, M., Tilmes, S., MacMartin, D. G., Kravitz, B., Doherty, S. J., Moore, J., Lennard, C., Watanabe, S., Muri, H., Niemeier, U., Boucher, O., Syed, A., Egbebiyi, T. S., Séférian, R., and Quaglia, I.: G6-1.5K-SAL: a new Geoengineering Model Intercomparison Project (GeoMIP) experiment integrating recent advances in solar radiation modification studies, *Geosci. Model Dev.*, 17, 2583–2596, <https://doi.org/10.5194/gmd-17-2583-2024>, 2024.
35. Vioni, D., Kravitz, B., Robock, A., Tilmes, S., Haywood, J., Boucher, O., Lawrence, M., Irvine, P., Niemeier, U., Xia, L., Chiodo, G., Lennard, C., Watanabe, S., Moore, J. C., and Muri, H.: Opinion: The scientific and community-building roles of the Geoengineering Model Intercomparison Project (GeoMIP) – past, present, and future, *Atmos. Chem. Phys.*, 23, 5149–5176, <https://doi.org/10.5194/acp-23-5149-2023>, 2023.
36. Lowe, S.J., Partridge, D.G., Davies, J.F., Wilson, K.R., Topping, D. and Riipinen, I., 2019. Key drivers of cloud response to surface-active organics. *Nature communications*, 10(1), p.5214.
37. Jones, A., Haywood, J., and Boucher, O., (2009), Climate impacts of geoengineering marine stratocumulus clouds, *J. Geophys. Res.*, 114, D10106, [doi:10.1029/2008JD011450](https://doi.org/10.1029/2008JD011450)
38. Jones, A.C., et al., Regional climate impacts of stabilizing global warming at 1.5 K using solar geoengineering, *Earth's Future*, doi.org/10.1002/2017EF000720, 2018.
39. Jones, A.C., J.M. Haywood, N. Dunstone, M.K. Hawcroft, K. Hodges, A. Jones, and K. Emanuel, Impacts of hemispheric solar geoengineering on tropical cyclone frequency, *Nature Communications*, 8, 1382, [doi:10.1038/s41467-017-01606-0](https://doi.org/10.1038/s41467-017-01606-0).

Section1: Programme and Technical

Aim. Advance the technical feasibility, social license and scientific understanding of efficacy and risks of Marine Cloud Brightening (MCB). By undertaking the next generation of outdoor experimentation enabled through the development of technology, methodology, numerical modelling, governance, and engagement.

Programme alignment. Anthropogenic climate change is increasing the global temperature, with serious consequences already observed in marine, terrestrial, and human ecosystems. A prominent example is the increase in frequency and severity of marine heatwaves leading to mass coral bleaching events which now threaten coral reefs globally. Aerosol emissions, through their light scattering properties and interactions with clouds, constitute the largest negative anthropogenic forcing in the global radiative energy balance¹. It follows that deliberately leveraging aerosol-cloud-radiation processes is the basis for several proposed methods to actively cool the earth, including the marine cloud brightening and marine sky brightening (MSB) techniques. The extent of uncertainty in the magnitude of these forcings¹ highlights the need to better constrain the numerous atmospheric processes which are impacted by a change in composition and quantity of aerosol loading². Understanding how MCB impacts these complex interactions (see Fig. 1A) can only be achieved through a program of real-world experimentation on clouds, combined with adequate, high-resolution numerical modelling of the underlying processes^{2,3}. To evaluate the benefits and risks of various MCB implementation scenarios, it is necessary to extend real-world experiments sufficiently to capture the impacted processes and conduct numerical modelling over multiple scales to not only consider local effects, but approach regional impacts that are inherently difficult to constrain³.

Background. Building on over 30+ years of theoretical study, Southern Cross University (SCU) and partners have advanced MCB research from theory and laboratory studies to outdoor experiments⁴ measuring *in-situ* with aircraft the cloud microphysical response to perturbation (Fig. 1 B&E). In our nozzle laboratory we refined the effervescent atomisation technique⁵ to create aerosols at MCB relevant sizes with number production rates and energy efficiency which enable outdoor field testing to occur^{4,6}. From 2020 to 2024 we successfully scaled up outdoor field-testing prototypes from 100 to 640 nozzles and developed the Aerosol, Radiation, and their Interactions Experimental Laboratory (ARIEL) spraying system. ARIEL can produce up to 10^{15} s^{-1} sea spray aerosol (SSA) in three distinctly different aerosol size spectra to tease out the influence of competing cloud processes and direct radiative responses (Fig. 1C).

A series of ‘point source’ perturbation experiments over the Great Barrier Reef (GBR) have been completed to evaluate the sensitivity of trade wind cumulus clouds to the artificially generated SSA. We have demonstrated a key underpinning hypothesis of the MCB concept, that supplying additional cloud condensation nuclei (CCN) can, for a given cloud liquid water content, decrease the cloud drop effective radius (Fig. 1D) and increase the droplet number concentration (Fig. 1E). These initial shifts in cloud microphysical properties are those proposed by Twomey⁷ (Fig. 1A) and are expected to result in a predictable initial albedo increase for the cloud (1st aerosol indirect effect). While the resulting albedo increase can be calculated⁸, it has not yet been measured explicitly during our field experiments due to their limited scale. Beyond the initial Twomey effect, MCB is expected to result in a series of adjustments to cloud properties (2nd aerosol indirect effects; Fig. 1A) which may further increase, or conversely reduce, the net radiative forcing. Both the sign and magnitude of these interacting effects are influenced by the concentration, composition, and size distribution of the artificially generated aerosol as well as that of the background aerosol, the prevailing atmospheric conditions, and the nature of clouds present. Understanding these interlinked processes sufficiently well to estimate their respective importance and cumulative impact on radiative forcing is key to accurately predicting the efficacy and risks of MCB for a given atmospheric and meteorological situation.

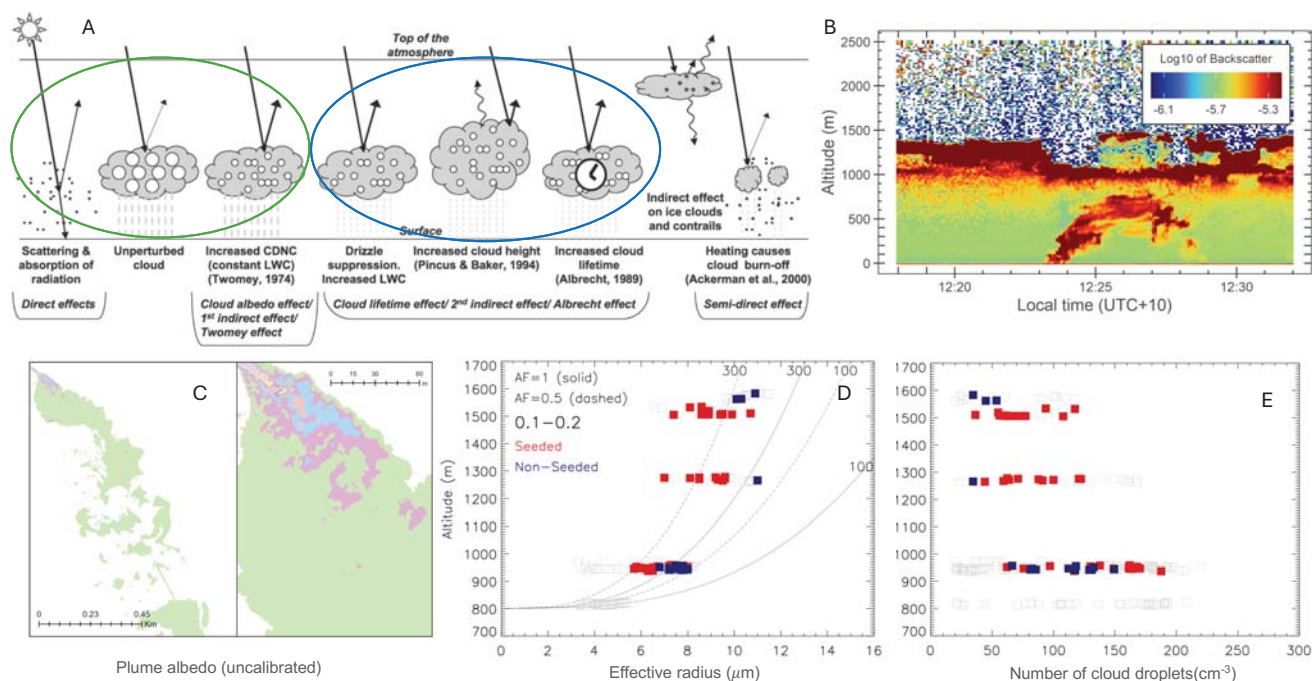


Figure 1: (A) Aerosol-cloud-radiative processes⁹, green circle represents MCB effects measured in past campaigns (C-E), blue indicates effects targeted in this proposal. (B) LiDAR measurement from a sampling vessel of the ARIEL produced MCB plume lifting into a cloud layer at $\sim 1000\text{m}$ cloud base altitude. (C) uncalibrated albedo of MSB (direct effect) from the aircraft mounted hyperspectral camera (still in processing), vessel is in upper left corner. (D&E) Within-cloud results demonstrating the Twomey effect.

Why the GBR? Low cloud over the GBR consists of stratocumulus, shallow trade wind cumulus, and cumulus of greater vertical development, with the latter two classifications being more common during our field campaign periods in summertime¹⁰. Our work has shown that meteorology and clouds in the GBR region play an important role in coral bleaching events^{11, 12}. Corals experience bleaching due to a combination of both heat and light stress¹³⁻¹⁵. Modelling¹⁶, field observations⁶, and our previous MCB experiments (Fig. 1B-E) demonstrates that sky and cloud albedo over the GBR is sensitive to aerosol perturbation. Hydrodynamic modelling indicates that the unique shallow semi-enclosed bathymetry of the GBR lagoon provides an ideal case study, where application of MCB at a regional scale could lead to significant sea surface temperature reductions¹⁷. Implementation over as little as 10% of the GBR would be effective in reducing ocean temperature and mitigating coral bleaching. Evidence that MCB could meaningfully alter the trajectory of live coral cover on the GBR over the coming decades¹⁸ makes this a promising application of technology to actively cool the earth. Our work on the GBR has proceeded under federal regulatory approval and with effective governance mechanisms in place^{19, 20}. The Australian public supports further research, and is 'accepting' of cloud brightening on the GBR with 63% supporting (69% within region), and 14% rejecting this intervention in a national survey²¹.

Advancing the state of the science. A challenge of measuring albedo change in cumulus cloud fields is that the perturbation does not necessarily affect the entire cloud at once and can progress in individually impacted clouds at different rates and locations (Fig. 2). We propose to address this challenge by employing an upscaled experimental approach. By including 2-3 MCB spraying vessels and increasing the output of the next generation of ARIEL, we will aim to achieve a degree of homogenisation of the enhanced CCN concentration within an area of approximately $10 \times 10 \text{ km}$. By utilising two sampling aircraft we will measure the albedo change in a more uniformly perturbed region of cloud and begin to examine experimentally the microphysics induced changes to whole-of-cloud structure with time (1-2 hours) that result in the 2nd aerosol indirect effects (Fig. 1A).

We will apply a state-of-the-art lagrangian cloud model (LCM)^{22, 23} coupled to a large-eddy simulation model²⁴ for high resolution MCB simulations. The LCM relies on individually simulated computational particles, each representing an ensemble of identical hydrometeors (aerosols, cloud droplets, rain drops), where process rates are determined from first principles. The use of individually simulated particles allows the physicochemical properties of the sprayed and natural aerosol to be directly described, a prerequisite to investigating the effects of MCB on clouds in the required detail. Within the two-way coupled LES-LCM

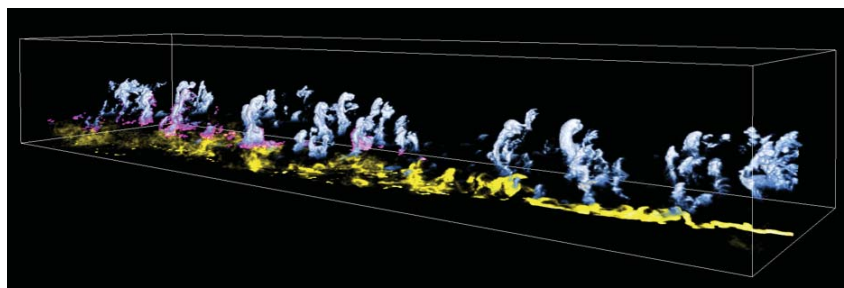


Figure 2: LES-LCM model results of a single MCB spraying vessel (at far right) in a shallow cumulus cloud field with wind right to left. White = cloud, Yellow = MCB aerosol, Magenta = aerosol impacted cloud.

framework, we can investigate the interactions of dynamics, aerosol, and cloud microphysics essential to quantifying aerosol indirect effects on clouds and radiation, e.g., the turbulent transport of sprayed aerosol to the cloud base (see. Fig. 1B), their subsequent activation determined by the cloud's updraft, as well as the turbulent mixing of the cloud with its environment and the subsequent effects on the number and size of cloud droplets and evolution of the cloud properties over time.

ACCESS-EMS-GBR is a convection-permitting, coupled atmosphere-ocean model of the GBR that has been configured to undertake assessments of MCB using simulations at local to global scales. The model consists of a regional atmosphere configuration of the Australian Community Climate and Earth System Simulator (ACCESS), coupled for this project to the CSIRO Environmental Modelling Suite (EMS) hydrodynamic and biogeochemical model of the GBR. The resulting coupled model represents aerosol-cloud-radiation interactions, atmosphere-ocean heat feedbacks and subsequent impacts on the underlying coral reef, making it ideal for assessing the impacts and risks associated with MCB applied to the GBR and wider region. Higher resolution convection-resolving simulations are also achievable, and wider insights into potential benefits and pitfalls of MCB beyond the GBR application can also be derived.

Work detail. We propose activity across five work streams (WS A-E) each consisting of work packages.

WS.A Proposed technology development. To support the next phase of MCB research it is necessary to increase the total output of ARIEL and construct additional units. The most important improvement is to increase the number CCN produced per unit energy required. It is also desirable to decrease the total footprint of the system to allow operation on smaller and less costly vessels. Two shipping containers of ARIEL are each fully occupied by 3 sizable air compressors (total 6) that supply the large quantity of compressed air required (Fig. 3C). The requirement for compressed air is responsible for most of the energy, space, and weight of the overall system. The current technique achieves ~66% of the SSA within the target size range (Fig. 3A). We aim to improve the current system by targeting a reduction in the gas to liquid ratio (and hence energy) while improving output. In parallel we will investigate alternate technologies which may remove the need for compressed air entirely while also improving the size distribution (Fig. 3B).

WP.A1 Nozzle tech development (UoC & SCU, yr 1-3). Five alternative technologies to atomise the seawater will be developed and tested for size specificity, production rate, and energy efficiency. These include; superheated water²⁵⁻²⁷, electrospray²⁸, Rayleigh jet breakup^{29, 30}, bubble formation from pressurised air³¹, and Powercloud derived from Archipelago's proprietary Powerdrop ® technology. Several of these techniques are already showing promise of improved energy efficiency and size mono-specificity (Fig. 3B). Initially these methods will be developed and tested in parallel at the nozzle development facilities. SCU's dedicated facility includes two sizes of non-recirculating wind tunnel developed specifically for MCB nozzle testing. There is custom designed industrial plant to supply high pressure air, water, and heat. The key objectives are to establish the resulting aerosol size distribution, the degree to which it can be manipulated, the production rate, and energy efficiency for each technology. The leading two technologies will move to the prototype stage (internal performance stage gate). Spray characterisation results will inform WP.C2.

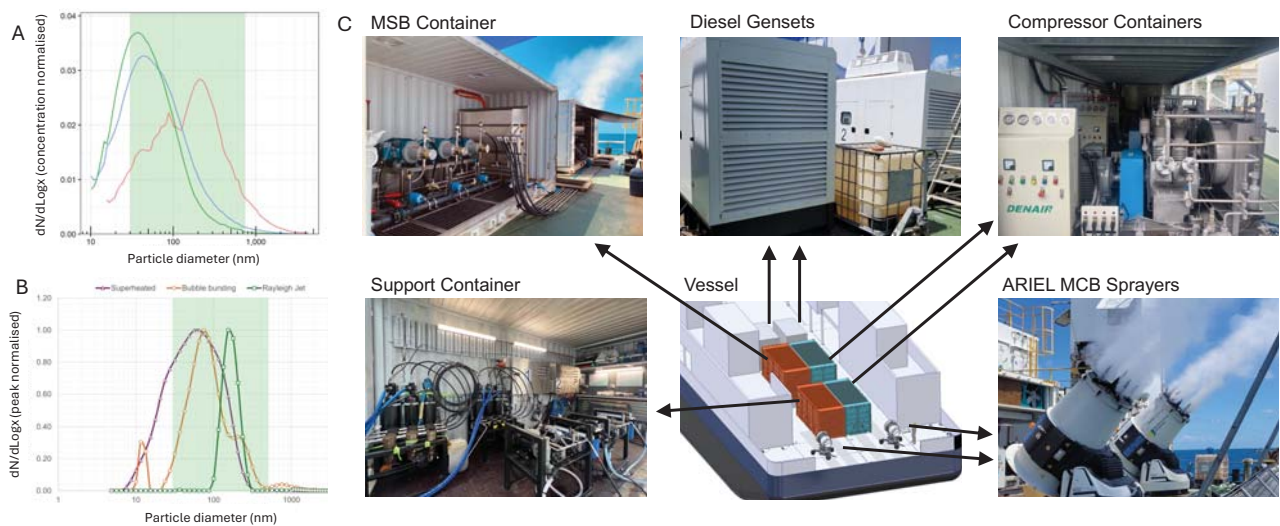


Figure 3: (A) Field measured size distributions for the 3 sprays currently produced by ARIEL. (B) Alternate spray technologies showing improved fraction in the target range (green shading). (C) ARIEL components.

WP.A2 Prototype development and testing (UoC & SCU, late yr 1 – yr 3). In this stage we will undertake the engineering design for an overall system of sufficient scale to achieve production of $0.5\text{-}1 \times 10^{16}$ CCN s^{-1} , targeting $\sim 10\times$ increase on the current ARIEL output. The design phase will confirm the viability of upscaling the most promising water atomisation techniques to field testable prototypes and determine the process inputs, feasibility, safety, and environmental considerations. Following the design phase review (stage-gate) prototypes will be manufactured for field testing. This process will involve engineering design consultants and certifiers to ensure safety and regulatory compliance. The prototypes will be tested in WP.B2.

WP.A3 Prototype upscaling and manufacture (SCU & UoC, yr 4). Based on the outcome of WP.B2 field testing (stage-gate) a technology prototype will be selected for the manufacture of 1-2 additional systems. The final number of sprayers (target 3) will be dependent on performance and informed by modelling undertaken in WP.C1 to support the experimental planning. The system selected may be the existing ARIEL technology if new prototypes prove unable to outperform the existing system or are found to be unreliable or impractical for operations at sea. ARIEL was improved iteratively over multiple field campaigns and the expectation is that there will be improvements to new prototypes following each round of field testing.

WS.B Fieldwork. Ahead of the proposed outdoor field experiments we will refine and test our methodologies for tracing the generated aerosol plume in the atmosphere and for quantifying the cloud microphysical and albedo response. In later stages, preliminary outdoor experiments on land and at sea will provide opportunity for real-world testing and refinement of the improved ARIEL prototypes prior to design finalisation and multiple unit manufacture. The major MCB perturbation experiment will consist of a multi-spraying-source field campaign in which we aim to validate model predictions and explicitly measure the response of cloud albedo, and the extended series of cloud physics impacts illustrated in Fig 1A.

WP.B1. Methodology development (SCU & UNSW, yr 1-2). All but two methodologies required for the proposed fieldwork are now well refined to practice including; logistics, vessel fit out and operation, ARIEL reliability, methods to manipulate the size and salt composition of the spray, use of drones^{4, 32-34}, aircraft sampling operations⁶, ground based remote sensing³⁴, and satellite observation of the perturbations. Methodology for tracking the plume without the addition of any chemical tracer has been developed and allows apportionment of the relative contributions of diesel exhaust and sea salt aerosol. There is, however, no independent validation as yet. The hyperspectral camera is mounted to the aircraft and acquiring data (Fig.1C) but the methodologies for retrieving cloud microphysical properties, calibrating albedo, and altitude for each pixel requires further development. We propose to further refine these two techniques in a low-cost manner during test flights with the aircraft, targeting aerosol plumes resulting from container ship exhaust.

WP.B2 Prototype land testing (UoC & SCU, late yr 2 / early yr 3). Initially the prototypes will be tested on land (stage-gated). This will serve to iron out any initial engineering issues, and confirm the performance of

the design by sampling the produced sea spray aerosols downwind while monitoring of the engineering parameters of seawater flow and energy consumption. SCU has developed proven methodologies for such land-based testing. This work may be in undertaken in conjunction with the U. Manchester (UoM) team.

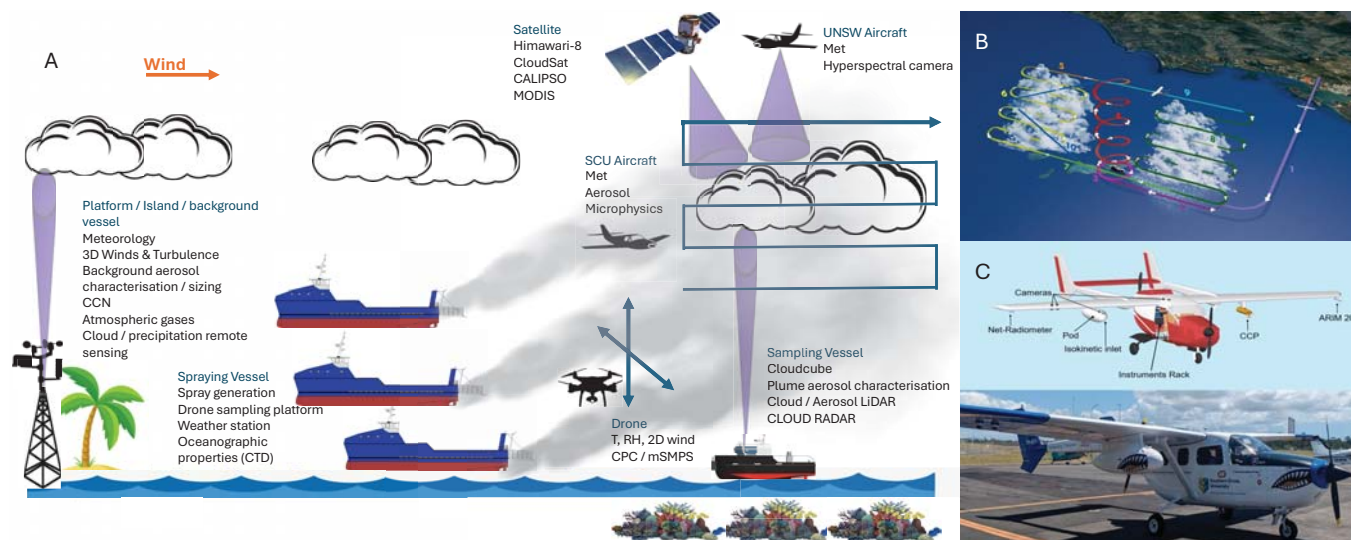


Figure 4: (A) The proposed major field campaign strategy. (B) Flight sampling strategy for aerosol and cloud physics sampling of upwind (background) and downwind (perturbed) cloud. (C) The SCU aircraft⁶.

WP.B3 Prototype sea testing (SCU, UoC, QUT, UNSW, late yr 3). Following the land-based testing, an iteration of engineering improvements is allowed for, prior to the Australian sea trials. These trials (stage gated) will serve as a smaller precursor to the major field campaign. It will consist of a single spraying vessel and a sampling vessel to operate downwind for characterising the SSA plume and remote sensing of cloud properties (a simplified version of the strategy illustrated in Fig. 4A). SCU has developed a small portable 8' x 8' containerised laboratory "CloudCube" that can be loaded aboard a vessel for this purpose. This fieldwork will offer the opportunity to compare and contrast the impacts of up to three different MCB technologies on cloud (ARIEL + prototypes developed in WP.A2). It will provide proof of concept demonstration for methodologies developed in WP.B1 prior to the major field campaign in yr 4 (WP.B4).

WP.B4 Next generation MCB field experiment (SCU, QUT, UNSW, UoC, late yr 4). This (stage gated) package delivers the major advancement in MCB research that our proposal is focused around. The field campaign strategy is illustrated in Fig. 4. It involves multiple spraying vessels (target of 3) operating in the optimum configuration informed by the outcomes of the high-resolution modelling in WP.C2. By operating multiple higher output systems together, we will have advanced the engineering aspects of MCB one step closer to potential implementation. The comprehensive measurement campaign will improve our process understanding of the multiple interconnected atmospheric and cloud microphysical implications of MCB.

WS.C High resolution modelling of aerosol and cloud processes. We will undertake high-resolution, large-eddy numerical simulations with Lagrangian cloud microphysics (LES-LCM)²². This computational tool will assimilate data from previous outdoor experiments into a numerical modelling framework, aid in the interpretation of results from past and future campaigns, and allow us to plan and predict outcomes of multi-vessel spraying scenarios and optimise sampling methodologies for the planned field campaign.

WP.C1 Model validation and hindcasts (LMU & SCU, yr 1-2). Our team is unique in that we have collected a wealth of field data on MCB which is yet to be incorporated into a numerical modelling framework, the LES-LCM is the most appropriate state of the art tool for this purpose. To validate the model and interpret past results a major objective is to conduct simulations of selected days during past field campaigns (hindcasts). For this, reanalysis data, and/or the modelling output from WP.D1 will provide the synoptic conditions that determine the development of the boundary layer and its clouds. The measurement campaigns will provide detailed information on the background aerosol, while sprayers will be added using the specifications from past lab studies and measured in WP.A1 (e.g., the size and number of sprayed aerosols). We expect that the large-scale conditions vary during the field campaigns (e.g., wind direction, background aerosol), therefore we plan to produce at least one simulation for each condition.

WP.C2 Informing fieldwork planning and interpreting results (LMU & SCU, yr 2-5). A primary purpose of the modelling will be to guide and augment observations. Our simulations will identify regions of cloud most susceptible to the MCB aerosols e.g. where to target observations for the Twomey effect and for cloud water adjustments (Albrecht effect), cloud lifetime, and cloud fraction effects (Fig. 1A). Our simulations will give a baseline on how strong these effects are expected to be in relation to background variability and indicate under what atmospheric, meteorological and spraying conditions they will be statistically discernable. The simulations will augment the field collected data by providing process-level insights that will support the interpretation of the observations. The modelling will also allow us to gain insight into (a) the impacts of negative buoyancy due to the evaporation of sprayed seawater droplets, which may limit the vertical transport of the sprayed particles, and will vary for different spraying technologies and atmospheric stability (b) the potential collisions of sprayed particles close to the sprayer where concentrations can be very high (Brownian coagulation), which reduces the number of sprayed particles reaching the cloud base, (c) the potential losses of very large sprayed particles to the ocean due to sedimentation, and (d) how the sprayed aerosol is distributed within the boundary layer³⁵.

WP.C3 Alternate scenarios (LMU & SCU, yr 5). Financial, technical, and meteorological constraints will limit what we can test in the field. Therefore, we will use our simulations to test how clouds would respond to increased or lowered spraying rates, alternative distributions of sprayed aerosols, spraying geometries and strategies, different conditions of background aerosols, and multiple meteorological situations. This will inform the design and assessment of future MCB implementation strategies and scenarios for WP.D1&2.

WS.D Understanding efficacy and risks of implementation. This workstream is focused on gaining insight into potential implications of MCB operated at a sufficient scale to derive regional benefit. Since LES-LCM is limited to geographical domains of ~ 20x20 km, and it is infeasible to directly test MCB under all variations of atmospheric condition, the broader evaluation of benefit and risk will use a larger domain model in which some processes are parameterised. We limit our focus in this work stream to address the key questions of scalability, efficacy, and risks of the most apparent concern, being those to regional weather, precipitation patterns, the marine and terrestrial environment, and atmospheric chemistry.

WP.D1 Simulating MCB impacts and efficacy (CSIRO & SCU, Yr 1-3).

We will use observations from field studies (WS.B) and insights from the high-resolution cloud microphysics modelling (WP.C1-2) to better represent aerosol indirect effects on cloud. A key consideration in determining the efficacy of MCB is the importance of the aerosol direct and indirect effects on the radiation budget. ACCESS-EMS-GBR includes detailed aerosol^{36, 37} and cloud microphysics³⁸ schemes that explicitly represent aerosol-cloud interactions and radiative effects. The model also includes a mechanism to represent sea spray aerosol emissions for MCB and can therefore be used to quantify the direct and indirect impacts on cloud, precipitation and radiation at implementation scales which are unachievable in the high-resolution modelling. Various sea spray injection MCB scenarios will be explored to identify the optimal scenario in terms of emissions parameters, timing and location, to maximise the cooling response while minimising resources and costs. Model performance will be benchmarked against the LES-LCM.

WP.D2 Quantifying risks of MCB (QUT, CSIRO & SCU, yr1-3).

The coupled ACCESS-EMS-GBR model will also be used to assess the risks associated with MCB, including the potential for precipitation changes. An increase in cloud droplet number concentration can suppress rainfall in low-level cumulus clouds^{6, 16} or enhance precipitation in deep convective clouds^{39, 40}, highlighting the complexity in aerosol-cloud-precipitation interactions. While the scale of any future sea spray injections for the GBR are not currently expected to seriously impact precipitation, long-term changes could influence flooding and/or drought in north-eastern Australia and therefore stakeholder concern and diligence require a detailed risk assessment. A series of control and perturbed simulations will be conducted at convection-permitting resolution to explore the impacts of sea spray injections on precipitation over the north-east Australia region. Impacts on atmospheric composition via altered aerosol pH, altered heterogeneous and aqueous-phase reactions and altered oxidative capacity, will also be assessed.

Supplementary chemical transport modelling will be conducted, supported by experiments to be undertaken in the QUT atmospheric chamber using nozzles developed in package WP.A1 with seawater samples collected from representative ocean regions and types. These experiments, combined with the modelling, aim to assess whether the addition of sea spray aerosol at levels necessary for effective MCB, will significantly impact secondary atmospheric chemistry in pristine regions.

WS.E / WP.E1 Governance and social license. Working with federal regulators from the outset, SCU and partners have conducted a total of five MCB field campaigns. Each incremental improvement in technology, scale and scientific ambition has been subject to permitting approval by the Great Barrier Reef Marine Park Authority, following review of the outcomes of the previous iteration. In this manner our research is progressed in responsible steps with appropriate monitoring, risk minimisation, regulatory oversight, indigenous consent and involvement, and societal support. Critically, this progress has occurred and would continue under ARIA within a fully transparent, federally legislated regulatory framework which includes public and indigenous community consultation²⁰. We have supplemented this external oversight through multiple levels of internal governance arrangements, including an independent risk review group, and our own community and traditional indigenous owner engagement, including community reference panels. We propose to continue similar arrangements to be determined in consultation with ARIA. This WP allocates time of the leadership team to comply with ARIA principles for outdoor experiments by continuing the aforementioned engagement and governance activities, with the goal of continuing to build societal support to explore MCB as a potential intervention to mitigate coral mass bleaching events in the GBR⁴¹ (yr 1-5). We are not requesting direct funding for social science or governance research, but rather will continue to collaborate with our now established network of social, legal, ethics, and regulatory scientists.

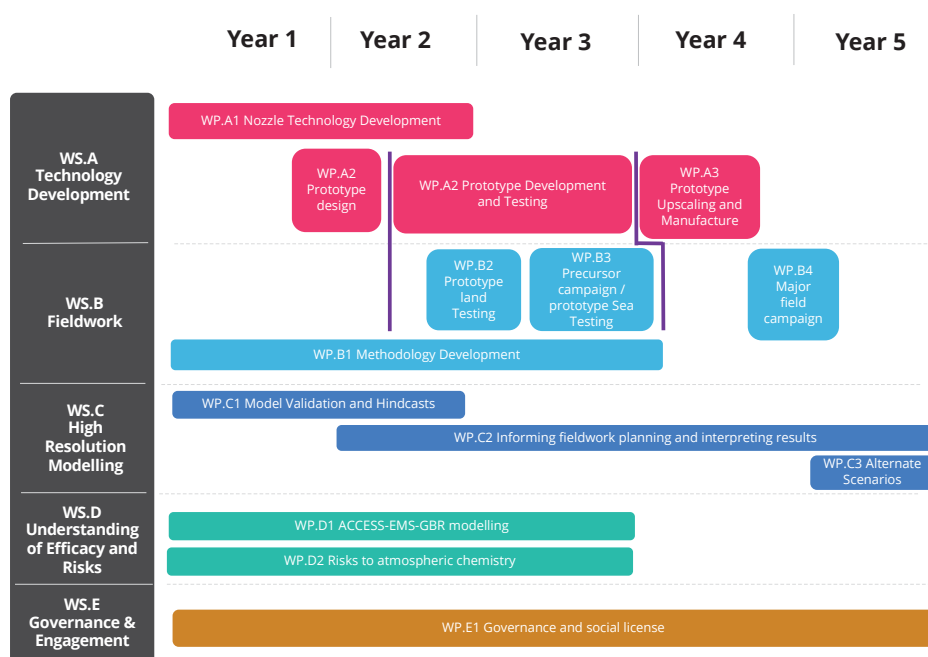


Figure 5: Project timeline. Purple lines indicate suggested stage gates.

sensor will be transferred for this work. The partners operate a comprehensive suite of meteorological, aerosol, and cloud microphysics instrumentation well suited to delivering this project. ARIA investment in our project effectively leverages on an \$AUD 36m investment by the Australian Government and other funders over the last 4 years, including \$AUD ~6m of new infrastructure, including our nozzle development facility. High performance computing in WS.C&D will be conducted on infrastructure to which we have access in Australia and Germany.

Linkages and benefits to the United Kingdom. This program of work has been developed in consultation with the team involved in the UoM led proposal. The scopes are complementary and we intend to work collaboratively amongst the two teams. The UoC contribution and costing of £1.84m including overhead is duplicated in both proposals. Our nozzle development work will be informed by the cloud chamber physics studies at UoM. Modelling, cloud chamber experiments, nozzle development, and fieldwork in the UK will

Infrastructure. The ARIEL system was developed by SCU to produce CCN for MCB research. It is the result of multiple iterations of engineering development and proven to run robustly under harsh conditions at sea (300 MCB and 140 MSB operating hours). "Bruce" is a Cessna 337 aircraft that SCU has developed specifically for MCB research⁶ and has recently been fitted with a NVIR+SWIR hyperspectral sensor to map cloud albedo and microphysical properties in high spatial resolution. UNSW operates a piper Seminole research aircraft to which the hyperspectral

benefit from access to existing and future real-world datasets and transfer of critical knowledge and experience developed during the previous Australian RRAP project. SCU has agreed to support outdoor experiments in the UK under the UoM led proposal by providing ARIEL (or its upgrade), technical staff to operate it, and researchers to contribute their expertise in outdoor MCB field experimentation. CSIRO are also able to offer their expertise in the regional modelling system identified for use in the UoM proposal.

Risks. The primary technical risk is that we are unable to significantly improve the output efficiency of ARIEL. This risk is mitigated by the parallel investigation of multiple alternate atomisation technologies with encouraging preliminary results (Fig 3B). Failure to achieve the output target, while discouraging for implementation scales, is mitigated because the primary science objectives of this project can likely be met using multiple copies of the existing ARIEL system. The modelling in WP.C2 will provide further clarity on spraying outputs required to meet objectives. Contingency for a *force majeure* event affecting the major field campaign is provided through the data collection in the preliminary campaign (WP.B3). Sufficient campaign length is planned to allow for weather and other interruptions. There is a small risk of an extended aircraft unavailability due to maintenance issues, this is mitigated by some redundancy in sampling with the 2nd aircraft, drone-based, and remote sampling capabilities. There is a risk of losing our existing indigenous, community, or regulatory support, although this is mitigated by our strong track record and continued program of engagement. There is a risk that the increase in scale of the major field experiment could trigger additional time-consuming regulatory processes (e.g. Assessment under Australia's EPBC Act⁴²), this is considered unlikely given the highly transient nature of any potential impacts. Further mitigation is provided by the modelling in WS.C&D which will provide input to the regulatory and governance risk assessment processes on the potential impacts of the outdoor experiments.

Deliverables. Improved spraying technologies for MCB, publications disseminating all aspects of the R&D. Documented community and indigenous engagement including publications on best practices adopted in MCB for the GBR. Indigenous involvement in co-design and delivering the research. International governance engagement including with the developing world (e.g. through SOLAS, The Alliance for Just Deliberation on Solar Geoengineering, Carnegie Climate Governance Initiative, and other scientific, NGO, and government organisations). Knowledge transfer to other ARIA funded projects and international involvement in field campaigns. Publicly available field campaign datasets.

Section 2: The Team

Our team brings together a discipline specific mix of senior, mid, early career, and student researchers, supported by an experienced professional, technical, and administrative staff.



The team are highly motivated to work on this project because of their passion for atmospheric, cloud physics, and ocean sciences, but also because it is apparent to us that current global action on climate change is insufficient to save some of the world's most precious ecosystems including the Great Barrier Reef.

Bibliography

1. IPCC, *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Core Writing Team, 2014. Geneva, Switzerland. p. 151.
2. Wood, R. and T.P. Ackerman, *Defining success and limits of field experiments to test geoengineering by marine cloud brightening*. Climatic Change, 2013. **121**(3): p. 459-472.
3. Feingold, G., et al., *Physical science research needed to evaluate the viability and risks of marine cloud brightening*. Science Advances, 2024. **10**(12): p. eadi8594.
4. Hernandez-Jaramillo, D.C., et al., *Evaporative Cooling Does Not Prevent Vertical Dispersion of Effervescent Seawater Aerosol for Brightening Clouds*. Environmental science & technology, 2023. **57**(49): p. 20559-20570.
5. Cooper, G., et al., *Preliminary results for salt aerosol production intended for marine cloud brightening, using effervescent spray atomization*. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 2014. **372**(2031): p. 20140055.
6. Hernandez-Jaramillo, D.C., et al., *New airborne research facility observes sensitivity of cumulus cloud microphysical properties to aerosol regime over the great barrier reef*. Environmental Science: Atmospheres, 2024. **4**(8): p.861-871.
7. Twomey, S., *Pollution and the planetary albedo*. Atmospheric Environment, 1974. **8**(12): p. 1251-1256.
8. Hoffmann, F. and G. Feingold, *Cloud Microphysical Implications for Marine Cloud Brightening: The Importance of the Seeded Particle Size Distribution*. Journal of the Atmospheric Sciences, 2021. **78**(10): p. 3247-3262.
9. IPCC, *Climate Change 2007 - The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the IPCC*, 2007.
10. Zhao, W., et al., *A characterization of clouds over the Great Barrier Reef and the role of local forcing*. International Journal of Climatology, 2022. **42**(12): p. 6647-6664.
11. Zhao, W., et al., *The Role of Clouds in Coral Bleaching Events Over the Great Barrier Reef*. Geophysical Research Letters, 2021. **48**(14): p. e2021GL093936.
12. Richards, L.S., et al., *The meteorological drivers of mass coral bleaching on the central Great Barrier Reef during the 2022 La Niña*. Scientific Reports, 2024. **14**(1): p. 23867.
13. Butcherine, P., et al., *Intermittent shading can moderate coral bleaching on shallow reefs*. Frontiers in Marine Science, 2023. **10**: p. 1162896.
14. Ellis, S.L., et al., *Shading responses are species-specific in thermally stressed corals*. Frontiers in Marine Science, 2024. **11**: p.1333806.
15. Tagliafico, A., et al., *The Effects of Shade and Light on Corals in the Context of Coral Bleaching and Shading Technologies*. Frontiers in Marine Science, 2022. **9**: p. 919382.
16. Zhao, W., et al., *Interactions between trade wind clouds and local forcings over the Great Barrier Reef: a case study using convection-permitting simulations*. Atmospheric Chemistry and Physics, 2024. **24**(9): p. 5713-5736.
17. Harrison, D.P., et al., *Environmental Modelling of Large Scale Solar Radiation Management*, 2019. Australian Institute of Marine Science: Townsville, Australia.
18. Condie, S.A., et al., *Large-scale interventions may delay decline of the Great Barrier Reef*. Royal Society Open Science, 2021. **8**(4): p. 201296.
19. Baresi, U., et al., *A call for strategic assessments of regional applications of solar radiation management: Exploring the challenges and opportunities from marine cloud brightening and albedo surface modification*. Environmental Impact Assessment Review, 2025. **110**: p. 107701.
20. GBRMPA, *Permit applications for restoration/adaptation projects to improve resilience of habitats in the Great Barrier Reef Marine Park*, 2018. Great Barrier Reef Marine Park Authority: Australia.
21. Sle, L., B.W. Ritchie, and S. Lockie, *Australian attitudes toward the protection and restoration of the Great Barrier Reef: Summary Findings*, 2022. Australian Institute of Marine Science. Townsville, Australia. p. 24.
22. Hoffmann, F., S. Raasch, and Y. Noh, *Entrainment of aerosols and their activation in a shallow cumulus cloud studied with a coupled LCM–LES approach*. Atmospheric Research, 2015. **156**: p. 43-57.
23. Hoffmann, F., T. Yamaguchi, and G. Feingold, *Inhomogeneous Mixing in Lagrangian Cloud Models: Effects on the Production of Precipitation Embryos*. Journal of the Atmospheric Sciences, 2019. **76**(1): p. 113-133.
24. Khairoutdinov, M.F. and D.A. Randall, *Cloud Resolving Modeling of the ARM Summer 1997 IOP: Model Formulation, Results, Uncertainties, and Sensitivities*. Journal of the Atmospheric Sciences, 2003. **60**(4): p. 607-625.

25. Zalkind, V.I., et al., *Superheated Water Atomization: Some New Aspects of Control and Determining Disperse Characteristics of Atomization Plume in Micron and Submicron Ranges of Droplet Size**. Journal of Physics: Conference Series, 2017. **891**: p. 012011.
26. Zalkind, V.I., et al., *Perspectives of Reaching Mono- and Bimodal Droplet Size Distribution of Atomized Superheated Water in Micron and Submicron Ranges*. Journal of Physics: Conference Series, 2018. **1128**: p. 012058.
27. Zalkind, V.I., et al., *Superheated Water Atomization: A Possibility of Obtaining Sprays of Droplets of Micron Diameters*. High Temperature, 2018. **56**(1): p. 153-155.
28. Cooper, G., et al., *A Review of Some Experimental Spray Methods for Marine Cloud Brightening*. International Journal of Geosciences, 2013. **4**(1): p. 78-97.
29. Salter, S., G. Sortino, and J. Latham, *Sea-going hardware for the cloud albedo method of reversing global warming*. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 2008. **366**(1882): p. 3989-4006.
30. Salter, S.H., T. Stevenson, and A. Tsiamis, *Engineering Ideas for Brighter Clouds*, in *Geoengineering of the Climate System*, 2014. Royal Society of Chemistry. p. 131-161.
31. Mezhericher, M., I. Ladizhensky, and I. Etlin, *Atomization of liquids by disintegrating thin liquid films using gas jets*. International Journal of Multiphase Flow, 2017. **88**: p. 99-115.
32. Eckert, C., et al., *Exploring Meteorological Conditions and Microscale Temperature Inversions above the Great Barrier Reef through Drone-Based Measurements*. Drones, 2023. **7**(12): p. 695.
33. Eckert, C., et al., *Drone-Based Measurement of the Size Distribution and Concentration of Marine Aerosols above the Great Barrier Reef*. Drones, 2024. **8**(7): p. 292.
34. Ryan, R.G., et al., *Boundary layer height above the Great Barrier Reef studied using drone and Mini-Micropulse LiDAR measurements*. Journal of Southern Hemisphere Earth Systems Science, 2024. **74**(3): p. ES24008 .
35. Stull, R.B., *An Introduction to Boundary Layer Meteorology*. Atmospheric and Oceanographic Sciences Library. Vol. 13. 2012: Springer Dordrecht.
36. Mann, G.W., et al., *Intercomparison of modal and sectional aerosol microphysics representations within the same 3-D global chemical transport model*. Atmospheric Chemistry and Physics, 2012. **12**(10): p. 4449-4476.
37. Mann, G.W., et al., *Description and evaluation of GLOMAP-mode: a modal global aerosol microphysics model for the UKCA composition-climate model*. Geoscientific Model Development, 2010. **3**(2): p. 519-551.
38. Field, P.R., et al., *Implementation of a double moment cloud microphysics scheme in the UK met office regional numerical weather prediction model*. Quarterly Journal of the Royal Meteorological Society, 2023. **149**(752): p. 703-739.
39. Fan, J., et al., *Substantial convection and precipitation enhancements by ultrafine aerosol particles*. Science, 2018. **359**(6374): p. 411-418.
40. Rosenfeld, D., et al., *Flood or Drought: How Do Aerosols Affect Precipitation?* Science, 2008. **321**(5894): p. 1309-1313.
41. Harrison, D.P., *An Overview of Environmental Engineering Methods for Reducing Coral Bleaching Stress*, in *Oceanographic Processes of Coral Reefs*, E. Wolanski and M. Kingsford, Editors, 2024. CRC Press. p. 484.
42. Australian Government, *Environment Protection and Biodiversity Conservation Act 1999*, 1999. Department of Climate Change and Water.

Section 1: Program and Technical

S 1.1: Project Title:

Exploring Geoengineering's Effects on the Dynamics and Thermodynamics of Monsoon and Precipitation Extremes

S1.2: Aims and Background

Precipitation is a critical component of the Earth's climate system, essential for sustaining ecosystems and supporting agricultural productivity. However, climate change is projected to significantly alter global precipitation patterns, particularly during monsoon seasons. Numerical models indicate an increase in both the intensity and variability of precipitation as a result of climate change (Lee et al, 2021). According to the Clausius-Clapeyron (CC) equation, atmospheric moisture content is expected to rise 6 to 7%, which contributes to an increase in precipitation by up to 3% globally for each degree Celsius of surface temperature rise (Allen and Ingram 2002). This phenomenon is not uniformly distributed; climate models exhibit regionally distinct projections of moisture increases under the CC framework with enhancement of regional extreme precipitation of CC or even super-CC scaling ($>7\%$ per $^{\circ}\text{C}$) (Allan et al., 2013; Martinez--Villalobos and Neelin 2023). Additionally, alterations in atmospheric circulation patterns driven by warming will further modulate the intensity and distribution of extreme precipitation events (Pfahl et al., 2017).

Our recent findings, Byju et al. (2024) suggest that as atmospheric temperatures rise, the dynamics governing monsoon precipitation and extreme weather events will be fundamentally altered for the Indian Summer monsoon precipitation. Specifically, there may be a reduction in the contribution of dynamic components influencing precipitation, while thermodynamic factors and nonlinear interactions complicate precipitation characteristics. Studies showed that geoengineering could lead to a reduction in temperature, but the response to precipitation would be regionally different. Such changes in precipitation would be critical for regions like India, where even slight changes in monsoon precipitation can significantly impact the socio-economic conditions. For example, Krishnamohan and Bala (2022) found that stratospheric sulphate injections in the Northern Hemisphere can lead to a reduction in precipitation over the Indian region by more than 20%, potentially resulting in permanent drought-like conditions. This raises some important questions: How will these critical physical factors (dynamic, thermodynamic and nonlinear causes of precipitation) evolve if human interventions aimed at cooling the Earth are implemented? How is it going to impact the extreme precipitation patterns? And, which component of precipitation is going to be impacted the most after the termination of Solar Radiation Management (SRM) interventions? Can we expect any seasonality changes?

The main aims of this project are to:

1. Conduct a comprehensive assessment of geoengineering's impact on monsoon and precipitation extremes across India and the UK—factors directly influencing agricultural practices and food production and economy.
2. Elucidate how the factors influencing precipitation frequency, intensity and seasonality such as atmospheric dynamics, thermodynamics, evaporation processes, and nonlinear physics are altered due to geoengineering interventions.
3. Investigate how these changes manifest in the precipitation and moisture budget terms following the termination of such interventions.

Background

The ongoing warming of the planet significantly influences precipitation patterns and extremes, which is a critical consideration when evaluating geoengineering strategies aimed at cooling the Earth. Research indicates that climate change exacerbates these patterns, leading to a scenario where wet regions become wetter and dry areas experience increased aridity (Donat et al., 2016). Specifically, models suggest that under the Shared Socioeconomic Pathway (SSP) 5-8.5 scenario, many regions will experience more intense

monsoon precipitation compared to the SSP2-4.5 scenario. This trend is attributed to an increase in the frequency and intensity of extreme daily events associated with climate change (Krishnan et al., 2016).

Research identified enhanced vertical moisture ascent, referred to as the vertical dynamic component, as a primary driver of extreme precipitation events (Pfahl et al., 2017; Sudharsan et al., 2020; Kaagita et al., 2024). This vertical motion is often linked to local convection or low-level convergence, which elevates atmospheric moisture levels. The resulting latent heating further intensifies upward motion, promoting condensation and heavy rainfall. While thermodynamic factors may contribute to an overall increase in future precipitation patterns, dynamic processes are critical at local scales (Pfahl et al., 2017), particularly in enhancing ascent velocities and moisture content in regions such as the Asian monsoon area (Pfahl et al., 2017). Similar findings have emerged from studies in the UK, where an extreme winter event in 2014 was linked to stronger vertical motions that increased atmospheric moisture and promoted convection (Oueslati et al., 2019). A recent analysis by Byju et al. (2024) reveals that the vertical dynamic component accounts for over 70% of extreme precipitation intensity during wet monsoon months across much of the study area within historical data. However, projections indicate a reduction of 10-35% in this component's contribution to extremes from near-future to far-future scenarios, particularly under high-emission SSP5-8.5 conditions (Figure 1). This decline is associated with a fractional decrease in extreme vertical velocity during significant events, likely due to increased tropospheric stability resulting from warming.

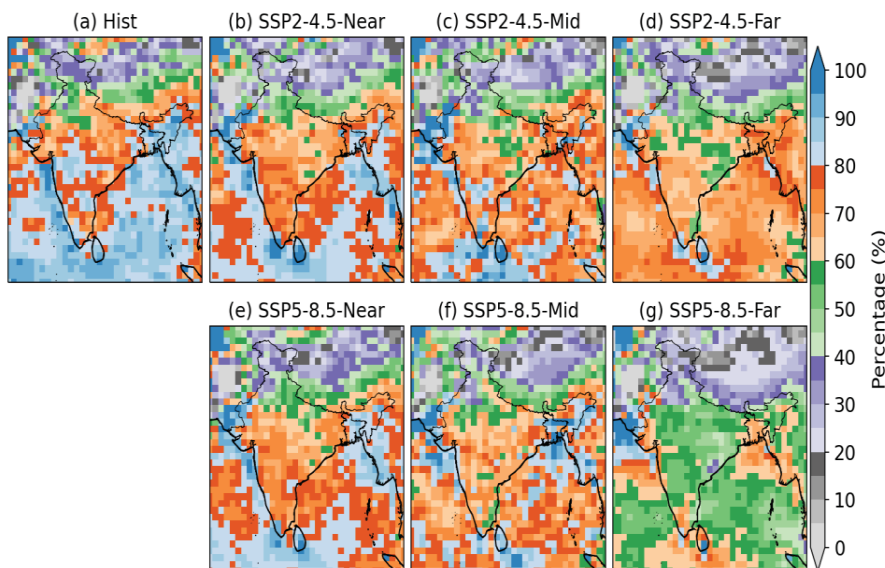


Figure 1: Spatial map showing ensemble mean percentage contribution of Vertical Dynamic component to extreme precipitation (a) for the historical time period 1995-2014 (Hist) (b-d) for SSP2-4.5 scenario near (2021- 2040), mid (2041-2060) and far (2081-2100) time period (e-g) for SSP5-8.5 scenario. Vertical Dynamic component is the major contributor for extreme precipitation, with global warming its effect is found to be reducing irrespective of increase in intensity of extreme precipitation. (Figure is adopted from Byju et al, 2024).

Geoengineering has gained attention as a potential approach for mitigating climate change impacts. However, it is crucial to thoroughly investigate the ramifications of geoengineering methods on hydrological cycle (Tilmes et al., 2013; Ricke et al., 2023), and their broader societal implications, particularly concerning agriculture. Current research indicates that while geoengineering strategies may effectively mitigate climate change impacts, they could also present significant drawbacks (Irvine et al., 2010, Parson and Keith, 2024). The nature and magnitude of these drawbacks are contingent upon specific geoengineering approaches. Additionally, uncontrolled termination of SRM interventions could lead to rapid climatic changes (Irvin et al, 2017).

Climate modelling studies available in this area are mainly focused on stratospheric aerosol injection (SAI), which is a proposed method to inject reflecting aerosols into stratosphere, which lead to a reduction in global and tropical precipitation (Ferraro and Griffiths, 2016). Several recent studies (e.g., Tilmes et al., 2018) indicate that planned simultaneous injections at multiple locations can effectively help maintain large-scale temperature metrics in a nearly stable state. The Stratospheric Aerosol Geoengineering Large Ensemble (GLENS) experiment involved the injection of sulphur dioxide (SO₂) at various latitudes with an adaptive feedback-control algorithm (Tilmes et al., 2018), revealing that such injections suppress tropical precipitation, particularly affecting monsoon regions in India and the Americas (Kravitz et al., 2019). In contrast, Arctic aerosol injection

is thought to have a lesser impact on tropical climates due to its shorter aerosol lifespan and smaller coverage area. Studies have indicated that both tropical and Arctic injections could decrease precipitation over monsoon regions in Asia and Africa (Robok et al, 2008). Specifically, research has shown that Arctic geoengineering and the resulting inter-hemispheric temperature difference can shift the Intertropical Convergence Zone southward, altering precipitation patterns in the Northern and Southern Hemispheres (Nalam et al., 2018). However, differences in injection intensities between tropical and Arctic SAI experiments complicate the assessment of their respective contributions to climate changes. While thermodynamic and nonlinear terms contribute to a decrease in global mean precipitation under Arctic SAI, dynamic terms may counteract this effect (Sun et al., 2020).

Studies shows that Indian Summer Monsoon (ISM) is sensitive to geoengineering (Bala et al., 2008) and to the location of aerosol injection, as interhemispheric differences in forcing and related temperature variations can lead to significant reductions in precipitation (Krishnamohan and Bala, 2022; Roose et al., 2023; Xavier et al., 2024). A recent study by Tilmes et al. (2024) shows that even in the GLENS simulation, where the large-scale temperature metrics remain unaltered, several factors such as upper tropospheric warming and circulation changes can lead to a weakening of the monsoon precipitation. Although the proposed geoengineering methods, such as SRM, Marine Cloud Brightening (MCB), and Cirrus Cloud Thinning (CCT), may lead to planetary cooling, their impacts on the processes controlling ISM will vary. Given the complexity of the Asian monsoon system and its numerous feedback mechanisms, establishing clear cause-and-effect relationships remains challenging. Nevertheless, considering that a significant portion of the population depends on the ISM for sustenance, these studies carry substantial regional implications—not only for solar geoengineering outcomes but also for intermediate climatic conditions during its implementation.

Studies have shown that while SAI may effectively moderate temperature increases, it also tends to reduce the frequency and intensity of extreme precipitation events. Ji et al. (2018) shows that the response of extreme precipitation to different geoengineering scenarios varies. While stratospheric aerosol injection is more efficient at decreasing extreme precipitation in tropical areas, solar dimming proves to be more effective in extra-tropical regions. Bal et al, (2019) shows that solar geoengineering can significantly compensate for the change in seasonality, peak precipitation timing and duration associated with enhanced warming. Several such studies also show that regional variability of precipitation responses to geoengineering is significant (Pinto et al., 2020; Obahoundje et al., 2022) but it is not uniform (Simpson et al., 2019). For Indian region, Tilmes et al. (2024) show that SAI can help reducing the monsoon extreme precipitation events relative to the SSP8.5 scenario in GLENS simulations. Study also shows that at the termination of geoengineering interventions, climatic conditions such as temperature, precipitation, winds, and moisture would abruptly revert to what they would have been under a global warming scenario (Bhowmick et al., 2021). This potential shift must also be considered when implementing methods aimed at cooling the planet.

Overall, while the proposed methods of geoengineering can cool the planet and negate some ill effects of climate warming, it carries complex implications for global and regional precipitation and requires careful consideration of the undesirable side effects, even after the termination of the method. The impacts of geoengineering on extreme precipitation can be multifaceted and can lead to both reductions and increases in precipitation extremes depending on the method used and the regional climatic conditions. Further, the relationship between warming/cooling and extreme precipitation is complex due to the interplay between dynamic and thermodynamic factors. **Utilising moisture budget decomposition methodologies as applied in our research article Byju et al. (2024), we aim to explore existing SRM methods while identifying necessary adjustments to current geoengineering proposals. Most importantly, understanding the basic science of causes of precipitation extremes and how it is modified due to warming/cooling effects is the motivation for this project.** The proposed project will offer valuable insights into regional variations and potential climate extremes hotspots, thereby providing policymakers, researchers, and stakeholders with meaningful information for decision-making processes on Geoengineering processes.

S1.3: APPROACH AND METHODOLOGY

Moisture budget analysis

Our primary objective of this proposal is to understand how the changes in atmospheric condition leading to a change in precipitation pattern. To address this, we can decompose the anomalous precipitation into different moisture budget components into dynamic, thermodynamic and nonlinear components. We believe that this will help us to identify the potential area where the changes stem from. Based on our recent article published (Byju et al, 2024; and the references in it) about the moisture budget changes in a warming world, changes in moisture balance in the atmosphere can be approximated by the following equation: -

$$P' = E' - \langle \bar{\omega} \cdot \partial_p q' \rangle - \langle \omega' \cdot \partial_p \bar{q} \rangle - \langle \omega' \cdot \partial_p q' \rangle - \langle \bar{V} \cdot \nabla q' \rangle - \langle V' \cdot \nabla \bar{q} \rangle - \langle V' \cdot \nabla q' \rangle + Res \quad \text{---Eq (1)}$$

where the angle brackets ($\langle \rangle$) denote the mass integration through the entire atmospheric column, and primes ($'$) denote the change in the monthly values relative to a reference period. P is precipitation, E is Evaporation rate, ' ω ' is vertical pressure velocity, u and v are zonal and meridional wind vectors, and q denotes specific humidity. 2nd and 5th term on the RHS is the dynamic terms, which are the climatological circulation (vertical and horizontal) advecting anomalous moisture and is referred to as thermodynamic component. The 3rd and 6th term represents the advection of climatological moisture by anomalous circulation, which is termed as dynamic component. The 4th and 7th components are the nonlinear cross component depicting the anomalous moisture advection due to both circulation and specific humidity changes. Finally, Res represents the residual term.

By applying this equation, we will gain insights into the physical components that are most sensitive to climate intervention methods resulting in anomalous precipitation. Furthermore, analysing changes across different regions and distinct geographical contexts, while utilising various climate model data for different geoengineering approaches, will enhance our understanding of the sensitivity of these interventions.

Seasonality changes

Understanding whether the warming or cooling of the planet will lead to changes in seasonality is crucial, as these changes can significantly impact local ecological and social processes. Seasonality changes can be assessed using matrices that include dimensionless relative entropy, dimensionless seasonality index, timing of the peak rainy season, and duration of the peak rainy season (Feng et al., 2013).

$$\bar{D} = \sum_{m=1}^{12} \bar{p}_m \log_2 (\bar{p}_m / q_m).$$

At each grid point, relative entropy ($\bar{D}$), which measures the deviation of the precipitation probability distribution (p_m) from a uniformly distributed precipitation (q_m), quantifies the concentration of precipitation during the peak precipitation season each year. The seasonality index (S), calculated as $S = \bar{D} \cdot R / R_{\max}$ is derived by taking the product of relative entropy (D) and mean annual precipitation (R), normalised by the spatial maximum annual precipitation ($R_{\max}$). Additionally, seasonality can be further

decomposed into 'timing' ($C = \frac{1}{\bar{R}} \sum_{m=1}^{12} m \bar{r}_m$), represents peak precipitation timing during the peak precipitation

period) and 'duration' ($Z = \sqrt{\frac{1}{\bar{R}} \sum_{m=1}^{12} |m - C|^2 \bar{r}_m}$), indicates the peak precipitation period duration), where ' r_m ' is monthly precipitation and 'm' is months.

By employing this method, we anticipate that we will effectively capture the impact of geoengineering methods on changes in seasonality, including peak precipitation timing and duration, as a result of the enhanced warming of the planet in both the present and future. Furthermore, we will also investigate whether cooling interventions lead to significant changes in seasonality that could affect society.

Data

A comprehensive analysis of the precipitation changes is proposed here by using existing GeoMIP model simulations. The Geoengineering Model Intercomparison Project (GeoMIP6) is a coordinated effort to understand the potential impacts of different geoengineering techniques on the Earth's climate system (Kravitz

et al., 2015). Model data can be downloaded from Earth System Grid Federation site (<https://esgf-index1.ceda.ac.uk/projects/esgf-ceda/>).

GeoMIP primarily focuses on SRM techniques, which aim to reduce incoming solar radiation to counteract global warming. These techniques include stratospheric aerosol injection, marine cloud brightening, and cirrus cloud thinning. A wide range of climate models, including global climate models (GCMs) and Earth system models (ESMs), participate in GeoMIP. This diversity helps capture a range of potential climate responses to geoengineering. It explores a variety of geoengineering scenarios, such as different deployment strategies, intensities, and durations. This allows for a comprehensive understanding of the potential range of outcomes.

We will also use data from models participating in the Coupled Model Intercomparison Project phase-6 (CMIP6) under historical, intermediate (SSP2-4.5), and high-emission (SSP5-8.5) scenarios to investigate characteristic changes in precipitation, extremes and seasonality.

We can identify extreme wet months, defined as those months with total precipitation values exceeding the 95th percentile of historical precipitation for each month at each grid point. The 95th percentile could be determined using the model's historical precipitation data from 1965 to 2014. We will focus exclusively on the grid points where precipitation values exceed this extreme wet threshold. At these selected grid points, we will analyse the moisture budget terms, calculating anomalies relative to the historical mean from 1995 to 2014, in accordance with the IPCC AR6 report.

S1.4: Work Plan

Stream 1: Assess precipitation pattern over India and the UK

Objective: Understand the changes in precipitation patterns and moisture budget components over India and the UK.

1) Historical changes in precipitation and moisture budget

Given the significant climate changes observed over recent decades, it is important to examine past variability in moisture budget components related to excessive precipitation. First, we will analyse historical changes in precipitation patterns and corresponding moisture budget in both India and the UK using CMIP6 historical simulation model data. Here, we also expected to get an insight on region wise (tropical versus midlatitude) response of climate change to different components (dynamic, thermodynamic and nonlinear) of precipitation including the extreme.

2) Changes under different climate change scenarios

Utilising CMIP6 scenarios (SSP24.5 and SSP58.8), we will analyse future changes in precipitation patterns and moisture budget components. This analysis will help assess the sensitivity of large excess precipitation events to different emission scenarios and warming levels. Additionally, we will explore the differential impacts of global warming on tropical and midlatitude regions, with a particular focus on precipitation extremes and moisture budget dynamics. We have already carried out similar analysis over Indian monsoon (Byju et al, 2024), but the understanding of these factors over the UK in the midlatitude region must be carried out.

Overall, the outcomes from Stream 1 will be utilised to compare and analyse the physics of precipitation changes linked to geoengineering interventions in Stream 2.

Stream 2: Assess the impact of Geoengineering methods in precipitation pattern

Objective: To quantify the impact of various geoengineering methods, specifically Solar Radiation Management techniques, on precipitation and large excess precipitation events. How the cooling of planet Earth modulates the dynamics and thermodynamics of precipitation? How it behaves after the termination?

To achieve this, we will utilise GeoMIP simulation data to assess changes in hydrological cycles resulting from different SRM techniques. Advanced statistical and data analysis techniques will be employed to decompose anomalies in precipitation extremes across various scenarios. By comparing the results from Stream 1 (historical and warming scenarios) with the changes in moisture budget components analysed using GeoMIP, we will identify how the dynamics and thermodynamics are changing? And, which component of the moisture budget has the largest impact on precipitation change? We will also analyse the changes in moisture budget terms at the termination of the interventions. This comparative analysis will help us analyse regional variations and potential hotspots for climate extremes because of the implementation of Geoengineering methods.

Stream 3: Analyse the changes in precipitation seasonality

Objective: Analyse the changes in seasonality, timing and duration of precipitation due to Geoengineering interventions and after the termination.

Climate change not only impacts annual precipitation accumulation but also alters the spatial and temporal distribution of precipitation, including the timing and length of peak precipitation periods. In this project, we will evaluate changes in seasonality using indicators such as annual precipitation totals, dimensionless relative entropy, dimensionless seasonality index, timing of the peak rainy season, and duration of the peak rainy season (using the methods discussed in Feng et al., 2013). This evaluation will involve comparing results from various geoengineering climate simulations against historical and warming scenario simulations. Ultimately, this analysis aims to enhance our understanding of potential seasonal changes induced by the planetary cooling through various geoengineering methods. We will also study how the seasonality would be altered at the termination? This would help us to identify potential hotspots for drought or flood situations under the implementation of geoengineering interventions.

Section 2: INVESTIGATORS

██████████ will serve as the **Principal Investigator (PI)** for this project. ██████████
██████████
██████████
██████████
██████████
██████████
██████████
██████████
██████████
██████████

██████████ will dedicate full time to this project, overseeing overall coordination and execution to ensure that research silos do not form. ██████ will lead the work program for Stream 1 and Stream 3, significantly contribute to Stream 2.

██████████ will act as the Geoengineering Expert for this project. ██████████
██████████
██████████

██████████ This project proposal is a collaborative effort with The Energy and Resources Institute (TERI). T ██████████

██████████
██████████
██████████
██████████
██████████
██████████
██████████
██████████
██████████

[illegible]

██████████ is engaged with the Climate Change and Air Quality Programme of The Energy and Resources Institute (TERI) as Director. ██████████
██████████
██████████
██████████ experience and expertise on climate change can be utilised for the proposed project.

All the team members will be responsible for writing high quality peer reviewed articles related to the project.

S3.1 Budget details

Description	Amount in GBP (£)
<i>Labour</i>	69600
<i>Material</i>	500
<i>Equipment and Facilities</i>	20000
<i>Travel</i>	6000
<i>Other</i>	6000
<i>Indirect Costs</i>	13920
Total	116020

This project will leverage publicly available climate datasets such as CMIP6 and GeoMIP6, as well as open-source software like Python. Further, the project will leverage the expertise and computing resources of TERI.

██████████ will adhere to the terms of our collaboration agreement to ensure the protection of intellectual property rights.

S3.3 Conflicts of interest Statement

To the best of our knowledge, there are no conflicts of interest associated with this project. The project team members have no financial, personal, or professional interests that could potentially compromise the objectivity or integrity of the research.

References

1. **Byju**, P., et al., (2024). <https://doi.org/10.1002/joc.8636>
2. **Krishnamohan** K. S, et al. (2019). <https://doi.org/10.5194/esd-10-885-2019>
3. **Krishnamohan** K S., et al. (2021). <https://iopscience.iop.org/article/10.1088/2515-7620/ac18d1>
4. **Krishnamohan**, K.S.,& Bala, G. (2022) <https://doi.org/10.1007/s00382-021-06121-z>
5. **Kaagita** et al. (2024) <https://doi.org/10.1007/s44292-024-00021-7>
6. **Roose**, S., Bala, G., **Krishnamohan**, K.S. et al. (2023) <https://doi.org/10.1007/s00382-023-06799-3>
7. Bala, G., et al. (2008). <https://doi.org/10.1073/pnas.0711648105>
8. Bhowmick, M., et al. (2021) <https://doi.org/10.1038/s41598-021-89249-6>
9. Donat, M. G.,et al.,(2016). <https://doi.org/10.1038/nclimate2941>
10. Kravitz B, Robock A, Tilmes S et al (2015) <https://doi.org/10.5194/gmd-8-3379-2015>
11. Kravitz B, MacMartin DG, Tilmes S et al (2019) <https://doi.org/10.1029/2019JD030329>
12. Irvine, P. J., A. Ridgwell, and D. J. Lunt (2010). <https://doi.org/10.1029/2010GL044447>
13. Parson, E. A., & Keith, D. W. (2024). <https://doi.org/10.1146/annurev-environ-112321-081911>
14. Ricke, K., et al., (2023). <https://doi.org/10.1146/annurev-earth-031920-083456>
15. Tilmes, S., et al., (2013). <https://doi.org/10.1002/jgrd.50868>
16. Tilmes, S., et al., (2018). <https://doi.org/10.1175/BAMS-D-17-0267.1>
17. Tilmes et al., (2024). <https://doi.org/10.21203/rs.3.rs-4631758/v1>
18. Nalam A, Bala G, Modak A (2018) <https://doi.org/10.1007/s00382-017-3810-y>
19. Sun, W., et al., (2020). <https://doi.org/10.1007/s00382-020-05371-7>
20. Lee, J.-Y. et al., (2021) <https://doi.org/10.1017/9781009157896.006>
21. Allen, M.R. and Ingram, W.J. (2002) <https://doi.org/10.1038/nature01092>
22. Pfahl, S., O’Gorman, P.A. and Fischer, E.M. (2017) <https://doi.org/10.1038/nclimate3287>
23. Ferraro AJ, Griffiths HG (2016) <https://iopscience.iop.org/article/10.1088/1748-9326/11/3/034012/meta>
24. Krishnan, R., et al., (2016). <https://doi.org/10.1007/s00382-015-2886-5>
25. Sudharsan, N.,et al., (2020) <https://doi.org/10.1007/s00382-020-05410-3>
26. Oueslati, B., Yiou, P. and Jézéquel, A. (2019) <https://doi.org/10.1038/s41598-019-39306-y>
27. Xavier, et al. (2024) <https://doi.org/10.1093/oxfclm/kgae016>
28. Ji, D., et al., (2018). <https://doi.org/10.5194/acp-18-10133-2018>
29. Pinto, I., et al, (2020). <https://doi.org/10.1029/2019GL086047>
30. Obahoundje, S., et al., (2022). <https://doi.org/10.1108/IJCCSM-03-2021-0028>
31. Simpson, I., et al., (2019). <https://doi.org/10.1029/2019JD031093>
32. Feng, X., et al., (2013). <https://doi.org/10.1038/nclimate1907>
33. Bal et al., (2019). <https://iopscience.iop.org/article/10.1088/1748-9326/aafc7d>

_____,¹ _____,² _____¹

1 _____

2 _____

Section 1: Programme and technical

Space-based solar radiation management using sunshades is seen as a means of reducing solar insolation to offset the radiative forcing due to increased CO₂ concentration [1-7]. A range of concepts have been proposed, with most centring on the use of multiple sunshades located sunward of the Sun-Earth L₁ Lagrange point on the line connecting the Sun and the Earth (Fig. 1a). These can be in a static configuration [1-6], or oscillating above and below the ecliptic plane to alternately cool each hemisphere during the local summer [7]. Solar insolation can be therefore reduced, but without directly impacting the chemistry of the Earth's atmosphere, as is the case for methods such as stratospheric aerosol injection. In order to offset the radiative forcing due to increased CO₂ concentration, the scale of engineering necessary for space-based solar radiation management is potentially immense. For example, to offset 2K of warming, a sunshade with a radius of 1400 km and a mass of 5×10^{10} kg is required [8].

While the operational deployment of space-based solar radiation management using sunshades is challenging, it can be noted that such measures can be envisaged operating synergistically with other climate engineering interventions. In such a scenario, a smaller, but still significant space-based infrastructure would be required. Moreover, there is a growing interest in the use of orbiting solar reflectors to illuminate large terrestrial solar power plants at night [9-11] (Fig. 1b). Such near-term developments could provide a clear step towards space-based solar radiation management. For example, these solar reflectors could be fabricated in Earth orbit using in-space manufacturing (ISM). ISM is a rapidly developing technology which could also underpin the fabrication sunshades for space-based solar radiation management. These developments, coupled with falling launch costs, increasing launch mass and the prospect of using ISM feedstock from near-Earth asteroid resources, points to a future where space-based solar radiation management could begin to be feasible.

In order to take the first steps towards such a future an end-to-end in-space demonstration is required. For example, a small sunshade could be deployed from a low-cost CubeSat platform in Earth orbit on a day/night orbit passing in front of the solar disk. An array of ground-based telescopes under the orbit ground track could then be used to image the sunshade as it passes in front of the solar disk, while attempting to measure the reduction in solar flux at the observation points. The observational challenge is that the ratio of the solid angle subtended by the sunshade and the Sun would be small. Therefore, photometric observations of the

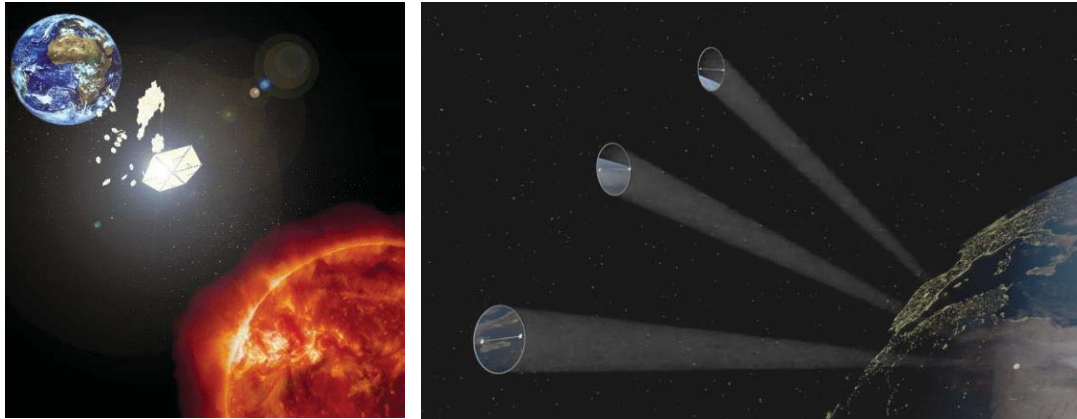


Figure 1: (a) Assembly of L_1 sunshades for solar radiation management (R Bewick/D Izzo)
(b) Orbiting solar reflectors for terrestrial clean energy services (A Viale/NASA)

occultation of planetary disks or stars by the sunshade can also be considered [12]. Such measurements would be a clear end-to-end demonstration of space-based solar radiation management and a first step towards future large-scale space-based climate engineering systems. The use of a CubeSat spacecraft, and a launch as a secondary payload, could in principle keep the total mission cost within an envelope which could be supported by ARIA.

It is envisaged that the CubeSat spacecraft would use commercially available technologies. However, the sunshade would be a custom device. Similar technologies exist for solar sails which use light pressure for propulsion. However, solar sails may be over-engineered for the purposes of a sunshade demonstrator. While a solar sail is typically tensioned to remove wrinkles, and so provide specular reflection of sunlight, a sunshade need only provide a fixed occulting area, and could be either absorbing or reflective. The sunshade must reliably deploy from its packaged state for launch, and then needs to maintain a planar geometry during the mission, independent of the attitude of the CubeSat platform.

The outcome of the project is expected to be a realistic assessment of the feasibility of measuring a reduction in solar insolation, or equivalent measurements using the Moon, planetary disks or stellar occultation. The CubeSat spacecraft and sunshade designs will be realistic and will leverage existing technology to develop a space-based solar radiation management demonstration mission which could be supported by ARIA. The cost and schedule for such a technology demonstration mission is at present uncertain, but will be one of the key deliverables of the project. If such a technology demonstration mission was found to be both feasible and affordable, it would represent an exciting opportunity for ARIA to take a measured first step towards space-based solar radiation management.

1.3 Objectives

The top-level objective of the project is to deliver a technical assessment, cost estimate and schedule for a space-based solar radiation management technology demonstrator.

The project will:

1. Define strategies which can demonstrate a measurable reduction in solar insolation;
2. Propose a mission concept to make such measurements;
3. Work with our industrial partner to determine technical feasibility and cost;
4. Define a multi-year phased development of the mission.

These objectives will be delivered through a 12-month project supported by two Research Assistants (to be appointed), one each at the University of Glasgow (GU) and Delft University

of Technology (TU), and our industrial partner AAC Clyde Space (CS). The final deliverable will be a technical report detailing our response to each of the objectives. This will provide the information required for ARIA to determine if such a mission fits with their long-term objectives.

1.4 Work packages

The 12-month project will comprise 4 key work packages (WP) to be led by GU, TU and CS:

WP1: Science goals for artificial solar occultation (TU)

WP1 will define the science goals, assess what occultation measurements could feasibly be made and provide inputs for subsequent WPs. The specific tasks comprise:

Task 1.1 Modelling of shading on Earth: Similar to the Earth's shadow on satellites, a mathematical model of the shadow of the sunshade on the Earth will be developed. The model will include perturbations in dynamics (Earth's oblateness, solar radiation pressure, etc.) and the Earth's orbit around the Sun for accurate estimations. The main output will be a generic model that can estimate the expected reduction in solar flux at the top of the atmosphere from a given sunshade altitude, and terrestrial location on the orbit ground track, for various Earth-centred orbit altitudes and sunshade sizes. This task will provide inputs for WP2 and WP3.

Task 1.2 Measurement strategies: The reduction in solar flux due to a sunshade is in principle measurable; however, the reduction is expected to be extremely small since a small sunshade demonstrator is likely for a low-cost mission. This scenario is akin to stellar occultation. Firstly, a sunshade on a day/night orbit passing in front of the solar disk will be considered with measurements made using ground-based telescopes. The model in WP1.1 will also be used to identify other scenarios similar to a small sunshade. Optical measurements of natural/artificial objects including the passage of International Space Station in front of the Sun and the Moon will be investigated. Moreover, the measured reduction in power generation from solar power plants during the passage of clouds and solar eclipses are similar scenarios to sunshades and will also be investigated. The output of the task will be the requirements for a measurable reduction in solar flux on ground, the size of the sunshade required as an input to WPs 2-4 to achieve a measurable reduction, and a strategy for a measurement campaign.

Task 1.3 Data analysis strategies: Using the model from Task 1.1 and the strategies outlined in Task 1.2, a data analysis pipeline will be created for noisy measurements to extract the reduction in solar flux. Inspired by stellar occultation scenarios, this pipeline will be tested against simulated noisy measurements and may be incorporated into open-access stellar occultation analysis tools, such as SORA¹. Similarly, strategies using data from reductions in solar power generation can also be analysed with the same data analysis pipeline. In the case of low solar flux reductions and highly noisy data, machine learning techniques will be explored to extract obtained reduction.

WP2: In-orbit technology demonstrator mission (GU)

WP2 will design the sunshade mission and spacecraft, trading off the different options and providing inputs for subsequent WPs 3 and 4. The specific tasks comprise:

Task 2.1 Mission design: A mission profile, from launch to disposal, will be designed. Starting from the selection of possible launchers, the operational orbit will be defined. The initial phases of the mission, from deployment from the launcher to deployment of the sunshade, will be defined. The orbit selected, also using inputs from WP 1, will determine the precise locations on Earth where the spacecraft will be viewed in front of the solar disk, hence informing the positioning of the observer ground stations. The duration of the operational phase will be estimated as determined by the action of atmospheric drag, which will be the primary cause

¹Available at <https://sora.readthedocs.io/latest/overview.html> (Accessed 22 November 2024)

of orbital decay due to the large area-to-mass ratio of the spacecraft. The end-of-life of the sunshade will also be investigated, to ensure that safe disposal will be guaranteed and is compliant with the current policies on space debris mitigation.

Task 2.2 ADCS: The attitude determination and control system (ADCS) will keep the sunshade normal vector pointing towards the Sun, to maximise the shaded area. Starting from a preliminary estimation of the disturbance torques (gravity gradient, solar radiation pressure, atmospheric forces) and the moments of inertia of the spacecraft with the deployed sunshade, a suite of actuators will be selected to maintain the pointing requirements. This will inform the mass, power and volume required by this subsystem.

Task 2.3 Spacecraft design: Starting from the requirements of the sunshade from WP 1, a range of mechanical configurations, membrane materials and deployment mechanisms will be proposed and traded-off. A traditional square membrane with four diagonal booms will be the likely baseline, however other configurations will be considered; for example, a boom-less circular membrane on a spinning platform could reduce system mass and complexity. Both mechanical and thermal properties will be considered in the membrane selection.

WP3: Industry assessment (CS)

WP3 will integrate the outputs of WP1 and WP2 to conduct an industrial assessment of the mission. This will include evaluating and defining a spacecraft solution, and identifying the necessary engineering modifications to AAC Clyde Space's EPIC spacecraft. Additionally, WP3 will assess the delivery timeline and total costs. WP3 will also provide support to WP1 and WP2 to ensure integration of the project tasks to deliver a feasible mission concept.

Task 3.1 Spacecraft Design: Mission requirements, derived from WP 1 and 2, will be translated into spacecraft requirements to define a proposed spacecraft solution. Subsequently, an engineering assessment will be conducted to evaluate the effort needed to adapt AAC Clyde Space's EPIC spacecraft solution to fulfil the specified requirements.

Task 3.2 Programmatic Assessment: The output of Task 3.1 will be utilised to evaluate the timeline for delivering a flight-ready spacecraft. Key design milestones, including the System Requirements Review, Preliminary Design Review, and Critical Design Review, will be established to ensure the successful design of the spacecraft. Following this, an assessment of the procurement and manufacturing of spacecraft subsystems will be conducted, enabling the Assembly, Integration, and Testing (AIT) of the spacecraft.

Task 3.3 Commercial Assessment: The outputs of Tasks 3.1 and 3.2 will be utilised to develop an accurate cost model for delivering a flight-ready spacecraft.

WP4: Mission roadmap, risks and reporting (GU, TU)

WP4 will define the future development of the technology demonstration mission with a realistic assessment of the technical challenges, schedule and budget. The final report for ARIA will be delivered at the end of WP4. The specific tasks to be undertaken comprise:

Task 4.1 Mission roadmap planning and cost estimation: The full mission roadmap will be detailed, which at top-level is expected to comprise; Phase 1: Technology demonstrator assessment study (current proposed project); Phase 2: Detailed development and critical design review; Phase 3: Spacecraft and sunshade build and qualification; Phase 4: Launch, operations and data reduction. Using the experience of our industrial partner we will use the cost model for the CubeSat spacecraft from Task 3.3 to add to launch and operations costs. The cost of the sunshade is uncertain, but a range of cost estimating methods will be used to assess the likely cost range. The output of the task will be a realistic schedule and budget which can be used to inform future ARIA planning.

Task 4.2 Key technical challenges, programmatic and regulatory risks: An assessment of the key risks associated with a future programme will be considered and reported. While the CubeSat platform is expected to represent low technical risk, the manufacture of the sunshade, its packing and its interaction with the CubeSat attitude control system are again uncertain. The future programmatic risks are expected to include slippage in schedule due to the fabrication and packing of the sunshade. In particular, reliable deployment of the sunshade is clearly essential. Regulatory risks are expected to include the debris hazard presented by the deployed sunshade and end-of-life disposal. Other public acceptance issues to consider include stay light reflection and the visibility of the sunshade in the night sky.

Task 4.3 Final reporting to ARIA: A final report will be prepared which will comprise an executive summary and a full technical report on the work undertaken. The report will provide a set of recommendations for ARIA, should the agency wish to pursue a space-based solar radiation management technology demonstration mission. In addition to the report, a final presentation will be delivered at ARIA premises as part of a half-day meeting to discuss the outcomes of the project and discuss future options and actions with ARIA staff. We expect the report to be public domain if required.

1.5 Project schedule

A 12-month project is planned comprising the 4 key Work Packages detailed in Section 1.4, as listed in Table 1. There are strong interdependencies between the tasks and project partners at GU and TU. While the main Work Package for CS is WP3, which will build on the output from WP3 and WP4, CS will also provide support for WP1 and WP2. The key milestones in the schedule are foreseen as a kick-off meeting (KO), mid-term review (MR) and final presentation (FP). We expect the schedule to adapt to the findings of the project, but the total duration will be limited to 12 months.

Month	Lead	1	2	3	4	5	6	7	8	9	10	11	12
WP1													
1.1	TU												
1.2	TU												
1.3	TU												
WP2													
2.1	GU												
2.2	GU												
2.3	GU												
WP3													
3.1	CS												
3.2	CS												
3.3	CS												
WP4													
4.1	GU/TU												
4.2	GU/TU												
4.3	GU/TU												
Event		KO					MR						FP

Table 1: Project schedule (KO kick-off, MR mid-term review, FP final presentation)

Section 2: The team

2.1 Project team

The project team comprises expertise from the GU, TU and our Glasgow-based industrial partner CS. Two full-time Research Assistants (RA), to be appointed, will deliver the key tasks associated with the project. CS will provide the industrial assessment of the mission concept. We believe that the project team provides complimentary expertise across science requirements, mission design and commercial evaluation. [REDACTED], has made longstanding contributions to space-based solar radiation management, [REDACTED] has developed new methodologies for solar flux modelling, [REDACTED] has direct experience of attitude control development, and our industrial partner is an international leader in CubeSat design and manufacture. The integration of academic research with pragmatic industrial design and evaluation is a key feature of our team. Moreover, the academic partners are well known to each other and the University of Glasgow and AAC Clyde Space are active collaborators on other work. This will ensure effective communication and collaboration across the project.

Space-based solar radiation management has long been discussed in the literature as a speculative concept for the future. The key motivation of the project team is to assess the feasibility of a near-term, low cost end-to-end demonstration mission which would lead to the first practical steps towards deploying such technology. This an exciting and important opportunity. Moreover, while space-based solar radiation management has been seen as speculative, there are now timely economic and technological shifts underway which could lead to nearer-term deployment. These include falling launch costs through reusability, increased launch mass, increased launch frequency and the development of in-space manufacturing technologies.

2.2 Key project members

[REDACTED]

[REDACTED]

[REDACTED]

AAC Clyde Space: AAC Clyde Space is a world-leading Glasgow-based company delivering design, manufacture, launch and operations of high-performance CubeSats, a range of low cost microsatellites which are typically launched as secondary payloads. They have been at the forefront of NewSpace innovation for over two decades and have developed numerous Commercial off the shelf (COTS) and hybrid solutions servicing missions from Low Earth Orbit (LEO), through Medium Earth Orbit (MEO), and into Geostationary Orbit (GEO). As well as delivering thousands of satellite subsystems, they have successfully delivered 36 satellites to orbit for a broad range of government, institutional and commercial customers for applications such as space science, Earth observation and telecommunications. AAC Clyde Space is currently working with University of Glasgow through a Royal Academy of Engineering Regional Engagement Award.

Research Assistants: The tasks associated with Work Packages 1, 2 and 4 will be delivered by two full-time Research Assistants (RA), one employed by GU and one employed by TU. RA1 (TU) will lead WP1 while RA2 (GU) will lead WP2. The two RAs are expected to be recruited after completion of a grant agreement with ARIA. From past experience recruitment for 12-month projects can be made from an existing pool of PhD researchers who elect to take a 12-month leave of absence from their projects. Alternatively, recruitment can also be made from PhD researchers who have just completed their programme of research. Given our prior experience we do not anticipate issues associated with recruiting high quality RAs.

Section 3: Administrative response

3.1 Project budget

The project costs are based on a 12-month project with two full-time RAs, 1 located at GU (100% FTE), 1 at TU (100% FTE) and relevant academic staff time. Support is also required for subcontracted work for industrial partner AAC Clyde Space, IT equipment and travel (travel to ARIA, partners and conference travel). The summary costs are provided in Table 2. A detailed costing is provided in the Full Cost Summary Table submitted separately.

Element	Description	Amount
Labour	2 x Research Associates + staff time	£129,508
Materials	Project IT equipment support	£7,189
Subcontract	AAC Clyde Space technical inputs	£25,000
Travel support	Travel to ARIA, project partners, conference	£13,278
Indirect costs	Institutional overheads	£167,244
Total		£342,219

Table 2: Project summary costs

3.2 Reporting to ARIA

A kick-off meeting is proposed at the University of Glasgow (or on-line) to agree on the project objectives and deliverables, with a presentation of the initial project plan. A mid-term review is proposed at month 6, again at the University of Glasgow (or on-line) to review progress and re-define the remainder of the project as required. A final presentation is proposed at ARIA to disseminate the outcomes of the project and discuss next steps with ARIA staff. In addition to

these milestone meetings, monthly reports will be provided to ARIA with online meetings with ARIA as required to discuss progress and future actions for the project.

3.3 Publication and dissemination

In order to ensure wide dissemination of the outcomes of the project and to ensure full public transparency, conference and international journal publication is proposed. Any publications will be placed on the University of Glasgow e-print server to ensure open access. The project team may also pursue public engagement publication routes such as The Conversation on-line magazine, after consultation with ARIA staff.

3.4 Intellectual property and conflict of interest

At present the outputs of the project are planned to be disseminated in the public domain. Dissemination routes include direct reports to ARIA, conferences and international journal papers. AAC Clyde Space will bring background IP through their EPIC spacecraft assembly, which will form the basis of the spacecraft platform sized during the project. Other work on orbiting solar reflectors for terrestrial energy services is on-going through the European Research Council SOLSPACE project (€2.5M, 2020-2025, [REDACTED]), with a recent conference paper led by TU on combined energy delivery and climate cooling [13]. [REDACTED] also holds a Royal Academy of Engineering Chair in Technologies (£1.3M 2018-2028) which is developing and seeking to commercialise in-space manufacturing technologies. The project PI and GU have other on-going collaborations with AAC Clyde Space.

References

- ¹Seifritz, W.: 'Mirrors to halt global warming', *Nature*, Vol. 340, p.603, 1989
- ²Early, J.T.: 'Space-based solar shield to offset greenhouse effect', *JBIS*, Vol. 42, pp.567-569, 1989
- ³Hudson, H.: 'A space parasol as a countermeasure against the greenhouse effect', *JBIS*, Vol. 44, pp.139-141, 1991
- ⁴Mautner, M.: 'A space-based solar screen against climatic warming', *JBIS*, Vol. 44, pp.135-138, 1991
- ⁵McInnes, C.R.: 'Minimum mass solar shield for terrestrial climate control', *JBIS*, Vol. 55, pp. 307-311, 2002
- ⁶Angel, R.: 'Feasibility of cooling the Earth with a cloud of small spacecraft near the inner Lagrange point (L_1)', *Proc. National Academy of Sciences*. 2006; Vol. 103, 17184–9, 2006
- ⁷Sánchez Cuartielles, J.P., and McInnes, C.R.: 'Optimal sunshade configuration for space-based geoengineering near the Sun-Earth L_1 point' *PLOS One*, DOI: 10.1371/journal.pone.0136648, 2015
- ⁸McInnes, C.R.: 'Planetary macro-engineering using orbiting solar reflectors', in *Macro-Engineering: A Challenge for the Future* (eds. Badescu, V., Cathcart, R., and Schuiling, B.D.), Springer, ISBN 1-402-03739-2, pp. 215-250, 2006
- ⁹Çelik, O., Viale, A., Oderinwale, T., Sulbhewar, L., and McInnes, C.R.: 'Enhancing terrestrial solar power using orbiting solar reflectors', *Acta Astronautica*, Vol. 195, June, pp. 276-286, 2022
- ¹⁰Viale, A., Çelik, O., Oderinwale, T., Sulbhewar, L., and McInnes, C.R.: 'A reference architecture for orbiting solar reflectors to enhance terrestrial solar power plant output', *Advances in Space Research*, Vol. 72, No. 4, pp. 1304-1348, 2023
- ¹¹Çelik, O., and McInnes, C. R.: 'A constellation design for orbiting solar reflectors to enhance terrestrial solar energy', *Acta Astronautica*, Vol. 217, pp. 145-161, 2024
- ¹²Groot, P.J.: 'Satellite shadows through stellar occultations', *Astronomy and Astrophysics*, Vol. 667, A45, 2022
- ¹³Çelik, O., and McInnes, C.R.: 'An investigation into a combined service of space-based solar energy and climate engineering via orbiting solar reflectors', Paper IAC-24-D1.1.12.x83911, 75th International Astronautical Congress, Milan, 14-18 October 2024

Annex 3: Exploring Climate Cooling Contracts

Imperial College of Science Technology and Medicine **(Grant Recipient)**

Exhibition Road
South Kensington
London
SW7 2AZ
England

03 June 2025

Attention: Sebastian Eastham

Dear Sebastian,

FPCW-PR01-P007 De-risking cirrus modification – Standard Grant Funding Letter

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to Exploring Climate Cooling and ARIA is pleased to offer you a Grant for the performance of the Project Activities up to the Maximum Sum, subject to your agreement to, and compliance with, the terms and conditions set out in this Grant Funding Letter and its Schedules.

1. Overview of the Grant

Any reference in this letter to "you" or "your" means the Grant Recipient and any capitalised terms have the meanings given in the ARIA Grant Conditions (Conditions).

The key elements of the Grant are described in the table below:

Project Activities	De-risking cirrus modification. A more detailed description of the Project Activities is set out in Schedule 2 (Project Activities).
Maximum Sum of the Grant (inclusive of taxes)	£3,554,534 (inclusive of all taxes where applicable)
Commencement Date	The commencement date is 3 June 2025
Completion Date	The completion is 2 June 2028
Grant Review Intervals	ARIA will review the Grant at quarterly intervals using the process referred to in clause 6 of the Conditions

Adequate Insurance	Employers' liability - At least £5 million (as required by the Employers' Liability (Compulsory Insurance Act 1969)) Public liability: £10 million (per year in aggregate)	
Monitoring and Reporting	The performance reports referred to in clause 7 of the Conditions shall be provided at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Project Representative	Sebastian Eastham, Senior Lecturer in Sustainable Aviation, [REDACTED]	
Grant Manager	Mark Symes, Programme Director [REDACTED]	
Escalation Contacts	ARIA	Grant Recipient
	Chief Product Officer [REDACTED]	[REDACTED], Faculty Chief Operating Officer, Faculty of Engineering, [REDACTED]
Notices	ARIA Contracts [REDACTED]	Head of Contracts, Faculty of Engineering, [REDACTED] [REDACTED] [REDACTED]

2. Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Grant and return it to finance@aria.org.uk

3. The Grant Agreement

- 3.1. Once you sign a copy of this Grant Funding Letter in accordance with paragraph 6 (Acceptance) below, it will form a binding "**Grant Agreement**" between you and ARIA that includes and incorporates the following documents:

3.1.1. the **Grant Conditions** in Schedule 1;

3.1.2. the **Project Activities, Milestones** and **Grant Application** in Schedule 2;

3.1.3. the **Royalty percentages** (including annexes) in Schedule 3; and

3.1.4. the terms relating to Data Protection in Schedule 4.

3.2. The parties confirm that it is their intention to be legally bound by the Grant Agreement.

4. Warranties

4.1. By signing this Grant Funding Letter, you warrant and represent that:

4.1.1. your obligations under the Grant Agreement are legal, valid, binding and enforceable;

4.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Grant Agreement have been obtained;

4.1.3. the person signing the Grant Agreement is duly authorised to sign on your behalf; and

4.1.4. your Project Representative referenced in the table above is authorised to make decisions and provide information on your behalf.

5. Amendments to the Grant Conditions

5.1. Not Used

6. Acceptance

6.1. To accept this Grant Funding Letter, please arrange for an authorised signatory to sign and date the duplicate copy of this Grant Funding Letter as indicated below, and return to ARIA as a complete signed original of the Grant Agreement including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Grant Agreement and to bind the Grant Recipient.

6.2. The offer of this Grant Funding Letter will expire on 6 June 2025.

Yours sincerely

for and on behalf of ARIA

Name of ARIA signatory:

Position Held:

Date:

I confirm the agreement of Imperial College of Science Technology and Medicine to the terms and conditions in this Grant Funding Letter and its Schedules.

Signature:

Name:

Position:

Date:

SCHEDULE 1 - GRANT CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up the Grant Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Grant Funding Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to the Grant Agreement with the exception of Schedule 2 Part 2 (the Grant Application);
 - (d) Schedule 2 Part 2 (the Grant Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, the Grant Agreement.

2. DURATION AND PURPOSE OF THE GRANT

- 2.1 The Grant Agreement will subsist for the duration of the Funding Period unless extended by written agreement signed by a duly authorised representative of the parties or terminated earlier in accordance with its terms. Any provision of the Grant Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Grant Agreement shall remain in full force and effect, including clauses 1, 2, 4, 7.4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.3, 22.7, 22.8, 22.11, 22.12, 23, 24, 26, 27, 28, and 30.
- 2.2 You may only use the Grant for carrying out the Project Activities. You may not make any changes to the Project Activities without ARIA's prior written agreement.
- 2.3 You may not unreasonably withhold, condition or delay your agreement to any changes requested by ARIA to the Project Activities or the amount of the Grant. Any agreed change will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

3. ENVIRONMENTAL AND SAFETY REQUIREMENTS

- 3.1 In performing the Project Activities, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. PAYMENT OF GRANT

- 4.1 Subject to the remainder of this clause 4, ARIA will pay the Grant to you:
- (a) up to the Maximum Sum;
 - (b) in pounds sterling (GBP) by wire transfer into your bank account, details of which you provided in the Confirmation of Bank Details form attached to the Grant Funding Letter; and
 - (c) if a tax is chargeable in respect of the Grant, all payments will be deemed to be inclusive of all such taxes and ARIA will not be obliged to pay any additional amount.
- 4.2 The bank account of which you provided details in your Confirmation of Bank Details form (and any alternative bank details nominated subsequently by you) must be an ordinary business bank account

with appropriate segregation of duties and control. During the Funding Period, you must notify ARIA of any change of bank account details as soon as reasonably practicable on the same form and signed by an approved signatory. You must notify ARIA of any change of signatory for approval, as soon as known.

- 4.3 You will be the sole recipient of the Grant and you will be responsible for managing the Grant as between you and any Third Parties involved in performing the Project Activities. This includes securing the repayment of the Grant if requested by ARIA in accordance with the Grant Conditions, including where the Grant has already been distributed to Third Parties.
- 4.4 You must promptly notify ARIA if any money is incorrectly paid to you for any reason, and must repay it as soon as reasonably practicable. Any amount not immediately repaid will be recoverable as a civil debt.
- 4.5 ARIA reserves the right not to pay any Grant Claims that are not submitted within the period set out in the Grant Funding Letter or that are incomplete, incorrect or not accompanied by full supporting documentation (including any documentation that ARIA reasonably requests).
- 4.6 You may not apply for or obtain Duplicate Funding for any Project Activities.
- 4.7 You may not retain any Unspent Monies and must repay them to ARIA within 30 days after ARIA's request for repayment.
- 4.8 You acknowledge the critical importance of cash flow for Sub-Contractors (including startups and small businesses) and commit to paying all valid and undisputed invoices relating to the Project within a maximum of 30 days from the date of receipt.
- 4.9 Where required, you will work with Sub-Contractors to arrange more frequent payment schedules (e.g., same day, weekly or milestone-based payments) to better support their cash flow needs.

5. ELIGIBLE AND INELIGIBLE EXPENDITURE

- 5.1 ARIA will only pay the Grant for Eligible Expenditure incurred by you in carrying out the Project Activities. You must provide ARIA with any evidence reasonably requested by ARIA (including receipts, invoices and other documentary evidence) that all Grant Claims relate to costs that are Eligible Expenditure.
- 5.2 You may not in any circumstance claim as Eligible Expenditure paid-for lobbying, which means using the Grant to fund lobbying (via an external firm or in-house staff) in order to undertake activities intended to influence or attempt to influence Parliament, government or political activity; or attempting to influence legislative or regulatory action.

6. GRANT REVIEW

- 6.1 ARIA will review the Grant at the intervals specified in the Grant Funding Letter. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.3.

- 6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:
- (a) consent to the Project Activities and the Grant Agreement continuing in line with existing plans;
 - (b) increase or decrease the Grant for the remainder of the Funding Period, as applicable;
 - (c) redefine the Milestones;
 - (d) require you to carry out remedial activity with the aim of improving delivery of the Project Activities; and/or
 - (e) terminate the Grant Agreement in accordance with clause 22.
- 6.3 Any change to these Grant Terms, the Project Activities, or the Grant pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Grant Agreement in accordance with clause 26.
- 6.4 For the avoidance of doubt any decision to terminate the Grant Agreement as a result of a Go/No Go Milestone will be made at ARIA's sole discretion and done so in accordance with clause 22.6.

7. MONITORING AND REPORTING

- 7.1 You must closely monitor the carrying out of the Project Activities throughout the Funding Period and must notify ARIA as soon as reasonably practicable of any actual or potential failure to comply with any of your obligations under the Grant Agreement.
- 7.2 ARIA does not limit its engagement with you to purely administrative activities and will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project Activities. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.
- 7.3 You must provide ARIA with:
- (a) the Milestones and a report on your performance against the Milestones at the intervals and for the periods of time specified in the Grant Funding Letter. ARIA may copy and adapt the contents of any of the Milestones and those reports for ARIA's internal use to review, develop and shape ARIA's funded research programmes, but ARIA will treat those contents as your Confidential Information under clause 11;
 - (b) any assistance and information reasonably requested by ARIA to establish whether you have used the Grant in accordance with the Grant Agreement; and
 - (c) a quarterly report on the use of the Maximum Sum, details broken down in accordance with ARIA's prescribed form.

- 7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its funding activities and compliance with the terms of the Grant Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time after the end of the Funding Period about the impact metrics, commercial exploitation or other dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Grant Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Grant Agreement.

8. AUDITING AND ASSURANCE

- 8.1 Annually, and on each anniversary of the Commencement Date and at the end of the Funding Period you must provide ARIA with independent assurance that the Grant has been used for carrying out the Project Activities. To satisfy this requirement you must provide a statement showing that the use of the Grant has been certified by an independent and appropriately qualified auditor or accountant.
- 8.2 Subject to clause 11, ARIA and/or its authorised representative may, at any time during the Funding Period and for up to 7 years after the end of the Funding Period, conduct audits in relation to your use of the Grant and your compliance with the Grant Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.
- 8.3 You must:
- (a) maintain an appropriate system of financial management and controls, maintain detailed records in relation to those controls, and provide copies of those records to ARIA on request; and
 - (b) retain, and procure that your Sub-Contractors retain and will provide to you on request, all relevant documentation relating to the Eligible Expenditure (including invoices, receipts and accounting records) during the Funding Period and for a period of 7 years thereafter.

9. FINANCIAL MANAGEMENT

- 9.1 You must:
- (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Grant; and
 - (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project Activities as soon as they are identified, and keep ARIA informed of your remedial actions.
- 9.2 In the event of any actual or suspected fraud, theft or other financial irregularity (which includes use of the Grant for any purpose other than that envisaged by the Grant Agreement), ARIA may, at its absolute discretion:

- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
- (b) suspend the Project Activities and future payment of the Grant to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

- 10.1 You must inform ARIA promptly of any actual, perceived or potential conflicts between your and your Representatives' obligations under the Grant Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Funding Period.
- 10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that these conflicts are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you or your Representative to cease the conflicting activity and if that is not acceptable to you or your Representative, either party may terminate the Grant Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

- 11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the provision of the Project Activities, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.
- 11.2 ARIA may publish a summary of the Grant Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Grant Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.
- 11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:
 - (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;
 - (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information necessary for the purpose

concerned and obtains appropriate confidentiality undertakings in relation to such information;

- (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and where no exception to disclosure under them is applicable; or
- (d) where that party (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.

- 11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under the Grant Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

- 12.1 Each party must comply with its obligations under the Law, including where applicable the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.
- 12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.
- 12.3 You acknowledge that ARIA, acting in accordance with the Information Acts (other than the FOIA), may disclose information concerning you and the Grant Agreement without consulting you. ARIA must take reasonable steps to notify you of any request for information to the extent permissible and reasonably practical and will give you adequate opportunity to make representations before ARIA discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.
- 12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or the Grant Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.
- 12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.
- 12.6 You must take account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

- 13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.
- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with the Grant Agreement. If either party anticipates that the other will process any Personal Data on its behalf under the Grant Agreement it must notify the other party and the parties must agree a variation to the Grant Agreement under clause 26 to incorporate appropriate provisions (such as those set out in Schedule 4) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. SUBSIDY CONTROL AND STATE AID

- 14.1 ARIA intends that the Grant complies with the Subsidy Control Act 2022 on the basis that the Project Activities are not economic activities and do not give a specific advantage to one or more enterprises. You must take all reasonable steps to maintain this position and to assist ARIA to comply with the requirements of the Act and must cooperate with any investigations under the Act.
- 14.2 Where the EU state aid laws apply to the Grant (where the Project Activities will affect trade between Northern Ireland and the EU), you acknowledge that the Project Activities are designed and performed so they are compatible with state aid laws. You will take all reasonable steps to assist ARIA to comply with state aid law requirements and cooperate with any investigations by the European Commission into the Project Activities.
- 14.3 ARIA will immediately stop future payments of the Grant and may require repayment of some or all of the Grant if subsidy control or state aid laws so require for the funding to be compliant.

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and not seek to avoid their application by artificial means.

Background IP

- 15.2 The Grant Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Funding Period if any additional Background IP is required either to carry out the Project Activities or to exploit commercially any of the Results.

Foreground IP ownership

- 15.3 You will own all Foreground IP unless your policy is for individual researchers to own the Foreground IP they create, or you agree your Sub-Contractor (or another third party) will own all, or parts of, the Foreground IP. Where your Sub-Contractor or individual researchers (or any other third party involved in the performance of the Project Activities) will own any of the Foreground IP you must impose on them the obligations relating to Foreground IP and Results contained in clauses 15 and 16. Where you

assign any Foreground IP to a Third Party (including your technology transfer company) you must impose on that Third Party the obligations relating to Foreground IP and Results contained in clauses 15 and 16.

- 15.4 You must submit all (i) all patents within or covering the Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the Future Proofing our Climate and Weather Intellectual Property Pledge] promptly following creation or filing (as applicable) of such patents and/or data (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge. You hereby agree to comply and uphold the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.5 You must ensure that whenever any Results are used with or communicated to Third Parties or are exploited commercially, ARIA's funding of the Project Activities is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and publication

- 15.6 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.7 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.8 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to fund future prosecution and maintenance and/or request the assignment of the patents to ARIA or its nominee.

Inventor first preference

- 15.9 Subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge] if any inventor or active participant in the Project Activities expresses interest in the exploitation of the Foreground IP they have developed, you must give them an opportunity to negotiate an assignment or commercial licence of the Foreground IP, on reasonable terms, prior to negotiating with any entity in which an inventor or active participant in the Project Activities is not involved as a shareholder or other key stakeholder.

16. COMMERCIALISATION OF RESULTS

- 16.1 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge], where they are capable of commercial exploitation you should seek to exploit the Results commercially. This should be done, where applicable, in accordance with the Commercialisation Hypothesis.
- 16.2 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge], if for any reason you choose not to exploit any such Results commercially within a reasonable timeframe (or, where applicable, the timeframe set out in the Commercialisation Hypothesis) you are encouraged to discuss the position with ARIA, and you may request that ARIA exploit them or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Non-UK Commercialisation

- 16.3 Save as set out in the [Future Proofing our Climate and Weather Intellectual Property Pledge], to avoid any restriction on commercialisation, no consent is required from ARIA for any Non-UK commercialisation or any sale of Foreground IP to a Non-UK Entity. However, ARIA is set up to create value for the UK and therefore you must secure a fee payable to ARIA (**ARIA Non-UK Fee**) in each of the following circumstances:
- (a) where you are a Non-UK Entity;
 - (b) where you become a Non-UK Entity;
 - (c) where you assign or Commercially License any Foreground IP to a Non-UK Entity; or
 - (d) where you have assigned or Commercially Licensed any Foreground IP to a UK Entity that subsequently becomes a Non-UK Entity.
- 16.4 In order to avoid any unnecessary complexity, the ARIA Non-UK Fee will be based on the terms that you agree with any person to which you assign or Commercially License the relevant Foreground IP. This ARIA Non-UK Fee will amount to an additional twenty-five per cent (25%) of the value of the consideration (including upfronts, licence fees, milestone payments, royalties, shares or other securities, buyouts, exit fees and other consideration) that you receive from the exploitation of the relevant Foreground IP during any period that the above circumstances exist.
- 16.5 For example, if you would receive £100 (via royalty or royalty buyout), you must ensure your contractual mechanism enables you to collect an additional £25 and pay that additional amount to ARIA.
- 16.6 The ARIA Non-UK Fee is payable within 90 days after the end of each relevant Financial Year for receipts related to that calendar year. You are encouraged to use the clauses in Annex 1 in your Commercialisation Licences of Foreground IP.

Crown Body customers

- 16.7 You must ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities, and in suitable quantities for the Crown Body's requirements.

Spin-outs

- 16.8 ARIA seeks to maximise future investment of entrepreneurial talent and capital in start-up companies commercialising the Results of its funded activities. To that end, having funded the full economic cost of the research, ARIA places restrictions on the level of equity stakes and royalties that you may negotiate in exchange for the assignment or Commercialisation Licence of any Foreground IP.
- 16.9 If you or your technology transfer company assign or licence any Foreground IP to any third party or to a start-up established for the purpose of commercially exploiting the Results (a NewCo) you together with any connected person (including any investment fund to which you may transfer any part of your stake) shall be entitled to:

EITHER

- (a) hold or have the right to hold no more than 10% in fully-dilutable shares or equity (pre investment) in the third party or NewCo (with no other preferential subscription rights), not including any shares or equity subscribed for cash on arm's length terms alongside other investors;

OR

- (b) charge a royalty, with no upfront payments, annual fees, milestone payments or minimum royalties, payable by the third party or NewCo under any licence or assignment of the Foreground IP at no more than the relevant rate, and on the other terms, set out in Schedule 3.

- 16.10 The provisions of clauses 16.9(a) and 16.9(b) shall not apply to any equity taken or royalty charged in consideration of:
- (a) IP other than Foreground IP licensed or assigned to the third party or NewCo; or
- (b) facilities, equipment, personnel or other material support or services provided to the third party or NewCo independent of the Project Activities,
- with such equity or royalty limited to the proportion that reflects the contribution made by IP that is not Foreground IP.
- 16.11 You must notify ARIA in writing before any transaction completes of the overall equity stake or royalty percentages agreed under clause 16.8 (and any impact of clause 16.9, if relevant).

17. ASSETS

- 17.1 You must keep a register during the Funding Period and for up to 7 years after the end of the Funding Period of all Assets, with all relevant details about each Asset. You must use any Assets purchased with Grant monies for the Project Activities.
- 17.2 At the end of the Funding Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

- 18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Grant Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUBCONTRACTING

- 19.1 You may not transfer, assign, novate or otherwise dispose of the whole or any part of the Grant Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.
- 19.2 You shall not subcontract any of the Project Activities to a Third Party except to the extent permitted, and to the person or persons identified, in Schedule 2 Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractor as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Grant Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Grant Agreement.

20. BORROWING, LOSSES, GIFTS, SPECIAL PAYMENTS

- 20.1 You must obtain ARIA's prior written consent before:
- (a) borrowing or lending money from any source in connection with the Grant Agreement;
 - (b) giving any guarantee, indemnity, security over any Asset or letter of comfort in relation to the Grant Agreement;
 - (c) making any gift or writing off any debt or liability in connection with the Grant, and must keep a record of all gifts given and received in connection with the Grant.

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Grant and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Grant or publicise details of the Grant Agreement without the other's consent, except as required by Law.
- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

- 22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events occur:

- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13, 15.5 or 25, or commit a material breach of any other term of the Grant Agreement in the reasonable opinion of ARIA;
- (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
- (c) you fail to improve the performance of the Project Activities, notwithstanding your having undertaken the remedial activity agreed with ARIA in the remedial plan under clause 6.2(d);
- (d) you or the researchers involved in the Project Activities obtain any funding from a Third Party that, in the opinion of ARIA, undertakes activities that are likely to bring the reputation of the Project Activities or ARIA into disrepute;
- (e) you provide ARIA with any materially misleading or inaccurate information in your grant application or in subsequent related correspondence;
- (f) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Third Party, immediately upon becoming aware of it;
- (g) you are subject to an Insolvency Event;
- (h) the Grant or any part of it is held by a court or competent authority to be a prohibited subsidy under the Subsidy Control Act 2022 or an illegal state aid;
- (i) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project Activities;
 - (ii) result in your being unable to receive the Grant; and/or
 - (iii) raises national security concerns.

Rights reserved for ARIA in relation to an Event of Default

- 22.2 If an Event of Default has or may have occurred, ARIA may by written notice to you take any one or more of the following actions:
- (a) suspend the Project Activities and payment of the whole or any part of the Grant for such period as ARIA may determine, acting reasonably;
 - (b) reduce the Maximum Sum, in which case the payment of Grant will thereafter be made in accordance with the reduction and notified to you; and/or
 - (c) subject to clause 22.4, terminate the Grant Agreement with immediate effect as from the date of service of the notice of that termination.
- 22.3 Where this Grant Agreement is terminated for an Event of Default described in clause 22.1(f) or 22.1(h), ARIA may require you to repay the entire amount of the Grant previously paid to you.

Opportunity for you to remedy an Event of Default

- 22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:
- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and

- (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

22.5 Without prejudice to any other provision of the Grant Agreement, you may terminate the Grant Agreement on written notice to ARIA if ARIA commits a material breach of the Grant Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

General Termination Rights

22.6 Notwithstanding ARIA's right to terminate the Grant Agreement under clause 22.2(c), either party may terminate the Grant Agreement (in whole or in part) at any time by giving at least 60 days' prior written notice to the other party.

22.7 You must promptly notify ARIA in writing if at any time the principal investigator or any key researcher(s) named in Schedule 2 working on the Project Activities is unable or unwilling to continue to be involved in the Project Activities or is moving to a new organisation without the desire to continue the research. Within 60 days after the date of that notice, you must either:

- (a) nominate one or more successors, subject to ARIA's approval; or
- (b) agree that the Grant is transferred to another organisation subject to your and the new organisation's agreement in writing and ARIA's approval of the transfer

If ARIA is unwilling to accept the nominated successor(s) or does not approve a request for transfer, it may terminate the Grant Agreement by at least 30 days' written notice to you.

Consequences of Termination

22.8 If the Grant Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.

22.9 Where ARIA terminates the Grant Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:

- (a) you taking all reasonable steps to mitigate such loss; and
- (b) the Unavoidable Costs being:
 - (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Grant Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA;

- (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you;
- (v) costs that would not have been incurred had this Grant Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period).

- 22.10 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Services, over £250,000 will terminate automatically and immediately upon termination of this Agreement.
- 22.11 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Grant Agreement in the event that the Grant Agreement was terminated (calculated on the basis described in clause 22.8).
- 22.12 ARIA's total liability under clause 22.9 shall be limited to the Maximum Sum under the Grant Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.13 If the Grant Agreement is terminated or expires ARIA will not be liable to pay any of your costs or those of any of your contractors or suppliers related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Grant Funding Letter and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Grant Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Grant Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the Grant Manager and the Project Representative.
- 23.3 If the dispute cannot be resolved between the Grant Manager and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to a formal meeting between the parties' Escalation Contacts.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:
- (a) fraudulent misrepresentation or any other fraudulent act or omission;
 - (b) payment of sums properly due and owing to the other in the normal course of performance of this Grant Agreement;
 - (c) a breach of clause 13;

- (d) liability arising under any indemnity in this Grant Agreement; or
- (e) liability which may not lawfully be excluded or limited.

24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Grant Agreement or for ARIA's breach of this Grant Agreement), whether arising directly or indirectly, that may arise in connection with:

- (a) your carrying out the Project Activities;
- (b) the use of the Grant by any person;
- (c) any reduction, suspension, withdrawal or request for repayment of the Grant in accordance with this Grant Agreement; or
- (d) termination of the Grant Agreement in accordance with this Grant Agreement.

24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:

- (a) loss of profit, sales or turnover;
- (b) loss of contracts or business opportunities;
- (c) loss of anticipated savings;
- (d) loss of goodwill or damage to reputation; or
- (e) any indirect, special or consequential loss or damage;

in each case arising out of or relating to the Grant Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.

24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to the Grant Agreement or its subject matter or anything which it has done or not done in connection with the Grant Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the amount of the Maximum Sum.

24.5 You shall under no circumstances in connection with this Grant Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.

24.6 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Grant Agreement.

25. RESEARCH ETHICS AND CODE OF CONDUCT

25.1 As a recipient of a Government grant you must operate in accordance with the Concordat.

25.2 All research data:

- (a) must be generated using sound scientific techniques and processes;
- (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and

(c) must be analysed appropriately, without bias and in accordance with good scientific practices.

25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.

25.4 You must comply with the Code of Conduct and ensure that your Representatives undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

26.1 Any variation to the Grant Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

27. GENERAL

27.1 Notices: All notices and other communications in relation to this Grant Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such communications will be deemed to have been given and received on the third Working Day following such mailing.

27.2 Change of control: You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(i) is likely to apply.

28. GOVERNING LAW

28.1 This Grant Agreement (including any non-contractual disputes or claims arising in connection with this Grant Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. Not used

30. DEFINITIONS AND INTERPRETATION

30.1 Where they appear in these Conditions or the Grant Agreement:

Adequate Insurance means the insurance requirements and amounts set out in the Grant Funding Letter.

Asset means any asset that is purchased, improved or developed using the Grant including equipment and fixed assets;

Background IP means IP that is:

(a) owned by or licensed to a party prior to the Commencement Date; or
(b) developed by or on behalf of a party during the Funding Period but not in connection with the Project Activities,

and is in either case used in connection with the Project Activities;

Bribery Act means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;

Change of Control means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Recipients of Government General Grants published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754555/2018-11-06_Code_of_Conduct_for_Grant_Recipients.pdf

including any subsequent updates from time to time;

Commencement Date means the date set out in the Grant Funding Letter;

Commercialisation Licence means a licence of IP other than a research or evaluation licence and/or subcontract manufacture (and **Commercially License** means to license under a Commercialisation Licence);

Commercialisation Hypothesis means the exploitation plan approved by ARIA and set out at Schedule 2 Part 2, as may be amended by agreement between the parties during and after the Funding Period;

Completion Date means the date set out in the Grant Funding Letter;

Concordat means the Concordat to Support Research Integrity which can be found at <https://ukrio.org/about-us/the-concordat-to-support-research-integrity/>

Conditions means these ARIA Grant Conditions;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Grant Agreement, that ought reasonably to be considered to be confidential (whether or not it is so marked), (a) including: (i) information relating to the business, affairs, customers, clients, suppliers or plans of the disclosing party; (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party; (iii) any information developed by the parties in the course of carrying out the Project Activities; (iv) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Grant Agreement; and (v) and any information derived from any of the above,

(b) but not including information which: (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11); (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party; (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or (iv) is independently developed without access to the Confidential Information; and (v) the content of this specific version of the Grant Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

Duplicate Funding means funding provided to you by a Third Party which is to fund the same activities as the Project Activities;

EA means the Equality Act 2000 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Eligible Expenditure means the payments made by you during the Funding Period for the purposes of carrying out the Project Activities which comply with clause 5 and ARIA's published eligibility rules (which provide for full economic cost reimbursement) and as agreed in the Grant Funding Letter;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Grant Funding Letter;

Event of Default means any of the events or circumstances set out in clause 22.1;

Financial Year means 1 April to 31 March;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means any IP in the Results;

Funding Period means the period commencing on the Commencement Date and ending on the Completion Date or such later date as may be agreed between the parties unless otherwise determined in accordance with the terms of the Grant Agreement;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification (operated by ARIA or by a third party), in the form set out at Annex A;

GDPR means Regulation (EU) 2016/679;

Go/No-Go Milestone means a decision point for ARIA to determine whether it wishes to proceed with or terminate the Project Activities (any decision regarding a Go/No-Go Milestone will be made at ARIA's sole discretion, following a Grant Review as outlined in Clause 6);

Grant means the sum or sums ARIA will pay to you up to the amount set out in the Grant Funding Letter, in accordance with clause 4 and subject to the provisions set out at clause 22.

Grant Agreement has the meaning given in the Grant Funding Letter;

Grant Claim means a request submitted by you to ARIA for payment of the Grant;

Grant Funding Letter means the letter from ARIA to you to which these Conditions are annexed;

Grant Manager means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Grant;

Grant Review means the process for reviewing the grant outlined in clause 6;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Ineligible Expenditure means expenditure incurred by you which is not Eligible Expenditure as set out in clause 5 and ARIA's published eligibility rules;

Information Acts means the Data Protection Legislation, FOIA and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property Rights or **IP** means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions, semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation;

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise;

Maximum Sum means the maximum amount of the Grant stated in the Grant Funding Letter;

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

NewCo has the meaning given in clause 16;

Non-UK Entity means a legal entity that is not a UK Entity;

Personal Data has the meaning given to it in the Data Protection Legislation as amended from time to time;

Prohibited Act means:

(a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Grant Agreement; and/or (ii) showing or not showing favour or disfavour to any person in relation to the Grant Agreement;

(b) committing any offence: (i) under the Bribery Act; (ii) under legislation creating offences in respect of fraudulent acts; and/or (iii) at common law in respect of fraudulent acts in relation to the Grant Agreement; and/or

(c) defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the activities to be carried out by you that are described in the Grant Funding Letter and in Schedule 2 Part 1;

Project Representative means the representative appointed by you, who at the Commencement Date will be the individual listed as such in the Grant Funding Letter;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means all information, data, techniques, inventions, discoveries, works, software and materials generated in the course of the Project Activities;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Project Activities or any part thereof or facilities or services necessary for the performance of the Project Activities or any part thereof or necessary for the management, direction or control of the Project Activities or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

UK Entity means a legal entity whose ultimate parent company has its headquarters and principal establishment in the United Kingdom;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Grant Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Funding Period because of termination or breach of the Grant Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination; and

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 In these Conditions and the Grant Agreement, unless the context otherwise requires:

- (a) references to "party" and "parties" are to the parties to the Grant Agreement;
- (b) the singular includes the plural and vice versa;
- (c) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (d) references to clauses and Schedules are to the clauses of these Conditions and to the Schedules to the Grant Agreement;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation"; and
- (g) the headings in the Grant Agreement are for ease of reference only and will not affect the interpretation or construction of the Grant Agreement.

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

This project will evaluate whether it could in theory be possible to intentionally modify the properties of cirrus clouds to achieve a useful ($>100 \text{ mW/m}^2$) global cooling effect. This includes understanding (1) how much susceptible cloud exists, (2) whether we might be able to increase outgoing longwave radiation (OLR), and (3) whether we can predict the circumstances under which this could potentially be done. We will address these questions in a two-phase experiment, starting with (P1) data mining followed by (P2) an aircraft campaign to observe existing atmospheric processes to resolve where and when cirrus modification might produce beneficial effects.

2. Aims and objectives of the Project Activities

The overall objective of the project is to experimentally evaluate the potential efficacy of cirrus cloud modification (CCM). This will be achieved by satisfying eight objectives across the two phases outlined above:

- O1A: Verify that clear-air aircraft soot produces observable changes in OLR from downwind cirrus.
- O1B: Establish instrument capabilities to measure ice nucleating particles (INPs) in-situ and therefore enable measurement of CCM in practice.
- O1C: Provide laboratory measurements of the ice nucleating properties of aircraft soot to inform O1A and Phase 2 campaign region selection.
- O1D: Establish modelling capabilities to predict the meteorological conditions under which aircraft soot produces an observable change in downwind cirrus.
- O1E: Develop a model which can translate research findings into an assessment of CCM efficacy.
- O2A: Execute an aircraft campaign testing our ability to achieve targeted CCM with exhaust soot.
- O2B: Translate findings into an assessment of the potential for at-scale CCM with optimal INPs.

Work packages to achieve these objectives are outlined below.

3. Project Activities

3.1 Funded activities are broken down into two phases:

Phase 1: Establish whether soot emissions from existing aircraft into soon-to-be ice supersaturated air already produce a satellite observable change in outgoing longwave radiation. Work packages in phase 1 are:

- **WP1: Signal quantification (ICL, O1A).** Identify circumstances in historical flight data (Milestone 2) where downwind cirrus was expected to form, and assess the effect of aircraft soot using satellite imaging (Milestone 4).

- **WP2: Forecast development (RIKEN, O1D).** Using historical data, implement a data assimilation system focused on identifying air masses which will later form cirrus clouds and are therefore likely to be modifiable by aircraft soot (Milestone 4).
- **WP3: Impact quantification (Vienna, O1E).** Incorporate developing understanding from WP1 into atmospheric modelling of cirrus modification, and thus better constrain the maximum potential for climate cooling (Milestone 4).
- **WP4: Instrumentation and lab experiments (Leeds, O1B/C).** Purchase and modify the instrument to sample ice nucleating particles (INPs) in-air (Milestones 2 and 6), and use the same techniques to quantify ice nucleation by aviation soot (Milestone 3).

Phase 2: Use a dedicated flight campaign with accurate INP measurements, using a custom-trained saturation prediction model, to verify that CCM can be achieved on demand – and in so doing determine the potential efficacy of CCM. Work packages in phase 2 are:

- **WP5: Execution (Leeds, O2A).** Plan (Milestone 6) and execute (Milestone 7) flight campaign to sample INPs and attempt to induce an observable change in downwind cirrus.
- **WP6: Forecasting (RIKEN, O2A).** Develop a forecasting plan (Milestone 6) and supply forecasts of soon-to-be-ice-supersaturated air masses for the flight campaign (Milestone 8).
- **WP7: Efficacy (ICL, O2A/B).** Use in-flight data and satellite imaging to evaluate whether the predicted cirrus modification was achieved through the addition of aircraft soot (Milestone 8).
- **WP8: Implications (Vienna, O2B).** Evaluate the degree to which the results of the aircraft campaign (Milestone 8) have further modified the predicted maximum achievable effect of cirrus modification.

Phasing, engagement, and administrative requirements (Milestones 1, 5, and 7) will be coordinated through ICL as the project lead.

If phases 1 and 2 are successful, there is also the potential for a phase 3, to support this you will provide:

- **WP9:** A proposal that sets a detailed mission plan, including team expansion requirements, information on regulation/health and safety and governance, and technical plans. The scope of the proposed phase 3 would present a measurable advance towards a near-term, practical option for regional and global cooling, evaluation of which is currently unable to proceed through modelling alone. For the avoidance of doubt WP9 is limited to the provision of a proposal only. Should ARIA choose to proceed with Phase 3, it would be contingent upon adherence to ARIA's technical and governance requirements for outdoor experiments, and subject to oversight from the designated oversight committee. **This is a Go/No Go Milestone**

3.2 The following Milestones will be used to monitor your delivery of the Project. The costs associated with completing these Milestones are estimated in the cost sheet breakdown [REDACTED]

ID	Milestones	Measure	Date

1	Engagement plan available	Draft communication and engagement plan agreed with ARIA and oversight committee	Commencement Date + 6 months
2	Aircraft campaign dataset finalisation and initiation of Phase 2 prep.	All existing in-situ aircraft data acquired and processed; PINEair purchase agreed.	Commencement Date + 6 months
3	Emissions characterization	Characterization of ice nucleating ability of engine emissions including soot	Commencement Date + 12 months
4	Lock-in of Phase 2. This is a Go/No Go Milestone	Aircraft verified, flight time booked, and costs finalised for Phase 2 campaign in Nov 2027 – Feb 2028.	Commencement Date + 15 months
5	Completion of Phase 1	Magnitude of CCM signal identified in observational data, preliminary global impact assessment completed, and performance of RIKEN tools evaluated Scoping for WP9 begins	Commencement Date + 24 month
6	Campaign prep completion	PINEair certified and campaign ready; successful dry run of decision structure for a week-long campaign	Commencement Date + 30 months
7	Formal submission of proposals for Phase 3 (WP9) Go/No Go for Phase 3.	Submission of detailed mission plan, including team expansion requirements, information on regulation/health and safety and governance, and technical plans. Award of funding for Phase 3 will be conditional on additional, engagement, environmental impact	Commencement Date + 30 months

		assessment, governance and oversight requirements.	
8	Completion of Phase 2	Quantification of CCM achieved by the aircraft campaign	Commencement Date + 36 months

In addition to the above Milestones, the following project plan will be used to track progress throughout the project and may be updated from time to time: [REDACTED]

3.3 The intended long-term outcomes are summarised below:

- Establishment of a new INP measurement capability in the UK through PINEair
- New understanding of the potential for deliberate modification of cirrus by aircraft soot
- Development of supersaturation forecasting capabilities with performance quantified for UK airspace.

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement
Planning	• Roles and responsibilities • External communications • Vision • Project details • Code and data management • Project plan + project management
Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Key Learning, discoveries and decisions • Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • Invoicing and cost reporting

	Optional: - technical evidence saved to drive e.g. report or presentation as requested by PD - review meeting slide deck saved to drive as requested by PD
Annual	- ARIA impact metrics - Attendance at annual ARIA event
Ad hoc	- As required, Programme Director/ Programme Team may request additional information and evidence - Workshops - potential to be invited to ARIA workshops
Project closure	Project closure report

5. Payment

5.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments quarterly in arrears.

5.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

5.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end of the relevant period.

5.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

6. Principal investigator/key researchers

For the purposes of clause 22.7, the following principal investigators or key researchers have been identified:

Name	Role	Organisation
Sebastian Eastham	Principal Investigator	Imperial College London
Marc Stettler	Imperial Co-PI	Imperial College London
Ed Gryspeerdt	Imperial Co-PI	Imperial College London

7. Sub-Contractors

7.1 For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Location of organisation
University of Leeds	Lead PI for instrument development, lab testing, and aircraft activities	Leeds
University of Vienna	Leading modelling and impact quantification for at-scale CCM	Austria
RIKEN	Leading data assimilation and near-term forecasting activities	Japan

PART 2 - GRANT APPLICATION

Application titled "De-risking cirrus modification" submitted 9 December 2024.

SCHEDULE 3

Royalty Percentages

Royalties on the sale or supply of products or services that are covered by, use or incorporate the Foreground IP licensed to the NewCo will only become due on aggregate net sales derived from the Foreground IP exceeding £50 million.

The maximum headline percentage royalty rate (i.e. before any royalty stacking, step-down or other reduction and excluding any ARIA Non-UK Fee) for products or services that are covered by, use or incorporate the Foreground IP, and of sublicensing income, shall be one of the following:

Type of product	Applicable headline royalty percentage (up to)
Low margin	0.5% of net sales
Medium margin	1% of net sales
High margin	2% of net sales
Sublicensing royalty	10% of net receipts

ANNEX 1

Clause for inclusion in licences of Foreground IP

[] **ARIA NON-UK FEE**

[].1 In this clause:

"ARIA" means the Advanced Research and Invention Agency;

"Crown Body" means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

"UK Entity" means a legal entity that has or whose ultimate parent company has its headquarters and principal establishment in the United Kingdom.

[].2 The Foreground IP was developed with funding from ARIA. As a condition of its funding ARIA requires that a benefit is returned to the United Kingdom where the Foreground IP is licensed by the Licensor to any person that is not a UK Entity. Accordingly, in addition to any other sums payable by the Licensee to the Licensor under this Agreement, the Licensee shall pay to the Licensor within 90 days after the end of each calendar year during the Relevant Period (as defined below), and within 90 days after the end of the Relevant Period, a fee (**ARIA Non-UK Fee**) on all amounts (including upfronts, licence fees, milestone payments, royalties, shares or other securities, exit fees, buyout or other consideration) payable by the Licensee to the Licensor under this Agreement in relation to the exploitation of any Foreground IP (**Relevant Amount**) that accrues during, or relates to, any period of time that the Licensee is not a UK Entity (**Relevant Period**). The amount of the ARIA Non-UK Fee is 25% of the Relevant Amount, and is payable by the Licensee to the Licensor in addition to the amounts that would otherwise be payable under this Agreement. For example if the Relevant Amount is £100 the ARIA Non-UK Fee is an additional £25, which the Licensee shall pay to the Licensor and the Licensor shall remit to ARIA.

Crown Body customers

[].3 You must also ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities and in suitable quantities for the Crown Body's requirements.

[].4 ARIA shall have the right to enforce this clause [] under the Contracts (Rights of Third Parties) Act 1999. Neither party may amend this Agreement in a way that detracts from ARIA's right to enforce its rights under this clause without ARIA's prior written consent.

[1] When using this clause you may substitute the relevant defined terms used elsewhere in the agreement to capture the concept of "Foreground IP". Where the clause refers to the "Licensor" and "Licensee" please use the appropriate defined terms to include the licensor, licensee, assignor and assignee of the Foreground IP. This clause is not suitable for assignments of the Foreground IP in consideration of the payment of one or more lump sum payments. In those cases the Licensor needs to be informed, and potentially make an additional payment, if the Foreground IP is subsequently assigned to a non-UK Entity or if the Assignee ceases to be a UK Entity.

SCHEDULE 4: Data Protection

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Grant Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Grant Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Grant Agreement:
- 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are

relying on Domestic Law as the basis for processing Personal Data, you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;

- 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);
- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Grant Agreement unless required by Domestic Law to store the Personal Data; and

3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.

3.4. [[ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):

3.4.1. cancel its plans to change the affected sub-Processor;

3.4.2. offer an alternative which is acceptable to ARIA; or

3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.

3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Grant Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.

3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]

3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Grant agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it, storing it, retrieving it, consulting it, disseminating it or destroying it, etc.

	Note the definition of processing in the UK GDPR: <i>“any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction”]</i>
Duration of Processing:	Duration of this Grant Agreement (and any post termination processing that is permitted / required).
Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called “special categories” of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: <i>“data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation”]</i>
Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors,

	clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. You shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.
- 4.2. Any limitation of liability set out in this Grant Agreement will not apply to this Schedule's indemnity or reimbursement obligations.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

1. Submission of Pledged Patents and Experimental Data

- 1.1 The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
- 1.2 The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.

2. Experimental Data Licence

- 2.1 Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
- 2.2 The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
- 2.3 The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
- 2.4 The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).

3. Research Licence

- 3.1 Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
- 3.2 The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
- 3.3 Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

- 3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.
- 3.5 The Research Licensee must:
- (a) at all times when using the Pledged Patents comply with all Laws; and
 - (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).

4. Commercial Licence

- 4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.
- 4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.
- 4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.

5. Pledgor Know-How

At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.

6. Termination

- 6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:
- (a) materially breaches the terms of such licence or this Pledge; or
 - (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).

7. Transfers of Pledged Patents and/or Experimental Data

The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.

8. No Warranty

The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and

Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

British Antarctic Survey (**Grant Recipient**)

High Cross, Madingley Road

Cambridge

CB3 0ET

11 June 2025

Attention: Amanda Burson

Dear Amanda,

FPCW- PR01-P019 - Eco-ICE – Standard Grant Funding Letter

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to **Exploring Climate Cooling** and ARIA is pleased to offer you a Grant for the performance of the Project Activities up to the Maximum Sum, subject to your agreement to, and compliance with, the terms and conditions set out in this Grant Funding Letter and its Schedules.

1. Overview of the Grant

Any reference in this letter to "you" or "your" means the Grant Recipient and any capitalised terms have the meanings given in the ARIA Grant Conditions (Conditions).

The key elements of the Grant are described in the table below:

Project Activities	The project entitled Eco-ICE: Ecological Impact Assessment of Earth Cooling Experiments in the Arctic. A more detailed description of the Project Activities is set out in Schedule 2 (Project Activities).
Maximum Sum of the Grant (inclusive of taxes)	£4,926,602 (inclusive of all taxes where applicable)
Commencement Date	The commencement date is 01 June 2025
Completion Date	The completion is 31 May 2029
Grant Review Intervals	ARIA will review the Grant at quarterly intervals using the process

	referred to in clause 6 of the Conditions	
Adequate Insurance	As a public body you do not take out insurance instead you will self-insure against any employer and public liabilities.	
Monitoring and Reporting	The performance reports referred to in clause 7 of the Conditions shall be provided at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Project Representative	Amanda Burson [REDACTED]	
Grant Manager	Mark Symes, Programme Director [REDACTED]	
Escalation Contacts	ARIA	Grant Recipient
	Chief Product Officer [REDACTED]	[REDACTED] Director of Science (Interim) - [REDACTED]
Notices	ARIA Contracts	[REDACTED]
	[REDACTED]	[REDACTED]

2. Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Grant and return it to finance@aria.org.uk

3. The Grant Agreement

- 3.1. Once you sign a copy of this Grant Funding Letter in accordance with paragraph 6 (Acceptance) below, it will form a binding "**Grant Agreement**" between you and ARIA that includes and incorporates the following documents:

- 3.1.1. the **Grant Conditions** in Schedule 1;
- 3.1.2. the **Project Activities, Milestones** and **Grant Application** in Schedule 2;
- 3.1.3. the **Royalty percentages** (including annexes) in Schedule 3; and

3.1.4. the terms relating to Data Protection in Schedule 4.

3.2. The parties confirm that it is their intention to be legally bound by the Grant Agreement.

4. Warranties

4.1. By signing this Grant Funding Letter, you warrant and represent that:

4.1.1. your obligations under the Grant Agreement are legal, valid, binding and enforceable;

4.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Grant Agreement have been obtained;

4.1.3. the person signing the Grant Agreement is duly authorised to sign on your behalf; and

4.1.4. your Project Representative referenced in the table above is authorised to make decisions and provide information on your behalf.

5. Amendments to the Grant Conditions

5.1. In the event that the following roles require an extended period of leave, such as parental, sick, or caring leave, which results in the PhD extending beyond the duration of the funding period, ARIA commits to covering the costs associated of completing the PhD, provided that the majority of the PhD is undertaken within the funding period:

5.1.1. BAS PHD student - Name to be confirmed no later than 31st December 2025

5.1.2 BAS PHD student - Name to be confirmed no later than 31st December 2025

For the avoidance of doubt, ARIA will not cover any directly incurred PhD-related costs during the extended period of leave. ARIA will consider proposals to temporarily backfill PhD roles in order to address capacity gaps during these periods of absence.

6. Acceptance

6.1. To accept this Grant Funding Letter, please arrange for an authorised signatory to sign and date the duplicate copy of this Grant Funding Letter as indicated below, and return to ARIA as a complete signed original of the Grant Agreement including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Grant Agreement and to bind the Grant Recipient.

6.2. The offer of this Grant Funding Letter will expire on 17 June 2025.

Yours sincerely

for and on behalf of ARIA

Name of ARIA signatory:

Position Held:

Date:

I confirm the agreement of United Kingdom Research and Innovation, as represented by the British Antarctic Survey, to the terms and conditions in this Grant Funding Letter and its Schedules.

Signature:

Name:

Position:

Date:

SCHEDULE 1 - GRANT CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up the Grant Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Grant Funding Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to the Grant Agreement with the exception of Schedule 2 Part 2 (the Grant Application);
 - (d) Schedule 2 Part 2 (the Grant Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, the Grant Agreement.

2. DURATION AND PURPOSE OF THE GRANT

- 2.1 The Grant Agreement will subsist for the duration of the Funding Period unless extended by written agreement signed by a duly authorised representative of the parties or terminated earlier in accordance with its terms. Any provision of the Grant Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Grant Agreement shall remain in full force and effect, including clauses 1, 2, 4, 7.4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.3, 22.7, 22.8, 22.11, 22.12, 23, 24, 26, 27, 28, and 30.
- 2.2 You may only use the Grant for carrying out the Project Activities. You may not make any changes to the Project Activities without ARIA's prior written agreement.
- 2.3 You may not unreasonably withhold, condition or delay your agreement to any changes requested by ARIA to the Project Activities or the amount of the Grant. Any agreed change will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

3. ENVIRONMENTAL AND SAFETY REQUIREMENTS

- 3.1 In performing the Project Activities, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. PAYMENT OF GRANT

- 4.1 Subject to the remainder of this clause 4, ARIA will pay the Grant to you:
- (a) up to the Maximum Sum;
 - (b) in pounds sterling (GBP) by wire transfer into your bank account, details of which you provided in the Confirmation of Bank Details form attached to the Grant Funding Letter; and
 - (c) if a tax is chargeable in respect of the Grant, all payments will be deemed to be inclusive of all such taxes and ARIA will not be obliged to pay any additional amount.
- 4.2 The bank account of which you provided details in your Confirmation of Bank Details form (and any alternative bank details nominated subsequently by you) must be an ordinary business bank account

with appropriate segregation of duties and control. During the Funding Period, you must notify ARIA of any change of bank account details as soon as reasonably practicable on the same form and signed by an approved signatory. You must promptly notify ARIA of any change of signatory for approval, as soon as known.

- 4.3 You will be the sole recipient of the Grant and you will be responsible for managing the Grant as between you and any Third Parties involved in performing the Project Activities. This includes securing the repayment of the Grant if requested by ARIA in accordance with the Grant Conditions, including where the Grant has already been distributed to Third Parties.
- 4.4 You must promptly notify ARIA if you become aware of any money being incorrectly paid to you for any reason, and must repay it as soon as reasonably practicable. Any amount not immediately repaid will be recoverable as a civil debt.
- 4.5 ARIA reserves the right not to pay those parts of any Grant Claims that are not submitted within the period set out in the Grant Funding Letter or that are incomplete, incorrect or not accompanied by full supporting documentation (including any documentation that ARIA reasonably requests).
- 4.6 You may not apply for or obtain Duplicate Funding for any Project Activities.
- 4.7 You may not retain any Unspent Monies and must repay them to ARIA within 30 days after ARIA's request for repayment.
- 4.8 You acknowledge the critical importance of cash flow for Sub-Contractors (including startups and small businesses) and commit to paying all valid and undisputed invoices relating to the Project within a maximum of 30 days from the date of receipt.
- 4.9 Where required, you will work with Sub-Contractors to arrange more frequent payment schedules (e.g., same day, weekly or milestone-based payments) to better support their cash flow needs.

5. ELIGIBLE AND INELIGIBLE EXPENDITURE

- 5.1 ARIA will only pay the Grant for Eligible Expenditure incurred by you in carrying out the Project Activities. You must provide ARIA with any evidence reasonably requested by ARIA (including receipts, invoices and other documentary evidence) that all Grant Claims relate to costs that are Eligible Expenditure.
- 5.2 You may not in any circumstance claim as Eligible Expenditure paid-for lobbying, which means using the Grant to fund lobbying (via an external firm or in-house staff) in order to undertake activities intended to influence or attempt to influence Parliament, government or political activity; or attempting to influence legislative or regulatory action.

6. GRANT REVIEW

- 6.1 ARIA will review the Grant at the intervals specified in the Grant Funding Letter. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.3.

- 6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:
- (a) consent to the Project Activities and the Grant Agreement continuing in line with existing plans;
 - (b) increase or decrease the Grant for the remainder of the Funding Period, as applicable;
 - (c) redefine the Milestones;
 - (d) require you to carry out remedial activity with the aim of improving delivery of the Project Activities; and/or
 - (e) terminate the Grant Agreement in accordance with clause 22.
- 6.3 Any change to these Grant Terms, the Project Activities, or the Grant pursuant to clause 6.2(b), 6.2(c) or 6.2(d) will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

7. MONITORING AND REPORTING

- 7.1 You must closely monitor the carrying out of the Project Activities throughout the Funding Period and must notify ARIA as soon as reasonably practicable of any actual or potential failure to comply with any of your obligations under the Grant Agreement.
- 7.2 ARIA does not limit its engagement with you to purely administrative activities and will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project Activities. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.
- 7.3 You must provide ARIA with:
- (a) the Milestones and a report on your performance against the Milestones at the intervals and for the periods of time specified in the Grant Funding Letter. ARIA may copy and adapt the contents of any of the Milestones and those reports for ARIA's internal use to review, develop and shape ARIA's funded research programmes, but ARIA will treat those contents as your Confidential Information under clause 11;
 - (b) any assistance and information reasonably requested by ARIA to establish whether you have used the Grant in accordance with the Grant Agreement; and
 - (c) a quarterly report on the use of the Maximum Sum, details broken down in accordance with ARIA's prescribed form.
- 7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its funding activities and compliance with the terms of the Grant Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time for a period of 10 years after the end

of the Funding Period about the impact metrics, commercial exploitation or other dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Grant Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Grant Agreement.

8. AUDITING AND ASSURANCE

- 8.1 Within six months after each anniversary of the Commencement Date and at the end of the Funding Period you must provide ARIA with independent assurance that the Grant has been used for carrying out the Project Activities. To satisfy this requirement you must provide a statement showing that the use of the Grant has been certified by an independent and appropriately qualified auditor or accountant.
- 8.2 Subject to clause 11, ARIA and/or its authorised representative may, at any time during the Funding Period and for up to 7 years after the end of the Funding Period, conduct audits in relation to your use of the Grant and your compliance with the Grant Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.
- 8.3 You must:
- (a) maintain an appropriate system of financial management and controls, maintain detailed records in relation to those controls, and provide copies of those records to ARIA on request; and
 - (b) retain, and procure that your Sub-Contractors retain and will provide to you on request, all relevant documentation relating to the Eligible Expenditure (including invoices, receipts and accounting records) during the Funding Period and for a period of 7 years thereafter.

9. FINANCIAL MANAGEMENT

- 9.1 You must:
- (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Grant; and
 - (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project Activities as soon as they are identified, and keep ARIA informed of your remedial actions.
- 9.2 In the event of any actual or suspected fraud, theft or other financial irregularity (which includes use of the Grant for any purpose other than that envisaged by the Grant Agreement), ARIA may, at its absolute discretion:
- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
 - (b) suspend the Project Activities and future payment of the Grant to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

- 10.1 You must inform ARIA promptly of any actual, perceived or potential conflicts between your and your Representatives' obligations under the Grant Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Funding Period.
- 10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that these conflicts are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you or your Representative to cease the conflicting activity and if that is not acceptable to you or your Representative, either party may terminate the Grant Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

- 11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the provision of the Project Activities, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.
- 11.2 ARIA may publish a summary of the Grant Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Grant Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.
- 11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:
- (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;
 - (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information necessary for the purpose concerned and obtains appropriate confidentiality undertakings in relation to such information;
 - (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and where no exception to disclosure under them is applicable; or

- (d) where that party (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.

11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under the Grant Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

12.1 Each party must comply with its obligations under the Law, including where applicable the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.

12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.

12.3 You acknowledge that ARIA, acting in accordance with the Information Acts (other than the FOIA), may disclose information concerning you and the Grant Agreement without consulting you. ARIA must take reasonable steps to notify you of any request for information to the extent permissible and reasonably practical and will give you adequate opportunity to make representations before ARIA discloses any information relating to such matters. When ARIA is the recipient of a request under the Information Acts, ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.

12.4 ARIA acknowledges that you are subject to the Information Acts and where you receive a request for disclosure that relates to ARIA or the Grant Agreement, ARIA will provide reasonable assistance and cooperation to you to assist your compliance with its information disclosure obligations. To the extent permissible and reasonably practical, you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters. When you are the recipient of a request under the Information Acts, you will be responsible for determining in your absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.

12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.

12.6 You must take account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

- 13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.
- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with the Grant Agreement. If either party anticipates that the other will process any Personal Data on its behalf under the Grant Agreement it must notify the other party and the parties must agree a variation to the Grant Agreement under clause 26 to incorporate appropriate provisions (such as those set out in Schedule 4) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. SUBSIDY CONTROL AND STATE AID

- 14.1 ARIA intends that the Grant complies with the Subsidy Control Act 2022 on the basis that the Project Activities are not economic activities and do not give a specific advantage to one or more enterprises. You must take all reasonable steps to maintain this position and to assist ARIA to comply with the requirements of the Act and must cooperate with any investigations under the Act.
- 14.2 Where the EU state aid laws apply to the Grant (where the Project Activities will affect trade between Northern Ireland and the EU), you acknowledge that the Project Activities are designed and performed so they are compatible with state aid laws. You will take all reasonable steps to assist ARIA to comply with state aid law requirements and cooperate with any investigations by the European Commission into the Project Activities.
- 14.3 ARIA will immediately stop future payments of the Grant and may require repayment of some or all of the Grant if subsidy control or state aid laws so require for the funding to be compliant.

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and not seek to avoid their application by artificial means.

Background IP

- 15.2 The Grant Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Funding Period if any additional Background IP is required either to carry out the Project Activities or to exploit commercially any of the Results.

Foreground IP ownership

- 15.3 You will own all Foreground IP unless your policy is for individual researchers to own the Foreground IP they create, or you agree your Sub-Contractor (or another third party) will own all, or parts of, the Foreground IP. Where your Sub-Contractor or individual researchers (or any other third party involved in the performance of the Project Activities) will own any of the Foreground IP you must impose on them the obligations relating to Foreground IP and Results contained in clauses 15 and 16. Where you

assign any Foreground IP to a Third Party (including your technology transfer company) you must impose on that Third Party the obligations relating to Foreground IP and Results contained in clauses 15 and 16.

- 15.4 You must submit all (i) Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the Future Proofing our Climate and Weather Intellectual Property Pledge promptly following creation or filing (as applicable) of such Foreground IP (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge. You hereby agree to comply and uphold the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.5 You must ensure that whenever any Results are used with or communicated to Third Parties or are exploited commercially, ARIA's funding of the Project Activities is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and publication

- 15.6 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.7 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.8 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to fund future prosecution and maintenance and/or request the assignment of the patents to ARIA or its nominee.

Inventor first preference

- 15.9 Subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge if any inventor or active participant in the Project Activities expresses interest in the exploitation of the Foreground IP they have developed, you must give them an opportunity to negotiate an assignment or commercial licence of the Foreground IP, on reasonable terms, prior to negotiating with any entity in which an inventor or active participant in the Project Activities is not involved as a shareholder or other key stakeholder.

16. COMMERCIALISATION OF RESULTS

- 16.1 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge], where they are capable of commercial exploitation you should seek to exploit the Results commercially. This should be done, where applicable, in accordance with the Commercialisation Hypothesis.
- 16.2 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge], if for any reason you choose not to exploit any such Results commercially within a reasonable timeframe (or, where applicable, the timeframe set out in the Commercialisation Hypothesis) you are encouraged to discuss the position with ARIA, and you may request that ARIA exploit them or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Non-UK Commercialisation

- 16.3 Save as set out in the [Future Proofing our Climate and Weather Intellectual Property Pledge], to avoid any restriction on commercialisation, no consent is required from ARIA for any Non-UK commercialisation or any sale of Foreground IP to a Non-UK Entity. However, ARIA is set up to create value for the UK and therefore you must secure a fee payable to ARIA (**ARIA Non-UK Fee**) in each of the following circumstances:
- (a) where you are a Non-UK Entity;
 - (b) where you become a Non-UK Entity;
 - (c) where you assign or Commercially License any Foreground IP to a Non-UK Entity; or
 - (d) where you have assigned or Commercially Licensed any Foreground IP to a UK Entity that subsequently becomes a Non-UK Entity.
- 16.4 In order to avoid any unnecessary complexity, the ARIA Non-UK Fee will be based on the terms that you agree with any person to which you assign or Commercially License the relevant Foreground IP. This ARIA Non-UK Fee will amount to an additional twenty-five per cent (25%) of the value of the consideration (including upfronts, licence fees, milestone payments, royalties, shares or other securities, buyouts, exit fees and other consideration) that you receive from the exploitation of the relevant Foreground IP during any period that the above circumstances exist.
- 16.5 For example, if you would receive £100 (via royalty or royalty buyout), you must ensure your contractual mechanism enables you to collect an additional £25 and pay that additional amount to ARIA.
- 16.6 The ARIA Non-UK Fee is payable within 90 days after the end of each relevant Financial Year for receipts related to that calendar year. You are encouraged to use the clauses in Annex 1 in your Commercialisation Licences of Foreground IP.

Crown Body customers

- 16.7 You must ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities, and in suitable quantities for the Crown Body's requirements.

Spin-outs

- 16.8 ARIA seeks to maximise future investment of entrepreneurial talent and capital in start-up companies commercialising the Results of its funded activities. To that end, having funded the full economic cost of the research, ARIA places restrictions on the level of equity stakes and royalties that you may negotiate in exchange for the assignment or Commercialisation Licence of any Foreground IP.
- 16.9 If you or your technology transfer company assign or licence any Foreground IP to any third party or to a start-up established for the purpose of commercially exploiting the Results (a NewCo) you together with any connected person (including any investment fund to which you may transfer any part of your stake) shall be entitled to:

EITHER

- (a) hold or have the right to hold no more than 10% in fully-dilutable shares or equity (pre investment) in the third party or NewCo (with no other preferential subscription rights), not including any shares or equity subscribed for cash on arm's length terms alongside other investors;

OR

- (b) charge a royalty, with no upfront payments, annual fees, milestone payments or minimum royalties, payable by the third party or NewCo under any licence or assignment of the Foreground IP at no more than the relevant rate, and on the other terms, set out in Schedule 3.

- 16.10 The provisions of clauses 16.9(a) and 16.9(b) shall not apply to any equity taken or royalty charged in consideration of:
- (a) IP other than Foreground IP licensed or assigned to the third party or NewCo; or
- (b) facilities, equipment, personnel or other material support or services provided to the third party or NewCo independent of the Project Activities,
- with such equity or royalty limited to the proportion that reflects the contribution made by IP that is not Foreground IP.
- 16.11 You must notify ARIA in writing before any transaction completes of the overall equity stake or royalty percentages agreed under clause 16.8 (and any impact of clause 16.9, if relevant).

17. ASSETS

- 17.1 You must keep a register during the Funding Period and for up to 7 years after the end of the Funding Period of all Assets, with all relevant details about each Asset. You must use any Assets purchased with Grant monies for the Project Activities.
- 17.2 At the end of the Funding Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

- 18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Grant Agreement. You must provide evidence of that insurance or self-insurance to ARIA on request.

19. ASSIGNMENT AND SUBCONTRACTING

- 19.1 You may not transfer, assign, novate or otherwise dispose of the whole or any part of the Grant Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.
- 19.2 You shall not subcontract any of the Project Activities to a Third Party except to the extent permitted, and to the person or persons identified, in Schedule 2 Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractor as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Grant Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Grant Agreement.

20. BORROWING, LOSSES, GIFTS, SPECIAL PAYMENTS

- 20.1 You must obtain ARIA's prior written consent before:
- (a) borrowing or lending money from any source in connection with the Grant Agreement;
 - (b) giving any guarantee, indemnity, security over any Asset or letter of comfort in relation to the Grant Agreement;
 - (c) making any gift or writing off any debt or liability in connection with the Grant, and must keep a record of all gifts given and received in connection with the Grant.

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Grant and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Grant or publicise details of the Grant Agreement without the other's consent, except as required by Law.
- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

- 22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events occur:

- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13, 15.5 or 25, or commit a material breach of any other term of the Grant Agreement in the reasonable opinion of ARIA;
- (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
- (c) you fail to improve the performance of the Project Activities, notwithstanding your having undertaken the remedial activity agreed with ARIA in the remedial plan under clause 6.2(d);
- (d) you or the researchers involved in the Project Activities obtain any funding from a Third Party that, in the opinion of ARIA, undertakes activities that are likely to bring the reputation of the Project Activities or ARIA into disrepute;
- (e) you provide ARIA with any materially misleading or inaccurate information in your grant application or in subsequent related correspondence;
- (f) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Third Party, immediately upon becoming aware of it;
- (g) you are subject to an Insolvency Event;
- (h) the Grant or any part of it is held by a court or competent authority to be a prohibited subsidy under the Subsidy Control Act 2022 or an illegal state aid;
- (i) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project Activities;
 - (ii) result in your being unable to receive the Grant; and/or
 - (iii) raises national security concerns.

Rights reserved for ARIA in relation to an Event of Default

- 22.2 If an Event of Default has or may have occurred, ARIA may by written notice to you take any one or more of the following actions:
- (a) suspend the Project Activities and payment of the whole or any part of the Grant for such period as ARIA may determine, acting reasonably;
 - (b) reduce the Maximum Sum, in which case the payment of Grant will thereafter be made in accordance with the reduction and notified to you; and/or
 - (c) subject to clause 22.4, terminate the Grant Agreement with immediate effect as from the date of service of the notice of that termination.
- 22.3 Where this Grant Agreement is terminated for an Event of Default described in clause 22.1(f) or 22.1(h), ARIA may require you to repay the entire amount of the Grant previously paid to you.

Opportunity for you to remedy an Event of Default

- 22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:
- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and

- (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

22.5 Without prejudice to any other provision of the Grant Agreement, you may terminate the Grant Agreement on written notice to ARIA if ARIA commits a material breach of the Grant Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

General Termination Rights

22.6 Notwithstanding ARIA's right to terminate the Grant Agreement under clause 22.2(c), either party may terminate the Grant Agreement (in whole or in part) at any time by giving at least 60 days' prior written notice to the other party.

22.7 You must promptly notify ARIA in writing if at any time the principal investigator or any key researcher(s) named in Schedule 2 working on the Project Activities is unable or unwilling to continue to be involved in the Project Activities or is moving to a new organisation without the desire to continue the research. Within 60 days after the date of that notice, you must either:

- (a) nominate one or more successors, subject to ARIA's approval; or
- (b) agree that the Grant is transferred to another organisation subject to your and the new organisation's agreement in writing and ARIA's approval of the transfer

If ARIA is unwilling to accept the nominated successor(s) or does not approve a request for transfer, it may terminate the Grant Agreement by at least 30 days' written notice to you.

Consequences of Termination

22.8 If the Grant Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.

22.9 Where ARIA terminates the Grant Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:

- (a) you taking all reasonable steps to mitigate such loss; and
- (b) the Unavoidable Costs being:
 - (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Grant Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA;

- (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you;
- (v) costs that would not have been incurred had this Grant Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period).

- 22.10 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Services, over £250,000 will terminate automatically and immediately upon termination of this Agreement.
- 22.11 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Grant Agreement in the event that the Grant Agreement was terminated (calculated on the basis described in clause 22.8).
- 22.12 ARIA's total liability under clause 22.9 shall be limited to the Maximum Sum under the Grant Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.13 If the Grant Agreement is terminated or expires ARIA will not be liable to pay any of your costs or those of any of your contractors or suppliers related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Grant Funding Letter and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Grant Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Grant Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the Grant Manager and the Project Representative.
- 23.3 If the dispute cannot be resolved between the Grant Manager and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to a formal meeting between the parties' Escalation Contacts.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause unless a liability limit or exclusion is permitted by law:
- (a) fraudulent misrepresentation or any other fraudulent act or omission;
 - (b) payment of sums properly due and owing to the other in the normal course of performance of this Grant Agreement;
 - (c) a breach of clause 13;

- (d) liability arising under any indemnity in this Grant Agreement; or
- (e) liability which may not lawfully be excluded or limited.

24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Grant Agreement or for ARIA's breach of this Grant Agreement), whether arising directly or indirectly, that may arise in connection with:

- (a) your carrying out the Project Activities;
- (b) the use of the Grant by any person;
- (c) any reduction, suspension, withdrawal or request for repayment of the Grant in accordance with this Grant Agreement; or
- (d) termination of the Grant Agreement in accordance with this Grant Agreement.

24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:

- (a) loss of profit, sales or turnover;
- (b) loss of contracts or business opportunities;
- (c) loss of anticipated savings;
- (d) loss of goodwill or damage to reputation; or
- (e) any indirect, special or consequential loss or damage;

in each case arising out of or relating to the Grant Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.

24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to the Grant Agreement or its subject matter or anything which it has done or not done in connection with the Grant Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the amount of the Maximum Sum.

24.5 You shall under no circumstances in connection with this Grant Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.

24.6 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Grant Agreement.

25. RESEARCH ETHICS AND CODE OF CONDUCT

25.1 As a recipient of a Government grant you must operate in accordance with the Concordat.

25.2 All research data:

- (a) must be generated using sound scientific techniques and processes;
- (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and

(c) must be analysed appropriately, without bias and in accordance with good scientific practices.

25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.

25.4 You must comply with the Code of Conduct and ensure that your Representatives undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

26.1 Any variation to the Grant Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

27. GENERAL

27.1 Notices: All notices and other communications in relation to this Grant Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such communications will be deemed to have been given and received on the third Working Day following such mailing.

27.2 Change of control: You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(i) is likely to apply.

28. GOVERNING LAW

28.1 This Grant Agreement (including any non-contractual disputes or claims arising in connection with this Grant Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. NOT USED

30. DEFINITIONS AND INTERPRETATION

30.1 Where they appear in these Conditions or the Grant Agreement:

Adequate Insurance means the insurance requirements and amounts set out in the Grant Funding Letter.

Asset means any asset that is purchased, improved or developed using the Grant including equipment and fixed assets;

Background IP means IP that is:

(a) owned by or licensed to a party prior to the Commencement Date; or
(b) developed by or on behalf of a party during the Funding Period but not in connection with the Project Activities,

and is in either case used in connection with the Project Activities;

Bribery Act means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;

Change of Control means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Recipients of Government General Grants published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754555/2018-11-06_Code_of_Conduct_for_Grant_Recipients.pdf

including any subsequent updates from time to time;

Commencement Date means the date set out in the Grant Funding Letter;

Commercialisation Licence means a licence of IP other than a research or evaluation licence and/or subcontract manufacture (and **Commercially License** means to license under a Commercialisation Licence);

Commercialisation Hypothesis means the exploitation plan approved by ARIA and set out at Schedule 2 Part 2, as may be amended by agreement between the parties during and after the Funding Period;

Completion Date means the date set out in the Grant Funding Letter;

Concordat means the Concordat to Support Research Integrity which can be found at <https://ukrio.org/about-us/the-concordat-to-support-research-integrity/>

Conditions means these ARIA Grant Conditions;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Grant Agreement, that ought reasonably to be considered to be confidential (whether or not it is so marked), (a) including: (i) information relating to the business, affairs, customers, clients, suppliers or plans of the disclosing party; (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party; (iii) any information developed by the parties in the course of carrying out the Project Activities; (iv) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Grant Agreement; and (v) and any information derived from any of the above,

(b) but not including information which: (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11); (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party; (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or (iv) is independently developed without access to the Confidential Information; and (v) the content of this specific version of the Grant Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

Duplicate Funding means funding provided to you by a Third Party which is to fund the same activities as the Project Activities;

EA means the Equality Act 2000 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Eligible Expenditure means the payments made by you during the Funding Period for the purposes of carrying out the Project Activities which comply with clause 5 and ARIA's published eligibility rules (which provide for full economic cost reimbursement) and as agreed in the Grant Funding Letter;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Grant Funding Letter;

Event of Default means any of the events or circumstances set out in clause 22.1;

Financial Year means 1 April to 31 March;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means any IP in the Results;

Funding Period means the period commencing on the Commencement Date and ending on the Completion Date or such later date as may be agreed between the parties unless otherwise determined in accordance with the terms of the Grant Agreement;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification (operated by ARIA or by a third party), in the form set out at Annex A;

GDPR means Regulation (EU) 2016/679;

Grant means the sum or sums ARIA will pay to you up to the amount set out in the Grant Funding Letter, in accordance with clause 4 and subject to the provisions set out at clause 22.

Grant Agreement has the meaning given in the Grant Funding Letter;

Grant Claim means a request submitted by you to ARIA for payment of the Grant;

Grant Funding Letter means the letter from ARIA to you to which these Conditions are annexed;

Grant Manager means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Grant;

Grant Review means the process for reviewing the grant outlined in clause 6;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Ineligible Expenditure means expenditure incurred by you which is not Eligible Expenditure as set out in clause 5 and ARIA's published eligibility rules;

Information Acts means the Data Protection Legislation, FOIA and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property Rights or **IP** means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions, semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation;

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise;

Maximum Sum means the maximum amount of the Grant stated in the Grant Funding Letter;

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

NewCo has the meaning given in clause 16;

Non-UK Entity means a legal entity that is not a UK Entity;

Personal Data has the meaning given to it in the Data Protection Legislation as amended from time to time;

Prohibited Act means:

(a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Grant Agreement; and/or (ii) showing or not showing favour or disfavour to any person in relation to the Grant Agreement;

(b) committing any offence: (i) under the Bribery Act; (ii) under legislation creating offences in respect of fraudulent acts; and/or (iii) at common law in respect of fraudulent acts in relation to the Grant Agreement; and/or

(c) defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the activities to be carried out by you that are described in the Grant Funding Letter and in Schedule 2 Part 1;

Project Representative means the representative appointed by you, who at the Commencement Date will be the individual listed as such in the Grant Funding Letter;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means all information, data, techniques, inventions, discoveries, works, software and materials generated in the course of the Project Activities;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Small or Micro Company means a Small or Micro Company as defined by the European Commission https://single-market-economy.ec.europa.eu/smes/sme-fundamentals/sme-definition_en

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Project Activities or any part thereof or facilities or services necessary for the performance of the Project Activities or any part thereof or necessary for the management, direction or control of the Project Activities or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

UK Entity means a legal entity whose ultimate parent company has its headquarters and principal establishment in the United Kingdom;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Grant Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Funding Period because of termination or breach of the Grant Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination; and

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 In these Conditions and the Grant Agreement, unless the context otherwise requires:

- (a) references to "party" and "parties" are to the parties to the Grant Agreement;
- (b) the singular includes the plural and vice versa;
- (c) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (d) references to clauses and Schedules are to the clauses of these Conditions and to the Schedules to the Grant Agreement;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation"; and
- (g) the headings in the Grant Agreement are for ease of reference only and will not affect the interpretation or construction of the Grant Agreement.

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

Eco-ICE: Ecological Impact Assessment of Earth Cooling Experiments in the Arctic

Eco-ICE aims to develop new insights and frameworks into the evaluation and governance of climate intervention activities. It is hoped that these outputs will allow us to move beyond divisive positions by providing a benchmark against which the ecological impact of an intervention can be independently and robustly evaluated. Not only will this approach provide a comprehensive, rather than partial evaluation of uncertainties, it reduces project risk through adequate contribution and time of highly experienced scientists and provides both novel experimental laboratory capabilities and more extensive numerical simulations along with the necessary scientific personnel time to utilise these capabilities. Most importantly, it allows for the co-development of a comprehensive framework and sequential guidance for evaluating future climate interventions. Eco-ICE aims to provide (i) a robust, independent evaluation of other climate intervention activities within the Arctic, (ii) the advancement of dialogue, evaluation and decision-making about the governance of climate intervention activities (iii) better informed local, regional and international efforts regarding proposed climate intervention activities in the polar marine environment. This would be an extraordinary legacy for ARIA's climate cooling program.

2. Aims and objectives of the Project Activities

At the highest level, our objectives for the 'Gold Standard' programme are to provide:

1. A robust, science-based Evaluation Framework that will underpin an independent evaluation of the physical and cascading ecological impacts on the polar marine environment.
2. Quantification and multi-method attribution of physical changes induced by the intervention in the ocean, atmosphere, and sea-ice system. These outputs will support a robust assessment and attribution of biogeochemical responses to the physical changes at local to regional scales, including through tracking shifts in nutrient cycling and ocean chemistry.
3. Modelling of ecological consequences focusing on the potential impacts on key Arctic marine species and ecosystem structure and mediated carbon export.
4. An ecological risk assessment (ERA) of the specific intervention, including information on the magnitude, duration, and reversibility of ecological impact.
5. Targeted guidance for ARIA on the suitability and environmental trade-offs of the specific intervention approach.
6. Two-way dialogue on decision-making and governance of climate intervention activities with Arctic organisations (e.g. AMAP) and a 'best practices' guidance for evaluation of future climate interventions.

3. Project Activities

3.1 Project Activities are as set out below:

WP1 Development of a robust evaluation framework

Inputs: Other ARIA projects, all WPs, IBoA

Outputs: WP2, WP3, WP4, WP5

Co-Leads: Jeremy Wilkinson (BAS), PDRA1 (first 12 mo)

Participants/CO-I: Amanda Burson (BAS), co-leads from all WPs

Overview: WP1 will develop a robust, science-based Evaluation Framework that underpins an independent evaluation of the physical and cascading ecological impacts on the polar marine environment associated with each ARIA-selected experiment. A recognised method for quantifying the effects of outside impacts on a marine ecosystem, such as a climate intervention, is through the establishment of an Evaluation Framework (EF). A well-designed, scientifically robust EF allows for definitive conclusions (with quantified uncertainties) to be drawn on the cascading ecological impact across different trophic levels. The main objective of the EF is 1) identify key ecological components and associated environmental parameters that are most likely to be impacted by the intervention and 2) design observational experiments and modelling studies to quantify the ecological consequences of the proposed intervention.

WP1.1 Round Table assessment. To initiate the drafting of the EF a series of round-table meetings will be held with the proponents of the assessed intervention. The aim of these meetings is to obtain a more complete understanding of (i) the intervention and its spatiotemporal domain, (ii) its expected environmental impacts and (iii) the magnitude of the intended perturbation and how it varies under different future Shared Socioeconomic Pathways (SSPs). Co-leads of WP2 to WP4 will participate in the round tables to ensure their modelling and laboratory experiments can be better linked to each intervention. (M1.1).

WP1.2 Production of Evaluation Framework. Using the outputs of WP1.1 we will co-design (with WP5.1) a step-by-step EF from which an interlinked and comprehensive understanding of physical changes (WP2), biogeochemical changes (WP3) and biological changes (WP4) caused by the intervention can be derived. The EF will include (i) defining clear and achievable objectives, (ii) determining the threshold and boundaries, as well as spatiotemporal limitations of the analysis, (iii) robustly selecting the ecological, environmental and pressure indicators to evaluate, and (iv) to identify/compile a baseline (control) dataset from which an assessment of the spatiotemporal impacts of the intervention can be assessed. Data availability, reliability and knowledge gaps will be key considerations when developing the EF. Once the draft EF has been completed it will be delivered to WP5.1 for evaluation by an Independent expert Board of Advisors (IBoA). This peer-review process is aimed at strengthening the EF, as well as ensuring the framework is flexible enough to be used for future assessments (beyond the ARIA Exploring Cooling Climate programme). Whilst the EF will remain consistent for the evaluation of selected ARIA-funded experiments, the practicalities must be developed on a case-by-case basis. (M1.2)

Milestones: M1.1 (month 6): Report on round table meetings for intervention. M1.2 (Draft: month 8, Peer-Reviewed: month 12): Delivery of the peer-reviewed Evaluation Framework.

WP2: The Regional to Global Physical Changes Associated with Climate Interventions

Inputs: WP1, ARIA/RaSI team

Outputs: WP3, WP4, & WP5

Co-Leads: Louise Sime and Neven Fučkar

Participants/CO-I: ESM Engineer (Alison McLaren), PhD_Reading

Overview: WP2 will diagnose the physical changes associated with a range of sea ice thickening approaches, by implementing ice thickening scenarios in the UKESM. It will fully isolate and robustly attribute the intervention's impacts on sea ice, oceans and climate, and quantify associated uncertainties. This will directly support the WP3, WP4, and WP5 synthesis (M2.4). WP2 will develop the UKESM sea ice sub model code base to ensure it can directly track the pathways of the added ice throughout the UKESM sea ice domain and beyond, including ascertaining when and where it enters the ocean or atmosphere, and tracking it also through these domains. A large ensemble of UKESM simulations of the targeted ice thickening interventions will underpin the analysis and multi-method attribution of biogeochemical (WP3) and biological changes (WP4).

WP2.1 Implement Sea Ice Thickened Interventions in UKESM. WP2.1 will implement the sea ice thickening intervention – as discussed with the RaSI team – in the UKESM and produce a large ensemble of simulations to ascertain the physical changes, and key uncertainties, associated with the intervention.

WP2.2 Track Global and Regional Impacts in the Sea Ice and Beyond. The UKESM atmosphere and land surface sub-models are already equipped with unique ice and water tracking capabilities, developed over the last seven years in BAS. WP2.2 will extend this type of capability to the UKESM sea ice model, called SI3. This new capability allows both (i) detailed assessment and attribution of the ice, water, and climate impacts critical to understanding the changes and dynamics; and (ii) in WP3 this capability will be used to improve the tracking of nutrients associated with the sea ice thickening intervention.

WP2.3 Attribute Simulated Changes to Intervention versus Projected Climate Change. Large ensemble UKESM simulations of future climate projection(s) and the associated intervention simulations will enable robust estimation of causal processes, pathways of changes, and multi-method attribution to sea ice thickening intervention versus climate change. Both storyline and probabilistic approaches to attribution will be used to infer crucial mechanisms and pathways.

Milestones: M2.1 (month 12, annually updated thereafter): Large ensembles of UKESM simulations to assess how the ice thickening interventions will affect the physical world and provide (global scale) data required for subsequent risk assessments, robust attribution and physical context for WP3 and WP4. M2.2 (month 36): Fully updated UKESM code base with new capability to track all ice and water properties throughout the UKESM sea ice sub-model logged with the UKESM MetOffice/UKESM code owners. M2.3 (month 36): Multi-method attribution and causality analysis for the selected intervention. M2.4 (first report month 18, then annually, and the last report at month 42): Report summarising the potential physical changes and multi-method attribution associated with the Arctic sea ice thickening intervention, designed for ecological assessment purposes.

WP3: Modelling the biogeochemical implications

Inputs: WP1, WP2

Outputs: WP4, & WP5

Co-Leads: Kate Hendry and Rhiannon Jones

Participants/CO-I: ESM Engineer (Alison McLaren), Clara Manno, Amanda Burson, Neven Fučkar, Dave Munday, Florence Atherden, PhD_UEA

Overview: WP3 will focus on the sensitivity of regional biogeochemical cycling due to the selected interventions in the Arctic. The polar regions play a key role in driving global productivity and carbon cycling, both by direct supply of nutrients to the polar surface ocean, and by setting the nutrient signature of global-scale ocean circulation. The flow of nutrients, alkalinity, and carbon cycling between sea ice and ocean is a key driver of seasonal Arctic productivity. Using the outputs from the UKESM biogeochemical sub-model MEDUSA-2, and the WP2 investigation of physical changes, WP3 will assess the biogeochemical impacts and conduct a multi-method attribution of intervention scenarios using both numerical model output and laboratory-based experimental approaches. Primarily, WP3 will determine the key drivers and rates of biogeochemical change and quantify changes relative to a baseline. WP3 will effectively provide the biogeochemical context required to feed into WP4, identifying key potential bottom-up drivers of ecological impacts of climate interventions (M3.3).

WP3.1 Physical modelling of biogeochemical impacts of different scenarios. Laboratory analyses will be carried out to calculate changes in the distribution and fluxes of macronutrients, total alkalinity and dissolved inorganic carbon (DIC), using existing and newly procured BAS laboratory facilities (nutrients, total alkalinity, DIC). Critically, the acquisition of DIC and total alkalinity analysers will facilitate rapid and reactive parameter analysis by co-leads and laboratory support technicians, with in-house quality control, providing outputs that can inform biogeochemical modelling and ecological assessment more effectively and with additional scope for adaptation with respect to the 'single budget' capabilities. Support for the additional biological carbon pump work for WP4 will be made possible with in-house analysers and additional expertise time, enabling effective and reactive knowledge exchange.

WP3.2 Numerical modelling of biogeochemical impacts of climate interventions. Using the UKESM biogeochemical sub-model we will perform a set of sensitivity simulations to evaluate changes to biogeochemical cycles with respect to Arctic sea-ice-thickening interventions. The additional expert time will facilitate more complex and reactive modelling capabilities and enable modelling of multiple complex scenarios beyond a single-scenario sea ice-thickening intervention. Output will be used to investigate the implications and multi-method attribution for marine biogeochemical processes of intervention versus non-intervention futures.

Milestones: M3.1 (month 24): Develop capability for, and carry out, a laboratory set of sea ice thickening experiments, resolving fundamental nutrient exchange between ice and seawater during sea ice growth and loss. M3.2 (draft month 24, final report month 36): Deliver output of UKESM model biogeochemical implications to inform WP4, 5 and framework. M3.3 (initially month 24 then annually; final inputs month 42): Provide a synthesis report on the potential changes and

multi-method attribution to nutrient cycles following climate intervention method implementation and disseminate research.

WP4 Understanding the Biological Change

Inputs: WP1, WP2, WP3

Outputs: WP2, WP3, WP5

Co-Leads: Clara Manno and [REDACTED]

Participants/CO-I: PDRA2, Simeon Hill, Kate Hendry, Neven Fučkar, Rhiannon Jones, Amanda Burson

Overview: WP4 will evaluate the potential impact of climate interventions on the composition, functioning, and resilience of the proximal pelagic Arctic ecosystem and on the ability of this ecosystem to support the uptake, transport and storage of atmospheric CO₂ in the deep ocean (biological carbon pump). The biological carbon pump at high latitudes has a significant influence on global climate regulation. The strength of the biological carbon pump in these regions is largely driven by plankton dynamics and food web process. We will focus on the impact of the intervention on the plankton component, which underpins both the biological carbon pump and the wider food web. We will assess individual and combined impacts of climate interventions including additive-synergistic and cascading effects. Using outputs from WP2 and WP3, we will identify potential direct (i.e. habitat changes, species mortality or displacement) and indirect impacts (i.e. altered community dynamics) on community structure and biological mediated carbon export along with multi-method attribution of these impacts from climate interventions. We will perform simulation experiments (using a combination of mesocosm incubation and modelling) where organisms will be exposed to environmental conditions reflecting pre- and post-ice thickening intervention scenarios. Findings will be relayed to WP2 and WP3 for any relevant adjustments to ecological models, synthesised to WP5, and disseminated through scientific publications.

WP4.1 Laboratory mesocosm simulation of biological impacts. Key marine plankton species will be cultivated/incubated and exposed to environmental stressors using multifactorial mesocosm experiments capable of supporting multiple treatments simulating different environmental conditions (i.e. control versus ice-thickening induced potential stressors, such as changed light or nutrient conditions). Any direct potential disturbances from equipment (such as chemical and plastic pollution) will also be addressed. Increased investigator time, coupled with adequate analysis and consumable budget, will allow us to incorporate experiments dedicated to understanding impacts to the highly climate relevant biological carbon pump. These mesocosm experiments will be carried out in BAS climate-controlled laboratories.

WP4.2 Modelling biological impacts. Models informed by WP4.1 outputs will be used to evaluate ecosystem impacts over larger spatial and temporal scales and to further explore the effects of individual and combined stressors. The 2D ecosystem models will represent the spatiotemporal dynamics and food web structure of marine plankton pre- and post- climate intervention. The models will be used to assess impacts and conduct multi-method attribution on regional biomass, species composition, network structure, predator-prey dynamics and their implications for ecological resilience including the cascading impact on the biological carbon pump. Additional investigator

time will facilitate a more comprehensive analysis of ecological resilience and crucially will include assessment of the biological carbon pump.

Milestones: M4.1 (month 30): Perform experiments to investigate impact on, and resilience of, plankton community structure and their role within the biological carbon pump after climate interventions. M4.2 (month 40): Deliver a model-based analysis of the impacts and multi-method attribution of climate interventions on plankton community structure, dynamics, resilience including the cascading effect on the biological carbon pump. M4.3 (Annually, final inputs month 42): Provide a synthesis report on the potential changes to the regional plankton community and biological carbon pump following climate intervention.

WP5 Synthesis and Ecological Risk Assessment reports

Inputs: WP2-4, IBoA, AMAP

Outputs: WP1, ARIA, UK policy Agencies

Co-Leads: Rachel Cavanagh and PDRA1 (mo. 13-48)

Participants/Co-I: [REDACTED] Amanda Burson, Simeon Hill, IBoA, all WP co-leads

Overview: WP5 will work with WP1 to ensure that the design of the Evaluation Framework (EF), is suitable for the delivery of an Ecological Risk Assessment (ERA), synthesise the modelling and experimental results from WP2-4, and produce an ERA report of the proposed climate intervention. Leads will ensure Eco-ICE addresses the three main phases of ecological risk: 1. problem formulation, 2. analysis of exposure and effects, and 3. risk characterisation with considerations of uncertainty.

WP5.1 Support development of Evaluation Framework. Once provided with an overview of the proposed climate intervention, WP5 will consult with the IBoA, via roundtable discussion, to inform the development of the EF. The environmental /ecological issues raised during the roundtable discussion will be collated and used to inform the EF design (M5.1).

WP5.2 Scientific synthesis of Eco-ICE programme. The results from WP2-4 will be collated, interpreted and summarised to provide a scientific synthesis report for the targeted climate intervention (M5.2). Importantly, the synthesis report will also identify uncertainties in analysis and results. The scientific synthesis report will be shared with the IBoA, as well as an expanded network of experts, if deemed necessary. Additional IBoA roundtable discussions will be held to incorporate input from a broad range of experts to yield a final scientific synthesis of the ecological impact which will ultimately inform the ERA. WP5 co-leads will meet regularly with WP2-4 research teams to receive a steady input of modelling and experimental results allowing a progressive development of the scientific synthesis report, and associated sections of the ERA, with a consolidated effort in the final months.

WP5.3 Ecological Risk Assessment report. Utilising the scientific synthesis report and the input from the IBoA roundtable discussions, an ERA will be undertaken to evaluate the level of ecological risk associated with the proposed ice-thickening (M5.3). This will include evaluation of the (i) likelihood (probability of impact occurring), (ii) magnitude (severity of the impact), (iii) duration (temporary, long-term, or permanent effects), (iv) reversibility (potential for recovery/restoration), and (v)

significance (ecological importance). We will provide scaling metrics for these evaluation criteria and ultimately provide a final assessment of the ecological risk associated with the ice-thickening intervention to be weighed against the potential climatological benefit. The structuring of the ERA will begin immediately following the development of the EF and progress in stages as new scientific results are documented during regular meetings with WP2-4 research teams. Upon completion, the ERA report will be disseminated to ARIA, the ice-thickening team and relevant stakeholders as well as presented at the end of project stakeholders conference.

WP5.4 Ecological Risk Assessment of Climate Interventions Guidance. Both the EF and ERA produced for the ice-thickening intervention will be used to develop the best practices guide for ecological risk assessment of other/future climate interventions in polar marine systems (M5.4). Both M5.3 and M5.4 will incorporate structuring from already established and utilised ERA frameworks in existence (i.e. from fisheries management, polar/marine infrastructure development etc.), but integrate aspects which are unique to climate interventions and are not currently accounted for in established ERA resources. M5.4 will differ from M5.3 as it will be a broader, guidance style document wherein future climate intervention assessors would provide the specific analysis appropriate to the intervention being assessed. This guidance framework will be co-developed with the IBoA formed for the ice-thickening intervention but also additional external bodies with vested interest in polar ecosystems and governance of future climate intervention efforts (e.g. AMAP).

Milestones: M5.1 (month 12): Hold IBoA roundtable discussions to support development of the EF with WP1. M5.2 (initial structuring from month 9, final conscripting month 40-45): Scientific synthesis report of modelling and experimental outputs of WP2-4. M5.3 (initial structuring from month 9, final conscripting 45-48): Development, completion and dissemination of ice-thickening ERA report. M5.4 (initial structuring from month 13, final conscripting 45-48): Development, completion and dissemination of EF & ERA best practice guides.

WP6 Project management and oversight

Inputs: WP1-5, ARIA, BAS Directorates

Outputs: WP1-5, ARIA

Co-Leads: Amanda Burson, BAS's Research Development and Support (ReDS) team

Participants/Co-I: All WP co-leads, BAS's Communication team, BAS's Polar Data Centre (PDC)

Overview: The project management structure of Eco-ICE is comparable to those utilised by similar-sized projects. To promote equality, diversity and inclusion, Eco-ICE have united professionals from various sectors, backgrounds and stages of career development. Importantly, we have ECR representation at all levels of our project, including co-leadership roles for all WPs, and we strive for gender balance within the project. Scientific and managerial decision-making revolves around the Project Management Team (PMT), which consists of the Project Lead (A. Burson), WP co-leads, and the British Antarctic Survey's (BAS) in-house Research Development and Support team (ReDS). Within ReDS, Eco-ICE has a dedicated Project Manager who will assist in management tasks including keeping track of deliverables, milestones and maintenance of a risk register. The PMT will oversee communication with the collaborators, organise the annual project meetings as well as facilitate quarterly updates on project activities and deliverables, dissemination priorities, ethics, and other reporting requirements to ARIA. Additionally, Eco-ICE has dedicated resources with BAS's

in-house communications team for support with project communications and outreach activities, including social media, website, and the stakeholder conference. Our annual project meetings (APM) will be in a hybrid format to ensure that all participants can equitably participate.

WP6.1 Establishment of the Data Management and Communication Management Plan. Due to the critical requirement for independent assessment, the Eco-ICE PMT will coordinate with the PDC and BAS's communications team to establish the best strategy to maintain this throughout the project. A Data Management Plan (DMP) and Communication Management Plan (CMP) will be established at the onset of the project in collaboration with the PDC and Communications team respectively. These plans will be reviewed regularly but at a minimum at quarterly PMT meetings to ensure continued fit for purpose.

WP6.2 Reporting to ARIA. The PMT will hold internal project meetings with WP co-leads minimally quarterly but more frequently as required. These project meetings will provide the needed updates on milestone progression, new learnings and developments and any challenges or changes which have occurred. We will also update/adjust the project risk register at these quarterly meetings. This information will then be passed onto ARIA via the quarterly project reports (M6.2). Finally, the PMT will develop the final project closure report as per ARIA's structuring requirements (M6.3).

Milestones: M6.1 (month 4): Establishment of the DMP and CMP for Eco-ICE programme. Hold IBoA roundtable discussions to support development of the EF with WP1. M6.2 (initial month 3, quarterly thereafter): Quarterly project reports on milestone progression and project developments/challenges. M6.3 (month 47-48): project closure report.

3.2 The following Milestones will be used to monitor your delivery of the Project. The costs associated with completing these Milestones are estimated in the cost breakdown sheet [REDACTED] (note these costs include an estimate for the use of the NERC facilities these costs are subject to agreement with NERC).

ID	Milestones	Measure	Date
M1.1	Report on round table meetings with ice-thickening team	Report is detailed enough to adequately inform the modelling parameterisations and experimental laboratory designs with WP2-4.	Commencement date + month 6
M1.2	Delivery of the peer-reviewed Evaluation Framework.	Dual purpose: to provide the scientific evidence-based framework for evaluation of sea-ice-thickening intervention as well flexible guidance for future programme assessments.	Commencement date + month 12
M2.1	Implementation of ice-thickening interventions	Large ensembles of UKESM simulations to assess how sea ice	Commencement date + 12 months, and annually

	in UKESM	thickening will affect the physical world and provide (global scale) data required for subsequent risk assessments, robust attribution and physical context for WP3 and WP4	updated thereafter
M2.2	Tracking global and regional impacts in sea ice	Fully updated UKESM code base with new capability to track ice and water throughout the UKESM sea ice sub-model logged with the UKESM MetOffice/UKESM code owners.	Commencement date + 36 months
M2.3	Attribute simulated changes from intervention vs. climate change	Multi-method attribution and causality analysis for the selected climate intervention.	Commencement date + 36 months
M2.4	WP2 input to synthesis report	Report summarising the potential physical changes and multi-method attribution associated with the Arctic sea ice thickening intervention, designed for ecological assessment purposes.	Commencement date + 18 months, then annually, and the final output at month 42
M3.1	Physical experiments of biogeochemical impacts	Develop capability for, and carry out, a set of sea ice thickening experiments in the laboratory, resolving fundamental nutrient exchange between ice and seawater during sea ice growth and loss.	Commencement date + 24 months
M3.2	Numerical modelling of biogeochemical impacts	Deliver output of UKESM model biogeochemical implications to inform WP4, 5 and framework	Commencement date + 36 months
M3.3	WP3 input to synthesis report	Provide a synthesis report on the potential changes and multi-method attribution to nutrient cycles following climate intervention method implementation and disseminate research.	Commencement date + 24 month, then annually and final input 42 months
M4.1	Laboratory mesocosms on biological impacts	M4.1 Perform laboratory experiments to investigate impact on and resilience of plankton community structure and the cascading effect on their role in the biological carbon pump after	Commencement date + 30 months

		ice-thickening interventions.	
M4.2	Modelling of biological impacts	Deliver a model-based analysis of the impacts and multi-method attribution of sea-ice-thickening interventions on plankton community structure, dynamics, resilience including the cascading effect on the biological carbon pump.	Commencement date + 40 months
M4.3	WP4 input to synthesis report	Provide a synthesis report on the potential changes to the regional plankton community and biological carbon pump efficiency following ice-thickening intervention	Commencement date + 30 months, final inputs 42 months
M5.1	Support development of Evaluation Framework (EF)	Develop and organise the Independent expert Board of Advisors for round table review of EF design.	Commencement date + 12 months
M5.2	Scientific synthesis report	Incorporate results from WP2-4 into scientific synthesis report on the ice-thickening project. Report will include uncertainties in analysis and results. It will be shared with IBoA and feedback from roundtable discussions will be incorporated. This provides the empirical basis for subsequent ERA.	Commencement date + 40-45 months
M5.3	Ecological Risk Assessment of ice-thickening project	ERA of ice-thickening intervention which evaluates the ecological impacts of the project including (i) likelihood, (ii) magnitude, (iii) duration, (iv) reversibility (v) and significance. Scaling metrics for these criteria will be included and weighed against the potential climatological benefit of the intervention.	Commencement date + 45-48 months
M5.4	Ecological Risk Assessment of Climate Interventions Guidance	Both the EF and ERA will be used to develop the best practices guidance on ecological risk evaluations of future climate intervention projects. This will be co-developed with IBoA	Commencement date + 45-48 months

		and additional external bodies with vested interest in polar ecosystems and governance of climate intervention efforts.	
M6.1	Establishment of Data and Communications Management plans	The project management team (PMT) will coordinate with the Polar Data Centre located with BAS and BAS's communications team to develop comprehensive Data Management and Communication Management Plans, respectively, for the project.	Commencement date + 4 months.

In addition to the above Milestones, the following project plan will be used to track progress throughout the project. The Project plan and may be reevaluated from time to time: [REDACTED]

3.3 The intended long-term outcomes are summarised below:

- The Evaluation Framework and Ecological Risk Assessment of Climate Interventions Guidance are both long-term outcomes which will improve future ecological evaluations of interventions as well as provide a substantive legacy of due diligence for the ARIA programme.

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement
Planning	• Roles and responsibilities • External communications • Vision • Project details • Code and data management • Project plan + project management
Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Key Learning, discoveries and decisions

	• Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • Invoicing and cost reporting Optional: • technical evidence saved to drive e.g. report or presentation as requested by PD • review meeting slide deck saved to drive as requested by PD
Annual	• ARIA impact metrics • Attendance at annual ARIA event
Ad hoc	• As required, Programme Director/ Programme Team may request additional information and evidence • Workshops - potential to be invited to ARIA workshops
Project closure	• Project closure report

5. Payment

5.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments quarterly in arrears based on actual costs incurred.

For quarterly payments, the cadence of payments will align with ARIAs financial year beginning 1st April e.g Quarter 1 Grant Claims will be for the period of 1st April to 30 June, Quarter 2 Grant Claims will be for the period of 1st July to 30 Sept and so on.

5.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

5.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end of the relevant period.

5.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

6. Principal investigator/key researchers

6.1 For the purposes of clause 22.7, the following principle investigators or key researchers have been identified:

Name	Role	Organisation
Amanda Burson	Principal Investigator, All WP participant	British Antarctic Survey
Jeremy Wilkinson	WP1 Co-lead	British Antarctic Survey
Louise Sime	WP2 Co-lead	British Antarctic Survey
Neven Fučkar	WP2 Co-lead, WP3 and WP4 participant	University of Oxford
Kate Hendry	WP3 Co-lead, WP4 participant	British Antarctic Survey
Rhiannon Jones*	WP3 Co-lead, WP4 participant	British Antarctic Survey
[REDACTED]	WP3, WP4 participant	British Antarctic Survey
Clara Manno	WP4 Co-lead, WP3 participant	British Antarctic Survey
Florence Atherden*	WP4 Co-lead, WP3 participant	British Antarctic Survey
Rachel Cavanagh	WP5 Co-lead,	British Antarctic Survey
Simeon Hill	WP4 Participant, WP5 participant	British Antarctic Survey
ESM Engineer [REDACTED] [REDACTED]	WP2, WP3 participant	British Antarctic Survey
PDRA 1*	WP1 (12 mo) & 5 (36 mo)	British Antarctic Survey
PDRA 2*	WP4	British Antarctic Survey
PhD Student 1	TBC	University of East Anglia
PhD Student 1	TBC	University of Reading

* indicates Early Career Researcher (ECR)

7. Sub-Contractors

7.1 For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Location

University of Oxford	WP2 Co-lead, WP3 and WP4 participant	Oxford, UK
University of East Anglia	WP3 PhD student co-supervision	Norwich, UK
University of Reading	WP2 PhD student co-supervision	Reading, UK

PART 2 - GRANT APPLICATION

Application titled "Eco-Gap: Ecological assessment of Geoengineering at the Poles" dated 09
December 2024

SCHEDULE 3

Royalty Percentages

1. Royalties on the sale or supply of products or services that are covered by, use or incorporate the Foreground IP licensed to the NewCo will only become due on aggregate net sales derived from the Foreground IP exceeding £50 million.
2. Where the Grant Recipient concludes, having first complied with clause 15.9 of the Grant Conditions (Inventor First Preference) that licence of the Foreground IP by the Grant Recipient or its technology transfer company to any third party other than a Small or Micro Company is the most viable route to commercialisation then the threshold restrictions related to net sales derived from the Foreground IP in paragraph 1 shall not apply.
3. In any case, the maximum headline percentage royalty rate (i.e. before any royalty stacking, step-down or other reduction and excluding any ARIA Non-UK Fee) for products or services that are covered by, use or incorporate the Foreground IP, and of sublicensing income, shall be one of the following:

Type of product	Applicable headline royalty percentage (up to)
Low margin	0.5% of net sales
Medium margin	1% of net sales
High margin	2% of net sales
Sublicensing royalty	10% of net receipts

ANNEX 1

Clause for inclusion in licences of Foreground IP

[] **ARIA NON-UK FEE**

[].1 In this clause:

"ARIA" means the Advanced Research and Invention Agency;

"Crown Body" means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

"UK Entity" means a legal entity that has or whose ultimate parent company has its headquarters and principal establishment in the United Kingdom.

[].2 The Foreground IP was developed with funding from ARIA. As a condition of its funding ARIA requires that a benefit is returned to the United Kingdom where the Foreground IP is licensed by the Licensor to any person that is not a UK Entity. Accordingly, in addition to any other sums payable by the Licensee to the Licensor under this Agreement, the Licensee shall pay to the Licensor within 90 days after the end of each calendar year during the Relevant Period (as defined below), and within 90 days after the end of the Relevant Period, a fee (**ARIA Non-UK Fee**) on all amounts (including upfronts, licence fees, milestone payments, royalties, shares or other securities, exit fees, buyout or other consideration) payable by the Licensee to the Licensor under this Agreement in relation to the exploitation of any Foreground IP (**Relevant Amount**) that accrues during, or relates to, any period of time that the Licensee is not a UK Entity (**Relevant Period**). The amount of the ARIA Non-UK Fee is 25% of the Relevant Amount, and is payable by the Licensee to the Licensor in addition to the amounts that would otherwise be payable under this Agreement. For example if the Relevant Amount is £100 the ARIA Non-UK Fee is an additional £25, which the Licensee shall pay to the Licensor and the Licensor shall remit to ARIA.

Crown Body customers

[].3 You must also ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities and in suitable quantities for the Crown Body's requirements.

[].4 ARIA shall have the right to enforce this clause [] under the Contracts (Rights of Third Parties) Act 1999. Neither party may amend this Agreement in a way that detracts from ARIA's right to enforce its rights under this clause without ARIA's prior written consent.

[1] When using this clause you may substitute the relevant defined terms used elsewhere in the agreement to capture the concept of "Foreground IP". Where the clause refers to the "Licensor" and "Licensee" please use the appropriate defined terms to include the licensor, licensee, assignor and assignee of the Foreground IP. This clause is not suitable for assignments of the Foreground IP in consideration of the payment of one or more lump sum payments. In those cases the Licensor needs to be informed, and potentially make an additional payment, if the Foreground IP is subsequently assigned to a non-UK Entity or if the Assignee ceases to be a UK Entity.

SCHEDULE 4: Data Protection

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Grant Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Grant Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Grant Agreement:
 - 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are

relying on Domestic Law as the basis for processing Personal Data, you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;

- 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);
- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Grant Agreement unless required by Domestic Law to store the Personal Data; and

- 3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.
- 3.4. [[ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):
- 3.4.1. cancel its plans to change the affected sub-Processor;
- 3.4.2. offer an alternative which is acceptable to ARIA; or
- 3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.
- 3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Grant Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.
- 3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]
- 3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Grant agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it, storing it, retrieving it, consulting it, disseminating it or destroying it, etc.

	Note the definition of processing in the UK GDPR: <i>“any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction”]</i>
Duration of Processing:	Duration of this Grant Agreement (and any post termination processing that is permitted / required).
Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called “special categories” of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: <i>“data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation”]</i>
Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors,

	clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. Subject to section 25 of this Grant Agreement, you shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.
- 4.2. Any limitation of liability set out in this Grant Agreement will not apply to this Schedule's indemnity or reimbursement obligations unless such a limit is permitted by law.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

1. Submission of Pledged Patents and Experimental Data

- 1.1 The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
- 1.2 The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.

2. Experimental Data Licence

- 2.1 Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
- 2.2 The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
- 2.3 The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
- 2.4 The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).

3. Research Licence

- 3.1 Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
- 3.2 The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
- 3.3 Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

- 3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.
- 3.5 The Research Licensee must:
- (a) at all times when using the Pledged Patents comply with all Laws; and
 - (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).

4. Commercial Licence

- 4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.
- 4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.
- 4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.

5. Pledgor Know-How

At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.

6. Termination

- 6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:
- (a) materially breaches the terms of such licence or this Pledge; or
 - (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).

7. Transfers of Pledged Patents and/or Experimental Data

The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.

8. No Warranty

The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and

Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

Inter-American Institute for Global Change Research **(Grant Recipient)**

Av. Italia 6201

11500 Montevideo

Departamento de Montevideo

Uruguay

23 June 2025

Attention: Dr. Ignacio Mastroleo

Dear Dr. Mastroleo,

FPCW-PR01-P016 - Ethics and governance of solar geoengineering research: from concepts to implementation— Standard Grant Funding Letter

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to Exploring Climate Cooling Programme and ARIA is pleased to offer you a Grant for the performance of the Project Activities up to the Maximum Sum, subject to your agreement to, and compliance with, the terms and conditions set out in this Grant Funding Letter and its Schedules.

1. Overview of the Grant

Any reference in this letter to "you" or "your" means the Grant Recipient and any capitalised terms have the meanings given in the ARIA Grant Conditions (Conditions).

The key elements of the Grant are described in the table below:

Project Activities	Ethics and governance of solar geoengineering research: from concepts to implementation. A more detailed description of the Project Activities is set out in Schedule 2 (Project Activities).
Maximum Sum of the Grant (inclusive of taxes)	£464,395 (inclusive of all taxes where applicable)
Commencement Date	The commencement date is 23 June 2025
Completion Date	The completion is 22 June 2027

Grant Review Intervals	ARIA will review the Grant at quarterly intervals using the process referred to in clause 6 of the Conditions	
Adequate Insurance	Employer's liability - As required by local laws	
Monitoring and Reporting	The performance reports referred to in clause 7 of the Conditions shall be provided at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Project Representative	Dr. Ignacio Mastroleo, [REDACTED]	
Grant Manager	Mark Symes, Programme Director, [REDACTED]	
Escalation Contacts	ARIA	Grant Recipient
	Chief Product Officer [REDACTED]	[REDACTED] IAI Science Director, [REDACTED] [REDACTED]
Notices	ARIA Contracts [REDACTED]	[REDACTED] IAI Science Director, [REDACTED] [REDACTED] [REDACTED] IAI Administration, Finance and Operations Officer, [REDACTED] [REDACTED]

2. Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Grant and return it to finance@aria.org.uk

3. The Grant Agreement

- 3.1. Once you sign a copy of this Grant Funding Letter in accordance with paragraph 6 (Acceptance) below, it will form a binding "**Grant Agreement**" between you and ARIA that includes and incorporates the following documents:

- 3.1.1. the **Grant Conditions** in Schedule 1;
 - 3.1.2. the **Project Activities, Milestones** and **Grant Application** in Schedule 2;
 - 3.1.3. the **Royalty percentages** (including annexes) in Schedule 3; and
 - 3.1.4. the terms relating to Data Protection in Schedule 4.
- 3.2. The parties confirm that it is their intention to be legally bound by the Grant Agreement.

4. Warranties

- 4.1. By signing this Grant Funding Letter, you warrant and represent that:
- 4.1.1. your obligations under the Grant Agreement are legal, valid, binding and enforceable;
 - 4.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Grant Agreement have been obtained;
 - 4.1.3. the person signing the Grant Agreement is duly authorised to sign on your behalf; and
 - 4.1.4. your Project Representative referenced in the table above is authorised to make decisions and provide information on your behalf.

5. Amendments to the Grant Conditions

For the avoidance of doubt, the following individuals are agreed as specified personnel:

5.1.1. Three PhD students:

- [REDACTED] at the University of Buenos Aires
- [REDACTED] at the University of Buenos Aires
- Name of final PhD student to be confirmed to ARIA no later than 31st July 2025

ARIA commits to funding these PhD students for the duration of the project only on the basis that there is no requirement for PhD students in Argentina to pay tuition fees. Students hired on the grant will be informed of this.

6. Acceptance

- 6.1. To accept this Grant Funding Letter, please arrange for an authorised signatory to sign and date the duplicate copy of this Grant Funding Letter as indicated below, and return to ARIA as a complete signed original of the Grant Agreement including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Grant Agreement and to bind the Grant Recipient.
- 6.2. The offer of this Grant Funding Letter will expire on 26 June 2025.

Yours sincerely

for and on behalf of ARIA

Name of ARIA signatory:

Position Held:

Date:

I confirm the agreement of Inter-American Institute for Global Change Research to the terms and conditions in this Grant Funding Letter and its Schedules.

Signature:

Name:

Position:

Date:

SCHEDULE 1 - GRANT CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up the Grant Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Grant Funding Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to the Grant Agreement with the exception of Schedule 2 Part 2 (the Grant Application);
 - (d) Schedule 2 Part 2 (the Grant Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, the Grant Agreement.

2. DURATION AND PURPOSE OF THE GRANT

- 2.1 The Grant Agreement will subsist for the duration of the Funding Period unless extended by written agreement signed by a duly authorised representative of the parties or terminated earlier in accordance with its terms. Any provision of the Grant Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Grant Agreement shall remain in full force and effect, including clauses 1, 2, 4, 7.4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.3, 22.7, 22.8, 22.11, 22.12, 23, 24, 26, 27, 28, and 30.
- 2.2 You may only use the Grant for carrying out the Project Activities. You may not make any changes to the Project Activities without ARIA's prior written agreement.
- 2.3 You may not unreasonably withhold, condition or delay your agreement to any changes requested by ARIA to the Project Activities or the amount of the Grant. Any agreed change will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

3. ENVIRONMENTAL AND SAFETY REQUIREMENTS

- 3.1 In performing the Project Activities, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. PAYMENT OF GRANT

- 4.1 Subject to the remainder of this clause 4, ARIA will pay the Grant to you:
- (a) up to the Maximum Sum;
 - (b) in pounds sterling (GBP) by wire transfer into your bank account, details of which you provided in the Confirmation of Bank Details form attached to the Grant Funding Letter; and
 - (c) if a tax is chargeable in respect of the Grant, all payments will be deemed to be inclusive of all such taxes and ARIA will not be obliged to pay any additional amount.
- 4.2 The bank account of which you provided details in your Confirmation of Bank Details form (and any alternative bank details nominated subsequently by you) must be an ordinary business bank account

with appropriate segregation of duties and control. During the Funding Period, you must notify ARIA of any change of bank account details as soon as reasonably practicable on the same form and signed by an approved signatory. You must notify ARIA of any change of signatory for approval, as soon as known.

- 4.3 You will be the sole recipient of the Grant and you will be responsible for managing the Grant as between you and any Third Parties involved in performing the Project Activities. This includes securing the repayment of the Grant if requested by ARIA in accordance with the Grant Conditions, including where the Grant has already been distributed to Third Parties.
- 4.4 You must promptly notify ARIA if any money is incorrectly paid to you for any reason, and must repay it as soon as reasonably practicable. Any amount not immediately repaid will be recoverable as a civil debt.
- 4.5 ARIA reserves the right not to pay any Grant Claims that are not submitted within the period set out in the Grant Funding Letter or that are incomplete, incorrect or not accompanied by full supporting documentation (including any documentation that ARIA reasonably requests).
- 4.6 You may not apply for or obtain Duplicate Funding for any Project Activities.
- 4.7 You may not retain any Unspent Monies and must repay them to ARIA within 30 days after ARIA's request for repayment.
- 4.8 You acknowledge the critical importance of cash flow for Sub-Contractors (including startups and small businesses) and commit to paying all valid and undisputed invoices relating to the Project within a maximum of 30 days from the date of receipt.
- 4.9 Where required, you will work with Sub-Contractors to arrange more frequent payment schedules (e.g., same day, weekly or milestone-based payments) to better support their cash flow needs.

5. ELIGIBLE AND INELIGIBLE EXPENDITURE

- 5.1 ARIA will only pay the Grant for Eligible Expenditure incurred by you in carrying out the Project Activities. You must provide ARIA with any evidence reasonably requested by ARIA (including receipts, invoices and other documentary evidence) that all Grant Claims relate to costs that are Eligible Expenditure.
- 5.2 You may not in any circumstance claim as Eligible Expenditure paid-for lobbying, which means using the Grant to fund lobbying (via an external firm or in-house staff) in order to undertake activities intended to influence or attempt to influence Parliament, government or political activity; or attempting to influence legislative or regulatory action.

6. GRANT REVIEW

- 6.1 ARIA will review the Grant at the intervals specified in the Grant Funding Letter. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.3.

- 6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:
- (a) consent to the Project Activities and the Grant Agreement continuing in line with existing plans;
 - (b) increase or decrease the Grant for the remainder of the Funding Period, as applicable;
 - (c) redefine the Milestones;
 - (d) require you to carry out remedial activity with the aim of improving delivery of the Project Activities; and/or
 - (e) terminate the Grant Agreement in accordance with clause 22.
- 6.3 Any change to these Grant Terms, the Project Activities, or the Grant pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

7. MONITORING AND REPORTING

- 7.1 You must closely monitor the carrying out of the Project Activities throughout the Funding Period and must notify ARIA as soon as reasonably practicable of any actual or potential failure to comply with any of your obligations under the Grant Agreement.
- 7.2 ARIA does not limit its engagement with you to purely administrative activities and will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project Activities. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.
- 7.3 You must provide ARIA with:
- (a) the Milestones and a report on your performance against the Milestones at the intervals and for the periods of time specified in the Grant Funding Letter. ARIA may copy and adapt the contents of any of the Milestones and those reports for ARIA's internal use to review, develop and shape ARIA's funded research programmes, but ARIA will treat those contents as your Confidential Information under clause 11;
 - (b) any assistance and information reasonably requested by ARIA to establish whether you have used the Grant in accordance with the Grant Agreement; and
 - (c) a quarterly report on the use of the Maximum Sum, details broken down in accordance with ARIA's prescribed form.
- 7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its funding activities and compliance with the terms of the Grant Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time after the end of the Funding Period

about the impact metrics, commercial exploitation or other dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Grant Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Grant Agreement.

8. AUDITING AND ASSURANCE

- 8.1 At the end of the Funding Period you must provide ARIA with independent assurance that the Grant has been used for carrying out the Project Activities. To satisfy this requirement you must provide a statement showing that the use of the Grant has been certified by an independent and appropriately qualified auditor or accountant.
- 8.2 Subject to clause 11, ARIA and/or its authorised representative may, at any time during the Funding Period and for up to 7 years after the end of the Funding Period, conduct audits in relation to your use of the Grant and your compliance with the Grant Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.
- 8.3 You must:
- (a) maintain an appropriate system of financial management and controls, maintain detailed records in relation to those controls, and provide copies of those records to ARIA on request; and
 - (b) retain, and procure that your Sub-Contractors retain and will provide to you on request, all relevant documentation relating to the Eligible Expenditure (including invoices, receipts and accounting records) during the Funding Period and for a period of 7 years thereafter.

9. FINANCIAL MANAGEMENT

- 9.1 You must:
- (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Grant; and
 - (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project Activities as soon as they are identified, and keep ARIA informed of your remedial actions.
- 9.2 In the event of any actual or suspected fraud, theft or other financial irregularity (which includes use of the Grant for any purpose other than that envisaged by the Grant Agreement), ARIA may, at its absolute discretion:
- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
 - (b) suspend the Project Activities and future payment of the Grant to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

- 10.1 You must inform ARIA promptly of any actual, perceived or potential conflicts between your and your Representatives' obligations under the Grant Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Funding Period.
- 10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that these conflicts are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you or your Representative to cease the conflicting activity and if that is not acceptable to you or your Representative, either party may terminate the Grant Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

- 11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the provision of the Project Activities, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.
- 11.2 ARIA may publish a summary of the Grant Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Grant Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.
- 11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:
- (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;
 - (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information necessary for the purpose concerned and obtains appropriate confidentiality undertakings in relation to such information;
 - (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and where no exception to disclosure under them is applicable; or

- (d) where that party (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.

11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under the Grant Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

12.1 Each party must comply with its obligations under the Law, including where applicable the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.

12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.

12.3 You acknowledge that ARIA, acting in accordance with the Information Acts (other than the FOIA), may disclose information concerning you and the Grant Agreement without consulting you. ARIA must take reasonable steps to notify you of any request for information to the extent permissible and reasonably practical and will give you adequate opportunity to make representations before ARIA discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.

12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or the Grant Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.

12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.

12.6 You must take account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.

- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with the Grant Agreement. If either party anticipates that the other will process any Personal Data on its behalf under the Grant Agreement it must notify the other party and the parties must agree a variation to the Grant Agreement under clause 26 to incorporate appropriate provisions (such as those set out in Schedule 4) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. SUBSIDY CONTROL AND STATE AID

- 14.1 ARIA intends that the Grant complies with the Subsidy Control Act 2022 on the basis that the Project Activities are not economic activities and do not give a specific advantage to one or more enterprises. You must take all reasonable steps to maintain this position and to assist ARIA to comply with the requirements of the Act and must cooperate with any investigations under the Act.
- 14.2 Where the EU state aid laws apply to the Grant (where the Project Activities will affect trade between Northern Ireland and the EU), you acknowledge that the Project Activities are designed and performed so they are compatible with state aid laws. You will take all reasonable steps to assist ARIA to comply with state aid law requirements and cooperate with any investigations by the European Commission into the Project Activities.
- 14.3 ARIA will immediately stop future payments of the Grant and may require repayment of some or all of the Grant if subsidy control or state aid laws so require for the funding to be compliant.

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and not seek to avoid their application by artificial means.

Background IP

- 15.2 The Grant Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Funding Period if any additional Background IP is required either to carry out the Project Activities or to exploit commercially any of the Results.

Foreground IP ownership

- 15.3 You will own all Foreground IP unless your policy is for individual researchers to own the Foreground IP they create, or you agree your Sub-Contractor (or another third party) will own all, or parts of, the Foreground IP. Where your Sub-Contractor or individual researchers (or any other third party involved in the performance of the Project Activities) will own any of the Foreground IP you must impose on them the obligations relating to Foreground IP and Results contained in clauses 15 and 16. Where you assign any Foreground IP to a Third Party (including your technology transfer company) you must impose on that Third Party the obligations relating to Foreground IP and Results contained in clauses 15 and 16.
- 15.4 You must submit all (i) all patents within or covering the Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the Future Proofing our Climate and

Weather Intellectual Property Pledge promptly following creation or filing (as applicable) of such patents and/or data (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge. You hereby agree to comply and uphold the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.5 You must ensure that whenever any Results are used with or communicated to Third Parties or are exploited commercially, ARIA's funding of the Project Activities is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and publication

- 15.6 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.7 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.8 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to fund future prosecution and maintenance and/or request the assignment of the patents to ARIA or its nominee.

Inventor first preference

- 15.9 Subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge if any inventor or active participant in the Project Activities expresses interest in the exploitation of the Foreground IP they have developed, you must give them an opportunity to negotiate an assignment or commercial licence of the Foreground IP, on reasonable terms, prior to negotiating with any entity in which an inventor or active participant in the Project Activities is not involved as a shareholder or other key stakeholder.

16. COMMERCIALISATION OF RESULTS

- 16.1 Save for Results that are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge, where they are capable of commercial exploitation you should seek to exploit the Results commercially. This should be done, where applicable, in accordance with the Commercialisation Hypothesis.
- 16.2 Save for Results that are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge, if for any reason you choose not to exploit any such Results commercially

within a reasonable timeframe (or, where applicable, the timeframe set out in the Commercialisation Hypothesis) you are encouraged to discuss the position with ARIA, and you may request that ARIA exploit them or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Non-UK Commercialisation

- 16.3 Save as set out in the Future Proofing our Climate and Weather Intellectual Property Pledge, to avoid any restriction on commercialisation, no consent is required from ARIA for any Non-UK commercialisation or any sale of Foreground IP to a Non-UK Entity. However, ARIA is set up to create value for the UK and therefore you must secure a fee payable to ARIA (**ARIA Non-UK Fee**) in each of the following circumstances:
- (a) where you are a Non-UK Entity;
 - (b) where you become a Non-UK Entity;
 - (c) where you assign or Commercially License any Foreground IP to a Non-UK Entity; or
 - (d) where you have assigned or Commercially Licensed any Foreground IP to a UK Entity that subsequently becomes a Non-UK Entity.
- 16.4 In order to avoid any unnecessary complexity, the ARIA Non-UK Fee will be based on the terms that you agree with any person to which you assign or Commercially License the relevant Foreground IP. This ARIA Non-UK Fee will amount to an additional twenty-five per cent (25%) of the value of the consideration (including upfronts, licence fees, milestone payments, royalties, shares or other securities, buyouts, exit fees and other consideration) that you receive from the exploitation of the relevant Foreground IP during any period that the above circumstances exist.
- 16.5 For example, if you would receive £100 (via royalty or royalty buyout), you must ensure your contractual mechanism enables you to collect an additional £25 and pay that additional amount to ARIA.
- 16.6 The ARIA Non-UK Fee is payable within 90 days after the end of each relevant Financial Year for receipts related to that calendar year. You are encouraged to use the clauses in Annex 1 in your Commercialisation Licences of Foreground IP.

Crown Body customers

- 16.7 You must ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities, and in suitable quantities for the Crown Body's requirements.

Spin-outs

- 16.8 ARIA seeks to maximise future investment of entrepreneurial talent and capital in start-up companies commercialising the Results of its funded activities. To that end, having funded the full economic cost of the research, ARIA places restrictions on the level of equity stakes and royalties that you may negotiate in exchange for the assignment or Commercialisation Licence of any Foreground IP.

- 16.9 If you or your technology transfer company assign or licence any Foreground IP to any third party or to a start-up established for the purpose of commercially exploiting the Results (a NewCo) you together with any connected person (including any investment fund to which you may transfer any part of your stake) shall be entitled to:

EITHER

- (a) hold or have the right to hold no more than 10% in fully-dilutable shares or equity (pre investment) in the third party or NewCo (with no other preferential subscription rights), not including any shares or equity subscribed for cash on arm's length terms alongside other investors;

OR

- (b) charge a royalty, with no upfront payments, annual fees, milestone payments or minimum royalties, payable by the third party or NewCo under any licence or assignment of the Foreground IP at no more than the relevant rate, and on the other terms, set out in Schedule 3.

- 16.10 The provisions of clauses 16.9(a) and 16.9(b) shall not apply to any equity taken or royalty charged in consideration of:

- (a) IP other than Foreground IP licensed or assigned to the third party or NewCo; or
(b) facilities, equipment, personnel or other material support or services provided to the third party or NewCo independent of the Project Activities,
with such equity or royalty limited to the proportion that reflects the contribution made by IP that is not Foreground IP.

- 16.11 You must notify ARIA in writing before any transaction completes of the overall equity stake or royalty percentages agreed under clause 16.8 (and any impact of clause 16.9, if relevant).

17. ASSETS

- 17.1 You must keep a register during the Funding Period and for up to 7 years after the end of the Funding Period of all Assets, with all relevant details about each Asset. You must use any Assets purchased with Grant monies for the Project Activities.
- 17.2 At the end of the Funding Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

- 18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Grant Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUBCONTRACTING

- 19.1 You may not transfer, assign, novate or otherwise dispose of the whole or any part of the Grant Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.
- 19.2 You shall not subcontract any of the Project Activities to a Third Party except to the extent permitted, and to the person or persons identified, in Schedule 2 Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractor as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Grant Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Grant Agreement.

20. BORROWING, LOSSES, GIFTS, SPECIAL PAYMENTS

- 20.1 You must obtain ARIA's prior written consent before:
- (a) borrowing or lending money from any source in connection with the Grant Agreement;
 - (b) giving any guarantee, indemnity, security over any Asset or letter of comfort in relation to the Grant Agreement;
 - (c) making any gift or writing off any debt or liability in connection with the Grant, and must keep a record of all gifts given and received in connection with the Grant.

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Grant and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Grant or publicise details of the Grant Agreement without the other's consent, except as required by Law.
- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

- 22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events occur:
- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13, 15.5 or 25, or commit a material breach of any other term of the Grant Agreement in the reasonable opinion of ARIA;
 - (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
 - (c) you fail to improve the performance of the Project Activities, notwithstanding your having undertaken the remedial activity agreed with ARIA in the remedial plan under clause 6.2(d);

- (d) you or the researchers involved in the Project Activities obtain any funding from a Third Party that, in the opinion of ARIA, undertakes activities that are likely to bring the reputation of the Project Activities or ARIA into disrepute;
- (e) you provide ARIA with any materially misleading or inaccurate information in your grant application or in subsequent related correspondence;
- (f) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Third Party, immediately upon becoming aware of it;
- (g) you are subject to an Insolvency Event;
- (h) the Grant or any part of it is held by a court or competent authority to be a prohibited subsidy under the Subsidy Control Act 2022 or an illegal state aid;
- (i) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project Activities;
 - (ii) result in your being unable to receive the Grant; and/or
 - (iii) raises national security concerns.

Rights reserved for ARIA in relation to an Event of Default

22.2 If an Event of Default has or may have occurred, ARIA may by written notice to you take any one or more of the following actions:

- (a) suspend the Project Activities and payment of the whole or any part of the Grant for such period as ARIA may determine, acting reasonably;
- (b) reduce the Maximum Sum, in which case the payment of Grant will thereafter be made in accordance with the reduction and notified to you; and/or
- (c) subject to clause 22.4, terminate the Grant Agreement with immediate effect as from the date of service of the notice of that termination.

22.3 Where this Grant Agreement is terminated for an Event of Default described in clause 22.1(f) or 22.1(h), ARIA may require you to repay the entire amount of the Grant previously paid to you.

Opportunity for you to remedy an Event of Default

22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:

- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and
- (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

22.5 Without prejudice to any other provision of the Grant Agreement, you may terminate the Grant Agreement on written notice to ARIA if ARIA commits a material breach of the Grant Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

General Termination Rights

- 22.6 Notwithstanding ARIA's right to terminate the Grant Agreement under clause 22.2(c), either party may terminate the Grant Agreement (in whole or in part) at any time by giving at least 60 days' prior written notice to the other party.
- 22.7 You must promptly notify ARIA in writing if at any time the principal investigator or any key researcher(s) named in Schedule 2 working on the Project Activities is unable or unwilling to continue to be involved in the Project Activities or is moving to a new organisation without the desire to continue the research. Within 60 days after the date of that notice, you must either:
- (a) nominate one or more successors, subject to ARIA's approval; or
 - (b) agree that the Grant is transferred to another organisation subject to your and the new organisation's agreement in writing and ARIA's approval of the transfer

If ARIA is unwilling to accept the nominated successor(s) or does not approve a request for transfer, it may terminate the Grant Agreement by at least 30 days' written notice to you.

Consequences of Termination

- 22.8 If the Grant Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.
- 22.9 Where ARIA terminates the Grant Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:
- (a) you taking all reasonable steps to mitigate such loss; and
 - (b) the Unavoidable Costs being:
 - (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Grant Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA;
 - (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you;
 - (v) costs that would not have been incurred had this Grant Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period).
- 22.10 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Services, over £250,000 will terminate automatically and immediately upon termination of this Agreement.

- 22.11 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Grant Agreement in the event that the Grant Agreement was terminated (calculated on the basis described in clause 22.8).
- 22.12 ARIA's total liability under clause 22.9 shall be limited to the Maximum Sum under the Grant Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.13 If the Grant Agreement is terminated or expires ARIA will not be liable to pay any of your costs or those of any of your contractors or suppliers related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Grant Funding Letter and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Grant Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Grant Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the Grant Manager and the Project Representative.
- 23.3 If the dispute cannot be resolved between the Grant Manager and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to a formal meeting between the parties' Escalation Contacts.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:
- (a) fraudulent misrepresentation or any other fraudulent act or omission;
 - (b) payment of sums properly due and owing to the other in the normal course of performance of this Grant Agreement;
 - (c) a breach of clause 13;
 - (d) liability arising under any indemnity in this Grant Agreement; or
 - (e) liability which may not lawfully be excluded or limited.
- 24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Grant Agreement or for ARIA's breach of this Grant Agreement), whether arising directly or indirectly, that may arise in connection with:
- (a) your carrying out the Project Activities;
 - (b) the use of the Grant by any person;
 - (c) any reduction, suspension, withdrawal or request for repayment of the Grant in accordance with this Grant Agreement; or

(d) termination of the Grant Agreement in accordance with this Grant Agreement.

24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:

- (a) loss of profit, sales or turnover;
- (b) loss of contracts or business opportunities;
- (c) loss of anticipated savings;
- (d) loss of goodwill or damage to reputation; or
- (e) any indirect, special or consequential loss or damage;

in each case arising out of or relating to the Grant Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.

24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to the Grant Agreement or its subject matter or anything which it has done or not done in connection with the Grant Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the amount of the Maximum Sum.

24.5 You shall under no circumstances in connection with this Grant Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.

24.6 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Grant Agreement.

25. RESEARCH ETHICS AND CODE OF CONDUCT

25.1 As a recipient of a Government grant you must operate in accordance with the Concordat.

25.2 All research data:

- (a) must be generated using sound scientific techniques and processes;
- (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and
- (c) must be analysed appropriately, without bias and in accordance with good scientific practices.

25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.

25.4 You must comply with the Code of Conduct and ensure that your Representatives undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

- 26.1 Any variation to the Grant Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

27. GENERAL

- 27.1 Notices: All notices and other communications in relation to this Grant Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such communications will be deemed to have been given and received on the third Working Day following such mailing.
- 27.2 Change of control: You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(i) is likely to apply.

28. GOVERNING LAW

- 28.1 This Grant Agreement (including any non-contractual disputes or claims arising in connection with this Grant Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. NOT USED

30. DEFINITIONS AND INTERPRETATION

- 30.1 Where they appear in these Conditions or the Grant Agreement:
- Adequate Insurance** means the insurance requirements and amounts set out in the Grant Funding Letter.
- Asset** means any asset that is purchased, improved or developed using the Grant including equipment and fixed assets;
- Background IP** means IP that is:
- (a) owned by or licensed to a party prior to the Commencement Date; or
 - (b) developed by or on behalf of a party during the Funding Period but not in connection with the Project Activities,
- and is in either case used in connection with the Project Activities;
- Bribery Act** means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;
- Change of Control** means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Recipients of Government General Grants published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754555/2018-11-06_Code_of_Conduct_for_Grant_Recipients.pdf

including any subsequent updates from time to time;

Commencement Date means the date set out in the Grant Funding Letter;

Commercialisation Licence means a licence of IP other than a research or evaluation licence and/or subcontract manufacture (and **Commercially License** means to license under a Commercialisation Licence);

Commercialisation Hypothesis means the exploitation plan approved by ARIA and set out at Schedule 2 Part 2, as may be amended by agreement between the parties during and after the Funding Period;

Completion Date means the date set out in the Grant Funding Letter;

Concordat means the Concordat to Support Research Integrity which can be found at <https://ukrio.org/about-us/the-concordat-to-support-research-integrity/>

Conditions means these ARIA Grant Conditions;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Grant Agreement, that ought reasonably to be considered to be confidential (whether or not it is so marked), (a) including: (i) information relating to the business, affairs, customers, clients, suppliers or plans of the disclosing party; (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party; (iii) any information developed by the parties in the course of carrying out the Project Activities; (iv) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Grant Agreement; and (v) and any information derived from any of the above,

(b) but not including information which: (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11); (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party; (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or (iv) is independently developed without access to the Confidential Information; and (v) the content of this specific version of the Grant Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

Duplicate Funding means funding provided to you by a Third Party which is to fund the same activities as the Project Activities;

EA means the Equality Act 2000 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Eligible Expenditure means the payments made by you during the Funding Period for the purposes of carrying out the Project Activities which comply with clause 5 and ARIA's published eligibility rules (which provide for full economic cost reimbursement) and as agreed in the Grant Funding Letter;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Grant Funding Letter;

Event of Default means any of the events or circumstances set out in clause 22.1;

Financial Year means 1 April to 31 March;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means any IP in the Results;

Funding Period means the period commencing on the Commencement Date and ending on the Completion Date or such later date as may be agreed between the parties unless otherwise determined in accordance with the terms of the Grant Agreement;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification (operated by ARIA or by a third party), in the form set out at Annex A;

GDPR means Regulation (EU) 2016/679;

Grant means the sum or sums ARIA will pay to you up to the amount set out in the Grant Funding Letter, in accordance with clause 4 and subject to the provisions set out at clause 22.

Grant Agreement has the meaning given in the Grant Funding Letter;

Grant Claim means a request submitted by you to ARIA for payment of the Grant;

Grant Funding Letter means the letter from ARIA to you to which these Conditions are annexed;

Grant Manager means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Grant;

Grant Review means the process for reviewing the grant outlined in clause 6;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Ineligible Expenditure means expenditure incurred by you which is not Eligible Expenditure as set out in clause 5 and ARIA's published eligibility rules;

Information Acts means the Data Protection Legislation, FOIA and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property Rights or **IP** means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions, semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation;

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise;

Maximum Sum means the maximum amount of the Grant stated in the Grant Funding Letter;

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

NewCo has the meaning given in clause 16;

Non-UK Entity means a legal entity that is not a UK Entity;

Personal Data has the meaning given to it in the Data Protection Legislation as amended from time to time;

Prohibited Act means:

(a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Grant Agreement; and/or (ii) showing or not showing favour or disfavour to any person in relation to the Grant Agreement;

(b) committing any offence: (i) under the Bribery Act; (ii) under legislation creating offences in respect of fraudulent acts; and/or (iii) at common law in respect of fraudulent acts in relation to the Grant Agreement; and/or

(c) defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the activities to be carried out by you that are described in the Grant Funding Letter and in Schedule 2 Part 1;

Project Representative means the representative appointed by you, who at the Commencement Date will be the individual listed as such in the Grant Funding Letter;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means all information, data, techniques, inventions, discoveries, works, software and materials generated in the course of the Project Activities;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Project Activities or any part thereof or facilities or services necessary for the performance of the Project Activities or any part thereof or necessary for the management, direction or control of the Project Activities or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

UK Entity means a legal entity whose ultimate parent company has its headquarters and principal establishment in the United Kingdom;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Grant Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Funding Period because of termination or breach of the Grant Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination; and

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 In these Conditions and the Grant Agreement, unless the context otherwise requires:

- (a) references to "party" and "parties" are to the parties to the Grant Agreement;
- (b) the singular includes the plural and vice versa;
- (c) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (d) references to clauses and Schedules are to the clauses of these Conditions and to the Schedules to the Grant Agreement;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation"; and
- (g) the headings in the Grant Agreement are for ease of reference only and will not affect the interpretation or construction of the Grant Agreement.

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

Solar geoengineering (SG) is a disruptive, international technology that raises many technical and social questions. Our international team is a UK - Latin America and the Caribbean (LAC) network of social scientists, anthropologists, and climatologists. You will build on our previous experience working on the ethics and governance of SG to provide a conceptual foundation (via “conceptual engineering”) of ethical concepts leading to the implementation of a governance framework for SG research. Importantly, our approach presupposes a neutral relational model for identification of climate interventions, making it applicable to both single SG interventions (e.g. stratospheric aerosol injection (SAI), marine cloud brightening (MCB), and cirrus management (CM)), or combined SG interventions (e.g. SAI+MCB, SAI+CM). You believe that this relational model of climate interventions, present in the literature of both climate models and social sciences, is necessary to provide a bridge between different approaches.

2. Aims and objectives of the Project Activities

There are two overarching and complementary long-term aims of the project related to content (workflow objectives) and capacity building (mentoring via senior researchers of research leads, postdoc researchers & PhD students in ethics and governance of SG research; expanding the UK—LAC network). Both priorities are central to the project’s three pillars (PROCESSES, PAPERS, PEOPLE, see 3.1).

2.1. General aims. The project has three interrelated general aims:

- (i) Contribute to ARIA’s mission of enhancing responsible governance of research of SG and other climate interventions for the common good (Rayner et al 2013, ARIA 2024b);
- (ii) build a research network across Argentina and further afield in Latin America and the Caribbean (LAC), alongside collaborators in the UK;
- (iii) protect global society from possible destabilisation and negative social tipping points associated with irresponsible use of SG (Spaiser et al 2024). Here, you understand responsibility from a common good, interspecies, and intergenerational justice perspective (London 2022, COMEST 2023).

2.2 Specific objectives. There are three specific objectives:

- (i) Content: provide an enhanced theoretical framework for proper governance of SG research that serves ARIA projects,
- (ii) Capacity building: build global south research capacity around SG by hiring new researchers, research assistants (PhD and/or postdoc), and advisors tailored to the novel work packages (WP) & research questions,

(iii) Processes: build inclusive, participatory ethics & governance institutions for SG research for LAC that emphasise centralised public engagement.

2.3 Methodological approach

2.3.1. Conceptual engineering for ethics & governance analysis

One of the unique features of our project is including conceptual (re)engineering as a key element of an ethics & governance framework for SG research. Our conceptual engineering approach involves the development or revision (reengineering) of basic concepts (e.g. geoengineering, intervention, research, deployment, etc.) and assumed models (e.g. single intervention models, multiple or combined interventions models) at the heart of the most developed ethics and governance frameworks of SG research to carve out relevant distinctions between SG projects according to their practical aims to enhance precision and reduce confusion. This aims-based definition has the following three properties:

- 1) It distinguishes between SG research and deployment as two distinct yet connected activities
- 2) It applies to climate interventions with an insufficient level of evidence for regular use
- 3) It is neutral to scale (e.g. small or large, weather or climate), mechanisms of action (e.g. reflectivity, emissivity, solar-constant), outcome (e.g. successful or unsuccessful), and ethical status (e.g. responsible or irresponsible research).

2.3.2. Responsible participatory governance of solar geoengineering

Public engagement is crucial to ensure transparency in decision making and to support democratic governance. Improving participation and engagement should be treated as a standard operating procedure for research and potential deployment on emergent, complex and uncertain technologies such as SG. Discussions concerning the risks, benefits, and governance challenges of SG are growing, and governments need to be prepared for inclusive, transparent, and participatory dialogues.

There is a growing interest in SG in the LAC region, and countries will need to build capacities to make informed decisions and foster collaboration to nurture multilateral science-policy processes. In the LAC region, SG is not yet a priority in the climate change portfolio of mitigation and adaptation strategies nor a topic in the radar of LAC governments, but as discussions are growing and unexpected events are occurring, governments will need to be part of the global conversations, and to establish regulatory processes and governance structures that emphasise, among other concerns, the following three characteristics:

- 1) Multi-stakeholder public engagement
- 2) Upstream assessment of scientific merit
- 3) Legal compliance and transparency

3. Project Activities

Product	Activities	Aim	Pillars

WP1 Daly	Clarifying concepts. What does the claim “SG is a socio-technical intervention ensemble” mean?	Explain the meaning of SG as a transformable “socio-technical intervention” to understand small-scale perturbation field or outdoor trials as part of the larger research pathway of SG interventions.	Papers & People
WP2 [REDACTED]	Debating reasonableness. What is a reasonable disagreement on SG research?	Map a multi-agent continuum of rejection-hesitancy-acceptance of SG research based on analogies from bioethics research.	Papers & People
WP3 [REDACTED]	Justifying ethical status. Is SG research forbidden, permissible and/or mandatory?	Dealing with the research question of justification of SG small scale outdoor research.	Papers & People
WP4 Carabajal	Implementing regional governance. What is an appropriate model of ethics and governance of SG in LAC?	Learn from the Mexican government’s intention to ban experimentation on SG following the Make Sunsets small-scale experimental deployment and put forward a participatory governance model.	Papers & Processes
WP5 Mastroleo	Mentoring. How should advanced SG researchers be educated?	Educating and training the next generation of UK-LAC advanced SG researchers, pre and postdoctoral, at the intersection of physical & human sciences.	People

3.1 The following Milestones will be used to monitor your delivery of the Project. The costs associated with completing these Milestones are estimated in the cost breakdown sheet [REDACTED]

3.2 In addition to the below Milestones, the following project plan will be used to track progress throughout the project and may be updated from time to time: [REDACTED]

ID	Milestones	Measure	Date
1	Predocctoral and postdoctoral researchers kick-off (Capacity Building). PEOPLE pillar	6 PhD students/postdoc researchers recruited and thesis topics defined, evidenced by production of 3 page research plans for each student	Commencement Date + 6 months
2	Work in progress (WIP) versions of	WP4. Make Sunsets paper + Open Access database. A submitted manuscript on media analysis of the	Commencement Date + 9 months

	papers and translations. PAPERS pillar	Make Sunsets case in Mexico plus open access database of the media (~100 entries) both in Spanish and English (metric : submitted paper + database). ¹	
3	Submission of foundational paper. PAPERS pillar	WPs 1—2. Intervention ensemble & relational model paper submitted (a paper on the formalization of “socio-technical intervention ensemble” in SG research).	Commencement Date + 15 months
4	Submission of disagreement paper. PAPERS pillar	WPs 2—3. Disagreement paper . A narrative review on disagreements of SG research, including an analysis of informal arguments in favour and against SG research (metric : submitted paper).	Commencement Date + 18 months
5	End-of-project roundtable & report on ethics & governance of SG research in LAC. PROCESSES pillar	5.1. An organised roundtable between different stakeholders (ARIA team, advisors, society) to establish potential future institutional or other requirements for SG research in LAC (e.g. SG Research Ethics Committee(s)). 5.2. Final report on ethics & governance of SG research in LAC.	Commencement Date + 24 months

¹ In January 2025 we submitted the paper “No governance is governance: Mapping solar geoengineering discussions in Latin American & the Caribbean” to the Special issue on Climate Intervention Governance, European Journal of Risk Regulation (EJRR), co-edited by Alberto Alemanno and Masahiro Sugiyama. Current status: accepted with major revision, to be resubmitted 25 April. Original submitted version is available upon request.

3.3 The intended long-term outcomes are summarised below:

The following are some moon-shot long-term outcomes that may require work and funding beyond the current project. These are useful to understand the potential of the current project's aims and objectives.

- Provide the basis for an independent research ethics committee (REC) for SG research in Latin America (at country level or intergovernmental organization, e.g. Inter-American Institute for Global Change Research (IAI)) (2030 horizon).
- Content 1. Contribution to the elaboration of LAC ethical principles for SG research similar to Oxford, Tollgate, etc.
- Content 2. Revision of the latest AGU ethical principles based on our intervention ensemble and relational model.
- Capacity building 1. Creation of a larger UK-LAC network of STEMP (science, technology engineering, mathematics & philosophy) for climate interventions research. Our project and research could work as a bridge for further talent across the STEMP spectrum, not only in the social sciences and humanities.
- Capacity building 2. Creation of a 100% online training and education program in ethics and governance of climate intervention research in LAC. It could start with an introductory course or seminar², move to a 6-month certificate of postgraduate studies or 1-year diploma, 2-year Master's program, and then a PhD programme. This trajectory closely follows our 25 years of experience with the US National Institutes of Health (NIH) Fogarty Training Program for research ethics in the Americas, but we expect the current timeline to be shorter given our previous experience. Similar trajectory and education programs could be replicated and/or coordinated in other LMIC regions (e.g. Africa, Asia, etc.) like the US NIH Fogarty has done for biomedical research ethics education and training worldwide since 2000³.

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement

² FLACSO has many such initiatives that currently exist.

³ Saenz, C., Heitman, E., Luna, F., Litewka, S., Goodman, K. W., & Macklin, R. (2014). Twelve Years of Fogarty-Funded Bioethics Training in Latin America and the Caribbean: Achievements and Challenges. *Journal of Empirical Research on Human Research Ethics : JERHRE*, 9(2), 80–91. <https://doi.org/10.1525/jer.2014.9.2.80>

Kick off	• Roles and responsibilities • External communications • Project details
Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Invoicing and cost reporting Optional: • Key Learning, discoveries and decisions • Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • technical evidence saved to drive e.g. report or presentation as requested by PD • review meeting slide deck saved to drive as requested by PD Review meeting with ARIA Programme Team
Annual	• ARIA impact metrics • Attendance at annual ARIA event
Ad hoc	• As required, Programme Director/ Programme Team may request additional information and evidence • Workshops - potential to be invited to ARIA workshops
Project closure	• Project closure report

5. Payment

5.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments quarterly in arrears.

Quarterly.

5.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

5.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the

end of the relevant period.

5.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

6. Principal investigator/key researchers

6.1 For the purposes of clause 22.7, the following principal investigators or key researchers have been identified.

Name	Role	Current Organisation, set to change depending on hosting programmes
Ignacio Mastroleo	Principal investigator (WP5)	Program of Bioethics, FLACSO Argentina-CONICET ⁴
[REDACTED]	Senior researcher (Climate science) (WP5)	University of Buenos Aires-CONICET; IPCC WG1
[REDACTED]	Senior researcher (Ethics & governance) (WP5)	Program of Bioethics, FLACSO Argentina-CONICET
[REDACTED]	Senior researcher (Logic & conceptual analysis) (WP5)	University of Buenos Aires-CONICET
Timothy Daly	Chief research officer & Research leader (WP1)	Program of Bioethics, FLACSO Argentina + UK/EU affiliation to be determined
[REDACTED]	Research fellow (WP2)	University of Tübingen
[REDACTED]	Research fellow (WP3)	University of Entre Ríos-CONICET
María Inés Carabajal	Chief research officer & Research leader (WP4)	University of Buenos Aires-CONICET
[To be determined]	Postdoc researcher 1 (WP1)	[To be determined]
[REDACTED]	Postdoc researcher 2 (WP2)	Postdoc Program, University of Buenos Aires; IIF-SADAF-CONICET ⁵

⁴ The National Scientific and Technical Research Council (Spanish: Consejo Nacional de Investigaciones Científicas y Técnicas, CONICET) is an Argentine government agency which directs and co-ordinates most of the scientific and technical research done in universities (e.g. FLACSO Argentina, University of Buenos Aires) and institutes in Argentina. In 2025, CONICET was ranked as the best Latin American government research institution by the Scimago Institutions Ranking. At the global level & all sectors ((including universities, governmental and private research institutions, research councils, etc.), CONICET holds the 125st position among the 9756 ranked research institutions worldwide. Scimago Lab. (2025). *Scimago Institutions Rankings*. <https://www.scimagoir.com/rankings.php?ranking=Research&sector=all> [consulted March 25, 2025]

⁵ Instituto de Investigaciones Filosóficas (IIF, Philosophical Investigations Institute), Sociedad Argentina de Análisis Filosófico (Argentine Society of Philosophical Analysis), CONICET

██████████	PhD student 1 (WP2)	PhD Program, University of Buenos Aires; IIF-SADAF-CONICET
██████████	PhD student 2(WP2)	PhD Program, University of Buenos Aires; IIF-SADAF-CONICET
[To be determined]	PhD student 3 (WP3)	[To be determined]
[To be determined]	Postdoc researcher 3 (WP4)	[To be determined]

7. Sub-Contractors

7.1 For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Location
Federal University of Santa Catarina, Brazil	WP4. Social science consultancy and LAC network building	Brazil
University of Edinburgh	WP3. Governance consultancy and UK network building	Edinburgh, UK
University of Buenos Aires; IIF-SADAF-CONICET	WP2 Climate Science, Logic & conceptual analysis & WP5 Mentoring PhD students & posdoc researchers	Argentina
Program of Bioethics, FLACSO Argentina-CONICET	WP1 Conceptual engineering and WP5 Mentoring PhD Students & Postdoc researchers	Argentina
University of Tübingen	WP2 Climate Science, Logic & conceptual analysis	Germany

PART 2 - GRANT APPLICATION

Application titled "Ethics and governance of solar geoengineering research: from concepts to implementation" submitted 9 December 2024.

SCHEDULE 3

Royalty Percentages

Royalties on the sale or supply of products or services that are covered by, use or incorporate the Foreground IP licensed to the NewCo will only become due on aggregate net sales derived from the Foreground IP exceeding £50 million.

The maximum headline percentage royalty rate (i.e. before any royalty stacking, step-down or other reduction and excluding any ARIA Non-UK Fee) for products or services that are covered by, use or incorporate the Foreground IP, and of sublicensing income, shall be one of the following:

Type of product	Applicable headline royalty percentage (up to)
Low margin	0.5% of net sales
Medium margin	1% of net sales
High margin	2% of net sales
Sublicensing royalty	10% of net receipts

ANNEX 1

Clause for inclusion in licences of Foreground IP

[] **ARIA NON-UK FEE**

[].1 In this clause:

“ARIA” means the Advanced Research and Invention Agency;

“Crown Body” means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

“UK Entity” means a legal entity that has or whose ultimate parent company has its headquarters and principal establishment in the United Kingdom.

[].2 The Foreground IP was developed with funding from ARIA. As a condition of its funding ARIA requires that a benefit is returned to the United Kingdom where the Foreground IP is licensed by the Licensor to any person that is not a UK Entity. Accordingly, in addition to any other sums payable by the Licensee to the Licensor under this Agreement, the Licensee shall pay to the Licensor within 90 days after the end of each calendar year during the Relevant Period (as defined below), and within 90 days after the end of the Relevant Period, a fee (**ARIA Non-UK Fee**) on all amounts (including upfronts, licence fees, milestone payments, royalties, shares or other securities, exit fees, buyout or other consideration) payable by the Licensee to the Licensor under this Agreement in relation to the exploitation of any Foreground IP (**Relevant Amount**) that accrues during, or relates to, any period of time that the Licensee is not a UK Entity (**Relevant Period**). The amount of the ARIA Non-UK Fee is 25% of the Relevant Amount, and is payable by the Licensee to the Licensor in addition to the amounts that would otherwise be payable under this Agreement. For example if the Relevant Amount is £100 the ARIA Non-UK Fee is an additional £25, which the Licensee shall pay to the Licensor and the Licensor shall remit to ARIA.

Crown Body customers

[].3 You must also ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities and in suitable quantities for the Crown Body's requirements.

[].4 ARIA shall have the right to enforce this clause [] under the Contracts (Rights of Third Parties) Act 1999. Neither party may amend this Agreement in a way that detracts from ARIA's right to enforce its rights under this clause without ARIA's prior written consent.

[1] When using this clause you may substitute the relevant defined terms used elsewhere in the agreement to capture the concept of "Foreground IP". Where the clause refers to the "Licensor" and "Licensee" please use the appropriate defined terms to include the licensor, licensee, assignor and assignee of the Foreground IP. This clause is not suitable for assignments of the Foreground IP in consideration of the payment of one or more lump sum payments. In those cases the Licensor needs to be informed, and potentially make an additional payment, if the Foreground IP is subsequently assigned to a non-UK Entity or if the Assignee ceases to be a UK Entity.

SCHEDULE 4: Data Protection

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Grant Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Grant Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Grant Agreement:
- 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are

relying on Domestic Law as the basis for processing Personal Data, you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;

- 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);
- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Grant Agreement unless required by Domestic Law to store the Personal Data; and

3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.

3.4. [[ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):

3.4.1. cancel its plans to change the affected sub-Processor;

3.4.2. offer an alternative which is acceptable to ARIA; or

3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.

3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Grant Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.

3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]

3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Grant agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it, storing it, retrieving it, consulting it, disseminating it or destroying it, etc.

	Note the definition of processing in the UK GDPR: <i>"any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction"</i>]
Duration of Processing:	Duration of this Grant Agreement (and any post termination processing that is permitted / required).
Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called "special categories" of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: <i>"data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person's sex life or sexual orientation"</i>]
Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors,

	clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. You shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.
- 4.2. Any limitation of liability set out in this Grant Agreement will not apply to this Schedule's indemnity or reimbursement obligations.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

- 1.** Submission of Pledged Patents and Experimental Data
 - 1.1** The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
 - 1.2** The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.
- 2.** Experimental Data Licence
 - 2.1** Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
 - 2.2** The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
 - 2.3** The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
 - 2.4** The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).
- 3.** Research Licence
 - 3.1** Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
 - 3.2** The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
 - 3.3** Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.

3.5 The Research Licensee must:

- (a) at all times when using the Pledged Patents comply with all Laws; and
- (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).

4. Commercial Licence

4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.

4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.

4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.

5. Pledgor Know-How

At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.

6. Termination

6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:

- (a) materially breaches the terms of such licence or this Pledge; or
- (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).

7. Transfers of Pledged Patents and/or Experimental Data

The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.

8. No Warranty

The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and
Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

COMSATS University Islamabad (**Grant Recipient**)
Park Road, Tarlai Kalan
Islamabad 45550
Pakistan

27 June 2025

Attention: Prof. Dr. Athar Hussain

Dear Dr. Athar,

FPCW-PR01-P010 - Evidence-based Assessments to Guide Perceptions, Governance, and Ethical Frameworks for South Asia: Comparing Marine Cloud Brightening Deployment Strategies vis-à-vis Carbon Dioxide Removal and Mitigation Efforts – Standard Grant Funding Letter

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to Exploring Climate Cooling and ARIA is pleased to offer you a Grant for the performance of the Project Activities up to the Maximum Sum, subject to your agreement to, and compliance with, the terms and conditions set out in this Grant Funding Letter and its Schedules.

1. Overview of the Grant

Any reference in this letter to "you" or "your" means the Grant Recipient and any capitalised terms have the meanings given in the ARIA Grant Conditions (Conditions).

The key elements of the Grant are described in the table below:

Project Activities	Evidence-based Assessments to Guide Perceptions, Governance, and Ethical Frameworks for South Asia: Comparing Marine Cloud Brightening Deployment Strategies vis-à-vis Carbon Dioxide Removal and Mitigation Efforts. A more detailed description of the Project Activities is set out in Schedule 2 (Project Activities).
Maximum Sum of the Grant (inclusive of taxes)	£574,032 (inclusive of all taxes where applicable)
Commencement Date	The commencement date is 27 June 2025

Completion Date	The completion is 26 June 2028	
Grant Review Intervals	ARIA will review the Grant at quarterly intervals using the process referred to in clause 6 of the Conditions	
Adequate Insurance	Employers' liability - At least £5 million (as required by the Employers' Liability (Compulsory Insurance Act 1969)) Public liability: £5 million (per year in aggregate)	
Monitoring and Reporting	The performance reports referred to in clause 7 of the Conditions shall be provided at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Project Representative	Dr. Athar Hussain Professor [REDACTED] [REDACTED] [REDACTED] [REDACTED] [REDACTED] [REDACTED] [REDACTED]	
Grant Manager	Mark Symes, Programme Director [REDACTED]	
Escalation Contacts	ARIA	Grant Recipient
	Chief Product Officer [REDACTED]	[REDACTED] Professor of Bio Science, Head Office of Research Innovation & Commercialization (ORIC) [REDACTED] [REDACTED] [REDACTED] [REDACTED] [REDACTED] [REDACTED]

Notices	ARIA Contracts [REDACTED]	Dr. Athar Hussain Professor Department of Meteorology [REDACTED] [REDACTED] [REDACTED] [REDACTED] [REDACTED] [REDACTED]

2. Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Grant and return it to finance@aria.org.uk

3. The Grant Agreement

- 3.1. Once you sign a copy of this Grant Funding Letter in accordance with paragraph 6 (Acceptance) below, it will form a binding "**Grant Agreement**" between you and ARIA that includes and incorporates the following documents:

- 3.1.1. the **Grant Conditions** in Schedule 1;
- 3.1.2. the **Project Activities, Milestones** and **Grant Application** in Schedule 2;
- 3.1.3. the **Royalty percentages** (including annexes) in Schedule 3; and
- 3.1.4. the terms relating to Data Protection in Schedule 4.

- 3.2. The parties confirm that it is their intention to be legally bound by the Grant Agreement.

4. Warranties

- 4.1. By signing this Grant Funding Letter, you warrant and represent that:
- 4.1.1. your obligations under the Grant Agreement are legal, valid, binding and enforceable;
 - 4.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Grant Agreement have been obtained;
 - 4.1.3. the person signing the Grant Agreement is duly authorised to sign on your behalf; and
 - 4.1.4. your Project Representative referenced in the table above is authorised to make decisions and provide information on your behalf.

5. Amendments to the Grant Conditions

- 5.1. Not used.

6. Acceptance

6.1. To accept this Grant Funding Letter, please arrange for an authorised signatory to sign and date the duplicate copy of this Grant Funding Letter as indicated below, and return to ARIA as a complete signed original of the Grant Agreement including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Grant Agreement and to bind the Grant Recipient.

6.2. The offer of this Grant Funding Letter will expire on 4 July 2025.

Yours sincerely

for and on behalf of ARIA

Name of ARIA signatory:

Position Held:

Date:

I confirm the agreement of COMSATS University Islamabad to the terms and conditions in this Grant Funding Letter and its Schedules.

Signature:

Name:

Position:

Date:

SCHEDULE 1 - GRANT CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up the Grant Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Grant Funding Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to the Grant Agreement with the exception of Schedule 2 Part 2 (the Grant Application);
 - (d) Schedule 2 Part 2 (the Grant Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, the Grant Agreement.

2. DURATION AND PURPOSE OF THE GRANT

- 2.1 The Grant Agreement will subsist for the duration of the Funding Period unless extended by written agreement signed by a duly authorised representative of the parties or terminated earlier in accordance with its terms. Any provision of the Grant Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Grant Agreement shall remain in full force and effect, including clauses 1, 2, 4, 7.4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.3, 22.7, 22.8, 22.11, 22.12, 23, 24, 26, 27, 28, and 30.
- 2.2 You may only use the Grant for carrying out the Project Activities. You may not make any changes to the Project Activities without ARIA's prior written agreement.
- 2.3 You may not unreasonably withhold, condition or delay your agreement to any changes requested by ARIA to the Project Activities or the amount of the Grant. Any agreed change will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

3. ENVIRONMENTAL AND SAFETY REQUIREMENTS

- 3.1 In performing the Project Activities, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. PAYMENT OF GRANT

- 4.1 Subject to the remainder of this clause 4, ARIA will pay the Grant to you:
- (a) up to the Maximum Sum;
 - (b) in pounds sterling (GBP) by wire transfer into your bank account, details of which you provided in the Confirmation of Bank Details form attached to the Grant Funding Letter; and
 - (c) if a tax is chargeable in respect of the Grant, all payments will be deemed to be inclusive of all such taxes and ARIA will not be obliged to pay any additional amount.
- 4.2 The bank account of which you provided details in your Confirmation of Bank Details form (and any alternative bank details nominated subsequently by you) must be an ordinary business bank account

with appropriate segregation of duties and control. During the Funding Period, you must notify ARIA of any change of bank account details as soon as reasonably practicable on the same form and signed by an approved signatory. You must notify ARIA of any change of signatory for approval, as soon as known.

- 4.3 You will be the sole recipient of the Grant and you will be responsible for managing the Grant as between you and any Third Parties involved in performing the Project Activities. This includes securing the repayment of the Grant if requested by ARIA in accordance with the Grant Conditions, including where the Grant has already been distributed to Third Parties.
- 4.4 You must promptly notify ARIA if any money is incorrectly paid to you for any reason, and must repay it as soon as reasonably practicable. Any amount not immediately repaid will be recoverable as a civil debt.
- 4.5 ARIA reserves the right not to pay any Grant Claims that are not submitted within the period set out in the Grant Funding Letter or that are incomplete, incorrect or not accompanied by full supporting documentation (including any documentation that ARIA reasonably requests).
- 4.6 You may not apply for or obtain Duplicate Funding for any Project Activities.
- 4.7 You may not retain any Unspent Monies and must repay them to ARIA within 30 days after ARIA's request for repayment.
- 4.8 You acknowledge the critical importance of cash flow for Sub-Contractors (including startups and small businesses) and commit to paying all valid and undisputed invoices relating to the Project within a maximum of 30 days from the date of receipt.
- 4.9 Where required, you will work with Sub-Contractors to arrange more frequent payment schedules (e.g., same day, weekly or milestone-based payments) to better support their cash flow needs.

5. ELIGIBLE AND INELIGIBLE EXPENDITURE

- 5.1 ARIA will only pay the Grant for Eligible Expenditure incurred by you in carrying out the Project Activities. You must provide ARIA with any evidence reasonably requested by ARIA (including receipts, invoices and other documentary evidence) that all Grant Claims relate to costs that are Eligible Expenditure.
- 5.2 You may not in any circumstance claim as Eligible Expenditure paid-for lobbying, which means using the Grant to fund lobbying (via an external firm or in-house staff) in order to undertake activities intended to influence or attempt to influence Parliament, government or political activity; or attempting to influence legislative or regulatory action.

6. GRANT REVIEW

- 6.1 ARIA will review the Grant at the intervals specified in the Grant Funding Letter. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.3.

- 6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:
- (a) consent to the Project Activities and the Grant Agreement continuing in line with existing plans;
 - (b) increase or decrease the Grant for the remainder of the Funding Period, as applicable;
 - (c) redefine the Milestones;
 - (d) require you to carry out remedial activity with the aim of improving delivery of the Project Activities; and/or
 - (e) terminate the Grant Agreement in accordance with clause 22.
- 6.3 Any change to these Grant Terms, the Project Activities, or the Grant pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

7. MONITORING AND REPORTING

- 7.1 You must closely monitor the carrying out of the Project Activities throughout the Funding Period and must notify ARIA as soon as reasonably practicable of any actual or potential failure to comply with any of your obligations under the Grant Agreement.
- 7.2 ARIA does not limit its engagement with you to purely administrative activities and will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project Activities. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.
- 7.3 You must provide ARIA with:
- (a) the Milestones and a report on your performance against the Milestones at the intervals and for the periods of time specified in the Grant Funding Letter. ARIA may copy and adapt the contents of any of the Milestones and those reports for ARIA's internal use to review, develop and shape ARIA's funded research programmes, but ARIA will treat those contents as your Confidential Information under clause 11;
 - (b) any assistance and information reasonably requested by ARIA to establish whether you have used the Grant in accordance with the Grant Agreement; and
 - (c) a quarterly report on the use of the Maximum Sum, details broken down in accordance with ARIA's prescribed form.
- 7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its funding activities and compliance with the terms of the Grant Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time after the end of the Funding Period

about the impact metrics, commercial exploitation or other dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Grant Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Grant Agreement.

8. AUDITING AND ASSURANCE

- 8.1 For Grants over £500k: Annually, and on each anniversary of the Commencement Date and at the end of the Funding Period you must provide ARIA with independent assurance that the Grant has been used for carrying out the Project Activities. To satisfy this requirement you must provide a statement showing that the use of the Grant has been certified by an independent and appropriately qualified auditor or accountant.
- 8.2 Subject to clause 11, ARIA and/or its authorised representative may, at any time during the Funding Period and for up to 7 years after the end of the Funding Period, conduct audits in relation to your use of the Grant and your compliance with the Grant Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.
- 8.3 You must:
- (a) maintain an appropriate system of financial management and controls, maintain detailed records in relation to those controls, and provide copies of those records to ARIA on request; and
 - (b) retain, and procure that your Sub-Contractors retain and will provide to you on request, all relevant documentation relating to the Eligible Expenditure (including invoices, receipts and accounting records) during the Funding Period and for a period of 7 years thereafter.

9. FINANCIAL MANAGEMENT

- 9.1 You must:
- (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Grant; and
 - (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project Activities as soon as they are identified, and keep ARIA informed of your remedial actions.
- 9.2 In the event of any actual or suspected fraud, theft or other financial irregularity (which includes use of the Grant for any purpose other than that envisaged by the Grant Agreement), ARIA may, at its absolute discretion:
- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
 - (b) suspend the Project Activities and future payment of the Grant to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

- 10.1 You must inform ARIA promptly of any actual, perceived or potential conflicts between your and your Representatives' obligations under the Grant Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Funding Period.
- 10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that these conflicts are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you or your Representative to cease the conflicting activity and if that is not acceptable to you or your Representative, either party may terminate the Grant Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

- 11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the provision of the Project Activities, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.
- 11.2 ARIA may publish a summary of the Grant Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Grant Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.
- 11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:
- (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;
 - (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information necessary for the purpose concerned and obtains appropriate confidentiality undertakings in relation to such information;
 - (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and where no exception to disclosure under them is applicable; or

- (d) where that party (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.

- 11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under the Grant Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

- 12.1 Each party must comply with its obligations under the Law, including where applicable the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.
- 12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.
- 12.3 You acknowledge that ARIA, acting in accordance with the Information Acts (other than the FOIA), may disclose information concerning you and the Grant Agreement without consulting you. ARIA must take reasonable steps to notify you of any request for information to the extent permissible and reasonably practical and will give you adequate opportunity to make representations before ARIA discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.
- 12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or the Grant Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.
- 12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.
- 12.6 You must take account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

- 13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.

- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with the Grant Agreement. If either party anticipates that the other will process any Personal Data on its behalf under the Grant Agreement it must notify the other party and the parties must agree a variation to the Grant Agreement under clause 26 to incorporate appropriate provisions (such as those set out in Schedule 4) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. SUBSIDY CONTROL AND STATE AID

- 14.1 ARIA intends that the Grant complies with the Subsidy Control Act 2022 on the basis that the Project Activities are not economic activities and do not give a specific advantage to one or more enterprises. You must take all reasonable steps to maintain this position and to assist ARIA to comply with the requirements of the Act and must cooperate with any investigations under the Act.
- 14.2 Where the EU state aid laws apply to the Grant (where the Project Activities will affect trade between Northern Ireland and the EU), you acknowledge that the Project Activities are designed and performed so they are compatible with state aid laws. You will take all reasonable steps to assist ARIA to comply with state aid law requirements and cooperate with any investigations by the European Commission into the Project Activities.
- 14.3 ARIA will immediately stop future payments of the Grant and may require repayment of some or all of the Grant if subsidy control or state aid laws so require for the funding to be compliant.

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and not seek to avoid their application by artificial means.

Background IP

- 15.2 The Grant Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Funding Period if any additional Background IP is required either to carry out the Project Activities or to exploit commercially any of the Results.

Foreground IP ownership

- 15.3 You will own all Foreground IP unless your policy is for individual researchers to own the Foreground IP they create, or you agree your Sub-Contractor (or another third party) will own all, or parts of, the Foreground IP. Where your Sub-Contractor or individual researchers (or any other third party involved in the performance of the Project Activities) will own any of the Foreground IP you must impose on them the obligations relating to Foreground IP and Results contained in clauses 15 and 16. Where you assign any Foreground IP to a Third Party (including your technology transfer company) you must impose on that Third Party the obligations relating to Foreground IP and Results contained in clauses 15 and 16.
- 15.4 You must submit all (i) all patents within or covering the Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the Future Proofing our Climate and

Weather Intellectual Property Pledge promptly following creation or filing (as applicable) of such patents and/or data (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge. You hereby agree to comply and uphold the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.5 You must ensure that whenever any Results are used with or communicated to Third Parties or are exploited commercially, ARIA's funding of the Project Activities is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and publication

- 15.6 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.7 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.8 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to fund future prosecution and maintenance and/or request the assignment of the patents to ARIA or its nominee.

Inventor first preference

- 15.9 Subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge] if any inventor or active participant in the Project Activities expresses interest in the exploitation of the Foreground IP they have developed, you must give them an opportunity to negotiate an assignment or commercial licence of the Foreground IP, on reasonable terms, prior to negotiating with any entity in which an inventor or active participant in the Project Activities is not involved as a shareholder or other key stakeholder.

16. COMMERCIALISATION OF RESULTS

- 16.1 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge], where they are capable of commercial exploitation you should seek to exploit the Results commercially. This should be done, where applicable, in accordance with the Commercialisation Hypothesis.
- 16.2 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge], if for any reason you choose not to exploit any such Results commercially

within a reasonable timeframe (or, where applicable, the timeframe set out in the Commercialisation Hypothesis) you are encouraged to discuss the position with ARIA, and you may request that ARIA exploit them or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Non-UK Commercialisation

- 16.3 Save as set out in the [Future Proofing our Climate and Weather Intellectual Property Pledge], to avoid any restriction on commercialisation, no consent is required from ARIA for any Non-UK commercialisation or any sale of Foreground IP to a Non-UK Entity. However, ARIA is set up to create value for the UK and therefore you must secure a fee payable to ARIA (**ARIA Non-UK Fee**) in each of the following circumstances:
- (a) where you are a Non-UK Entity;
 - (b) where you become a Non-UK Entity;
 - (c) where you assign or Commercially License any Foreground IP to a Non-UK Entity; or
 - (d) where you have assigned or Commercially Licensed any Foreground IP to a UK Entity that subsequently becomes a Non-UK Entity.
- 16.4 In order to avoid any unnecessary complexity, the ARIA Non-UK Fee will be based on the terms that you agree with any person to which you assign or Commercially License the relevant Foreground IP. This ARIA Non-UK Fee will amount to an additional twenty-five per cent (25%) of the value of the consideration (including upfronts, licence fees, milestone payments, royalties, shares or other securities, buyouts, exit fees and other consideration) that you receive from the exploitation of the relevant Foreground IP during any period that the above circumstances exist.
- 16.5 For example, if you would receive £100 (via royalty or royalty buyout), you must ensure your contractual mechanism enables you to collect an additional £25 and pay that additional amount to ARIA.
- 16.6 The ARIA Non-UK Fee is payable within 90 days after the end of each relevant Financial Year for receipts related to that calendar year. You are encouraged to use the clauses in Annex 1 in your Commercialisation Licences of Foreground IP.

Crown Body customers

- 16.7 You must ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities, and in suitable quantities for the Crown Body's requirements.

Spin-outs

- 16.8 ARIA seeks to maximise future investment of entrepreneurial talent and capital in start-up companies commercialising the Results of its funded activities. To that end, having funded the full economic cost of the research, ARIA places restrictions on the level of equity stakes and royalties that you may negotiate in exchange for the assignment or Commercialisation Licence of any Foreground IP.

- 16.9 If you or your technology transfer company assign or licence any Foreground IP to any third party or to a start-up established for the purpose of commercially exploiting the Results (a NewCo) you together with any connected person (including any investment fund to which you may transfer any part of your stake) shall be entitled to:

EITHER

- (a) hold or have the right to hold no more than 10% in fully-dilutable shares or equity (pre investment) in the third party or NewCo (with no other preferential subscription rights), not including any shares or equity subscribed for cash on arm's length terms alongside other investors;

OR

- (b) charge a royalty, with no upfront payments, annual fees, milestone payments or minimum royalties, payable by the third party or NewCo under any licence or assignment of the Foreground IP at no more than the relevant rate, and on the other terms, set out in Schedule 3.

- 16.10 The provisions of clauses 16.9(a) and 16.9(b) shall not apply to any equity taken or royalty charged in consideration of:

- (a) IP other than Foreground IP licensed or assigned to the third party or NewCo; or
(b) facilities, equipment, personnel or other material support or services provided to the third party or NewCo independent of the Project Activities,
with such equity or royalty limited to the proportion that reflects the contribution made by IP that is not Foreground IP.

- 16.11 You must notify ARIA in writing before any transaction completes of the overall equity stake or royalty percentages agreed under clause 16.8 (and any impact of clause 16.9, if relevant).

17. ASSETS

- 17.1 You must keep a register during the Funding Period and for up to 7 years after the end of the Funding Period of all Assets, with all relevant details about each Asset. You must use any Assets purchased with Grant monies for the Project Activities.
- 17.2 At the end of the Funding Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

- 18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Grant Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUBCONTRACTING

- 19.1 You may not transfer, assign, novate or otherwise dispose of the whole or any part of the Grant Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.
- 19.2 You shall not subcontract any of the Project Activities to a Third Party except to the extent permitted, and to the person or persons identified, in Schedule 2 Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractor as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Grant Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Grant Agreement.

20. BORROWING, LOSSES, GIFTS, SPECIAL PAYMENTS

- 20.1 You must obtain ARIA's prior written consent before:
- (a) borrowing or lending money from any source in connection with the Grant Agreement;
 - (b) giving any guarantee, indemnity, security over any Asset or letter of comfort in relation to the Grant Agreement;
 - (c) making any gift or writing off any debt or liability in connection with the Grant, and must keep a record of all gifts given and received in connection with the Grant.

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Grant and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Grant or publicise details of the Grant Agreement without the other's consent, except as required by Law.
- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

- 22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events occur:
- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13, 15.5 or 25, or commit a material breach of any other term of the Grant Agreement in the reasonable opinion of ARIA;
 - (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
 - (c) you fail to improve the performance of the Project Activities, notwithstanding your having undertaken the remedial activity agreed with ARIA in the remedial plan under clause 6.2(d);

- (d) you or the researchers involved in the Project Activities obtain any funding from a Third Party that, in the opinion of ARIA, undertakes activities that are likely to bring the reputation of the Project Activities or ARIA into disrepute;
- (e) you provide ARIA with any materially misleading or inaccurate information in your grant application or in subsequent related correspondence;
- (f) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Third Party, immediately upon becoming aware of it;
- (g) you are subject to an Insolvency Event;
- (h) the Grant or any part of it is held by a court or competent authority to be a prohibited subsidy under the Subsidy Control Act 2022 or an illegal state aid;
- (i) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project Activities;
 - (ii) result in your being unable to receive the Grant; and/or
 - (iii) raises national security concerns.

Rights reserved for ARIA in relation to an Event of Default

22.2 If an Event of Default has or may have occurred, ARIA may by written notice to you take any one or more of the following actions:

- (a) suspend the Project Activities and payment of the whole or any part of the Grant for such period as ARIA may determine, acting reasonably;
- (b) reduce the Maximum Sum, in which case the payment of Grant will thereafter be made in accordance with the reduction and notified to you; and/or
- (c) subject to clause 22.4, terminate the Grant Agreement with immediate effect as from the date of service of the notice of that termination.

22.3 Where this Grant Agreement is terminated for an Event of Default described in clause 22.1(f) or 22.1(h), ARIA may require you to repay the entire amount of the Grant previously paid to you.

Opportunity for you to remedy an Event of Default

22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:

- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and
- (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

22.5 Without prejudice to any other provision of the Grant Agreement, you may terminate the Grant Agreement on written notice to ARIA if ARIA commits a material breach of the Grant Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

General Termination Rights

- 22.6 Notwithstanding ARIA's right to terminate the Grant Agreement under clause 22.2(c), either party may terminate the Grant Agreement (in whole or in part) at any time by giving at least 60 days' prior written notice to the other party.
- 22.7 You must promptly notify ARIA in writing if at any time the principal investigator or any key researcher(s) named in Schedule 2 working on the Project Activities is unable or unwilling to continue to be involved in the Project Activities or is moving to a new organisation without the desire to continue the research. Within 60 days after the date of that notice, you must either:
- (a) nominate one or more successors, subject to ARIA's approval; or
 - (b) agree that the Grant is transferred to another organisation subject to your and the new organisation's agreement in writing and ARIA's approval of the transfer

If ARIA is unwilling to accept the nominated successor(s) or does not approve a request for transfer, it may terminate the Grant Agreement by at least 30 days' written notice to you.

Consequences of Termination

- 22.8 If the Grant Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.
- 22.9 Where ARIA terminates the Grant Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:
- (a) you taking all reasonable steps to mitigate such loss; and
 - (b) the Unavoidable Costs being:
 - (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Grant Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA;
 - (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you;
 - (v) costs that would not have been incurred had this Grant Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period).
- 22.10 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Services, over £250,000 will terminate automatically and immediately upon termination of this Agreement.

- 22.11 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Grant Agreement in the event that the Grant Agreement was terminated (calculated on the basis described in clause 22.8).
- 22.12 ARIA's total liability under clause 22.9 shall be limited to the Maximum Sum under the Grant Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.13 If the Grant Agreement is terminated or expires ARIA will not be liable to pay any of your costs or those of any of your contractors or suppliers related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Grant Funding Letter and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Grant Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Grant Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the Grant Manager and the Project Representative.
- 23.3 If the dispute cannot be resolved between the Grant Manager and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to a formal meeting between the parties' Escalation Contacts.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:
- (a) fraudulent misrepresentation or any other fraudulent act or omission;
 - (b) payment of sums properly due and owing to the other in the normal course of performance of this Grant Agreement;
 - (c) a breach of clause 13;
 - (d) liability arising under any indemnity in this Grant Agreement; or
 - (e) liability which may not lawfully be excluded or limited.
- 24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Grant Agreement or for ARIA's breach of this Grant Agreement), whether arising directly or indirectly, that may arise in connection with:
- (a) your carrying out the Project Activities;
 - (b) the use of the Grant by any person;
 - (c) any reduction, suspension, withdrawal or request for repayment of the Grant in accordance with this Grant Agreement; or

(d) termination of the Grant Agreement in accordance with this Grant Agreement.

24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:

- (a) loss of profit, sales or turnover;
- (b) loss of contracts or business opportunities;
- (c) loss of anticipated savings;
- (d) loss of goodwill or damage to reputation; or
- (e) any indirect, special or consequential loss or damage;

in each case arising out of or relating to the Grant Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.

24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to the Grant Agreement or its subject matter or anything which it has done or not done in connection with the Grant Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the amount of the Maximum Sum.

24.5 You shall under no circumstances in connection with this Grant Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.

24.6 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Grant Agreement.

25. RESEARCH ETHICS AND CODE OF CONDUCT

25.1 As a recipient of a Government grant you must operate in accordance with the Concordat.

25.2 All research data:

- (a) must be generated using sound scientific techniques and processes;
- (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and
- (c) must be analysed appropriately, without bias and in accordance with good scientific practices.

25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.

25.4 You must comply with the Code of Conduct and ensure that your Representatives undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

- 26.1 Any variation to the Grant Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

27. GENERAL

- 27.1 Notices: All notices and other communications in relation to this Grant Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such communications will be deemed to have been given and received on the third Working Day following such mailing.
- 27.2 Change of control: You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(i) is likely to apply.

28. GOVERNING LAW

- 28.1 This Grant Agreement (including any non-contractual disputes or claims arising in connection with this Grant Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. NOT USED

30. DEFINITIONS AND INTERPRETATION

- 30.1 Where they appear in these Conditions or the Grant Agreement:
- Adequate Insurance** means the insurance requirements and amounts set out in the Grant Funding Letter.
- Asset** means any asset that is purchased, improved or developed using the Grant including equipment and fixed assets;
- Background IP** means IP that is:
- (a) owned by or licensed to a party prior to the Commencement Date; or
 - (b) developed by or on behalf of a party during the Funding Period but not in connection with the Project Activities,
- and is in either case used in connection with the Project Activities;
- Bribery Act** means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;
- Change of Control** means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Recipients of Government General Grants published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754555/2018-11-06_Code_of_Conduct_for_Grant_Recipients.pdf

including any subsequent updates from time to time;

Commencement Date means the date set out in the Grant Funding Letter;

Commercialisation Licence means a licence of IP other than a research or evaluation licence and/or subcontract manufacture (and **Commercially License** means to license under a Commercialisation Licence);

Commercialisation Hypothesis means the exploitation plan approved by ARIA and set out at Schedule 2 Part 2, as may be amended by agreement between the parties during and after the Funding Period;

Completion Date means the date set out in the Grant Funding Letter;

Concordat means the Concordat to Support Research Integrity which can be found at <https://ukrio.org/about-us/the-concordat-to-support-research-integrity/>

Conditions means these ARIA Grant Conditions;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Grant Agreement, that ought reasonably to be considered to be confidential (whether or not it is so marked), (a) including: (i) information relating to the business, affairs, customers, clients, suppliers or plans of the disclosing party; (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party; (iii) any information developed by the parties in the course of carrying out the Project Activities; (iv) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Grant Agreement; and (v) and any information derived from any of the above,

(b) but not including information which: (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11); (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party; (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or (iv) is independently developed without access to the Confidential Information; and (v) the content of this specific version of the Grant Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

Duplicate Funding means funding provided to you by a Third Party which is to fund the same activities as the Project Activities;

EA means the Equality Act 2000 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Eligible Expenditure means the payments made by you during the Funding Period for the purposes of carrying out the Project Activities which comply with clause 5 and ARIA's published eligibility rules (which provide for full economic cost reimbursement) and as agreed in the Grant Funding Letter;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Grant Funding Letter;

Event of Default means any of the events or circumstances set out in clause 22.1;

Financial Year means 1 April to 31 March;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means any IP in the Results;

Funding Period means the period commencing on the Commencement Date and ending on the Completion Date or such later date as may be agreed between the parties unless otherwise determined in accordance with the terms of the Grant Agreement;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification (operated by ARIA or by a third party), in the form set out at Annex A;

GDPR means Regulation (EU) 2016/679;

Grant means the sum or sums ARIA will pay to you up to the amount set out in the Grant Funding Letter, in accordance with clause 4 and subject to the provisions set out at clause 22.

Grant Agreement has the meaning given in the Grant Funding Letter;

Grant Claim means a request submitted by you to ARIA for payment of the Grant;

Grant Funding Letter means the letter from ARIA to you to which these Conditions are annexed;

Grant Manager means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Grant;

Grant Review means the process for reviewing the grant outlined in clause 6;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Ineligible Expenditure means expenditure incurred by you which is not Eligible Expenditure as set out in clause 5 and ARIA's published eligibility rules;

Information Acts means the Data Protection Legislation, FOIA and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property Rights or **IP** means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions, semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation;

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise;

Maximum Sum means the maximum amount of the Grant stated in the Grant Funding Letter;

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

NewCo has the meaning given in clause 16;

Non-UK Entity means a legal entity that is not a UK Entity;

Personal Data has the meaning given to it in the Data Protection Legislation as amended from time to time;

Prohibited Act means:

(a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Grant Agreement; and/or (ii) showing or not showing favour or disfavour to any person in relation to the Grant Agreement;

(b) committing any offence: (i) under the Bribery Act; (ii) under legislation creating offences in respect of fraudulent acts; and/or (iii) at common law in respect of fraudulent acts in relation to the Grant Agreement; and/or

(c) defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the activities to be carried out by you that are described in the Grant Funding Letter and in Schedule 2 Part 1;

Project Representative means the representative appointed by you, who at the Commencement Date will be the individual listed as such in the Grant Funding Letter;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means all information, data, techniques, inventions, discoveries, works, software and materials generated in the course of the Project Activities;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Project Activities or any part thereof or facilities or services necessary for the performance of the Project Activities or any part thereof or necessary for the management, direction or control of the Project Activities or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

UK Entity means a legal entity whose ultimate parent company has its headquarters and principal establishment in the United Kingdom;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Grant Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Funding Period because of termination or breach of the Grant Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination; and

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 In these Conditions and the Grant Agreement, unless the context otherwise requires:

- (a) references to "party" and "parties" are to the parties to the Grant Agreement;
- (b) the singular includes the plural and vice versa;
- (c) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (d) references to clauses and Schedules are to the clauses of these Conditions and to the Schedules to the Grant Agreement;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation"; and
- (g) the headings in the Grant Agreement are for ease of reference only and will not affect the interpretation or construction of the Grant Agreement.

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

South Asia, a highly populated and climate-vulnerable region, faces significant environmental challenges, including extreme weather events, rising sea levels, glacial melt, and prolonged heatwaves. The region is home to nearly a quarter of the world's population and is characterized by diverse geography, including vast coastlines, fertile plains, and mountainous terrains. Climate risks in South Asia are exacerbated by socio-economic vulnerabilities, resource limitations, and governance complexities. Coastal nations such as India, Pakistan, and Bangladesh are increasingly threatened by rising sea levels and cyclonic storms, while landlocked countries like Nepal and Bhutan face challenges related to glacial melt, water scarcity, and temperature rise.

Marine Cloud Brightening (MCB) is a regional Solar Radiation Modification (SRM) technique aimed at increasing cloud reflectivity to cool atmospheric temperatures and mitigate some climate change impacts. This project seeks to evaluate the feasibility and potential consequences of MCB in South Asia by comparing it with Carbon Dioxide Removal (CDR) and traditional mitigation strategies. The study will explore technical, governance, and ethical considerations associated with the use of MCB and assess its socio-economic and political implications.

This project aims to address existing research disparities by centering South Asian perspectives, offering a framework for more inclusive and ethically grounded MCB research that holds global relevance. The study will focus on selected coastal countries (Bangladesh, India, Pakistan) and non-coastal nations (Bhutan, Nepal) to examine the socio-economic, political, and environmental dimensions critical to decision-making around the potential use or non-use of MCB. By integrating stakeholder perspectives—including policymakers, academics, civil society, and the media—alongside ethical considerations and governance frameworks, the project will develop inclusive and equitable SRM strategies tailored to the region.

While global research on MCB has been conducted, its application in South Asia remains largely unexplored. Existing studies on SRM have primarily focused on technical outcomes, with limited engagement of regional stakeholders. This project seeks to bridge that gap by integrating climate impact modeling with stakeholder engagement, policy analysis, and ethical evaluations to ensure that any potential interventions are both scientifically sound and socially acceptable. The study will generate region-specific insights to inform potential governance frameworks, supporting decision-making on climate interventions in South Asia. In this context, by bridging the gap between scientific innovation and socio-economic and political realities, this research seeks to contribute to a deeper understanding of how SRM strategies, particularly MCB, can be responsibly and effectively implemented in South Asia, if and when needed. Additionally, the study aims to provide key insights into governance structures and public perception analyses that will inform future climate intervention strategies in the region.

2. Aims and objectives of the Project Activities

The project aims to:

- Conduct comparative climate impact modeling analyses of MCB, CDR, and traditional mitigation approaches in South Asia.
- Investigate public perceptions, governance challenges, and ethical concerns associated with MCB.
- Develop governance frameworks for responsible climate intervention strategies in the region.
- Engage key stakeholders, including policymakers, civil society, academics, and media, to ensure inclusive decision-making.
- Assess the socio-economic implications and potential risks associated with the use of MCB in South Asia.

3. Project Activities

3.1 This project is divided into five interrelated research components:

WP1: MCB Climate Projection and Impact Modeling

- o Employ MCB runs of CESM under CMIP6 framework to assess MCB's regional impacts, particularly on monsoon rainfall and coastal weather patterns.
- o Analyze temperature, and precipitation, under different climate change and MCB scenarios, across South Asia.

WP2, WP3: Comparative Analysis with CDR and Mitigation Strategies

- o Evaluate the feasibility, cost, and scalability of MCB compared to CDR techniques and conventional mitigation efforts.
- o Develop a multi-criteria decision analysis framework for assessing trade-offs among these solutions.

WP1, WP2, WP3: Stakeholder Engagement and Perception Analysis

- o Conduct surveys and focus groups across five South Asian countries (Bangladesh, Bhutan, India, Nepal, Pakistan) to understand public attitudes toward MCB.
- o Ensure logistical feasibility by establishing clear protocols for survey distribution, data collection, and analysis.
- o Develop partnerships with local institutions to facilitate data collection and ensure culturally appropriate engagement strategies.

- o Utilize digital and in-person data collection methods to maximize outreach and accuracy of survey responses.

WP2, WP3: Policy Review and Ethical Framework Development

- o Identify gaps in existing policies regarding SRM.
- o Develop ethical guidelines that ensure equity, transparency, and inclusiveness in decision-making processes.

WP1, WP2, WP3: Risk Assessment and Governance Framework

- o Address potential environmental, legal, and socio-economic risks associated with MCB.
- o Develop governance mechanisms aligned with international climate agreements, and regional regulatory frameworks.

Logistics Plan for Data Collection and Survey Execution

- **Survey Methodology:** Surveys will be conducted using a mixed-methods approach, including structured questionnaires, semi-structured interviews, and focus groups.
- **Participant Selection:** A representative sample of stakeholders, including policymakers, civil society members, academics, and journalists, will be targeted in the five selected countries.
- **Data Collection Strategy:**
 - o Digital surveys will be distributed through secure online platforms to maximize participation across diverse locations.
 - o In-person data collection will be conducted where necessary, facilitated by regional research partners.
- **Survey Execution Timeline:**
 - o **Until November 2025:** Development and pilot testing of survey instruments.
 - o **Until May 2026:** Full-scale survey implementation in target countries.
 - o **Until November 2026:** Data analysis and integration into governance and decision making frameworks.
- **Quality Control Measures:**
 - o Cross-validation of survey responses through triangulation methods.

- o Regular monitoring and reporting on survey response rates.
- o Ethical considerations, including informed consent and data confidentiality, will be strictly followed.

Research Objectives

Comparative Analysis of MCB (GeoMIP) CDR (CDRMIP), mitigation (CMIP) Projections:

- Compare the efficacy of MCB and ocean alkalization (CDR) in addressing climate vulnerabilities.
- Assess socio-political dimensions of MCB strategies in coastal (Bangladesh, India, Pakistan) vs. non-coastal (Bhutan, Nepal) countries, focusing on public perceptions, technical feasibility, governance, and ethical challenges.

Perceptions and Stakeholder Engagement:

- Investigate public perceptions of MCB and CDR across coastal and non-coastal countries in South Asia.
- Examine socio-economic factors influencing acceptance of MCB and assess stakeholder engagement, including governments, civil society, and local communities.

Policy Analysis:

- Analyse national and regional policies to identify gaps related to MCB.

Ethical Frameworks and Socio-Economic Dimensions:

- Review existing SRM ethical frameworks and develop guidelines for South Asia's geopolitical context.

3.2 The following Milestones will be used to monitor your delivery of the Project. The costs associated with completing these Milestones are estimated in the [REDACTED]

ID	Milestones	Measure (Decision Points & Outputs)	Date
1	Completion of literature review and initial climate impact modelling	Literature review report, initial climate impact model outputs. Report submission	Commencement Date + 6 months
2	Stakeholder survey design pilot testing including logistics plan for data collection	Detailed survey execution plan, pilot survey completion report, survey validation, feasibility assessment	Commencement Date + 12 months
3	Full-scale climate modeling analyses, validation of survey methodology and survey execution	Verified climate impact model results, survey data collection completion, successful pilot survey completion	Commencement Date + 18 months
4	Stakeholder engagement and governance framework refinement	Focus group feedback summary, preliminary governance framework	Commencement Date + 24 months
5	Finalization of governance and ethical guidelines with stakeholder input	Ethical framework publication, governance recommendations plan	Commencement Date + 30 months
6	Project synthesis and dissemination of results	Final project report, stakeholder workshop, public dissemination materials and governance recommendations	Commencement Date + 36 months

In addition to the above Milestones, the following project plan will be used to track progress throughout the project and may be updated from time to time:

Phase	Months	Key Activities
Phase 1: Project Initiation	1-6	Conduct literature review, finalize research methodology, develop impact climate models, establish initial stakeholder contacts, design survey instruments.
Phase 2: Data Collection & Initial Analysis	7-12	Implement climate impact modeling simulations, analyze early climate data trends, conduct pilot surveys, hold preliminary stakeholder consultations.
Phase 3: Full-Scale Stakeholder Engagement & Comparative Analysis	13-18	Execute large-scale stakeholder surveys, conduct focus group discussions, compare MCB with CDR and mitigation strategies, refine climate impact model projections.
Phase 4: Policy Review and Ethical Framework Development	19-24	Complete stakeholder data analysis, review existing policy frameworks, conduct validation workshops, engage policymakers for feedback.
Phase 5: Governance & Risk Mitigation Strategies	25-30	Finalize governance models, refine ethical guidelines, complete risk assessment studies, draft regulatory recommendations.
Phase 6: Dissemination & Final Recommendations	31-36	Publish research findings, organize dissemination workshops, present results at conferences, finalize governance recommendations.

3.3 The intended long-term outcomes are summarised below:

Enhanced Climate Resilience: The project will contribute to improving climate adaptation and resilience in South Asia by assessing the feasibility of MCB as a short-term intervention strategy.

Informed Decision making: Policymakers will have access to data-driven well-researched governance frameworks that balance climate intervention techniques with ethical considerations and regional needs.

Stakeholder-Driven Climate Strategies: By integrating community and expert perspectives, the project ensures that climate intervention strategies are inclusive and ethically responsible.

Scientific and Technological Advancements: The research will enhance climate impact modeling capabilities and contribute to the growing body of knowledge on SRM.

Global Relevance: The insights gained from South Asia will provide a template for similar assessments in other climate-vulnerable regions worldwide.

Guidance for Future Research: The ethical and governance frameworks developed will serve as a foundational reference for future studies and potential field experiments in climate intervention.

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement
Planning	• Roles and responsibilities • External communications • Vision • Project details • Code and data management • Project plan + project management
Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Key Learning, discoveries and decisions • Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • Invoicing and cost reporting Optional: • technical evidence saved to drive e.g. report or presentation as requested by PD • review meeting slide deck saved to drive as requested by PD

Annual	• ARIA impact metrics • Attendance at annual ARIA event
Ad hoc	• As required, Programme Director/ Programme Team may request additional information and evidence • Workshops - potential to be invited to ARIA workshops
Project closure	• Project closure report

5. Payment

5.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments quarterly in arrears.

For quarterly payments, the cadence of payments will align with ARIAs financial year beginning 1st April e.g Quarter 1 Grant Claims will be for the period of 1st April to 30 June, Quarter 2 Grant Claims will be for the period of 1st July to 30 Sept and so on.

5.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

5.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end of the relevant period.

5.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

6. Principal investigator/key researchers

6.1 For the purposes of clause 22.7, the following principal investigators or key researchers have been identified:

Name	Role	Organisation
Dr. Athar Hussain	Principal Investigator. Leading project management (WP1, WP2, WP3)	COMSATS University Islamabad
Dr. Thomas Fischer	Collaborator, Technical Expert and Leading environmental assessment support (WP2, WP3)	University of Liverpool, UK
[REDACTED]	Team Member/Social Scientist-	COMSATS University

	Policy Analyst. Leading coordination with survey subcontractors, and leading key informant interviews, and ethical framings for research and publications outputs (WP1, WP2, WP3)	Islamabad
	Team Member Coordinating communication between team members, and supporting key stakeholders, focus group discussions activities (WP1, WP2, WP3)	COMSATS University Islamabad
Dr. Sajida Kousar	Team Member/Expert in Analytic Model Development. Providing analytical modeling support for policy analysis and ethical framings project outputs (WP2, WP3)	International Islamic University, Islamabad
Mr. Hassaan Sipra	Team Member/Climate and SRM Governance. Supporting policy analysis and ethical framings research, publications outputs and project management (WP1, WP2, WP3)	The Alliance for Just Deliberation on Solar Geoengineering, Washington DC, USA
	Data Development Specialist. Developing GIS and database outputs for project deliverables (WP2, WP3)	COMSATS University Islamabad
	Team Member/Research Analyst. Leading climate modelling assessments for research and publications output (WP1, WP2)	COMSATS University Islamabad
	Team Member/Research Analyst. Supporting climate modelling assessments for research and publications, and providing project management support (WP1, WP2)	COMSATS University Islamabad, Pakistan
	Communication Manager (for media interactions across South	COMSATS University Islamabad, Pakistan

	Asia, development of briefings, website, short memos, etc.) (WP1, WP2, WP3)	
██████████	GIS Expert and support in Project Management (WP1, WP2, WP3)	COMSATS University Islamabad, Pakistan
██████████	Web Developer and Infographics Support (WP1, WP2, WP3)	COMSATS University Islamabad

7. Sub-Contractors

7.1 For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Location
Proposed Focal Person: Dr. Muhammad Mumtaz and ██████████	Survey/Study across multiple demographics	Fatima Jinnah Women University, Rawalpindi And COMSATS University Islamabad, Pakistan
Proposed Focal Person: Mr. Hassaan Sipra	Focus group discussions activities	The Alliance for Just Deliberation on Solar Geoengineering, Washington DC, USA

PART 2 - GRANT APPLICATION

Application titled “Evidence-based Assessments to Guide Perceptions, Governance, and Ethical Frameworks for South Asia: Comparing Marine Cloud Brightening Deployment Strategies vis-à-vis Carbon Dioxide Removal and Mitigation Efforts” submitted 9 December 2024.

SCHEDULE 3

Royalty Percentages

Royalties on the sale or supply of products or services that are covered by, use or incorporate the Foreground IP licensed to the NewCo will only become due on aggregate net sales derived from the Foreground IP exceeding £50 million.

The maximum headline percentage royalty rate (i.e. before any royalty stacking, step-down or other reduction and excluding any ARIA Non-UK Fee) for products or services that are covered by, use or incorporate the Foreground IP, and of sublicensing income, shall be one of the following:

Type of product	Applicable headline royalty percentage (up to)
Low margin	0.5% of net sales
Medium margin	1% of net sales
High margin	2% of net sales
Sublicensing royalty	10% of net receipts

ANNEX 1

Clause for inclusion in licences of Foreground IP

[] **ARIA NON-UK FEE**

[].1 In this clause:

“ARIA” means the Advanced Research and Invention Agency;

“Crown Body” means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

“UK Entity” means a legal entity that has or whose ultimate parent company has its headquarters and principal establishment in the United Kingdom.

[].2 The Foreground IP was developed with funding from ARIA. As a condition of its funding ARIA requires that a benefit is returned to the United Kingdom where the Foreground IP is licensed by the Licensor to any person that is not a UK Entity. Accordingly, in addition to any other sums payable by the Licensee to the Licensor under this Agreement, the Licensee shall pay to the Licensor within 90 days after the end of each calendar year during the Relevant Period (as defined below), and within 90 days after the end of the Relevant Period, a fee (**ARIA Non-UK Fee**) on all amounts (including upfronts, licence fees, milestone payments, royalties, shares or other securities, exit fees, buyout or other consideration) payable by the Licensee to the Licensor under this Agreement in relation to the exploitation of any Foreground IP (**Relevant Amount**) that accrues during, or relates to, any period of time that the Licensee is not a UK Entity (**Relevant Period**). The amount of the ARIA Non-UK Fee is 25% of the Relevant Amount, and is payable by the Licensee to the Licensor in addition to the amounts that would otherwise be payable under this Agreement. For example if the Relevant Amount is £100 the ARIA Non-UK Fee is an additional £25, which the Licensee shall pay to the Licensor and the Licensor shall remit to ARIA.

Crown Body customers

[].3 You must also ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities and in suitable quantities for the Crown Body's requirements.

[].4 ARIA shall have the right to enforce this clause [] under the Contracts (Rights of Third Parties) Act 1999. Neither party may amend this Agreement in a way that detracts from ARIA's right to enforce its rights under this clause without ARIA's prior written consent.

- [1] When using this clause you may substitute the relevant defined terms used elsewhere in the agreement to capture the concept of "Foreground IP". Where the clause refers to the "Licensor" and "Licensee" please use the appropriate defined terms to include the licensor, licensee, assignor and assignee of the Foreground IP. This clause is not suitable for assignments of the Foreground IP in consideration of the payment of one or more lump sum payments. In those cases the Licensor needs to be informed, and potentially make an additional payment, if the Foreground IP is subsequently assigned to a non-UK Entity or if the Assignee ceases to be a UK Entity.

SCHEDULE 4: Data Protection

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Grant Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Grant Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Grant Agreement:
 - 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are

relying on Domestic Law as the basis for processing Personal Data, you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;

- 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);
- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Grant Agreement unless required by Domestic Law to store the Personal Data; and

- 3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.
- 3.4. [[ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):
- 3.4.1. cancel its plans to change the affected sub-Processor;
- 3.4.2. offer an alternative which is acceptable to ARIA; or
- 3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.
- 3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Grant Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.
- 3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]
- 3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Grant agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it, storing it, retrieving it, consulting it, disseminating it or destroying it, etc.

	Note the definition of processing in the UK GDPR: <i>“any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction”]</i>
Duration of Processing:	Duration of this Grant Agreement (and any post termination processing that is permitted / required).
Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called “special categories” of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: <i>“data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation”]</i>
Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors,

	clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. You shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.
- 4.2. Any limitation of liability set out in this Grant Agreement will not apply to this Schedule's indemnity or reimbursement obligations.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

1. Submission of Pledged Patents and Experimental Data
 - 1.1 The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
 - 1.2 The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.
2. Experimental Data Licence
 - 2.1 Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
 - 2.2 The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
 - 2.3 The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
 - 2.4 The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).
3. Research Licence
 - 3.1 Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
 - 3.2 The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
 - 3.3 Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.

3.5 The Research Licensee must:

- (a) at all times when using the Pledged Patents comply with all Laws; and
- (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).

4. Commercial Licence

4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.

4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.

4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.

5. Pledgor Know-How

At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.

6. Termination

6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:

- (a) materially breaches the terms of such licence or this Pledge; or
- (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).

7. Transfers of Pledged Patents and/or Experimental Data

The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.

8. No Warranty

The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and

**Submission
Guidelines**

means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

The Degrees Initiative (**Contractor**)

c/o Sedulo London

Office 605, Albert House

256–260 Old Street

London

EC1V 9DD

02 July 2025

Attention: Andy Parker

Dear Andy,

FPCW-PR01-P021 GRID-CC: Global to Regional Impacts Downscaling for Climate Cooling— Research Contract Agreement - Offer Letter

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to Exploring Climate Cooling. We are pleased to confirm that ARIA wishes to appoint you to deliver the contract research services as described in the Project for ARIA, subject to the terms and conditions set out in this Offer Letter and its Schedules.

1. Overview of the Agreement

- 1.1. Any reference in this Offer Letter to you or your means the Contractor and any capitalised terms have the meanings given in Schedule 1 below).

Certain variables of the Agreement are set out in the table below:

Project	The project entitled GRID-CC: Global to Regional Impacts Downscaling for Climate Cooling, details of which can be found in Schedule 2.
Maximum Approved Cost (inclusive of taxes)	Maximum Approved Cost (inclusive of all taxes where applicable) is: £2,078,254
Commencement Date	The commencement date is 02 July 2025
Completion Date	The completion is 01 July 2028
Adequate Insurance	Employers' liability - At least £5 million (as required by the Employers' Liability (Compulsory Insurance Act 1969)) Public liability: £10 million (per year in aggregate)

Monitoring and Reporting	The performance reports referred to in clause 7 of Schedule 1 shall be provided by you at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Contractor's Representative	[REDACTED] Programmes Director, [REDACTED] & cc [REDACTED] Chief Operating Officer, [REDACTED]	
ARIA's Representative	Mark Symes, Programme Director [REDACTED]	
Escalation Contacts	ARIA	Contractor
	Chief Product Officer [REDACTED]	[REDACTED], Programmes Director, [REDACTED] & cc [REDACTED] Chief Operating Officer, [REDACTED]
Notices	ARIA Contracts [REDACTED]	[REDACTED] Programmes Director, [REDACTED] & cc [REDACTED] Chief Operating Officer, [REDACTED]

2. Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Contract and return it to finance@aria.org.uk.

3. Obligations

- 3.1. You will undertake the Project as a contract research and development project carried out at the direction of and for the benefit of ARIA's programmes.
- 3.2. ARIA will pay you the Approved Cost as set out in Schedule 2 for undertaking the Project in accordance with Offer Letter and its Schedules.

4. The Agreement

- 4.1. Once you sign a copy of this Offer Letter in accordance with paragraph 7 (Acceptance) below, it will form a binding **Agreement** between you and ARIA that includes and

incorporates the following documents:

- 4.1.1. the **Conditions** in Schedule 1;
 - 4.1.2. the **Project Activities, Milestones** and **Application** in Schedule 2; and
 - 4.1.3. the terms relating to Data Protection in Schedule 3.
- 4.2. The contract effected by the signing of this Offer Letter constitutes the whole agreement between the parties and supersedes all prior negotiations, agreements, representations or understandings between them relating to the subject matter of this Agreement.
- 4.3. Each party acknowledges that, in entering into the Agreement, it does not rely on any statement, representation, assurance or warranty (Representation) of any person (whether a party to this Agreement or not) other than as expressly set out in the Agreement. Each party agrees that the only remedies available to it arising out of or in connection with a Representation shall be for breach of contract.

5. Warranties

- 5.1. By signing this Offer Letter, you warrant and represent that:
- 5.1.1. your obligations under the Agreement are legal, valid, binding and enforceable;
 - 5.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Agreement have been obtained;
 - 5.1.3. the person signing the Agreement is duly authorised to sign on your behalf;
 - 5.1.4. there are no actions, suits or proceedings pending or, to your knowledge, threatened against or affecting you before any court or administrative body or tribunal that might affect the ability of you to meet and carry out your obligations under this Agreement;
 - 5.1.5. the Project will be carried out by appropriately experienced, qualified and trained personnel with all due skill, care and diligence;
 - 5.1.6. you will discharge your obligations hereunder with all due skill, care and diligence, including, but not limited to, good industry practice and (without limiting the generality of the foregoing) in accordance with your own established internal procedures; and
 - 5.1.7. the provision of the Project and ARIA's use of the Intellectual Property rights in the Foreground IP granted shall not infringe any Intellectual Property rights of any Third Party.

6. Amendments

Not Used

7. Acceptance

- 7.1. To confirm your acceptance of the Agreement please arrange for an authorised signatory to sign and date the duplicate copy of this Offer Letter as indicated below and return to ARIA as a complete signed original of the Offer Letter including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Agreement and to bind the Contractor.
- 7.2. This Offer Letter expires on 4 July 2025 and any acceptance received after this date will not be valid.

Yours sincerely

Signed by the duly authorised signatory of ARIA:

Signature

Name

Position

Date

Signed by the duly authorised signatory of The Degrees Initiative

Signature

Name

Position

Date

SCHEDULE 1 - CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up this Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Offer Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to this Agreement with the exception of Schedule 2 Part 2 (the Application);
 - (d) Schedule 2 Part 2 (the Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, this Agreement.

2. DURATION AND OBLIGATIONS OF THE PARTIES

- 2.1 The Agreement will subsist for the duration of the Project Period unless extended by agreement or terminated earlier in accordance with its terms. Any provision of the Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Agreement shall remain in full force and effect.
- 2.2 You shall manage and complete the Project in accordance with the specification as set out in Schedule 2 Part 1 and shall allocate sufficient resources to the Project to enable you to comply with this obligation.
- 2.3 ARIA may request changes to the Project Activities (including changing the Approved Cost and/or the scope of the Project Activities) by providing at least 30 days written notice to you of such changes and the rationale. ARIA will agree with you the terms of any variation to the Agreement requested by ARIA to implement such changes subject to clause 26 with your agreement to the variation not to be unreasonably withheld, delayed or conditioned.
- 2.4 You shall use reasonable endeavours to meet any performance dates specified in Schedule 2 Part 1 or elsewhere in the Agreement and the obligations of this clause 2.
- 2.5 You shall:
- (a) reasonably co-operate with ARIA in all matters relating to the Project; and
 - (b) promptly inform ARIA of the absence of the Contractor's Representative and/or Key Staff and you must provide a suitably qualified replacement approved by ARIA (such approval not to be unreasonably withheld or delayed);
 - (c) observe, and ensure that all member of your Staff observe, all rules and regulations and any other reasonable requirements of ARIA that ARIA has provided to you; this shall include and not be limited to ensuring that the Approved Cost shall be utilised in accordance with the Project cost breakdown (referred to in Schedule 2) covering all Project materials, equipment and any applicable Sub-Contractor costs;
 - (d) notify ARIA as soon as you become aware of any issues which arise in relation to the Project; and

- (e) before the Commencement Date obtain, and at all times maintain, all necessary licences and consents and comply with all relevant legislation in relation to your obligations under the Agreement.

3. ENVIRONMENTAL REQUIREMENTS

- 3.1 In performing the Project, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. ACCOUNTING AND PAYMENTS

- 4.1 The total amount to be paid by ARIA to you shall not exceed the Approved Cost. Invoices raised by you for Milestone Payments shall be paid by ARIA in accordance with the Agreement (including Schedule 2).
- 4.2 Payments to third parties including Sub-Contractors shall remain your responsibility and you shall ensure that such payments are made promptly within 30 days from the receipt of a valid invoice.
- 4.3 ARIA may suspend payment at any time if (i) in the view of ARIA, acting reasonably, satisfactory progress on the Project has not been maintained (but suspension shall be limited to the affected portions of the activities), or (ii) reports have not been submitted as required under Clause 7. In the event that ARIA suspends payment under (i), you may suspend performance of the Project Activities (and ARIA's corresponding payment obligations shall also suspend) until the parties have agreed, acting in a good faith, a course of action to progress the Project Activities, in which case you shall reinstate your performance of the Project Activities and ARIA shall resume payment (including, as agreed, in respect of any missed payments) in accordance with the provisions of this Agreement. If the parties are unable to agree a course of action and/or ARIA's payment suspension lasts for two (2) months, this Agreement shall automatically terminate.
- 4.4 On completion of the Project Period, the final payment in respect of costs properly incurred under the Agreement will be paid by ARIA to you within 30 (thirty) days, provided that:
 - (a) the Project has been completed in accordance with the Agreement;
 - (b) the reports required under clause 7 have been submitted by you; and
 - (c) an agreement has been reached in respect of any items remaining for disposal.
- 4.5 If at any time an overpayment has been made to you for any reason whatsoever, the amount of such overpayment shall be taken into account in the assessing of any further payments or shall be recoverable from you at ARIA's discretion.
- 4.6 You shall keep and maintain until seven years after this Agreement has been completed, or as long a period as may be agreed between the Parties, full and accurate records of the Project including:
 - (a) all aspects of the Project;
 - (b) all expenditure reimbursed by ARIA; and
 - (c) all payments made by ARIA;

and you shall on request afford ARIA or ARIA's representatives such access to those records as may be required in connection with the Agreement.

4.7 You shall make any payments due to ARIA without any deduction whether by way of set-off, counterclaim, discount, abatement or otherwise, unless you have a valid court order requiring an amount equal to such deduction to be paid by ARIA to you.

4.8 If any sum of money shall be due from you to ARIA or any other government department, the same may be deducted from any sum due now or in future to you under this Agreement or any other agreement with ARIA or with any other Crown Body.

5. NOT USED

6. PROJECT REVIEW

6.1 ARIA will review the Project at the intervals specified in Schedule 2 Part 1. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.

6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:

- (a) consent to the Services and the Project continuing in line with existing plans;
- (b) increase or decrease the Approved Cost for the remainder of the Project Period, as applicable;
- (c) redefine the Milestones;
- (d) require you to carry out remedial activity with the aim of improving delivery of the Services; and/or
- (e) terminate the Agreement in accordance with clause 22.

6.3 Any change to these Agreement terms, Project Activities, or Approved Cost pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Agreement in accordance with clause 26.

7. MONITORING AND REPORTING

7.1 NOT USED

7.2 ARIA will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project against the specifications detailed in Schedule 2 Part 1. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.

7.3 You must provide ARIA with:

- (a) the Milestones and a report on your performance against them at the intervals and for the periods of time specified in Schedule 2 Part 1 and otherwise in compliance with the request of ARIA's Representative and shall detail all Data, methods, Results and

provisional conclusions together with management information and any other information relating to the Project;

- (b) verbal or written reports and ad hoc meetings or discussions as reasonably required by ARIA on any aspect of the Project; and.
- (c) a quarterly report on your use of the Approved Costs, with details broken down in accordance with ARIA's prescribed form.

7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its Project activities and compliance with the terms of the Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time after the end of the Project about any commercial exploitation or other dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Agreement.

8. AUDITING AND ASSURANCE

- 8.1 You must provide supporting evidence as ARIA may reasonably require to prove that you have used the Approved Costs to carry out the Project and provide the Services in accordance with Schedule 2. The supporting evidence shall clearly identify all Project and associated overhead costs. You shall maintain proper financial records relating to the Project at all times during the Project Period and for a period of seven years after the end of the Project Period.
- 8.2 Subject to clause 11, ARIA and/or its authorised representative or any statutory or regulatory auditors may, at any time during the Project Period and for up to 7 years after the end of the Project Period, conduct audits in relation to your financial records for the Project and your compliance with this Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.

9. FINANCIAL MANAGEMENT

- 9.1 You must:
- (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Project; and
 - (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project as soon as they are identified, and keep ARIA informed of your remedial actions.
- 9.2 In the event of any actual or suspected fraud, theft or other financial irregularity ARIA may, at its absolute discretion:
- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or

(b) suspend the Project and future Milestone Payments to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

10.1 You must inform ARIA promptly of any actual, perceived or potential conflict of interest between your and your Representatives obligations under the Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Project Period.

10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that they are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you to cease the conflicting activity and if that is not acceptable to you, either party may terminate this Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the Project, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.

11.2 ARIA may publish a summary of this Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.

11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:

- (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;
- (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information that is necessary for the purpose concerned and obtains appropriate confidentiality undertakings in relation to such information;
- (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and to the extent that no exception to disclosure under them is applicable; or

- (d) where ARIA (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.

11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under this Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

12.1 Each party must comply with its obligations under the Law, including where applicable, the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.

12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.

12.3 You acknowledge that ARIA, acting in accordance with the codes of practice issued and revised from time to time under the Information Acts (other than the FOIA), may disclose information concerning you and this Agreement without consulting you. ARIA must notify you of any request for information to the extent that it is permissible and reasonably practical for it to do so and will give you adequate opportunity to make representations to ARIA before it discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.

12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or this Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.

12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.

12.6 You must take account of the account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.

- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with this Agreement. Where either party anticipates that the other will process any Personal Data on its behalf under this Agreement it must notify the other party and the parties must agree a variation to this Agreement to incorporate appropriate provisions (such as those set out in Schedule 3) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. NOT USED

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and not seek to avoid their application by artificial means.

Background IP

- 15.2 This Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Term if any additional Background IP is required either to carry out the Project Activities or to exploit commercially any of the Results.

Foreground IP ownership and licensing

- 15.3 Subject to Clauses 15.4 and 16.2, the Foreground IP shall belong to you and:
- (a) you hereby grant to ARIA a royalty-free non-exclusive licence to use the Foreground IP for internal non-commercial purposes in ARIA's programmes; and
 - (b) you will cooperate with ARIA to facilitate collaborations and future licensing arrangements with Third Parties, including by participating in confidential discussions with ARIA and other Third Parties participating in ARIA's programme, in order to develop and commercialise the Foreground IP, subject to an appropriate agreement being in place with the Third Party. The foregoing shall not require you to enter into any agreement with, or license the Foreground IP to, any Third Party.
- 15.4 Where you assign or grant an exclusive or sole license the Foreground IP to a Third Party, you must impose on that Third Party all of the obligations set out in clause 15 and 16.
- 15.5 You must submit all (i) all patents within or covering the Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the Future Proofing our Climate and Weather Intellectual Property Pledge promptly following creation or filing (as applicable) of such patents and/or data (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge. You hereby agree to comply and uphold the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.6 You must ensure that whenever any Results are used with or communicated to Third Parties or are exploited commercially, ARIA's funding of the Project is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and Publication

- 15.7 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.8 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.9 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to request the assignment of the patents to ARIA or its nominee.

16. COMMERCIALISATION OF FOREGROUND IP AND RESULTS

- 16.1 Save for Results that are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge, where they are capable of exploitation you should use all reasonable endeavours to exploit the Results. This should be done in accordance with the Commercialisation Hypothesis.
- 16.2 Save for Results that are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge, if for any reason you choose not to exploit any such Results within a reasonable timeframe (or, where applicable, the timeframe set out in the Commercialisation Hypothesis) you are encouraged to discuss the position with ARIA, and you may request that ARIA exploit them or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Non-UK Commercialisation

- 16.3 A royalty of 0.25% of your Net Sales which use or incorporate Foreground IP shall be payable to ARIA if you are incorporated outside of the United Kingdom (the "**ARIA Non-UK Fee**"). For the avoidance of doubt, the ARIA Non-UK Fee shall be calculated solely in respect of the share of the Net Sales which corresponds to the value resulting directly from the Foreground IP.
- 16.4 The ARIA Non-UK Fee shall be payable within 90 days following the end of each relevant calendar year, for a period of ten (10) years from the First Sale Date, up to an aggregate total equal to 20 times the Approved Cost.
- 16.5 In the event that:
- (a) there is a change of control of the Foreground IP, such that you assign or grant an exclusive licence to the Foreground IP to another person; or

- (b) you extend rights to the Foreground IP within your Group, such that you grant another entity within your Group a licence to the Foreground IP,

then,
- (c) you must notify ARIA immediately; and
- (d) include clauses 16.3 to 16.5 in the relevant instrument and ensure that it expressly provides that the provisions are intended to be enforceable by ARIA by virtue of the Contracts (Rights of Third Parties) Act 1999 (or any equivalent in any jurisdiction) and take any other step required to ensure that the ARIA Non-UK Fee is payable by the transferee or licensee (as applicable).

16.6 For the avoidance of doubt, in respect of:

- (a) clause 16.5(a), provided that you have complied with clause 16.5(d), your obligation to pay the ARIA Non-UK Fee shall cease and pass to the transferee or licensee (until, in the case of an exclusive licence, the termination or expiry of such licence); and
- (b) clause 16.5(d) the transferee or licensee shall only be liable to pay the ARIA Non-UK Fee to ARIA for the remainder of the aggregated total amount and the ten (10) year period specified in clause 16.4 prorated from the date of the relevant instrument.

Assignment of IP

16.7 You must, on written request by ARIA, promptly assign any Foreground IP to ARIA (or to a Third Party nominated by ARIA) if you do not:

- (a) undertake further research and development work in respect of that Foreground IP; or
- (b) commercially exploit (and you are not using reasonable endeavours to commercially exploit) that Foreground IP,

within eight years of its creation, and each party shall bear its own costs in relation to any such assignment.

Pricing for Crown Body customers

16.8 You must ensure that any Crown Body is able to procure, in a reasonable timeframe and in suitable quantities for its requirements, any products and services that are covered by, use or incorporate the relevant Foreground IP:

- (a) at the Crown Discount price until the total Crown Discount given to all Crown Bodies equals two times the Approved Cost; and
- (b) thereafter at the Most Favoured Nation Price; and

you must provide details of the yearly amount of Crown Discount being provided to ARIA within 90 days after the end of each calendar year. You must use reasonable endeavours to reach the total set out in clause 16.9(a) within 10 years after the first sale to a Crown Body.

17. ASSETS

17.1 You must take all practical steps to purchase all materials and equipment at a fair and reasonable price and provide invoices issued to you for assets purchased in connection with the Project as part of the Approved Cost.

17.2 At the end of the Project Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUB-CONTRACTING

19.1 You may not, transfer, assign, novate or otherwise dispose of the whole or any part of the Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.

19.2 You may only subcontract any of the Services or Project Activities except to the extent permitted, and to the Sub-Contractors identified, in Schedule 2, Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractors as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Agreement.

20. NOT USED

21. PUBLICITY

21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Project and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Project or publicise details of the Agreement without the other's consent, except as required by Law.

21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events (**Events of Default**) occur:

- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13 or 25, or commit a material breach of any other term of this Agreement in the reasonable opinion of ARIA;

- (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
- (c) you fail to improve the performance of the Project Activities, notwithstanding your having undertaken the remedial activity agreed with ARIA under clause 6.2;
- (d) you provide ARIA with any materially misleading or inaccurate information in the specification for the Project as detailed in Schedule 2 or in subsequent related correspondence;
- (e) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Sub-Contractor, immediately upon becoming aware of it;
- (f) you are subject to an Insolvency Event;
- (g) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project;
 - (ii) result in your being unable to undertake the Project; and/or
 - (iii) raise national security concerns.

Rights reserved for ARIA in relation to an Event of Default

- 22.2 If an Event of Default has or may have occurred, ARIA may by written notice to you take any one or more of the following actions:
- (a) suspend the Project and the payment of the whole or any part of Milestone Payments for such period as ARIA may determine, acting reasonably;
 - (b) reduce the Approved Cost, in which case the Milestone Payments will thereafter be made in accordance with the reduction and notified to you; and/or
 - (c) subject to clause 22.4, terminate this Agreement with immediate effect as from the date of service of the notice of that termination.
- 22.3 Where this Agreement is terminated for an Event of Default that is or includes a Prohibited Act, ARIA may require you to repay the entire amount of the Milestone Payments previously paid to you.

Opportunity for you to remedy an Event of Default

- 22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:
- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and
 - (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.
- 22.5 Without prejudice to any other provision of the Agreement, you may terminate the Agreement on written notice to ARIA if ARIA commits a material breach of the Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so. Notwithstanding anything to the contrary in the Agreement, termination of the Agreement under this Clause 22.5 also results in the automatic termination of the licence granted to ARIA under Clause 15.3(a).

General Termination Rights

- 22.6 Without prejudice to any other provision of the Agreement, either party may terminate the Agreement at any time by giving at least 60 days' prior written notice to the other party.
- 22.7 Pursuant to clause 2.5, if ARIA is unwilling to accept a nominated successor(s) to Key Staff on it may terminate the Agreement by at least 30 days' written notice to you.

Consequences of Termination

- 22.8 Termination of this Agreement, however caused, shall not:
- (a) release either party from any duty or obligation of confidence which falls on such party or its servants, agents, employees or former employees under this Agreement or under the general law governing confidential information;
 - (b) prejudice or affect any rights, action or remedy which shall have accrued before termination or shall accrue thereafter to any party; or
 - (c) affect the continuing obligations of the parties under this Agreement.
- 22.9 If the Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.
- 22.10 Where ARIA terminates the Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:
- (a) you taking all reasonable steps to mitigate such loss; and
 - (b) the Unavoidable Costs being:
 - (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA; and
 - (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you.
 - (v) costs that would not have been incurred had this Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period);
- 22.11 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Services, over £250,000 will terminate automatically and immediately upon termination of this Agreement.
- 22.12 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Agreement in

the event that the Agreement was terminated (calculated on the basis described in clause 22.10).

- 22.13 ARIA's total liability under clause 22.10 shall be limited to the Maximum Approved Cost under the Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.14 If the Agreement is terminated or expires ARIA will not be liable to pay any of your costs (or those of any of your contractors or suppliers) related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Offer Letter, and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the ARIA Representative and the Contractor's Representative.
- 23.3 If the dispute cannot be resolved between the ARIA Representative and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to senior officers of the parties for resolution.
- 23.4 If within a further 10 Working Days after such meeting the dispute has not been resolved, the dispute may be referred, by either party, to mediation. The parties shall agree the mediator within 10 Working Days. The fee for the appointed mediator shall be shared equally between the parties.
- 23.5 Nothing in this Clause 23 shall preclude either party from commencing proceedings.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:
- (a) fraudulent misrepresentation or any other fraudulent act or omission;
 - (b) payment of sums properly due and owing to the other in the normal course of performance of this Agreement;
 - (c) a breach of clause 13;
 - (d) liability arising under any indemnity in this Agreement; or
 - (e) liability which may not lawfully be excluded or limited.
- 24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Agreement or for ARIA's breach of this Agreement), whether arising directly or indirectly, that may arise in connection with:
- (a) your carrying out the Project Activities;
 - (b) any reduction, suspension, withdrawal or request for repayment of the Approved Cost in accordance with this Agreement; or
 - (c) termination of the Agreement in accordance with this Agreement.

- 24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:
- (a) loss of profit, sales or turnover;
 - (b) loss of contracts or business opportunities;
 - (c) loss of anticipated savings;
 - (d) loss of goodwill or damage to reputation; or
 - (e) any indirect, special or consequential loss or damage;
- in each case arising out of or relating to this Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.
- 24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to this Agreement or its subject matter or anything which it has done or not done in connection with this Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the Approved Cost.
- 24.5 You shall indemnify and defend ARIA against all Losses (including but not limited to any direct, indirect or consequential losses, loss of profit, loss of reputation and all interest, penalties and reasonable legal costs (calculated on a full indemnity basis) and all other reasonable professional costs and expenses) suffered or incurred by ARIA arising out of or in connection with:
- (a) any claim brought against ARIA for actual or alleged infringement of a Third Party's intellectual property rights arising out of, or in connection with, the receipt, use or supply of the Services; and
 - (b) any claim made against ARIA by a Third Party arising out of, or in connection with, the supply of the Services,
- provided that the foregoing shall not apply to the extent that a claim arises as a result of ARIA's negligence or breach of this Agreement.
- 24.6 If ARIA receives a claim which falls within the scope of the indemnity at clause 24.5 (**Claim**), ARIA shall:
- (a) notify you without unreasonable delay in writing of the Claim;
 - (b) allow you, at your own cost, to conduct all negotiations and proceedings and to settle the Claim, always provided that you shall obtain ARIA's prior approval of any settlement terms, such approval not to be unreasonably withheld;
 - (c) provide you with such reasonable assistance regarding the Claim as is required by you, subject to reimbursement by you of ARIA's costs so incurred; and
 - (d) not, without prior consultation with you, make any admission relating to the Claim or attempt to settle it, provided that you consider and defend the Claim diligently, using competent counsel and in such a way so as not to bring the reputation of ARIA into disrepute.
- 24.7 You shall under no circumstances in connection with this Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.

24.8 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Agreement.

25. RESEARCH ETHICS AND INTEGRITY

25.1 Not Used

25.2 All research data:

- (a) must be generated using sound scientific techniques and processes;
- (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and
- (c) must be analysed appropriately, without bias and in accordance with good scientific practices.

25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.

25.4 You must comply with the Code of Conduct and ensure that your Staff undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

26.1 Any variation to this Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

26.2 You may request a variation to the Agreement or the Project at any time giving full details of the justification of the request and ARIA may agree to vary the Agreement or refuse the request and require the continuation of the Project in accordance with the Agreement.

27. GENERAL

27.1 **Force majeure:** Neither party shall be in breach of this Agreement nor liable for delay in performing, or failure to perform, any obligations under this Agreement to the extent such delay or failure result from events, circumstances or causes beyond its reasonable control. In such circumstances the affected party shall be entitled to a reasonable extension of the time for performing such obligations. If the period of delay or non-performance continues for 3 months, the party not affected may terminate this agreement by giving 30 days' written notice to the affected party.

27.2 **Notices:** All notices and other communications in relation to this Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all

such communications will be deemed to have been given and received on the third Working Day following such mailing.

- 27.3 **Change of control:** You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(g) is likely to apply.
- 27.4 **Severability:** If any provision of this Agreement is held invalid, illegal or unenforceable for any reason by any court of competent jurisdiction, such provision shall be severed and the remainder of the provisions shall continue in full force and effect as if this Agreement had been executed with the invalid provisions eliminated.
- 27.5 **Waiver:** The waiver by either party of any right or remedy in respect of any breach of any term or condition or requirement of this Agreement shall not prevent the subsequent enforcement and shall not be deemed to be a waiver of any right or remedy in respect of any subsequent breach.
- 27.6 **Relationships:** Nothing in this Agreement shall be construed as to make any party the employee, agent, partner or legal representative of the other party for any purpose whatsoever. No party is granted any right to assume or create any obligation or responsibility, expressed or implied, on behalf of or in the name of the other party. In fulfilling obligations pursuant to this Agreement, you will be acting as an independent contractor at arm's length from ARIA.
- 27.7 **Contracts (Rights of Third Parties) Act 1999:** A person who is not a party to this Agreement shall have no right to enforce any terms of it which confer a benefit on him.

28. GOVERNING LAW

This Agreement (including any non-contractual disputes or claims arising in connection with this Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. NOT USED

30. DEFINITIONS AND INTERPRETATION

- 30.1 As used in this Agreement the following terms and expressions shall have the meaning ascribed to them below:

Adequate Insurance means the insurance requirements and amounts set out in the Offer Letter;

Approved Cost means the total cost agreed between the parties for the Project as set out in Offer Letter, inclusive of VAT or other sales tax;

ARIA's Representative means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Project as set out in clause 2.1 of the Offer Letter;

Background IP means IP that is:

- (a) owned by or licensed to a party prior to the Commencement Date; or

(b) developed by or on behalf of a party during the Project Period but not in connection with the Project Activities,

and is in either case used in connection with the Project;

Bribery Act means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;

Change of Control means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Suppliers published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at https://assets.publishing.service.gov.uk/media/648c3ab5b32b9e000ca968c3/Supplier_Code_of_Conduct_v3.pdf, including any subsequent updates from time to time;

Commencement Date means the date set out in the Offer Letter;

Commercialisation Hypothesis means the exploitation plan set out in Schedule 2 Part 2, as may be amended by agreement between the parties during and after the Project Period;

Completion Date means the date set out in the Offer Letter;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Agreement, that ought reasonably to be considered to be confidential (whether or not it is so marked),

(a) including: (i) information relating to the business, affairs, customers, clients, suppliers or plans of the disclosing party; (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party; (iii) any information developed by the parties in the course of carrying out the Project Activities; (iv) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Agreement; and (v) and any information derived from any of the above,

(b) but not including information which: (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11); (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party; (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or (iv) is independently developed without access to the Confidential Information; and (v) the content of this specific version of the Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Contractor's Representative means a person authorised to represent you in respect of this Agreement and who shall have the authority to bind you in all matters under this Agreement as set out in clause 2.1 of the Offer Letter;

Crown or Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Crown Discount means the monetary value of the discount from the Most Favoured Nation Price given to a Crown Body;

Data means information collected and/or used for the purposes of the Project, which can be processed manually, electronically or by other means;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by

Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

EA means the Equality Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Offer Letter;

First Sale Date means the date on which you first bill an amount to a customer in respect of the sale of goods or services (or any other transaction) which use or incorporate Foreground IP;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means the Intellectual Property developed during and in connection with the Project;

Future Proofing our Climate and Weather Intellectual Property Pledge means [the pledging system for patents relating to approaches for actively cooling the earth operated by ARIA/a third party in the form at Annex A;

Gross Sales means total invoiced value of sales made during a specific period, including all amounts billed to customers such as from the sale of goods, services, licence income, royalty income, franchise fees, commissions, subscription fees, before any deductions;

Group in relation to a company, that company, any subsidiary or holding company from time to time of that company;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation.

Information Acts means the Data Protection Legislation and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property or IP means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions, semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Key Staff means the persons named in Schedule 2 Part 1;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation.

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise.

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

Milestone Payments means the payments made based on progress towards the Milestones as set out in Schedule 2 of this Agreement;

Most Favoured Nation Price means a price that is no higher than that offered to or agreed with any other customer for equivalent quantities of equivalent products or services;

Net Sales means Gross Sales after relevant accounting deductions, such as sales tax, packaging, insurance, carriage and freight, trade discounts and credits, returns and allowances, import taxes and similar applicable government levies;

Non-UK Entity means a legal entity that is not a UK Entity;

Personal Data has the meaning as defined in the Data Protection Act 2018 or successor legislation;

Prohibited Act means:

(a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for: (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Services; and/or (ii) showing or not showing favour or disfavour to any person in relation to the Agreement; or

(b) committing any offence: (i) under the Bribery Act; (ii) under legislation creating offences in respect of fraudulent acts; and/or (iii) at common law in respect of fraudulent acts in relation to this Agreement; and/or defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the scope specified in Schedule 2 Part 1;

Project Period means the period commencing on the Commencement Date and ending on the Completion Date or such later date as may be agreed between the parties unless otherwise determined in accordance with the terms of the Agreement;

Project Review means the process for reviewing the Project outlined in clause 6;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means any Data, reports or information or other material generated by the Project;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Services means the services being provided by you to enable fulfilment of the Project;

Staff means your Representative and all employees, consultants agents and Sub-Contractors which you engage in relation to the Project;

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Services or any part thereof or facilities or services necessary for the provision of the Services or any part thereof or necessary for the management, direction or control of the Services or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

UK Entity means a legal entity that has or whose ultimate parent company has, its headquarters and principal establishment in the United Kingdom;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Project Period because of termination or breach of the Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination; and

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 The interpretation and construction of the Agreement shall be subject to the following provisions:

- (a) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (b) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (c) the headings to Clauses are for ease of reference only and shall not affect the interpretation or construction of the Clauses;
- (d) references to Clauses are references to Clauses in the part of the Agreement (i.e. the Offer Letter or particular Schedule or Annex as the case may be) in which they appear, unless otherwise stated;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time; and
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation".

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

For the world to make evidence-based and equitable decisions about climate intervention, it must accelerate SRM (solar radiation modification) evaluation in the world's most climate vulnerable regions. Access to high-quality and relevant climate data is a prerequisite for the evaluation of SRM and its impacts in the Global South. Data provision is currently underwritten by the goodwill and volunteerism of experts in the Global North, but this approach is reaching its limits. The proposed project would fill this gap by initially performing global statistical downscaling on relevant climate data sets and then creating an accessible data repository housed at the University of Cape Town (UCT). The repository of downscaled data would constitute a public good that would enable much more accessible SRM analysis across the Global South.

The proposed project would then demonstrate the potential of the repository and the downscaled data. It would convene a consortium of SRM experts from Asia, Africa, the Americas and Europe to conduct a global modelling pilot study on key global and regional climate impacts, with particular attention to potential regional tipping elements. Having single, authoritative, global studies on the impacts of SRM on key processes and sectors would be invaluable for developing the necessary evidence base to inform proper debate.

This project is proposed by a coalition that is uniquely capable of delivering such an ambitious programme of work. The Degrees Initiative (UK) has singularly transformed the global SRM research environment, and the Degrees Modelling Fund is the largest SRM research programme in the world, supporting 26 SRM research projects in 22 developing countries and emerging economies. Project data provision and downscaling would be managed by leading SRM scientists from the University of Cape Town (South Africa) and Cornell University (USA), and the data repository would be managed at the University of Cape Town, which is already well set up to do this.

2. Aims and objectives of the Project Activities

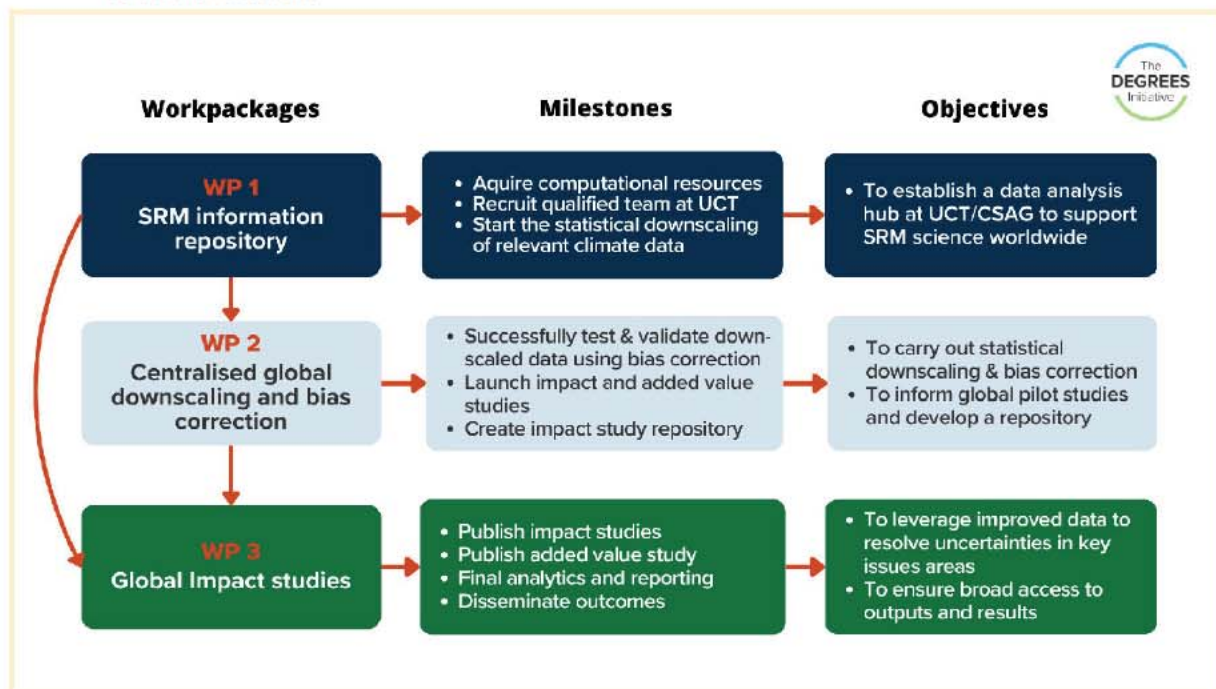
Overall aim:

To advance data accessibility and policy-relevant research on SRM, especially for vulnerable regions in the Global South, by building tools, data infrastructure, and international scientific collaborations necessary to evaluate SRM's potential impacts at regional scales.

Primary objectives:

- Enhance access to downscaled climate data for SRM research, focusing on regions most vulnerable to climate change, via a data analysis hub at UCT/CSAG.
- Establish a publicly accessible SRM data repository at UCT, enabling remote analysis without requiring local downloads.
- Improve global capacity for evaluating SRM impacts through downscaling and bias correction of key climate variables using advanced methodologies.

- Demonstrate the utility of downscaled data by coordinating a global pilot study modelling the regional impacts of SRM on policy-relevant sectors such as health, agriculture, water availability, and/or potential tipping points.
- Produce a structured, peer-reviewed repository of SRM impact studies to inform debate and further scientific research.



3. Project Activities

3.1 Work packages

You propose a project in three related work packages (WPs), all coordinated by the Degrees Initiative with partners from the USA and across the Global South. The first two WPs would conduct statistical downscaling and bias correction of key global SRM modelling datasets and create a repository for SRM research output. Together, these WPs would improve global access to regional-scale data, provide a foundation for modelling SRM impacts and reduce barriers to research, especially in the Global South. Scientists would be empowered to more easily and accurately understand how SRM might impact their regions which would act as an “output multiplier” for more and better SRM research around the world.

The third WP would convene a global consortium of scientists to produce a study modelling the effects of SRM on key policy-relevant climate impacts, such as health, agriculture or water availability, with additional attention to potential tipping elements. These would demonstrate the potential of downscaled data while producing new, policy-relevant science.

WP 1 – SRM information repository

You propose to create a repository of SRM research data and research output housed at the University of Cape Town and managed by a dedicated data technician. This repository will serve as an online, remote data analysis tool that does not require the user to download the data locally, e.g. a Jupyter Hub; a catalogue of all SRM research papers to provide access to a knowledge base often unavailable to researchers at institutions unable to pay article costs; and provide a structured platform to support the

broader SRM community. Establishing the hub would represent a public good that acts as an “output multiplier” for SRM evaluation, enabling better and more accessible SRM research worldwide. One post-doctoral researcher will be employed at UCT over years 2 and 3 to support the creation of a repository of SRM research data, and to carry out the technical work in WP3.

WP 2 - Centralised global downscaling and bias correction

This work package will complete a statistical downscaling and bias correction of global climate data using a range of methodologies that have already been employed for future projections of climate change, and that will make the evaluation of the local impacts of SRM more reliable, robust and accessible in conjunction with WP1. The downscaling and bias correction methodologies may include, depending on feasibility, quality of the products, as well as the team’s capacity, Ensemble Generalised Analog Regression Downscaling (En-GARD), bias-correction spatial disaggregation (BCSD, as used in the ISIMIP and NASA-NEX-GDDP-CMIP6 projects) and Multivariate Adapted Constructed Analogs (MACA), as well as new potential machine-learning driven methods of downscaling. Most SD methods downscale only rainfall and temperature. However, this proposal aims to improve existing downscaled products, and you will explore the possibility to downscale also other variables such as wind, humidity, and incoming solar radiation, which are required by many impact models, including those for agriculture, health, and renewable energy.

It will leverage current climate model outputs, including the new GeoMIP simulations, which are part of CMIP7 and the ARISE and GAUSS ensembles. The team will employ two post-doctoral researchers, one at UCT who will assist with the downscaling and the other at Cornell University to perform the downscaling based on GeoMIP data. Additionally, the project will provide funding for workshops to educate scientists about the use and limitations of downscaled outputs. The repository mentioned in WP1 will be used to share these outputs globally. The constant engagement with the Degrees Initiative’s community will ensure that the downscaled and bias-corrected data can be validated in the regions that matter most, providing a “reality-check” that will allow for a robust, trustworthy product.

WP 3 - Global impacts studies

Degrees will convene a global scientific consortium, with members from Africa, Asia, and South and Central America to conduct a modelling study on important impacts of global warming. Possible initial impact studies would include agriculture and food security, water security, extreme heat and heat exposure, health (climate-borne diseases and heat exposure) and biodiversity with additional attention to potential tipping elements. Such impact studies are reliant on downscaled and bias-corrected climate data, as opposed to the large-scale direct GCM output, to better capture the regionalised and local impacts of changes in temperature and hydrology that are context-dependent (i.e. they might depend on orography in a way that is not captured at the global scale), and therefore will greatly benefit from the output of WP2, which will provide a communal framework for worldwide impact assessments. These studies would represent a significant advancement in global SRM evaluation, offering an unprecedented level of granularity because of the downscaling and bias correction conducted in this project. The same post-doctoral researcher that was mentioned in WP1 will be employed at UCT to conduct the research for years 2 and 3 of the project, as the downscaled data will be produced during year 1. Having demonstrated what is possible and its impact on SRM evaluation, you would then seek further funding from other sources to continue studies on additional impacts. As such, any ARIA funding would leverage additional external funding.

Year 1 - Laying foundations and establishing infrastructure

1. Establish a data analysis hub at UCT/CSAG (Months 1 - 6)
 - a. Procure computational hardware for the Climate Systems Analysis Group at the University of Cape Town.
 - b. Install and configure hardware to create a high-performance hub for data analysis, processing and hosting.
 - c. Recruit a qualified technician to support the CSAG analysis hub.
 - d. Hire one post-doctoral research fellow specialising in statistical downscaling and data accessibility.
 - e. Begin the downscaling and secure transfer of relevant datasets to UCT.
2. Begin statistical downscaling (Months 6 - 12):
 - a. Complete statistical downscaling of relevant data sets.
 - b. Testing and validation of initial results.

Year 2: Data processing and regional output development

1. Complete statistical downscaling (Months 1-4):
 - a. Finalise downscaling of datasets and validate outputs for accuracy and reliability using bias-correction.
2. Enhance data accessibility (Months 1-12):
 - a. Ensure the centre maintains high quality downscaled data for key regions including Southeast Asia, Latin America and the Caribbean, South Asia, and Africa.
 - b. Ensuring the centre's data, including the research repository, is easily accessible.
3. Global pilot study (Months 1-12):
 - a. Design and execute a pilot study focusing on a specific climate variable (e.g., precipitation trends or temperature variability) or sector (e.g. agriculture, health, water availability).
4. Create impact study repository (Months 6-12):
 - a. Collect and curate 50 impact studies to begin building the SRM research repository.
5. Data access and usage analytics (Months 3-12):
 - a. Establish tracking systems to monitor data access and usage.
6. Added value study (Months 6-12):
 - a. Begin the analysis to quantify added value the downscaling brings over the raw GCM-scale data. Work closely with CORDEX in this study as they have similar questions.

Year 3: Expansion, validation, and delivery

4. Maintain high-quality regional datasets (Months 1-12):

- 4.1 Ensure datasets are continually updated, refined, and validated for priority regions.
- 4.2 Collaborate with international partners to address emerging research needs.

5. Complete impact study repository (Months 1-8):

5.1 Expand the repository to contain 100 rigorously reviewed impact studies, accessible via the research hub.

6. Complete global impact studies (Months 8-12):

6.1 Complete analysis on chosen impact studies for write up in an international journal.

7. Complete added value study (Months 6-12):

7.1 Complete analysis of added value for write up in an international journal.

8. Final analytics and reporting (Months 8-12):

8.1 Analyse and report on data usage, identifying trends and areas for improvement.

8.2 Develop a comprehensive project report summarising achievements, lessons learned, and recommendations for future initiatives.

9. Dissemination and stakeholder engagement (Months 6-12):

9.1 Host workshops and webinars to share project findings and outputs.

9.2 Engage with stakeholders to identify future collaborative opportunities and funding sources

9.3 The following Milestones will be used to monitor your delivery of the Project. The costs associated with completing these Milestones are estimated in the [REDACTED]

ID	Milestones	Measure	Date
1	WP1: Cape Town Hub (x1) fully operational and repository of initial datasets loaded.	Hardware installed at UCT, software tested and operational including Jupyter hub, and datasets loaded e.g. geoMIP data.	Commencement Date + 10 months
2	WP2: Workshop run on use and limitations of downscaled outputs.	Workshop educates at least 20 scientists on how to use downscaled outputs. Suggestions and engagement info collated from users and synthesized into action items.	Commencement Date + 12 months
3	WP3: Consortium	A consortium of SRM experts from Asia, Africa, the Americas and Europe formed, agrees on a	Commencement Date + 12 months

	research topic chosen	research topic that will use the outputs of WP1 and WP2 to explore an impact of global warming, and delivers a short scoping report outlining rationale for topic selection.	
4	WP2: Completion of statistical downscaling for selected global datasets.	*insert measure here* Final validation and bias-correction of datasets completed. Initial draft of paper outlining results, including comparison across different downscaling methods, differences between large scale and downscaled data and outcomes of bias corrections.	Commencement Date + 14 months
5	WP1: Impact study of repository completed	Monitoring report on repository usage complete on e.g. number of users, terabytes added, hours spent on system, CPU hours run, where users are located and whether they are a continuing or new entrant to the field. The aim is to have between 4 and 12 user teams in year 2. Feedback on the system will be collected in a Degrees meeting.	Commencement Date + 16 months
6	WP3: Commencement of pilot studies	Four separate two year agreements signed between Degrees and institutions of consortium members to work on the research topic chosen in milestone 3.	Commencement Date +16 months
7	WP2: Validation that key regions are using the repository.	At least four key Global South regions (Southeast Asia, Latin America, South Asia, Africa) datasets are available and are being used by researchers.	Commencement Date + 24 months
8	WP2: Value of downscaled data shown.	Submission of an “added-value” analysis publication to an international, indexed, and peer-reviewed journal demonstrating improvements of downscaled data over raw GCM data.	Commencement Date + 36 months

9	WP3: Results from studies using repository are published.	At least four scientific papers accepted in international, indexed, and peer-reviewed journals and a synthesis report published. <i>Data related to published papers uploaded to open-access ARIA repository.</i>	Commencement Date + 36 months

In addition to the above Milestones, the following project plan will be used to track progress throughout the project and may be updated from time to time: [REDACTED]

10. **Project Reporting requirements**

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement
Planning	• Roles and responsibilities • External communications • Vision • Project details • Code and data management • Project plan + project management
Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Key Learning, discoveries and decisions • Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • Invoicing and cost reporting Optional: • technical evidence saved to drive e.g. report or presentation as requested by PD • review meeting slide deck saved to drive as requested by PD
Annual	• ARIA impact metrics • Attendance at annual ARIA event

Ad hoc	- As required, Programme Director/ Programme Team may request additional information and evidence - Workshops - potential to be invited to ARIA workshops
Project closure	Project closure report

11. **Payment**

11.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments quarterly in arrears.

For quarterly payments, the cadence of payments will align with ARIAs financial year beginning 1st April e.g Quarter 1 Grant Claims will be for the period of 1st April to 30 June, Quarter 2 Grant Claims will be for the period of 1st July to 30 Sept and so on.

11.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

11.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end of the relevant period.

11.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

12. **Principal investigator/key researchers**

12.1 For the purposes of clause 22.7, the following principle investigators or key researchers have been identified:

Name	Role	Organisation
Andy Parker	Principal Investigator	The Degrees Initiative
Prof. Babatunde Abiodun	WP2 lead	University of Cape Town
Dr Christopher Lennard	WP1 lead	University of Cape Town
Dr Daniele Visioni	Cornell lead	Cornell University

13. **Sub-Contractors**

13.1 For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Location
University of Cape Town, Climate Systems Analysis Group	This is the location for the setup, installation and future management of the hardware in work package one, with the creation of an accessible data repository that will be housed at the University of Cape Town (UCT)	South Africa
University of Cape Town, Environmental & Geographical Science department	Work package two, global statistical downscaling on relevant climate data sets will be performed by this group at University of Cape Town (UCT)	South Africa
Cornell University	Project data provision and downscaling at UCT would be supported by leading SRM scientists from Cornell University (USA)	USA
TBC scientists	Per work package 3 – a consortium of scientists will be working on the global impact study	Global North countries (including UK) & Global South countries (non-UK)

PART 2: APPLICATION FORM

Application titled 'Global to Local Impacts of SRM Project (GLISP)' submitted 9 December 2024.

SCHEDULE 3: Data Protection

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Agreement:
 - 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are relying on Domestic Law as the basis for processing Personal Data, you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;
 - 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of

Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);

- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Agreement unless required by Domestic Law to store the Personal Data; and
- 3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.

- 3.4. [ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an

opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):

- 3.4.1. cancel its plans to change the affected sub-Processor;
- 3.4.2. offer an alternative which is acceptable to ARIA; or
- 3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.

3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.

3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]

3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it, storing it, retrieving it, consulting it, disseminating it or destroying it, etc. Note the definition of processing in the UK GDPR: "any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction"]
Duration of Processing:	Duration of this Agreement (and any post termination processing that is permitted / required).

Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called “special categories” of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: “data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation”]
Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors, clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. You shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.
- 4.2. Any limitation of liability set out in this Agreement will not apply to this Schedule’s indemnity or reimbursement obligations.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

1. Submission of Pledged Patents and Experimental Data
 - 1.1 The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
 - 1.2 The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.
2. Experimental Data Licence
 - 2.1 Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
 - 2.2 The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
 - 2.3 The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
 - 2.4 The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).
3. Research Licence
 - 3.1 Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
 - 3.2 The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
 - 3.3 Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

- 3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.
- 3.5 The Research Licensee must:
- (a) at all times when using the Pledged Patents comply with all Laws; and
 - (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).
4. Commercial Licence
- 4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.
- 4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.
- 4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.
5. Pledgor Know-How
- At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.
6. Termination
- 6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:
- (a) materially breaches the terms of such licence or this Pledge; or
 - (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).
7. Transfers of Pledged Patents and/or Experimental Data
- The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.
8. No Warranty
- The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and
Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

The University of Leeds (**Grant Recipient**)

School of Earth and Environment

University of Leeds

Woodhouse Lane

LS2 9JT

24 June 2025

Attention: Thomas Whale

Dear Thomas

FPCW-PR01-P005– Ice Nucleating Particles in the Upper Troposphere: Advancing Cirrus Control and Experimental Science Strength “INPUT:ACCESS” – **Standard Grant Funding Letter**

Congratulations, we can’t wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to ARIA’s Exploring Climate Cooling call and ARIA is pleased to offer you a Grant for the performance of the Project Activities up to the Maximum Sum, subject to your agreement to, and compliance with, the terms and conditions set out in this Grant Funding Letter and its Schedules.

1. Overview of the Grant

Any reference in this letter to “you” or “your” means the Grant Recipient and any capitalised terms have the meanings given in the ARIA Grant Conditions (Conditions).

The key elements of the Grant are described in the table below:

Project Activities	Ice-Nucleating Particles in the Upper Troposphere: Advancing Cirrus Control and Experimental Science Strength “INPUT:ACCESS” A more detailed description of the Project Activities is set out in Schedule 2 (Project Activities).
Maximum Sum of the Grant (inclusive of taxes)	£1,305,879 (inclusive of all taxes where applicable)
Commencement Date	24 June 2025

Completion Date	23 June 2028	
Grant Review Intervals	ARIA will review the Grant at quarterly intervals using the process referred to in clause 6 of the Conditions	
Adequate Insurance	Employers' liability - At least £5 million (as required by the Employers' Liability (Compulsory Insurance Act 1969)) Public liability: £5 million (per year in aggregate)	
Monitoring and Reporting	The performance reports referred to in clause 7 of the Conditions shall be provided at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Project Representative	Thomas Whale [REDACTED]	
Grant Manager	Mark Symes, Programme Director, [REDACTED]	
Escalation Contacts	ARIA	Grant Recipient
	Chief Product Officer [REDACTED]	[REDACTED], Interim Head of School of Earth and Environment, [REDACTED]
Notices	ARIA Contracts [REDACTED]	Lynne Nelson, SEE Postaward Team, [REDACTED]

2. Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Grant and return it to finance@aria.org.uk

3. The Grant Agreement

- 3.1. Once you sign a copy of this Grant Funding Letter in accordance with paragraph 6 (Acceptance) below, it will form a binding "**Grant Agreement**" between you and ARIA that includes and incorporates the following documents:

- 3.1.1. the **Grant Conditions** in Schedule 1;

3.1.2. the **Project Activities, Milestones** and **Grant Application** in Schedule 2;

3.1.3. the **Royalty percentages** (including annexes) in Schedule 3; and

3.1.4. the terms relating to Data Protection in Schedule 4.

3.2. The parties confirm that it is their intention to be legally bound by the Grant Agreement.

3.3. Not used

4. Warranties

4.1. By signing this Grant Funding Letter, you warrant and represent that:

4.1.1. your obligations under the Grant Agreement are legal, valid, binding and enforceable;

4.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Grant Agreement have been obtained;

4.1.3. the person signing the Grant Agreement is duly authorised to sign on your behalf; and

4.1.4. your Project Representative referenced in the table above is authorised to make decisions and provide information on your behalf.

5. Amendments to the Grant Conditions

NOT USED

6. Acceptance

6.1. To accept this Grant Funding Letter, please arrange for an authorised signatory to sign and date the duplicate copy of this Grant Funding Letter as indicated below, and return to ARIA as a complete signed original of the Grant Agreement including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Grant Agreement and to bind the Grant Recipient.

6.2. The offer of this Grant Funding Letter will expire on 26 June 2025.

Yours sincerely

for and on behalf of ARIA

Name of ARIA signatory:

Position Held:

Date:

I confirm the agreement of The University of Leeds to the terms and conditions in this Grant Funding Letter and its Schedules.

Signature:

Name:

Position:

Date:

SCHEDULE 1 - GRANT CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up the Grant Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Grant Funding Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to the Grant Agreement with the exception of Schedule 2 Part 2 (the Grant Application);
 - (d) Schedule 2 Part 2 (the Grant Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, the Grant Agreement.

2. DURATION AND PURPOSE OF THE GRANT

- 2.1 The Grant Agreement will subsist for the duration of the Funding Period unless extended by written agreement signed by a duly authorised representative of the parties or terminated earlier in accordance with its terms. Any provision of the Grant Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Grant Agreement shall remain in full force and effect, including clauses 1, 2, 4, 7.4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.3, 22.7, 22.8, 22.11, 22.12, 23, 24, 26, 27, 28, and 30.
- 2.2 You may only use the Grant for carrying out the Project Activities. You may not make any changes to the Project Activities without ARIA's prior written agreement.
- 2.3 You may not unreasonably withhold, condition or delay your agreement to any changes requested by ARIA to the Project Activities or the amount of the Grant. Any agreed change will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

3. ENVIRONMENTAL AND SAFETY REQUIREMENTS

- 3.1 In performing the Project Activities, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. PAYMENT OF GRANT

- 4.1 Subject to the remainder of this clause 4, ARIA will pay the Grant to you:
- (a) up to the Maximum Sum;
 - (b) in pounds sterling (GBP) by wire transfer into your bank account, details of which you provided in the Confirmation of Bank Details form attached to the Grant Funding Letter; and
 - (c) if a tax is chargeable in respect of the Grant, all payments will be deemed to be inclusive of all such taxes and ARIA will not be obliged to pay any additional amount.

- 4.2 The bank account of which you provided details in your Confirmation of Bank Details form (and any alternative bank details nominated subsequently by you) must be an ordinary business bank account with appropriate segregation of duties and control. During the Funding Period, you must notify ARIA of any change of bank account details as soon as reasonably practicable on the same form and signed by an approved signatory. You must notify ARIA of any change of signatory for approval, as soon as known.
- 4.3 You will be the sole recipient of the Grant and you will be responsible for managing the Grant as between you and any Third Parties involved in performing the Project Activities. This includes securing the repayment of the Grant if requested by ARIA in accordance with the Grant Conditions, including where the Grant has already been distributed to Third Parties.
- 4.4 You must promptly notify ARIA if any money is incorrectly paid to you for any reason, and must repay it as soon as reasonably practicable. Any amount not immediately repaid will be recoverable as a civil debt.
- 4.5 ARIA reserves the right not to pay any Grant Claims that are not submitted within the period set out in the Grant Funding Letter or that are incomplete, incorrect or not accompanied by full supporting documentation (including any documentation that ARIA reasonably requests).
- 4.6 You may not apply for or obtain Duplicate Funding for any Project Activities.
- 4.7 You may not retain any Unspent Monies and must repay them to ARIA within 30 days after ARIA's request for repayment.
- 4.8 You acknowledge the critical importance of cash flow for Sub-Contractors (including startups and small businesses) and commit to paying all valid and undisputed invoices relating to the Project within a maximum of 30 days from the date of receipt.
- 4.9 Where required, you will work with Sub-Contractors to arrange more frequent payment schedules (e.g., same day, weekly or milestone-based payments) to better support their cash flow needs.

5. ELIGIBLE AND INELIGIBLE EXPENDITURE

- 5.1 ARIA will only pay the Grant for Eligible Expenditure incurred by you in carrying out the Project Activities. You must provide ARIA with any evidence reasonably requested by ARIA (including receipts, invoices and other documentary evidence) that all Grant Claims relate to costs that are Eligible Expenditure.
- 5.2 You may not in any circumstance claim as Eligible Expenditure paid-for lobbying, which means using the Grant to fund lobbying (via an external firm or in-house staff) in order to undertake activities intended to influence or attempt to influence Parliament, government or political activity; or attempting to influence legislative or regulatory action.

6. GRANT REVIEW

- 6.1 ARIA will review the Grant at the intervals specified in the Grant Funding Letter. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.3.
- 6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:
- (a) consent to the Project Activities and the Grant Agreement continuing in line with existing plans;
 - (b) increase or decrease the Grant for the remainder of the Funding Period, as applicable;
 - (c) redefine the Milestones;
 - (d) require you to carry out remedial activity with the aim of improving delivery of the Project Activities; and/or
 - (e) terminate the Grant Agreement in accordance with clause 22.
- 6.3 Any change to these Grant Terms, the Project Activities, or the Grant pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Grant Agreement in accordance with clause 26.
- 6.4 For the avoidance of doubt any decision to terminate the Grant Agreement as a result of a Go/No Go Milestone will be made at ARIA's sole discretion and done so in accordance with clause 22.6.

7. MONITORING AND REPORTING

- 7.1 You must closely monitor the carrying out of the Project Activities throughout the Funding Period and must notify ARIA as soon as reasonably practicable of any actual or potential failure to comply with any of your obligations under the Grant Agreement.
- 7.2 ARIA does not limit its engagement with you to purely administrative activities and will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project Activities. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.
- 7.3 You must provide ARIA with:
- (a) the Milestones and a report on your performance against the Milestones at the intervals and for the periods of time specified in the Grant Funding Letter. ARIA may copy and adapt the contents of any of the Milestones and those reports for ARIA's internal use to review, develop and shape ARIA's funded research programmes, but ARIA will treat those contents as your Confidential Information under clause 11;

- (b) any assistance and information reasonably requested by ARIA to establish whether you have used the Grant in accordance with the Grant Agreement; and
- (c) a quarterly report on the use of the Maximum Sum, details broken down in accordance with ARIA's prescribed form.

7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its funding activities and compliance with the terms of the Grant Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time after the end of the Funding Period about the impact metrics, commercial exploitation or other dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Grant Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Grant Agreement.

8. AUDITING AND ASSURANCE

- 8.1 Within six months after the end of each Financial Year and after the end of the Funding Period you must provide ARIA with assurance that the Grant has been used for carrying out the Project Activities. To satisfy this requirement you must provide a statement signed by a senior finance individual within your organisation showing that the Grant has been used for carrying out the Project Activities.
- 8.2 Subject to clause 11, ARIA and/or its authorised representative may, at any time during the Funding Period and for up to 7 years after the end of the Funding Period, conduct audits in relation to your use of the Grant and your compliance with the Grant Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.
- 8.3 You must:
 - (a) maintain an appropriate system of financial management and controls, maintain detailed records in relation to those controls, and provide copies of those records to ARIA on request; and
 - (b) retain, and procure that your Sub-Contractors retain and will provide to you on request, all relevant documentation relating to the Eligible Expenditure (including invoices, receipts and accounting records) during the Funding Period and for a period of 7 years thereafter.

9. FINANCIAL MANAGEMENT

- 9.1 You must:
 - (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Grant; and

- (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project Activities as soon as they are identified, and keep ARIA informed of your remedial actions.

9.2 In the event of any actual or suspected fraud, theft or other financial irregularity (which includes use of the Grant for any purpose other than that envisaged by the Grant Agreement), ARIA may, at its absolute discretion:

- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
- (b) suspend the Project Activities and future payment of the Grant to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

10.1 You must inform ARIA promptly of any actual, perceived or potential conflicts between your and your Representatives' obligations under the Grant Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Funding Period.

10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that these conflicts are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you or your Representative to cease the conflicting activity and if that is not acceptable to you or your Representative, either party may terminate the Grant Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the provision of the Project Activities, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.

11.2 ARIA may publish a summary of the Grant Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Grant Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.

- 11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:
- (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;
 - (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information necessary for the purpose concerned and obtains appropriate confidentiality undertakings in relation to such information;
 - (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and where no exception to disclosure under them is applicable; or
 - (d) where that party (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.
- 11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under the Grant Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

- 12.1 Each party must comply with its obligations under the Law, including where applicable the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.
- 12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.
- 12.3 You acknowledge that ARIA, acting in accordance with the Information Acts (other than the FOIA), may disclose information concerning you and the Grant Agreement without consulting you. ARIA must take reasonable steps to notify you of any request for information to the extent permissible and reasonably practical and will give you adequate opportunity to make representations before ARIA discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.
- 12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or the Grant Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.
- 12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or

licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.

- 12.6 You must take account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

- 13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.
- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with the Grant Agreement. If either party anticipates that the other will process any Personal Data on its behalf under the Grant Agreement it must notify the other party and the parties must agree a variation to the Grant Agreement under clause 26 to incorporate appropriate provisions (such as those set out in Schedule 4) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. SUBSIDY CONTROL AND STATE AID

- 14.1 ARIA intends that the Grant complies with the Subsidy Control Act 2022 on the basis that the Project Activities are not economic activities and do not give a specific advantage to one or more enterprises. You must take all reasonable steps to maintain this position and to assist ARIA to comply with the requirements of the Act and must cooperate with any investigations under the Act.
- 14.2 Where the EU state aid laws apply to the Grant (where the Project Activities will affect trade between Northern Ireland and the EU), you acknowledge that the Project Activities are designed and performed so they are compatible with state aid laws. You will take all reasonable steps to assist ARIA to comply with state aid law requirements and cooperate with any investigations by the European Commission into the Project Activities.
- 14.3 ARIA will immediately stop future payments of the Grant and may require repayment of some or all of the Grant if subsidy control or state aid laws so require for the funding to be compliant.

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and not seek to avoid their application by artificial means.

Background IP

- 15.2 The Grant Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Funding Period if any additional Background IP is required either to carry out the Project Activities or to exploit commercially any of the Results.

Foreground IP ownership

- 15.3 You will own all Foreground IP unless your policy is for individual researchers to own the Foreground IP they create, or you agree your Sub-Contractor (or another third party) will own all, or parts of, the Foreground IP. Where your Sub-Contractor or individual researchers (or any other third party involved in the performance of the Project Activities) will own any of the Foreground IP you must impose on them the obligations relating to Foreground IP and Results contained in clauses 15 and 16. Where you assign any Foreground IP to a Third Party (including your technology transfer company) you must impose on that Third Party the obligations relating to Foreground IP and Results contained in clauses 15 and 16.
- 15.4 You must submit all (i) all patents within or covering the Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the Future Proofing our Climate and Weather Intellectual Property Pledge promptly following creation or filing (as applicable) of such patents and/or data (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge. You hereby agree to comply and uphold the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.5 You must ensure that whenever any Results are used with or communicated to Third Parties or are exploited commercially, ARIA's funding of the Project Activities is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and publication

- 15.6 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.7 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.8 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to fund future prosecution and maintenance and/or request the assignment of the patents to ARIA or its nominee.

Inventor first preference

- 15.9 Subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge if any inventor or active participant in the Project Activities expresses interest in the exploitation of the Foreground IP they have developed, you must give them an opportunity to negotiate an assignment or

commercial licence of the Foreground IP, on reasonable terms, prior to negotiating with any entity in which an inventor or active participant in the Project Activities is not involved as a shareholder or other key stakeholder.

16. COMMERCIALISATION OF RESULTS

- 16.1 Save for Results that are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge, where they are capable of commercial exploitation you should seek to exploit the Results commercially. This should be done, where applicable, in accordance with the Commercialisation Hypothesis.
- 16.2 Save for Results that are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge, if for any reason you choose not to exploit any such Results commercially within a reasonable timeframe (or, where applicable, the timeframe set out in the Commercialisation Hypothesis) you are encouraged to discuss the position with ARIA, and you may request that ARIA exploit them or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Non-UK Commercialisation

- 16.3 Save as set out in the Future Proofing our Climate and Weather Intellectual Property Pledge, to avoid any restriction on commercialisation, no consent is required from ARIA for any Non-UK commercialisation or any sale of Foreground IP to a Non-UK Entity. However, ARIA is set up to create value for the UK and therefore you must secure a fee payable to ARIA (**ARIA Non-UK Fee**) in each of the following circumstances:
- (a) where you are a Non-UK Entity;
 - (b) where you become a Non-UK Entity;
 - (c) where you assign or Commercially License any Foreground IP to a Non-UK Entity; or
 - (d) where you have assigned or Commercially Licensed any Foreground IP to a UK Entity that subsequently becomes a Non-UK Entity.
- 16.4 In order to avoid any unnecessary complexity, the ARIA Non-UK Fee will be based on the terms that you agree with any person to which you assign or Commercially License the relevant Foreground IP. This ARIA Non-UK Fee will amount to an additional twenty-five per cent (25%) of the value of the consideration (including upfronts, licence fees, milestone payments, royalties, shares or other securities, buyouts, exit fees and other consideration) that you receive from the exploitation of the relevant Foreground IP during any period that the above circumstances exist.
- 16.5 For example, if you would receive £100 (via royalty or royalty buyout), you must ensure your contractual mechanism enables you to collect an additional £25 and pay that additional amount to ARIA.
- 16.6 The ARIA Non-UK Fee is payable within 90 days after the end of each relevant Financial Year for receipts related to that calendar year. You are encouraged to use the clauses in Annex 1 in your Commercialisation Licences of Foreground IP.

Crown Body customers

- 16.7 You must ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities, and in suitable quantities for the Crown Body's requirements.

Spin-outs

- 16.8 ARIA seeks to maximise future investment of entrepreneurial talent and capital in start-up companies commercialising the Results of its funded activities. To that end, having funded the full economic cost of the research, ARIA places restrictions on the level of equity stakes and royalties that you may negotiate in exchange for the assignment or Commercialisation Licence of any Foreground IP.
- 16.9 If you or your technology transfer company assign or licence any Foreground IP to any third party or to a start-up established for the purpose of commercially exploiting the Results (a NewCo) you together with any connected person (including any investment fund to which you may transfer any part of your stake) shall be entitled to:

EITHER

- (a) hold or have the right to hold no more than 10% in fully-dilutable shares or equity (pre investment) in the third party or NewCo (with no other preferential subscription rights), not including any shares or equity subscribed for cash on arm's length terms alongside other investors;

OR

- (b) charge a royalty, with no upfront payments, annual fees, milestone payments or minimum royalties, payable by the third party or NewCo under any licence or assignment of the Foreground IP at no more than the relevant rate, and on the other terms, set out in Schedule 3.

- 16.10 The provisions of clauses 16.9(a) and 16.9(b) shall not apply to any equity taken or royalty charged in consideration of:

- (a) IP other than Foreground IP licensed or assigned to the third party or NewCo; or
(b) facilities, equipment, personnel or other material support or services provided to the third party or NewCo independent of the Project Activities,
with such equity or royalty limited to the proportion that reflects the contribution made by IP that is not Foreground IP.

- 16.11 You must notify ARIA in writing before any transaction completes of the overall equity stake or royalty percentages agreed under clause 16.8 (and any impact of clause 16.9, if relevant).

17. ASSETS

- 17.1 You must keep a register during the Funding Period and for up to 7 years after the end of the Funding Period of all Assets, with all relevant details about each Asset. You must use any Assets purchased with Grant monies for the Project Activities.
- 17.2 At the end of the Funding Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

- 18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Grant Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUBCONTRACTING

- 19.1 You may not transfer, assign, novate or otherwise dispose of the whole or any part of the Grant Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.
- 19.2 You shall not subcontract any of the Project Activities to a Third Party except to the extent permitted, and to the person or persons identified, in Schedule 2 Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractor as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Grant Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Grant Agreement.

20. BORROWING, LOSSES, GIFTS, SPECIAL PAYMENTS

- 20.1 You must obtain ARIA's prior written consent before:
- (a) borrowing or lending money from any source in connection with the Grant Agreement;
 - (b) giving any guarantee, indemnity, security over any Asset or letter of comfort in relation to the Grant Agreement;
 - (c) making any gift or writing off any debt or liability in connection with the Grant, and must keep a record of all gifts given and received in connection with the Grant.

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Grant and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Grant or publicise details of the Grant Agreement without the other's consent, except as required by Law.

- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

- 22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events occur:

- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13, 15.5 or 25, or commit a material breach of any other term of the Grant Agreement in the reasonable opinion of ARIA;
- (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
- (c) you fail to improve the performance of the Project Activities, notwithstanding your having undertaken the remedial activity agreed with ARIA in the remedial plan under clause 6.2(d);
- (d) you or the researchers involved in the Project Activities obtain any funding from a Third Party that, in the opinion of ARIA, undertakes activities that are likely to bring the reputation of the Project Activities or ARIA into disrepute;
- (e) you provide ARIA with any materially misleading or inaccurate information in your grant application or in subsequent related correspondence;
- (f) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Third Party, immediately upon becoming aware of it;
- (g) you are subject to an Insolvency Event;
- (h) the Grant or any part of it is held by a court or competent authority to be a prohibited subsidy under the Subsidy Control Act 2022 or an illegal state aid;
- (i) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project Activities;
 - (ii) result in your being unable to receive the Grant; and/or
 - (iii) raises national security concerns.

Rights reserved for ARIA in relation to an Event of Default

- 22.2 If an Event of Default has or may have occurred, ARIA may by written notice to you take any one or more of the following actions:

- (a) suspend the Project Activities and payment of the whole or any part of the Grant for such period as ARIA may determine, acting reasonably;
- (b) reduce the Maximum Sum, in which case the payment of Grant will thereafter be made in accordance with the reduction and notified to you; and/or
- (c) subject to clause 22.4, terminate the Grant Agreement with immediate effect as from the date of service of the notice of that termination.

- 22.3 Where this Grant Agreement is terminated for an Event of Default described in clause 22.1(f) or 22.1(h), ARIA may require you to repay the entire amount of the Grant previously paid to you.

Opportunity for you to remedy an Event of Default

- 22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:
- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and
 - (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

- 22.5 Without prejudice to any other provision of the Grant Agreement, you may terminate the Grant Agreement on written notice to ARIA if ARIA commits a material breach of the Grant Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

General Termination Rights

- 22.6 Notwithstanding ARIA's right to terminate the Grant Agreement under clause 22.2(c), either party may terminate the Grant Agreement (in whole or in part) at any time by giving at least 60 days' prior written notice to the other party.
- 22.7 You must promptly notify ARIA in writing if at any time the principal investigator or any key researcher(s) named in Schedule 2 working on the Project Activities is unable or unwilling to continue to be involved in the Project Activities or is moving to a new organisation without the desire to continue the research. Within 60 days after the date of that notice, you must either:
- (a) nominate one or more successors, subject to ARIA's approval; or
 - (b) agree that the Grant is transferred to another organisation subject to your and the new organisation's agreement in writing and ARIA's approval of the transfer

If ARIA is unwilling to accept the nominated successor(s) or does not approve a request for transfer, it may terminate the Grant Agreement by at least 30 days' written notice to you.

Consequences of Termination

- 22.8 If the Grant Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.
- 22.9 Where ARIA terminates the Grant Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:
- (a) you taking all reasonable steps to mitigate such loss; and
 - (b) the Unavoidable Costs being:

- (i) proven, reasonable, and not capable of avoidance or recovery;
- (ii) incurred under arrangements or agreements that are directly associated with this Grant Agreement;
- (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA;
- (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you;
- (v) costs that would not have been incurred had this Grant Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period).

- 22.10 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Services, over £250,000 will terminate automatically and immediately upon termination of this Agreement.
- 22.11 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Grant Agreement in the event that the Grant Agreement was terminated (calculated on the basis described in clause 22.8).
- 22.12 ARIA's total liability under clause 22.9 shall be limited to the Maximum Sum under the Grant Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.13 If the Grant Agreement is terminated or expires ARIA will not be liable to pay any of your costs or those of any of your contractors or suppliers related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Grant Funding Letter and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Grant Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Grant Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the Grant Manager and the Project Representative.
- 23.3 If the dispute cannot be resolved between the Grant Manager and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to a formal meeting between the parties' Escalation Contacts.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:
- (a) fraudulent misrepresentation or any other fraudulent act or omission;
 - (b) payment of sums properly due and owing to the other in the normal course of performance of this Grant Agreement;
 - (c) a breach of clause 13;
 - (d) liability arising under any indemnity in this Grant Agreement; or
 - (e) liability which may not lawfully be excluded or limited.
- 24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Grant Agreement or for ARIA's breach of this Grant Agreement), whether arising directly or indirectly, that may arise in connection with:
- (a) your carrying out the Project Activities;
 - (b) the use of the Grant by any person;
 - (c) any reduction, suspension, withdrawal or request for repayment of the Grant in accordance with this Grant Agreement; or
 - (d) termination of the Grant Agreement in accordance with this Grant Agreement.
- 24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:
- (a) loss of profit, sales or turnover;
 - (b) loss of contracts or business opportunities;
 - (c) loss of anticipated savings;
 - (d) loss of goodwill or damage to reputation; or
 - (e) any indirect, special or consequential loss or damage;
- in each case arising out of or relating to the Grant Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.
- 24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to the Grant Agreement or its subject matter or anything which it has done or not done in connection with the Grant Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the amount of the Maximum Sum.
- 24.5 You shall under no circumstances in connection with this Grant Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.
- 24.6 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Grant Agreement.

25. RESEARCH ETHICS AND CODE OF CONDUCT

- 25.1 As a recipient of a Government grant you must operate in accordance with the Concordat.
- 25.2 All research data:
- (a) must be generated using sound scientific techniques and processes;
 - (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and
 - (c) must be analysed appropriately, without bias and in accordance with good scientific practices.
- 25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.
- 25.4 You must comply with the Code of Conduct and ensure that your Representatives undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

- 26.1 Any variation to the Grant Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

27. GENERAL

- 27.1 Notices: All notices and other communications in relation to this Grant Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such communications will be deemed to have been given and received on the third Working Day following such mailing.
- 27.2 Change of control: You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(i) is likely to apply.

28. GOVERNING LAW

- 28.1 This Grant Agreement (including any non-contractual disputes or claims arising in connection with this Grant Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. Not used

30. DEFINITIONS AND INTERPRETATION

30.1 Where they appear in these Conditions or the Grant Agreement:

Adequate Insurance means the insurance requirements and amounts set out in the Grant Funding Letter.

Asset means any asset that is purchased, improved or developed using the Grant including equipment and fixed assets;

Background IP means IP that is:

(a) owned by or licensed to a party prior to the Commencement Date; or

(b) developed by or on behalf of a party during the Funding Period but not in connection with the Project Activities,

and is in either case used in connection with the Project Activities;

Bribery Act means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;

Change of Control means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Recipients of Government General Grants published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754555/2018-11-06_Code_of_Conduct_for_Grant_Recipients.pdf

including any subsequent updates from time to time;

Commencement Date means the date set out in the Grant Funding Letter;

Commercialisation Licence means a licence of IP other than a research or evaluation licence and/or subcontract manufacture (and **Commercially License** means to license under a Commercialisation Licence);

Commercialisation Hypothesis means the exploitation plan approved by ARIA and set out at Schedule 2 Part 2, as may be amended by agreement between the parties during and after the Funding Period;

Completion Date means the date set out in the Grant Funding Letter;

Concordat means the Concordat to Support Research Integrity which can be found at <https://ukrio.org/about-us/the-concordat-to-support-research-integrity/>

Conditions means these ARIA Grant Conditions;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Grant Agreement, that ought reasonably to be considered to be confidential (whether or not it is so marked), (a) including: (i) information relating to the business, affairs, customers, clients, suppliers or plans of the disclosing party; (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party; (iii) any information developed by the parties in the course of carrying out the Project Activities; (iv) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Grant Agreement; and (v) and any information derived from any of the above,

(b) but not including information which: (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11); (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party; (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or (iv) is independently developed without access to the Confidential Information; and (v) the content of this specific version of the Grant Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

Duplicate Funding means funding provided to you by a Third Party which is to fund the same activities as the Project Activities;

EA means the Equality Act 2000 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Eligible Expenditure means the payments made by you during the Funding Period for the purposes of carrying out the Project Activities which comply with clause 5 and ARIA's published eligibility rules (which provide for full economic cost reimbursement) and as agreed in the Grant Funding Letter;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Grant Funding Letter;

Event of Default means any of the events or circumstances set out in clause 22.1;

Financial Year means 1 April to 31 March;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means any IP in the Results;

Funding Period means the period commencing on the Commencement Date and ending on the Completion Date or such later date as may be agreed between the parties unless otherwise determined in accordance with the terms of the Grant Agreement;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification (operated by ARIA or by a third party), in the form set out at Annex A.

GDPR means Regulation (EU) 2016/679;

Go/No-Go Milestone means a decision point for ARIA to determine whether it wishes to proceed with or terminate the Project Activities (any decision regarding a Go/No-Go Milestone will be made at ARIA's sole discretion, following a Grant Review as outlined in Clause 6);

Grant means the sum or sums ARIA will pay to you up to the amount set out in the Grant Funding Letter, in accordance with clause 4 and subject to the provisions set out at clause 22.

Grant Agreement has the meaning given in the Grant Funding Letter;

Grant Claim means a request submitted by you to ARIA for payment of the Grant;

Grant Funding Letter means the letter from ARIA to you to which these Conditions are annexed;

Grant Manager means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Grant;

Grant Review means the process for reviewing the grant outlined in clause 6;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Ineligible Expenditure means expenditure incurred by you which is not Eligible Expenditure as set out in clause 5 and ARIA's published eligibility rules;

Information Acts means the Data Protection Legislation, FOIA and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property Rights or **IP** means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions, semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation;

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise;

Maximum Sum means the maximum amount of the Grant stated in the Grant Funding Letter;

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

NewCo has the meaning given in clause 16;

Non-UK Entity means a legal entity that is not a UK Entity;

Personal Data has the meaning given to it in the Data Protection Legislation as amended from time to time;

Prohibited Act means:

(a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Grant Agreement; and/or (ii) showing or not showing favour or disfavour to any person in relation to the Grant Agreement;

(b) committing any offence: (i) under the Bribery Act; (ii) under legislation creating offences in respect of fraudulent acts; and/or (iii) at common law in respect of fraudulent acts in relation to the Grant Agreement; and/or

(c) defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the activities to be carried out by you that are described in the Grant Funding Letter and in Schedule 2 Part 1;

Project Representative means the representative appointed by you, who at the Commencement Date will be the individual listed as such in the Grant Funding Letter;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means all information, data, techniques, inventions, discoveries, works, software and materials generated in the course of the Project Activities;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Project Activities or any part thereof or facilities or services necessary for the performance of the Project Activities or any part thereof or necessary for the management, direction or control of the Project Activities or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

UK Entity means a legal entity whose ultimate parent company has its headquarters and principal establishment in the United Kingdom;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Grant Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Funding Period because of termination or breach of the Grant Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination; and

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 In these Conditions and the Grant Agreement, unless the context otherwise requires:

- (a) references to "party" and "parties" are to the parties to the Grant Agreement;
- (b) the singular includes the plural and vice versa;
- (c) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (d) references to clauses and Schedules are to the clauses of these Conditions and to the Schedules to the Grant Agreement;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;

- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation"; and
- (g) the headings in the Grant Agreement are for ease of reference only and will not affect the interpretation or construction of the Grant Agreement.

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

Cirrus processes are one of the largest sources of uncertainty in surface temperature response to climate change, and central to several intervention ideas. Hence, in situ measurements are needed to assess specific drivers of ice nucleation in cirrus. You will address this need by combining expertise in 1) balloon-borne measurements, 2) ice nucleating particle (INP) measurements, and 3) cirrus modelling. Your proposed efforts will enable us to advance both the measurement technology and the understanding of ice processes and parameters relevant to cirrus interventions. You will launch small weather balloons with novel instrumentation to collect ice nucleating particles from the cirrus regime, analyse them under laboratory recreations of cirrus conditions, and port your findings to improve model assessment of cirrus intervention impacts. These capabilities, which have never previously been achieved, will dramatically change the landscape of cirrus-relevant research. If large-scale outdoor testing ever occurs in regard to related cirrus climate interventions, then the balloon payload and analysis techniques developed in this proposal will be essential for monitoring. Climate intervention via manipulating upper troposphere cirrus may provide significant surface cooling; this study will allow more accurate evaluation of potential cirrus cloud related interventions.

2. Aims and objectives of the Project Activities

1. Develop ability to collect INP from cirrus regions using weather-balloon borne instruments
2. Develop off-line analyses of INP relevant to cirrus processes
3. Develop in situ measurements of cirrus ice crystals via weather-balloon borne instruments
4. Apply these technological advances to measurements of upper troposphere ice INP concentrations in the mid-latitudes
5. Apply your observations to advance modelling of cirrus-relevant climate cooling strategies.

3. Project Activities

3.1 1) **Develop a balloon-borne electrostatic precipitator (ESP):** (from CD+0 to CD+12, Led by NOAA). Develop the technology necessary to collect INP from cirrus regimes onto substrates for off-line analysis. To do this you will build an electrostatic precipitator (ESP) capable of operating in the low pressures, temperatures and humidities of the upper troposphere with low weight and power requirements

2) **Develop methods for transporting slides carrying collected aerosol particles:** (from CD+6 to CD+12, Led by UoL). This will allow slides containing aerosol collected from the upper troposphere (UT) to be sent from Boulder to Leeds for INP measurements without contamination. This technology will also be vital for prospective large-scale application of offline INP measurements in the UT.

3) **Design and construct an isothermal diffusion chamber (IDC) for offline INP measurements in cirrus conditions:** (from CD+0 to CD+12, Led by UoL). The instrument will be

based on the FRIDGE IDC built by Goethe University Frankfurt, but adapted to work at lower temperatures by using a smaller working substrate and coating materials known to allow cirrus conditions to be accessed. The University of Leeds team will coordinate with the NOAA team on slide geometry and coating to ensure compatibility of the IDC with the ESP.

4) Develop approach for using scanning electron microscopy and energy dispersive spectroscopy (SEM-EDX) to assess composition of INP collected from the UT (From CD+9 to CD+15, Led by UoL). UoL will adapt an existing approach for visualisation and compositional analysis of aerosol collected on filters to allow analysis of aerosol collected on slides by the ESP.

5) Develop the In situ Balloon-borne Ice Spectrometer (IBIS) for in-situ measurement of ice crystal sizes in cirrus clouds. (From CD+0 to CD+12, Led by NOAA-CSL). A prototype of IBIS exists and has been shown to resolve particles to below 3 μm diameter, a requirement for detecting tropical tropopause layer (TTL) cirrus and more than adequate in the mid-latitudes. This instrument will be developed and finalised to allow it to be used on balloon launches in concert with the ESP. For collection of INP, IBIS will only need to work as a cirrus discriminator.

6) Conduct balloon launches (location TBC) carrying the ESP, IBIS and appropriate equipment for measuring water vapour concentration. (From CD+12 to CD+24, Led by NOAA-CSL). You will conduct 10 balloon launches to collect cirrus-regime INP with timings informed by the modelling efforts described in activity 8. Launch timing will be optimized based on transport model forecasting coupled with initialization via GPS-radio occultation temperature measurements. Modeling work from Imperial College London (activity 8) will help with these forecasts.

7) Measure INP concentrations of balloon-collected samples using the IDC (From CD+12 to CD+30, Led by UoL). Slides containing aerosol collected from the UT will be sent from NOAA-CSL to UoL, where the IDC will be used to measure INP concentrations. After INP concentrations and spatial locations on slides are determined, SEM-EDX will be used to assess the morphology and composition of the INPs, with a view to identifying the INPs present in the UT.

8) Data analysis activities (From CD+24 to CD+36, joint activity between all partners). All project partners will work together to combine the INP concentrations, ice crystal numbers and water vapour (WV) concentrations determined from balloon flights into a data product suitable for use by the research community. This data will be uploaded on <http://archive.researchdata.leeds.ac.uk/> and a paper describing it published in an appropriate journal, as well as being uploaded to a central ARIA data repository.

8) Modelling activities (From CD+0 to CD+36, led by Imperial College). Global cirrus frequency and properties will be generated using an ensemble of conventional runs of the Community Earth System Model Version 2 (CESM2) climate model (Year 1), which will in turn be used to inform launch timing (Year 2). The output from these runs will be compared to the INPUT:ACCESS observations, with the goal of generating statistical corrections (Year 3). These will in turn be used to assess the degree to which efficacy of different climate cooling approaches might have been historically over- or under-estimated. Results from the “De-risking Cirrus Modification” ARIA proposal will also be incorporated into this effort.

9) Dissemination activities (CD+12 to CD+36, joint activity between all partners). You will aim to write up work for publication as soon as possible. Your publication strategy will naturally depend to

a large extent on your findings so is subject to change. This said, you expect to publish one or more papers describing the IDC, ESP, and IBIS and their use for determining cirrus INP concentrations. In addition to public uploads of datasets from balloon flights you intended to write a paper describing the datasets. Finally, you expect to write a paper constituting an updated assessment of cirrus modification climate cooling feasibility in light of your field measurements. This may be a joint publication with the “De-risking Cirrus Modification” team, using data from that project.

3.2 The following Milestones will be used to monitor your delivery of the Project. The costs associated with completing these Milestones are estimated in the [REDACTED]

ID	Milestones	Measure	Date
1	Balloon launch plan agreed	Evidence supplied that launches are compliant with local regulations	Commencement Date
2	First flights to evaluate IBIS performance	IBIS returns housekeeping data on light source stability, air flow rate, swinging and detector stability from one or more balloon experiments.	Commencement Date + 6 months
3	Initial proof of concept for the electrostatic precipitator (or INP collector with similar function) obtained	Particles collected onto slides by collector prototype on a balloon flight. Slides recovered from UT demonstrated to carry aerosol particles by light microscopy.	Commencement Date + 12 months
4	IDC demonstrated to be able to access conditions necessary for assessment of cirrus condition INP concentrations This is a Go/No go milestone	Clean slides of type to be used in the ESP shown not to stimulate ice formation in the IDC until a RH_i (relative humidity with respect to ice) of 140% is reached below 240 K. Test aerosols shown to nucleate ice crystals in the IDC.	Commencement Date + 18 months
5	First balloon launches made to UT with all INPUT:ACCESS instruments carried, successful measurements and aerosol collections made	WV and ice crystal number datasets retrieved from balloon flights concurrently with ESP collection of aerosol particles	Commencement date + 18 months
6	Capability to measure cirrus condition INP	INP concentration datasets from UT produced and available to project team	Commencement date +24 months

	concentrations on slides collected from UT demonstrated		
7	First complete, analysed datasets comprising INP concentrations, ice crystal number, WV concentration from balloon launches obtained and placed in publicly accessible database, demonstrating viability of the technology developed for UT INP measurements.	Datasets uploaded to http://archive.researchdata.leeds.ac.uk/ as well as being uploaded to a central ARIA data repository.	Commencement date +30 months
8	Completion of INPUT@ACCESS research program	Descriptions of ESP and IDC either submitted for publication or uploaded to http://archive.researchdata.leeds.ac.uk/ as well as being uploaded to a central ARIA data repository.	Commencement date +36 months

In addition to the above Milestones, the following project plan will be used to track progress throughout the project and may be updated from time to time: [REDACTED]

3.3 The intended long-term outcomes are summarised below:

The capability to collect INPs from the cirrus regime currently does not exist. Through this project, you will develop the technology required for routine monitoring of UT INP concentrations and to make your collected dataset of INP concentration and character publicly available. This will better constrain the feasibility and potential efficacy + impacts of interventions in cirrus.

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement

Planning	• Roles and responsibilities • External communications • Vision • Project details • Code and data management • Project plan + project management
Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Key Learning, discoveries and decisions • Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • Invoicing and cost reporting Optional: • technical evidence saved to drive e.g. report or presentation as requested by PD • review meeting slide deck saved to drive as requested by PD
Annual	• ARIA impact metrics • Attendance at annual ARIA event
Ad hoc	• As required, Programme Director/ Programme Team may request additional information and evidence • Workshops - potential to be invited to ARIA workshops
Project closure	• Project closure report

5. Payment

5.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments quarterly in arrears.

For quarterly payments, the cadence of payments will align with ARIAs financial year beginning 1st April e.g. Quarter 1 Grant Claims will be for the period of 1st April to 30 June, Quarter 2 Grant Claims will be for the period of 1st July to 30 Sept and so on.

5.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried

out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

5.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end of the relevant period.

5.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

6. Principal investigator/key researchers

6.1 For the purposes of clause 22.7, the following principle investigators or key researchers have been identified:

Name	Role	Organisation
Dr Thomas Whale	PI and co-lead researcher	University of Leeds
[REDACTED]	Co-Investigator	University of Leeds

7. Sub-Contractors

7.1 For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Location
CIRES	Co-lead researcher, coordinator of INPUT-ACCESS research activities at NOAA-CSL	Colorado, USA
Imperial College London	Earth systems modelling support for INPUT:ACCESS	London, UK

PART 2 - GRANT APPLICATION

Application titled "Ice-Nucleating Particles in the Upper Troposphere: Advancing Cirrus Control and Experimental Science Strength "INPUT:ACCESS" submitted 8 December 2024

Commercialisation Hypothesis submitted as part of the above referenced application 8 December 2024.

SCHEDULE 3

Royalty Percentages

Royalties on the sale or supply of products or services that are covered by, use or incorporate the Foreground IP licensed to the NewCo will only become due on aggregate net sales derived from the Foreground IP exceeding £50 million.

The maximum headline percentage royalty rate (i.e. before any royalty stacking, step-down or other reduction and excluding any ARIA Non-UK Fee) for products or services that are covered by, use or incorporate the Foreground IP, and of sublicensing income, shall be one of the following:

Type of product	Applicable headline royalty percentage (up to)
Low margin	0.5% of net sales
Medium margin	1% of net sales
High margin	2% of net sales
Sublicensing royalty	10% of net receipts

ANNEX 1

Clause for inclusion in licences of Foreground IP

[] **ARIA NON-UK FEE**

[].1 In this clause:

"ARIA" means the Advanced Research and Invention Agency;

"Crown Body" means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

"UK Entity" means a legal entity that has or whose ultimate parent company has its headquarters and principal establishment in the United Kingdom.

[].2 The Foreground IP was developed with funding from ARIA. As a condition of its funding ARIA requires that a benefit is returned to the United Kingdom where the Foreground IP is licensed by the Licensor to any person that is not a UK Entity. Accordingly, in addition to any other sums payable by the Licensee to the Licensor under this Agreement, the Licensee shall pay to the Licensor within 90 days after the end of each calendar year during the Relevant Period (as defined below), and within 90 days after the end of the Relevant Period, a fee (**ARIA Non-UK Fee**) on all amounts (including upfronts, licence fees, milestone payments, royalties, shares or other securities, exit fees, buyout or other consideration) payable by the Licensee to the Licensor under this Agreement in relation to the exploitation of any Foreground IP (**Relevant Amount**) that accrues during, or relates to, any period of time that the Licensee is not a UK Entity (**Relevant Period**). The amount of the ARIA Non-UK Fee is 25% of the Relevant Amount, and is payable by the Licensee to the Licensor in addition to the amounts that would otherwise be payable under this Agreement. For example if the Relevant Amount is £100 the ARIA Non-UK Fee is an additional £25, which the Licensee shall pay to the Licensor and the Licensor shall remit to ARIA.

Crown Body customers

[].3 You must also ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities and in suitable quantities for the Crown Body's requirements.

[].4 ARIA shall have the right to enforce this clause [] under the Contracts (Rights of Third Parties) Act 1999. Neither party may amend this Agreement in a way that detracts from ARIA's right to enforce its rights under this clause without ARIA's prior written consent.

[1] When using this clause you may substitute the relevant defined terms used elsewhere in the agreement to capture the concept of "Foreground IP". Where the clause refers to the "Licensor" and "Licensee" please use the appropriate defined terms to include the licensor, licensee, assignor and assignee of the Foreground IP. This clause is not suitable for assignments of the Foreground IP in consideration of the payment of one or more lump sum payments. In those cases the Licensor needs to be informed, and potentially make an additional payment, if the Foreground IP is subsequently assigned to a non-UK Entity or if the Assignee ceases to be a UK Entity.

SCHEDULE 4: Data Protection

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Grant Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Grant Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Grant Agreement:
- 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are

relying on Domestic Law as the basis for processing Personal Data, you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;

- 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);
- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Grant Agreement unless required by Domestic Law to store the Personal Data; and

3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.

3.4. [[ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):

3.4.1. cancel its plans to change the affected sub-Processor;

3.4.2. offer an alternative which is acceptable to ARIA; or

3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.

3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Grant Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.

3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]

3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Grant agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it,

	storing it, retrieving it, consulting it, disseminating it or destroying it, etc. Note the definition of processing in the UK GDPR: <i>“any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction”</i>]
Duration of Processing:	Duration of this Grant Agreement (and any post termination processing that is permitted / required).
Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called “special categories” of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: <i>“data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person's sex life or sexual orientation”</i>]

Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors, clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. You shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.
- 4.2. Any limitation of liability set out in this Grant Agreement will not apply to this Schedule's indemnity or reimbursement obligations.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

1. Submission of Pledged Patents and Experimental Data

- 1.1 The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
- 1.2 The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.

2. Experimental Data Licence

- 2.1 Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
- 2.2 The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
- 2.3 The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
- 2.4 The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).

3. Research Licence

- 3.1 Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
- 3.2 The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
- 3.3 Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

- 3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.
- 3.5 The Research Licensee must:
- (a) at all times when using the Pledged Patents comply with all Laws; and
 - (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).

4. Commercial Licence

- 4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.
- 4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.
- 4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.

5. Pledgor Know-How

At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.

6. Termination

- 6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:
- (a) materially breaches the terms of such licence or this Pledge; or
 - (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).

7. Transfers of Pledged Patents and/or Experimental Data

The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.

8. No Warranty

The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and
Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

University of Bristol (**Grant Recipient**)

Wills Memorial Building

Queens Road

Clifton

Bristol, BS8 1RJ

30 May 2025

Attention: Professor Matthew Watson

Dear Matthew,

FPCW-PR01-P006- Monitoring Aerosol Climate Engineering (MACE) – **Standard Grant Funding Letter**

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to Exploring Climate Cooling and ARIA is pleased to offer you a Grant for the performance of the Project Activities up to the Maximum Sum, subject to your agreement to, and compliance with, the terms and conditions set out in this Grant Funding Letter and its Schedules.

1. Overview of the Grant

Any reference in this letter to "you" or "your" means the Grant Recipient and any capitalised terms have the meanings given in the ARIA Grant Conditions (Conditions).

The key elements of the Grant are described in the table below:

Project Activities	Monitoring Aerosol Climate Engineering (MACE). A more detailed description of the Project Activities is set out in Schedule 2 (Project Activities).
Maximum Sum of the Grant (inclusive of taxes)	£4,257,144 (inclusive of all taxes where applicable)
Commencement Date	The commencement date is 1 June 2025
Completion Date	The completion is 31 May 2029

		Copy to:

2. Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Grant and return it to finance@aria.org.uk

3. The Grant Agreement

- 3.1. Once you sign a copy of this Grant Funding Letter in accordance with paragraph 6 (Acceptance) below, it will form a binding "**Grant Agreement**" between you and ARIA that includes and incorporates the following documents:

- 3.1.1. the **Grant Conditions** in Schedule 1;
- 3.1.2. the **Project Activities, Milestones** and **Grant Application** in Schedule 2;
- 3.1.3. the **Royalty percentages** (including annexes) in Schedule 3; and
- 3.1.4. the terms relating to Data Protection in Schedule 4.

- 3.2. The parties confirm that it is their intention to be legally bound by the Grant Agreement.

4. Warranties

- 4.1. By signing this Grant Funding Letter, you warrant and represent that:
- 4.1.1. your obligations under the Grant Agreement are legal, valid, binding and enforceable;
 - 4.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Grant Agreement have been obtained;
 - 4.1.3. the person signing the Grant Agreement is duly authorised to sign on your behalf; and
 - 4.1.4. your Project Representative referenced in the table above is authorised to make decisions and provide information on your behalf.

5. Amendments to the Grant Conditions

- 5.1. Not used.

6. Acceptance

- 6.1. To accept this Grant Funding Letter, please arrange for an authorised signatory to sign and date

the duplicate copy of this Grant Funding Letter as indicated below, and return to ARIA as a complete signed original of the Grant Agreement including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Grant Agreement and to bind the Grant Recipient.

6.2. The offer of this Grant Funding Letter will expire on 01 June 2025.

Yours sincerely

for and on behalf of ARIA

Name of ARIA signatory:

Position Held:

Date:

I confirm the agreement of the University of Bristol to the terms and conditions in this Grant Funding Letter and its Schedules.

Signature:

Name:

Position:

Date:

SCHEDULE 1 - GRANT CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up the Grant Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Grant Funding Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to the Grant Agreement with the exception of Schedule 2 Part 2 (the Grant Application);
 - (d) Schedule 2 Part 2 (the Grant Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, the Grant Agreement.

2. DURATION AND PURPOSE OF THE GRANT

- 2.1 The Grant Agreement will subsist for the duration of the Funding Period unless extended by written agreement signed by a duly authorised representative of the parties or terminated earlier in accordance with its terms. Any provision of the Grant Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Grant Agreement shall remain in full force and effect, including clauses 1, 2, 4, 7.4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.3, 22.7, 22.8, 22.11, 22.12, 23, 24, 26, 27, 28, and 30.
- 2.2 You may only use the Grant for carrying out the Project Activities. You may not make any changes to the Project Activities without ARIA's prior written agreement.
- 2.3 You may not unreasonably withhold, condition or delay your agreement to any changes requested by ARIA to the Project Activities or the amount of the Grant. Any agreed change will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

3. ENVIRONMENTAL AND SAFETY REQUIREMENTS

- 3.1 In performing the Project Activities, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. PAYMENT OF GRANT

- 4.1 Subject to the remainder of this clause 4, ARIA will pay the Grant to you:
- (a) up to the Maximum Sum;
 - (b) in pounds sterling (GBP) by wire transfer into your bank account, details of which you provided in the Confirmation of Bank Details form attached to the Grant Funding Letter; and
 - (c) if a tax is chargeable in respect of the Grant, all payments will be deemed to be inclusive of all such taxes and ARIA will not be obliged to pay any additional amount.
- 4.2 The bank account of which you provided details in your Confirmation of Bank Details form (and any alternative bank details nominated subsequently by you) must be an ordinary business bank account

with appropriate segregation of duties and control. During the Funding Period, you must notify ARIA of any change of bank account details as soon as reasonably practicable on the same form and signed by an approved signatory. You must notify ARIA of any change of signatory for approval, as soon as known.

- 4.3 You will be the sole recipient of the Grant and you will be responsible for managing the Grant as between you and any Third Parties involved in performing the Project Activities. This includes securing the repayment of the Grant if requested by ARIA in accordance with the Grant Conditions, including where the Grant has already been distributed to Third Parties.
- 4.4 You must promptly notify ARIA if any money is incorrectly paid to you for any reason, and must repay it as soon as reasonably practicable. Any amount not immediately repaid will be recoverable as a civil debt.
- 4.5 ARIA reserves the right not to pay any Grant Claims that are not submitted within the period set out in the Grant Funding Letter or that are incomplete, incorrect or not accompanied by full supporting documentation (including any documentation that ARIA reasonably requests).
- 4.6 You may not apply for or obtain Duplicate Funding for any Project Activities.
- 4.7 You may not retain any Unspent Monies and must repay them to ARIA within 30 days after ARIA's request for repayment.
- 4.8 You acknowledge the critical importance of cash flow for Sub-Contractors (including startups and small businesses) and commit to paying all valid and undisputed invoices relating to the Project within a maximum of 30 days from the date of receipt.
- 4.9 Where required, you will work with Sub-Contractors to arrange more frequent payment schedules (e.g., same day, weekly or milestone-based payments) to better support their cash flow needs.

5. ELIGIBLE AND INELIGIBLE EXPENDITURE

- 5.1 ARIA will only pay the Grant for Eligible Expenditure incurred by you in carrying out the Project Activities. You must provide ARIA with any evidence reasonably requested by ARIA (including receipts, invoices and other documentary evidence) that all Grant Claims relate to costs that are Eligible Expenditure.
- 5.2 You may not in any circumstance claim as Eligible Expenditure paid-for lobbying, which means using the Grant to fund lobbying (via an external firm or in-house staff) in order to undertake activities intended to influence or attempt to influence Parliament, government or political activity; or attempting to influence legislative or regulatory action.

6. GRANT REVIEW

- 6.1 ARIA will review the Grant at the intervals specified in the Grant Funding Letter. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.3.

- 6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:
- (a) consent to the Project Activities and the Grant Agreement continuing in line with existing plans;
 - (b) increase or decrease the Grant for the remainder of the Funding Period, as applicable;
 - (c) redefine the Milestones;
 - (d) require you to carry out remedial activity with the aim of improving delivery of the Project Activities; and/or
 - (e) terminate the Grant Agreement in accordance with clause 22.
- 6.3 Any change to these Grant Terms, the Project Activities, or the Grant pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Grant Agreement in accordance with clause 26.
- 6.4 to be removed when not used - For the avoidance of doubt any decision to terminate the Grant Agreement as a result of a Go/No Go Milestone will be made at ARIA's sole discretion and done so in accordance with clause 22.6.

7. MONITORING AND REPORTING

- 7.1 You must closely monitor the carrying out of the Project Activities throughout the Funding Period and must notify ARIA as soon as reasonably practicable of any actual or potential failure to comply with any of your obligations under the Grant Agreement.
- 7.2 ARIA does not limit its engagement with you to purely administrative activities and will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project Activities. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.
- 7.3 You must provide ARIA with:
- (a) the Milestones and a report on your performance against the Milestones at the intervals and for the periods of time specified in the Grant Funding Letter. ARIA may copy and adapt the contents of any of the Milestones and those reports for ARIA's internal use to review, develop and shape ARIA's funded research programmes, but ARIA will treat those contents as your Confidential Information under clause 11;
 - (b) any assistance and information reasonably requested by ARIA to establish whether you have used the Grant in accordance with the Grant Agreement; and
 - (c) a quarterly report on the use of the Maximum Sum, details broken down in accordance with ARIA's prescribed form.

- 7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its funding activities and compliance with the terms of the Grant Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time after the end of the Funding Period about the impact metrics, commercial exploitation or other dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Grant Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Grant Agreement.

8. AUDITING AND ASSURANCE

- 8.1 Annually, and on each anniversary of the Commencement Date and at the end of the Funding Period you must provide ARIA with independent assurance that the Grant has been used for carrying out the Project Activities. To satisfy this requirement you must provide a statement showing that the use of the Grant has been certified by an independent and appropriately qualified auditor or accountant.
- 8.2 Subject to clause 11, ARIA and/or its authorised representative may, at any time during the Funding Period and for up to 7 years after the end of the Funding Period, conduct audits in relation to your use of the Grant and your compliance with the Grant Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.
- 8.3 You must:
- (a) maintain an appropriate system of financial management and controls, maintain detailed records in relation to those controls, and provide copies of those records to ARIA on request; and
 - (b) retain, and procure that your Sub-Contractors retain and will provide to you on request, all relevant documentation relating to the Eligible Expenditure (including invoices, receipts and accounting records) during the Funding Period and for a period of 7 years thereafter.

9. FINANCIAL MANAGEMENT

- 9.1 You must:
- (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Grant; and
 - (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project Activities as soon as they are identified, and keep ARIA informed of your remedial actions.
- 9.2 In the event of any actual or suspected fraud, theft or other financial irregularity (which includes use of the Grant for any purpose other than that envisaged by the Grant Agreement), ARIA may, at its absolute discretion:

- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
- (b) suspend the Project Activities and future payment of the Grant to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

- 10.1 You must inform ARIA promptly of any actual, perceived or potential conflicts between your and your Representatives' obligations under the Grant Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Funding Period.
- 10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that these conflicts are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you or your Representative to cease the conflicting activity and if that is not acceptable to you or your Representative, either party may terminate the Grant Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

- 11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the provision of the Project Activities, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.
- 11.2 ARIA may publish a summary of the Grant Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Grant Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.
- 11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:
 - (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;
 - (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information necessary for the purpose

concerned and obtains appropriate confidentiality undertakings in relation to such information;

- (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and where no exception to disclosure under them is applicable; or
- (d) where that party (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.

11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under the Grant Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

- 12.1 Each party must comply with its obligations under the Law, including where applicable the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.
- 12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.
- 12.3 You acknowledge that ARIA, acting in accordance with the Information Acts (other than the FOIA), may disclose information concerning you and the Grant Agreement without consulting you. ARIA must take reasonable steps to notify you of any request for information to the extent permissible and reasonably practical and will give you adequate opportunity to make representations before ARIA discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.
- 12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or the Grant Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.
- 12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.
- 12.6 You must take account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

- 13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.
- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with the Grant Agreement. If either party anticipates that the other will process any Personal Data on its behalf under the Grant Agreement it must notify the other party and the parties must agree a variation to the Grant Agreement under clause 26 to incorporate appropriate provisions (such as those set out in Schedule 4) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. SUBSIDY CONTROL AND STATE AID

- 14.1 ARIA intends that the Grant complies with the Subsidy Control Act 2022 on the basis that the Project Activities are not economic activities and do not give a specific advantage to one or more enterprises. You must take all reasonable steps to maintain this position and to assist ARIA to comply with the requirements of the Act and must cooperate with any investigations under the Act.
- 14.2 Where the EU state aid laws apply to the Grant (where the Project Activities will affect trade between Northern Ireland and the EU), you acknowledge that the Project Activities are designed and performed so they are compatible with state aid laws. You will take all reasonable steps to assist ARIA to comply with state aid law requirements and cooperate with any investigations by the European Commission into the Project Activities.
- 14.3 ARIA will immediately stop future payments of the Grant and may require repayment of some or all of the Grant if subsidy control or state aid laws so require for the funding to be compliant.

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and not seek to avoid their application by artificial means.

Background IP

- 15.2 The Grant Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Funding Period if any additional Background IP is required either to carry out the Project Activities or to exploit commercially any of the Results.

Foreground IP ownership

- 15.3 You will own all Foreground IP unless your policy is for individual researchers to own the Foreground IP they create, or you agree your Sub-Contractor (or another third party) will own all, or parts of, the Foreground IP. Where your Sub-Contractor or individual researchers (or any other third party involved in the performance of the Project Activities) will own any of the Foreground IP you must impose on them the obligations relating to Foreground IP and Results contained in clauses 15 and 16. Where you

assign any Foreground IP to a Third Party (including your technology transfer company) you must impose on that Third Party the obligations relating to Foreground IP and Results contained in clauses 15 and 16.

- 15.4 You must submit all (i) Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the Future Proofing our Climate and Weather Intellectual Property Pledge promptly following creation or filing (as applicable) of such Foreground IP (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge]. You hereby agree to comply and uphold the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.5 You must ensure that whenever any Results are used with or communicated to Third Parties or are exploited commercially, ARIA's funding of the Project Activities is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and publication

- 15.6 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.7 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.8 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to fund future prosecution and maintenance and/or request the assignment of the patents to ARIA or its nominee.

Inventor first preference

- 15.9 Subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge] if any inventor or active participant in the Project Activities expresses interest in the exploitation of the Foreground IP they have developed, you must give them an opportunity to negotiate an assignment or commercial licence of the Foreground IP, on reasonable terms, prior to negotiating with any entity in which an inventor or active participant in the Project Activities is not involved as a shareholder or other key stakeholder.

16. COMMERCIALISATION OF RESULTS

- 16.1 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge], where they are capable of commercial exploitation you should seek to

exploit the Results commercially. This should be done, where applicable, in accordance with the Commercialisation Hypothesis.

- 16.2 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge], if for any reason you choose not to exploit any such Results commercially within a reasonable timeframe (or, where applicable, the timeframe set out in the Commercialisation Hypothesis) you are encouraged to discuss the position with ARIA, and you may request that ARIA exploit them or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Non-UK Commercialisation

- 16.3 Save as set out in the [Future Proofing our Climate and Weather Intellectual Property Pledge], to avoid any restriction on commercialisation, no consent is required from ARIA for any Non-UK commercialisation or any sale of Foreground IP to a Non-UK Entity. However, ARIA is set up to create value for the UK and therefore you must secure a fee payable to ARIA (**ARIA Non-UK Fee**) in each of the following circumstances:
- (a) where you are a Non-UK Entity;
 - (b) where you become a Non-UK Entity;
 - (c) where you assign or Commercially License any Foreground IP to a Non-UK Entity; or
 - (d) where you have assigned or Commercially Licensed any Foreground IP to a UK Entity that subsequently becomes a Non-UK Entity.
- 16.4 In order to avoid any unnecessary complexity, the ARIA Non-UK Fee will be based on the terms that you agree with any person to which you assign or Commercially License the relevant Foreground IP. This ARIA Non-UK Fee will amount to an additional twenty-five per cent (25%) of the value of the consideration (including upfronts, licence fees, milestone payments, royalties, shares or other securities, buyouts, exit fees and other consideration) that you receive from the exploitation of the relevant Foreground IP during any period that the above circumstances exist.
- 16.5 For example, if you would receive £100 (via royalty or royalty buyout), you must ensure your contractual mechanism enables you to collect an additional £25 and pay that additional amount to ARIA.
- 16.6 The ARIA Non-UK Fee is payable within 90 days after the end of each relevant Financial Year for receipts related to that calendar year. You are encouraged to use the clauses in Annex 1 in your Commercialisation Licences of Foreground IP.

Crown Body customers

- 16.7 You must ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities, and in suitable quantities for the Crown Body's requirements.

Spin-outs

- 16.8 ARIA seeks to maximise future investment of entrepreneurial talent and capital in start-up companies commercialising the Results of its funded activities. To that end, having funded the full economic cost of the research, ARIA places restrictions on the level of equity stakes and royalties that you may negotiate in exchange for the assignment or Commercialisation Licence of any Foreground IP.
- 16.9 If you or your technology transfer company assign or licence any Foreground IP to any third party or to a start-up established for the purpose of commercially exploiting the Results (a NewCo) you together with any connected person (including any investment fund to which you may transfer any part of your stake) shall be entitled to:

EITHER

- (a) hold or have the right to hold no more than 10% in fully-dilutable shares or equity (pre investment) in the third party or NewCo (with no other preferential subscription rights), not including any shares or equity subscribed for cash on arm's length terms alongside other investors;

OR

- (b) charge a royalty, with no upfront payments, annual fees, milestone payments or minimum royalties, payable by the third party or NewCo under any licence or assignment of the Foreground IP at no more than the relevant rate, and on the other terms, set out in Schedule 3.

- 16.10 The provisions of clauses 16.9(a) and 16.9(b) shall not apply to any equity taken or royalty charged in consideration of:
- (a) IP other than Foreground IP licensed or assigned to the third party or NewCo; or
- (b) facilities, equipment, personnel or other material support or services provided to the third party or NewCo independent of the Project Activities,
- with such equity or royalty limited to the proportion that reflects the contribution made by IP that is not Foreground IP.
- 16.11 You must notify ARIA in writing before any transaction completes of the overall equity stake or royalty percentages agreed under clause 16.8 (and any impact of clause 16.9, if relevant).

17. ASSETS

- 17.1 You must keep a register during the Funding Period and for up to 7 years after the end of the Funding Period of all Assets, with all relevant details about each Asset. You must use any Assets purchased with Grant monies for the Project Activities.
- 17.2 At the end of the Funding Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

- 18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Grant Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUBCONTRACTING

- 19.1 You may not transfer, assign, novate or otherwise dispose of the whole or any part of the Grant Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.
- 19.2 You shall not subcontract any of the Project Activities to a Third Party except to the extent permitted, and to the person or persons identified, in Schedule 2 Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractor as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Grant Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Grant Agreement.

20. BORROWING, LOSSES, GIFTS, SPECIAL PAYMENTS

- 20.1 You must obtain ARIA's prior written consent before:
- (a) borrowing or lending money from any source in connection with the Grant Agreement;
 - (b) giving any guarantee, indemnity, security over any Asset or letter of comfort in relation to the Grant Agreement;
 - (c) making any gift or writing off any debt or liability in connection with the Grant, and must keep a record of all gifts given and received in connection with the Grant.

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Grant and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Grant or publicise details of the Grant Agreement without the other's consent, except as required by Law.
- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

- 22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events occur:

- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13, 15.5 or 25, or commit a material breach of any other term of the Grant Agreement in the reasonable opinion of ARIA;
- (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
- (c) you fail to improve the performance of the Project Activities, notwithstanding your having undertaken the remedial activity agreed with ARIA in the remedial plan under clause 6.2(d);
- (d) you or the researchers involved in the Project Activities obtain any funding from a Third Party that, in the opinion of ARIA, undertakes activities that are likely to bring the reputation of the Project Activities or ARIA into disrepute;
- (e) you provide ARIA with any materially misleading or inaccurate information in your grant application or in subsequent related correspondence;
- (f) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Third Party, immediately upon becoming aware of it;
- (g) you are subject to an Insolvency Event;
- (h) the Grant or any part of it is held by a court or competent authority to be a prohibited subsidy under the Subsidy Control Act 2022 or an illegal state aid;
- (i) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project Activities;
 - (ii) result in your being unable to receive the Grant; and/or
 - (iii) raises national security concerns.

Rights reserved for ARIA in relation to an Event of Default

22.2 If an Event of Default has or may have occurred, ARIA may by written notice to you take any one or more of the following actions:

- (a) suspend the Project Activities and payment of the whole or any part of the Grant for such period as ARIA may determine, acting reasonably;
- (b) reduce the Maximum Sum, in which case the payment of Grant will thereafter be made in accordance with the reduction and notified to you; and/or
- (c) subject to clause 22.4, terminate the Grant Agreement with immediate effect as from the date of service of the notice of that termination.

22.3 Where this Grant Agreement is terminated for an Event of Default described in clause 22.1(f) or 22.1(h), ARIA may require you to repay the entire amount of the Grant previously paid to you.

Opportunity for you to remedy an Event of Default

22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:

- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and

- (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

22.5 Without prejudice to any other provision of the Grant Agreement, you may terminate the Grant Agreement on written notice to ARIA if ARIA commits a material breach of the Grant Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

General Termination Rights

22.6 Notwithstanding ARIA's right to terminate the Grant Agreement under clause 22.2(c), either party may terminate the Grant Agreement (in whole or in part) at any time by giving at least 60 days' prior written notice to the other party.

22.7 You must promptly notify ARIA in writing if at any time the principal investigator or any key researcher(s) named in Schedule 2 working on the Project Activities is unable or unwilling to continue to be involved in the Project Activities or is moving to a new organisation without the desire to continue the research. Within 60 days after the date of that notice, you must either:

- (a) nominate one or more successors, subject to ARIA's approval; or
- (b) agree that the Grant is transferred to another organisation subject to your and the new organisation's agreement in writing and ARIA's approval of the transfer

If ARIA is unwilling to accept the nominated successor(s) or does not approve a request for transfer, it may terminate the Grant Agreement by at least 30 days' written notice to you.

Consequences of Termination

22.8 If the Grant Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.

22.9 Where ARIA terminates the Grant Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:

- (a) you taking all reasonable steps to mitigate such loss; and
- (b) the Unavoidable Costs being:
 - (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Grant Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA;

- (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you;
- (v) costs that would not have been incurred had this Grant Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period).

- 22.10 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Services, over £250,000 will terminate automatically and immediately upon termination of this Agreement.
- 22.11 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Grant Agreement in the event that the Grant Agreement was terminated (calculated on the basis described in clause 22.8).
- 22.12 ARIA's total liability under clause 22.9 shall be limited to the Maximum Sum under the Grant Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.13 If the Grant Agreement is terminated or expires ARIA will not be liable to pay any of your costs or those of any of your contractors or suppliers related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Grant Funding Letter and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Grant Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Grant Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the Grant Manager and the Project Representative.
- 23.3 If the dispute cannot be resolved between the Grant Manager and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to a formal meeting between the parties' Escalation Contacts.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:
- (a) fraudulent misrepresentation or any other fraudulent act or omission;
 - (b) payment of sums properly due and owing to the other in the normal course of performance of this Grant Agreement;
 - (c) a breach of clause 13;

- (d) liability arising under any indemnity in this Grant Agreement; or
- (e) liability which may not lawfully be excluded or limited.

24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Grant Agreement or for ARIA's breach of this Grant Agreement), whether arising directly or indirectly, that may arise in connection with:

- (a) your carrying out the Project Activities;
- (b) the use of the Grant by any person;
- (c) any reduction, suspension, withdrawal or request for repayment of the Grant in accordance with this Grant Agreement; or
- (d) termination of the Grant Agreement in accordance with this Grant Agreement.

24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:

- (a) loss of profit, sales or turnover;
- (b) loss of contracts or business opportunities;
- (c) loss of anticipated savings;
- (d) loss of goodwill or damage to reputation; or
- (e) any indirect, special or consequential loss or damage;

in each case arising out of or relating to the Grant Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.

24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to the Grant Agreement or its subject matter or anything which it has done or not done in connection with the Grant Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the amount of the Maximum Sum.

24.5 You shall under no circumstances in connection with this Grant Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.

24.6 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Grant Agreement.

25. RESEARCH ETHICS AND CODE OF CONDUCT

25.1 As a recipient of a Government grant you must operate in accordance with the Concordat.

25.2 All research data:

- (a) must be generated using sound scientific techniques and processes;
- (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and

- (c) must be analysed appropriately, without bias and in accordance with good scientific practices.

25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.

25.4 You must comply with the Code of Conduct and ensure that your Representatives undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

26.1 Any variation to the Grant Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

27. GENERAL

27.1 Notices: All notices and other communications in relation to this Grant Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such communications will be deemed to have been given and received on the third Working Day following such mailing.

27.2 Change of control: You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(i) is likely to apply.

28. GOVERNING LAW

28.1 This Grant Agreement (including any non-contractual disputes or claims arising in connection with this Grant Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. NOT USED

30. DEFINITIONS AND INTERPRETATION

30.1 Where they appear in these Conditions or the Grant Agreement:

Adequate Insurance means the insurance requirements and amounts set out in the Grant Funding Letter.

Asset means any asset that is purchased, improved or developed using the Grant including equipment and fixed assets;

Background IP means IP that is:

(a) owned by or licensed to a party prior to the Commencement Date; or
(b) developed by or on behalf of a party during the Funding Period but not in connection with the Project Activities,

and is in either case used in connection with the Project Activities;

Bribery Act means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;

Change of Control means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Recipients of Government General Grants published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754555/2018-11-06_Code_of_Conduct_for_Grant_Recipients.pdf

including any subsequent updates from time to time;

Commencement Date means the date set out in the Grant Funding Letter;

Commercialisation Licence means a licence of IP other than a research or evaluation licence and/or subcontract manufacture (and **Commercially License** means to license under a Commercialisation Licence);

Commercialisation Hypothesis means the exploitation plan approved by ARIA and set out at Schedule 2 Part 2, as may be amended by agreement between the parties during and after the Funding Period;

Completion Date means the date set out in the Grant Funding Letter;

Concordat means the Concordat to Support Research Integrity which can be found at <https://ukrio.org/about-us/the-concordat-to-support-research-integrity/>

Conditions means these ARIA Grant Conditions;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Grant Agreement, that ought reasonably to be considered to be confidential (whether or not it is so marked), (a) including: (i) information relating to the business, affairs, customers, clients, suppliers or plans of the disclosing party; (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party; (iii) any information developed by the parties in the course of carrying out the Project Activities; (iv) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Grant Agreement; and (v) and any information derived from any of the above,

(b) but not including information which: (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11); (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party; (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or (iv) is independently developed without access to the Confidential Information; and (v) the content of this specific version of the Grant Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

Duplicate Funding means funding provided to you by a Third Party which is to fund the same activities as the Project Activities;

EA means the Equality Act 2000 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Eligible Expenditure means the payments made by you during the Funding Period for the purposes of carrying out the Project Activities which comply with clause 5 and ARIA's published eligibility rules (which provide for full economic cost reimbursement) and as agreed in the Grant Funding Letter;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Grant Funding Letter;

Event of Default means any of the events or circumstances set out in clause 22.1;

Financial Year means 1 April to 31 March;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means any IP in the Results;

Funding Period means the period commencing on the Commencement Date and ending on the Completion Date or such later date as may be agreed between the parties unless otherwise determined in accordance with the terms of the Grant Agreement;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification (operated by ARIA or by a third party), in the form set out at Annex A.

GDPR means Regulation (EU) 2016/679;

Go/No-Go Milestone means a decision point for ARIA to determine whether it wishes to proceed with or terminate the Project Activities (any decision regarding a Go/No-Go Milestone will be made at ARIA's sole discretion, following a Grant Review as outlined in Clause 6);

Grant means the sum or sums ARIA will pay to you up to the amount set out in the Grant Funding Letter, in accordance with clause 4 and subject to the provisions set out at clause 22.

Grant Agreement has the meaning given in the Grant Funding Letter;

Grant Claim means a request submitted by you to ARIA for payment of the Grant;

Grant Funding Letter means the letter from ARIA to you to which these Conditions are annexed;

Grant Manager means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Grant;

Grant Review means the process for reviewing the grant outlined in clause 6;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Ineligible Expenditure means expenditure incurred by you which is not Eligible Expenditure as set out in clause 5 and ARIA's published eligibility rules;

Information Acts means the Data Protection Legislation, FOIA and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property Rights or **IP** means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions, semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation;

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise;

Maximum Sum means the maximum amount of the Grant stated in the Grant Funding Letter;

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

NewCo has the meaning given in clause 16;

Non-UK Entity means a legal entity that is not a UK Entity;

Personal Data has the meaning given to it in the Data Protection Legislation as amended from time to time;

Prohibited Act means:

(a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Grant Agreement; and/or (ii) showing or not showing favour or disfavour to any person in relation to the Grant Agreement;

(b) committing any offence: (i) under the Bribery Act; (ii) under legislation creating offences in respect of fraudulent acts; and/or (iii) at common law in respect of fraudulent acts in relation to the Grant Agreement; and/or

(c) defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the activities to be carried out by you that are described in the Grant Funding Letter and in Schedule 2 Part 1;

Project Representative means the representative appointed by you, who at the Commencement Date will be the individual listed as such in the Grant Funding Letter;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means all information, data, techniques, inventions, discoveries, works, software and materials generated in the course of the Project Activities;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Project Activities or any part thereof or facilities or services necessary for the performance of the Project Activities or any part thereof or necessary for the management, direction or control of the Project Activities or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

UK Entity means a legal entity whose ultimate parent company has its headquarters and principal establishment in the United Kingdom;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Grant Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Funding Period because of termination or breach of the Grant Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination; and

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 In these Conditions and the Grant Agreement, unless the context otherwise requires:

- (a) references to "party" and "parties" are to the parties to the Grant Agreement;
- (b) the singular includes the plural and vice versa;
- (c) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (d) references to clauses and Schedules are to the clauses of these Conditions and to the Schedules to the Grant Agreement;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation"; and
- (g) the headings in the Grant Agreement are for ease of reference only and will not affect the interpretation or construction of the Grant Agreement.

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

Climate Engineering can be defined as deliberate intervention into the Earth's climate system in order to reduce the risks from anthropogenic climate change. Technologies that might achieve that aim fall broadly into two categories, those that focus on removing warming gases from the atmosphere, and those that focus on altering the Earth's radiation budget, typically by increasing scattering of incoming solar radiation. Known as Greenhouse Gas Removal (GGR) and Solar Radiation Management (SRM) respectively, the two categories have different challenges around efficacy, speed, scalability and, critically for this proposal, risk. SRM technologies focus mostly upon either injection of aerosols into the stratosphere or brightening of clouds in marine environments in the troposphere, and are generally considered to be effective, fast, scalable and risky opposite GGR technologies. One important pathway to quantify and reduce risk, particularly for SRM technologies, is through the study of natural analogues.

Large episodic volcanic eruptions regularly inject millions of tons of sulfur-bearing species into the stratosphere which form sulfate aerosols and subsequently reflect sunlight back into space, cooling the Earth's surface. Persistent passive degassing of volcanoes into the troposphere has been observed to alter cloud microphysics, brightening clouds and also altering the Earth's radiation balance. Active volcanoes can be used as an analogue to develop and test the systems required to observe and monitor the injection, evolution and impacts of SRM technologies whilst also providing vital observations of how aerosols and clouds form and evolve.

2. Aims and objectives of the Project Activities

The overall aim of this project is to develop and test aerial robotics (Uncrewed Air Vehicles, UAS / Drones) carrying a suite of sensors that will quantify droplet and aerosol behaviour at injection altitudes from the lower troposphere to the lower stratosphere. Specifically, this system will be developed to meet the following three objectives:

1. investigate natural analogues for both MCB and SAI and learn from frequent, smaller scale eruptions (injection altitudes up to 10 km above mean sea level (AMSL)) and passive volcanism, with a focus on aerosol and cloud formation and associated changes in radiative forcing,
2. standby aerial systems and expertise in UAS based volcanic monitoring ready for response during the next significant global volcanic eruption and
3. monitor and measure outdoor SRM experiments within this programme and beyond.

We will develop the capability to monitor subsequent testing of both SAI and MCB technologies, whilst also investigating the natural processes that make active volcanism important analogues for SAI and MCB. The outcomes of this research project will be a system ready to be employed quickly in the event of a significant volcanic eruption, a framework for monitoring, a capability demonstrator for higher altitude sampling and more complete understanding of volcanoes as analogues for SAI and MCB, with a particular focus on the relationship between aerosol size and composition and radiative transfer.

3. Project Activities

3.1 **WP1 Development of a platform capable of operating in the troposphere and lower stratosphere.** WP1 is made up of three sub-tasks. (T1.1) MCB typically operates in the boundary layer whereas SAI efficacy broadly increases, per delivered volume of material, as a function of altitude. The aircraft will be modular in terms of the onboard sensor systems, and capable of undertaking measurements that pertain to both target technologies. The nominal design brief is to have an electric fixed-wing aircraft, capable of lifting the required sensor payload from WP2, plus the associated avionics for autonomous operation, to 10 km AMSL. The team has extensive experience with both modifying existing COTS airframes and original new designs to meet stringent mission requirements. (T1.2) Software development will deliver an integrated simulation environment for the aircraft system and its controlling AI in digital representations of the target environments, including plume models. Autonomous guidance will permit dynamic re-sampling in 4D to measure evolution of the same air 'parcel' over time, exploiting machine learning and dynamic replanning to track and revisit the plume. On-ground, in-air and remote automation will support pilot and science situational awareness with manageable workloads. (T1.3) Initial flight tests of the MACE aircraft will be carried out at the university field site in Bristol, moving to alternative UK sites as the required airspace increases. An agile approach will be used for UAS development with regular flight tests throughout the project. The data collected during these UK tests will lead to rapid airframe iteration and code development, as well as performance analysis for AI based mission optimization and preparation for field testing. **Supporting Milestones 1, 2 and 6. Responsible for Deliverables D1.1, D2.1 and D6.1.**

3.2 **WP2 Payload selection, integration and field testing.** With a functional prototype aircraft, the aircraft systems and operations will also be developed iteratively during the payload integration phase. WP2 is made up of three subsections. (T2.1) We will down-select from a larger suite of instrumentation capable of quantifying two critical types of coupled observations. Firstly, we will consider in-situ measurement of gas, aerosol and droplet properties such as concentration, shape, number density and particle size distribution. There are a wide variety of lightweight electrochemical gas sensors (e.g. H_2O , SO_2) and laser-based optical particle counters designed to measure CCN at submicron scale, coarse mode sulphate aerosols (0.5-10 μm) and cloud droplets at a range of 5-50 μm that will be reviewed according to scientific and engineering requirements. Radiative transfer observations constitute the second suite of observations from which we will delimit radiative forcing. Pyrometers will measure diffuse and direct upwelling and downwelling SW radiation across the visible and near-infrared spectrum ($\sim 0.4\text{-}2.7$ μm wavelength). This will be coupled with LW radiation (5-100 μm) measurement using pyrgeometers capable of quantifying broad spectrum upwelling and downwelling thermal radiative fluxes. Laboratory and field testing of the onboard sensors will be carried out at selected sites in the UK and at Fuego volcano, Guatemala. During a careful programme of flight tests, we will increase flight altitudes whilst working within regulatory frameworks. Active volcanoes present significant opportunities as airspace above them is often closed to above cruise altitudes, as has been the case at Fuego since 2015. (T2.3) Preparation for rapid response. By the end of year 1 the MACE team will assemble an initial UAS capability for rapid (48hr) response to a large-scale volcanic eruptive event. This will develop annually with the project, incorporating step changes in sensing, processing, aircraft and expertise. **Supporting Milestones 1, 3 and 7. Responsible for Deliverables D3.1 and D7.1.**

3.3 **WP3 Volcanic plume and secondary aerosol sampling across a range of altitudes.**

(T3.1) We will conduct a two-phase campaign at reliable producers of SO₂. Our first target is Fuego, Guatemala (3,780 m AMSL) where the team have flown UAS extensively to > 5,000 m AMSL. We have a longstanding relationship with both the national institute for atmospheric, geophysical and hydrological hazards (INSIVUMEH) and the Guatemalan civil aviation authority (DGAC) and have hundreds of hours of experience flying beyond visual line of sight (BVLOS). Here we will fly within established flight envelopes, and gather preliminary data from within, above and below the plume. We will use machine learning to train the system to repeatedly intersect the same section of the plume at Fuego and investigate SO₂ loss, aerosol formation and radiative transfer across the vertical profile of the plume. (T3.2) Following two Fuego campaigns, two other sites, the Soufriere Hills Volcano, Montserrat (1,050 m AMSL and British Overseas Territory) and Lascar in Chile, will become the focus of the project. The Soufriere Hills Volcano, Montserrat, is an MCB analogue, where SO₂ is rapidly converted into sulphate aerosol, an effective source of cloud condensation nuclei observed at volcanoes during passive degassing. Lower plume altitudes mean potential heavier payloads and/or longer flight times and, given the rapid conversion of SO₂, allows us to investigate a series of physico-chemical reactions from heterogeneous nucleation of aerosols through to cloud formation and brightening. We will observe radiative transfer processes as a function of time, potentially through coordinated multi-aircraft campaigns. In contrast, Lascar is one of the highest persistent emitters in the world at ~5,600 m AMSL, which emits into the dry free troposphere of the Atacama Desert. Here we will undertake plume characterisation experiments in conditions as close to those of the stratosphere as is possible from a passive degasser, again looking at aerosol microphysics and radiative transfer through the plume. **Supporting Milestones 3, 4, 5 and 7. Responsible for Deliverables D4.1 and D5.1.**

3.4 **WP4 Readiness planning, monitoring strategies and targets of opportunity.**

This WP is dedicated to putting in place the processes, protocols, software and paperwork required to operate at short notice internationally. Due to technological and regulatory challenges, relatively few in-situ measurements of sulfur-bearing species have been made, particularly in the stratosphere. The next volcanic eruption and/or small-scale experiment will require monitoring, and small scale SRM experiments are highly likely to operate at scales below those easily detected from orbital platforms. In addition to the hardware preparations for rapid response identified in WP2, we will prepare for targets of opportunity, including, but not limited to volcanic eruptions, noting that kgs of SO₂ are already being released by companies, such as Make Sunsets, in the US. The MACE team at Bristol have extensive experience operating UAS internationally including Papua New Guinea, Cameroon, Chile, Italy and Kenya. (T4.1) We will develop the capacity for rapid response to targets of opportunity such as a significant volcanic eruption, leveraging simulation capability and automated planning from WP1 to design, train and verify missions in advance, as far as possible, and during the 48-hour response window. (T4.2) The required permissions can often be just as challenging as the hardware and software. The team will be building on previous research in the automation of UAS safety cases and in-flight operations around regulation planning. Selected potential operational vignettes will be used as test cases. (T4.3) A 20 km altitude safety case will be developed to facilitate further development of UAS monitoring at likely SAI injection altitudes. **Supporting Milestones 3 and 7. Responsible for Deliverables D3.2 and D8.1.**

3.5 **WP5. Project Management, Impact and Outreach.**

(T5.1) We will have regular project meetings involving team members on at least a weekly basis and (T5.2) in person, all hands

quarterly review meetings (T5.3) Outreach materials and publications (T5.4). We will develop outreach videos, as part of a broader suite of materials to inform stakeholders, academics and the public of our work and our findings. **Supporting Milestones 2, 4 and 6. Responsible for Deliverables D2.2, 4.2 and D6.2.**

3.6 The following Milestones will be used to monitor your delivery of the Project. The costs associated with completing these Milestones are estimated in the cost breakdown sheet

ID	Milestones	Measure (Deliverables = DX.X)	Date
1	Engagement plan available	Draft communication and engagement plan agreed with ARIA and oversight committee	Commencement Date + 6 months
2	Report: MACE Sensor and Uncrewed Aircraft System (UAS) Requirements.	Objectives and Requirements Defined. Supporting material will be a single Document (D1.1) to include: - Scientific Objectives and Methodology - MACE Sensor Requirements - MACE UAS Requirements - Submission of permits for flights, such that these are available before field tests	Commencement Date + 6 months
3	Test: Successful experimental MACE UAS flight test at UK airfield. This is a go/no go milestone	Successful Experimental Test Flight. Supporting material will be a single Document (D2.1) to include: - CAA Safety Case submitted for Beyond Visual Line of Sight (BVLOS) flight test operations. - Flight Test Report on successful experimental MACE UAS flight test. Success is defined as a minimum of four BVLOS flights of over one hour each, collecting flight performance data. Stretch target is sensor validation and in-flight sensor data acquisition. and Video (D2.2): 3-minute promotional video of MACE flight test.	Commencement Date + 12 months

4	Report: Detailed mission and data acquisition plan for each target site. Document: Draft documentation for international UAS rapid response.	Detailed Mission Design and Simulation. Supporting material will be Document (D3.1): • Mission definition and detailed data acquisition plan for each target field site to meet the Science Objectives. • Submission of permits for flights, such that these are available before field tests and Document (D3.2): • Draft documentation for international UAS rapid response for review. To include two sample vignettes covering safety case, legal requirements and mission design.	Commencement Date + 18 months
5	Test: Successful MACE UAS field tests and flight demonstrations. This is a go/no go milestone	Successful Field Tests. Supporting material will be Document (D4.1): • Flight Test Report on MACE UAS field test at one of the three identified target sites: Volcán de Fuego, Soufrière Hills or Lascar. Success is defined as a minimum of four BVLOS flights of over one hour each, collecting flight performance data. Stretch target is sensor validation and science data acquisition. and Video (D4.2): • 3-minute promotional video of MACE UAS field test	Commencement Date + 24 months
6	Test: First science data capture research flights in the field.	First Field Dataset Capture. Supporting material will be Document (D5.1): • Report on science findings using MACE aircraft for one target science data capture campaign. • Data submitted to publicly available ARIA repository.	Commencement Date + 30 months

7	Test: MACE flight test. Fully automated flights with onboard AI and on-the-fly route planning for multiple intercepts.	Successful Flight Test with Onboard Automated Real-time Route Planning. Supporting material will be a single Document (D6.1): • Flight Test Report on successful onboard AI and real-time route planning tests for multiple plume intercepts. and Video (D6.2): • 3-minute promotional video of MACE updated aircraft UK flight test.	Commencement Date + 36 months
8	Test: All target volcanoes successfully sampled.	In-flight Data Capture at all Three Target Sites. Supporting material will be a single Document (D7.1): • Scientific report on successful data capture campaigns at Soufrière Hills, Fuego and Lascar volcanoes. To include details on the time-dependent relationships between aerosol formation rate, size, and radiative transfer through the plume as a function of environmental conditions. Success is defined as capture of representative science data, for publication, at each of the three sites. • Data submitted to publicly available ARIA repository.	Commencement Date + 42 months

In addition to the above Milestones, the following project plan will be used to track progress throughout the project and may be updated from time to time: 

3.7 The intended long-term outcomes are summarised below:

- To design and build a state-of-the-art aircraft capable of sampling aerosols at 10 km amsl that can be deployed quickly after a volcanic eruption or during a climate engineering experiment that will outlast the project lifetime. For example, the likelihood of another ash crisis in the next ten years is non-zero and there is limited current capability in the UK for ash sampling (an extension that could easily be made to this aircraft).
- Use this project as a first step towards developing an aircraft that could monitor full-scale SAI at 20 km amsl.

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement
Planning	• Roles and responsibilities • External communications • Vision • Project details • Code and data management • Project plan + project management
Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Key Learning, discoveries and decisions • Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • Invoicing and cost reporting Optional: • technical evidence saved to drive e.g. report or presentation as requested by PD • review meeting slide deck saved to drive as requested by PD
Annual	• ARIA impact metrics • Attendance at annual ARIA event
Ad hoc	• As required, Programme Director/ Programme Team may request additional information and evidence • Workshops - potential to be invited to ARIA workshops
Project closure	• Project closure report

5. Payment

5.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant

payments quarterly in arrears.

For quarterly payments, the cadence of payments will align with ARIAs financial year beginning 1st April e.g Quarter 1 Grant Claims will be for the period of 1st April to 30 June, Quarter 2 Grant Claims will be for the period of 1st July to 30 Sept and so on.

5.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

5.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end of the relevant period.

5.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

6. Principal investigator/key researchers

6.1 For the purposes of clause 22.7, the following principal investigators or key researchers have been identified:

Name	Role	Organisation
Professor Matt Watson	Principal Investigator	University of Bristol
Professor Tom Richardson	Co-Investigator	University of Bristol
Professor Arthur Richards	Co-Investigator	University of Bristol
	Key researcher	University of Bristol

7. Sub-Contractors

7.1 For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Location
N/A	N/A	N/A

PART 2 - GRANT APPLICATION

Application titled "Monitoring Aerosol Climate Engineering (MACE)" submitted 9 December 2024

Commercialisation Hypothesis submitted as part of the above referenced application, 9 December 2024

.

SCHEDULE 3

Royalty Percentages

Royalties on the sale or supply of products or services that are covered by, use or incorporate the Foreground IP licensed to the NewCo will only become due on aggregate net sales derived from the Foreground IP exceeding £50 million.

The maximum headline percentage royalty rate (i.e. before any royalty stacking, step-down or other reduction and excluding any ARIA Non-UK Fee) for products or services that are covered by, use or incorporate the Foreground IP, and of sublicensing income, shall be one of the following:

Type of product	Applicable headline royalty percentage (up to)
Low margin	0.5% of net sales
Medium margin	1% of net sales
High margin	2% of net sales
Sublicensing royalty	10% of net receipts

ANNEX 1

Clause for inclusion in licences of Foreground IP

[] **ARIA NON-UK FEE**

[].1 In this clause:

“ARIA” means the Advanced Research and Invention Agency;

“Crown Body” means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

“UK Entity” means a legal entity that has or whose ultimate parent company has its headquarters and principal establishment in the United Kingdom.

[].2 The Foreground IP was developed with funding from ARIA. As a condition of its funding ARIA requires that a benefit is returned to the United Kingdom where the Foreground IP is licensed by the Licensor to any person that is not a UK Entity. Accordingly, in addition to any other sums payable by the Licensee to the Licensor under this Agreement, the Licensee shall pay to the Licensor within 90 days after the end of each calendar year during the Relevant Period (as defined below), and within 90 days after the end of the Relevant Period, a fee (**ARIA Non-UK Fee**) on all amounts (including upfronts, licence fees, milestone payments, royalties, shares or other securities, exit fees, buyout or other consideration) payable by the Licensee to the Licensor under this Agreement in relation to the exploitation of any Foreground IP (**Relevant Amount**) that accrues during, or relates to, any period of time that the Licensee is not a UK Entity (**Relevant Period**). The amount of the ARIA Non-UK Fee is 25% of the Relevant Amount, and is payable by the Licensee to the Licensor in addition to the amounts that would otherwise be payable under this Agreement. For example if the Relevant Amount is £100 the ARIA Non-UK Fee is an additional £25, which the Licensee shall pay to the Licensor and the Licensor shall remit to ARIA.

Crown Body customers

[].3 You must also ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities and in suitable quantities for the Crown Body's requirements.

[].4 ARIA shall have the right to enforce this clause [] under the Contracts (Rights of Third Parties) Act 1999. Neither party may amend this Agreement in a way that detracts from ARIA's right to enforce its rights under this clause without ARIA's prior written consent.

[1] When using this clause you may substitute the relevant defined terms used elsewhere in the agreement to capture the concept of "Foreground IP". Where the clause refers to the "Licensor" and "Licensee" please use the appropriate defined terms to include the licensor, licensee, assignor and assignee of the Foreground IP. This clause is not suitable for assignments of the Foreground IP in consideration of the payment of one or more lump sum payments. In those cases the Licensor needs to be informed, and potentially make an additional payment, if the Foreground IP is subsequently assigned to a non-UK Entity or if the Assignee ceases to be a UK Entity.

SCHEDULE 4: Data Protection

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Grant Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Grant Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Grant Agreement:
- 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are

relying on Domestic Law as the basis for processing Personal Data, you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;

- 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);
- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Grant Agreement unless required by Domestic Law to store the Personal Data; and

- 3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.
- 3.4. [[ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):
- 3.4.1. cancel its plans to change the affected sub-Processor;
- 3.4.2. offer an alternative which is acceptable to ARIA; or
- 3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.
- 3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Grant Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.
- 3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]
- 3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Grant agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it, storing it, retrieving it, consulting it, disseminating it or destroying it, etc.

	Note the definition of processing in the UK GDPR: <i>“any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction”]</i>
Duration of Processing:	Duration of this Grant Agreement (and any post termination processing that is permitted / required).
Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called “special categories” of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: <i>“data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation”]</i>
Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors,

	clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. You shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.
- 4.2. Any limitation of liability set out in this Grant Agreement will not apply to this Schedule's indemnity or reimbursement obligations.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

1. Submission of Pledged Patents and Experimental Data

- 1.1 The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
- 1.2 The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.

2. Experimental Data Licence

- 2.1 Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
- 2.2 The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
- 2.3 The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
- 2.4 The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).

3. Research Licence

- 3.1 Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
- 3.2 The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
- 3.3 Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

- 3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.
- 3.5 The Research Licensee must:
- (a) at all times when using the Pledged Patents comply with all Laws; and
 - (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).

4. Commercial Licence

- 4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.
- 4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.
- 4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.

5. Pledgor Know-How

At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.

6. Termination

- 6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:
- (a) materially breaches the terms of such licence or this Pledge; or
 - (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).

7. Transfers of Pledged Patents and/or Experimental Data

The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.

8. No Warranty

The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and
Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

The Chancellor, Masters, and Scholars of the University of Cambridge (**Grant Recipient**)

The Old Schools, Trinity Lane, Cambridge, CB2 1TN

9th June 2025

Attention: Hugh Hunt

Dear Hugh,

FPCW-PR01-P018 Novel Materials for Stratospheric Aerosol Injection— Standard Grant Funding Letter

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to Exploring Climate Cooling and ARIA is pleased to offer you a Grant for the performance of the Project Activities up to the Maximum Sum, subject to your agreement to, and compliance with, the terms and conditions set out in this Grant Funding Letter and its Schedules.

1. Overview of the Grant

Any reference in this letter to "you" or "your" means the Grant Recipient and any capitalised terms have the meanings given in the ARIA Grant Conditions (Conditions).

The key elements of the Grant are described in the table below:

Project Activities	Novel Materials for Stratospheric Aerosol Injection. A more detailed description of the Project Activities is set out in Schedule 2 (Project Activities).
Maximum Sum of the Grant (inclusive of taxes)	£5,525,150 (inclusive of all taxes where applicable)
Commencement Date	The commencement date is 11 June 2025
Completion Date	The completion is 10 June 2028
Grant Review Intervals	ARIA will review the Grant at quarterly intervals using the process referred to in clause 6 of the Conditions

Adequate Insurance	Employers' liability - At least £5 million (as required by the Employers' Liability (Compulsory Insurance Act 1969)) Public liability: £10 million (per year in aggregate)	
Monitoring and Reporting	The performance reports referred to in clause 7 of the Conditions shall be provided at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Project Representative	Hugh Hunt, Project Lead, [REDACTED]	
Grant Manager	Mark Symes, Programme Director [REDACTED]	
Escalation Contacts	ARIA	Grant Recipient
	Chief Product Officer [REDACTED]	[REDACTED] Research Support Manager, School of Technology University of Cambridge, Research Operations Office, [REDACTED] [REDACTED] Email: [REDACTED]
Notices	ARIA Contracts [REDACTED]	Assistant Director, School of Technology University of Cambridge, Research Operations Office, [REDACTED] [REDACTED] Email: [REDACTED]

2. Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Grant and return it to finance@aria.org.uk

3. The Grant Agreement

3.1. Once you sign a copy of this Grant Funding Letter in accordance with paragraph 6 (Acceptance) below, it will form a binding "**Grant Agreement**" between you and ARIA that includes and incorporates the following documents:

3.1.1. the **Grant Conditions** in Schedule 1;

3.1.2. the **Project Activities, Milestones** and **Grant Application** in Schedule 2;

3.1.3. the **Royalty percentages** (including annexes) in Schedule 3; and

3.1.4. the terms relating to Data Protection in Schedule 4.

3.2. The parties confirm that it is their intention to be legally bound by the Grant Agreement.

3.3. Not used

4. Warranties

4.1. By signing this Grant Funding Letter, you warrant and represent that:

4.1.1. your obligations under the Grant Agreement are legal, valid, binding and enforceable;

4.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Grant Agreement have been obtained;

4.1.3. the person signing the Grant Agreement is duly authorised to sign on your behalf; and

4.1.4. your Project Representative referenced in the table above is authorised to make decisions and provide information on your behalf.

5. Amendments to the Grant Conditions

5.1 Not used

6. Acceptance

6.1. To accept this Grant Funding Letter, please arrange for an authorised signatory to sign and date the duplicate copy of this Grant Funding Letter as indicated below, and return to ARIA as a complete signed original of the Grant Agreement including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Grant Agreement and to bind the Grant Recipient.

6.2. The offer of this Grant Funding Letter will expire on 11 June 2025.

Yours sincerely

for and on behalf of ARIA

Name of ARIA signatory:

Position Held:

Date:

I confirm the agreement of The Chancellor, Masters, and Scholars of the University of Cambridge to the terms and conditions in this Grant Funding Letter and its Schedules.

Signature:

Name:

Position:

Date:

SCHEDULE 1 - GRANT CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up the Grant Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Grant Funding Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to the Grant Agreement with the exception of Schedule 2 Part 2 (the Grant Application);
 - (d) Schedule 2 Part 2 (the Grant Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, the Grant Agreement.

2. DURATION AND PURPOSE OF THE GRANT

- 2.1 The Grant Agreement will subsist for the duration of the Funding Period unless extended by written agreement signed by a duly authorised representative of the parties or terminated earlier in accordance with its terms. Any provision of the Grant Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Grant Agreement shall remain in full force and effect, including clauses 1, 2, 4, 7.4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.3, 22.7, 22.8, 22.11, 22.12, 23, 24, 26, 27, 28, and 30.
- 2.2 You may only use the Grant for carrying out the Project Activities. You may not make any changes to the Project Activities without ARIA's prior written agreement.
- 2.3 You may not unreasonably withhold, condition or delay your agreement to any changes requested by ARIA to the Project Activities or the amount of the Grant. Any agreed change will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

3. ENVIRONMENTAL AND SAFETY REQUIREMENTS

- 3.1 In performing the Project Activities, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. PAYMENT OF GRANT

- 4.1 Subject to the remainder of this clause 4, ARIA will pay the Grant to you:
- (a) up to the Maximum Sum;
 - (b) in pounds sterling (GBP) by wire transfer into your bank account, details of which you provided in the Confirmation of Bank Details form attached to the Grant Funding Letter; and
 - (c) if a tax is chargeable in respect of the Grant, all payments will be deemed to be inclusive of all such taxes and ARIA will not be obliged to pay any additional amount.
- 4.2 The bank account of which you provided details in your Confirmation of Bank Details form (and any alternative bank details nominated subsequently by you) must be an ordinary business bank account

with appropriate segregation of duties and control. During the Funding Period, you must notify ARIA of any change of bank account details as soon as reasonably practicable on the same form and signed by an approved signatory. You must notify ARIA of any change of signatory for approval, as soon as known.

- 4.3 You will be the sole recipient of the Grant and you will be responsible for managing the Grant as between you and any Third Parties involved in performing the Project Activities. This includes securing the repayment of the Grant if requested by ARIA in accordance with the Grant Conditions, including where the Grant has already been distributed to Third Parties.
- 4.4 You must promptly notify ARIA if any money is incorrectly paid to you for any reason, and must repay it as soon as reasonably practicable. Any amount not immediately repaid will be recoverable as a civil debt.
- 4.5 ARIA reserves the right not to pay any Grant Claims that are not submitted within the period set out in the Grant Funding Letter or that are incomplete, incorrect or not accompanied by full supporting documentation (including any documentation that ARIA reasonably requests).
- 4.6 You may not apply for or obtain Duplicate Funding for any Project Activities.
- 4.7 You may not retain any Unspent Monies and must repay them to ARIA within 30 days after ARIA's request for repayment.
- 4.8 You acknowledge the critical importance of cash flow for Sub-Contractors (including startups and small businesses) and commit to paying all valid and undisputed invoices relating to the Project within a maximum of 30 days from the date of receipt.
- 4.9 Where required, you will work with Sub-Contractors to arrange more frequent payment schedules (e.g., same day, weekly or milestone-based payments) to better support their cash flow needs.

5. ELIGIBLE AND INELIGIBLE EXPENDITURE

- 5.1 ARIA will only pay the Grant for Eligible Expenditure incurred by you in carrying out the Project Activities. You must provide ARIA with any evidence reasonably requested by ARIA (including receipts, invoices and other documentary evidence) that all Grant Claims relate to costs that are Eligible Expenditure.
- 5.2 You may not in any circumstance claim as Eligible Expenditure paid-for lobbying, which means using the Grant to fund lobbying (via an external firm or in-house staff) in order to undertake activities intended to influence or attempt to influence Parliament, government or political activity; or attempting to influence legislative or regulatory action.

6. GRANT REVIEW

- 6.1 ARIA will review the Grant at the intervals specified in the Grant Funding Letter. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.3.

- 6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:
- (a) consent to the Project Activities and the Grant Agreement continuing in line with existing plans;
 - (b) increase or decrease the Grant for the remainder of the Funding Period, as applicable;
 - (c) redefine the Milestones;
 - (d) require you to carry out remedial activity with the aim of improving delivery of the Project Activities; and/or
 - (e) terminate the Grant Agreement in accordance with clause 22.
- 6.3 Any change to these Grant Terms, the Project Activities, or the Grant pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Grant Agreement in accordance with clause 26.
- 6.4 For the avoidance of doubt any decision to terminate the Grant Agreement as a result of a Go/No Go Milestone will be made at ARIA's sole discretion and done so in accordance with clause 22.6.

7. MONITORING AND REPORTING

- 7.1 You must closely monitor the carrying out of the Project Activities throughout the Funding Period and must notify ARIA as soon as reasonably practicable of any actual or potential failure to comply with any of your obligations under the Grant Agreement.
- 7.2 ARIA does not limit its engagement with you to purely administrative activities and will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project Activities. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.
- 7.3 You must provide ARIA with:
- (a) the Milestones and a report on your performance against the Milestones at the intervals and for the periods of time specified in the Grant Funding Letter. ARIA may copy and adapt the contents of any of the Milestones and those reports for ARIA's internal use to review, develop and shape ARIA's funded research programmes, but ARIA will treat those contents as your Confidential Information under clause 11;
 - (b) any assistance and information reasonably requested by ARIA to establish whether you have used the Grant in accordance with the Grant Agreement; and
 - (c) a quarterly report on the use of the Maximum Sum, details broken down in accordance with ARIA's prescribed form.

- 7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its funding activities and compliance with the terms of the Grant Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time after the end of the Funding Period about the impact metrics, commercial exploitation or other dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Grant Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Grant Agreement.

8. AUDITING AND ASSURANCE

8.1

For Grants over £500k: Annually, and on each anniversary of the Commencement Date and at the end of the Funding Period you must provide ARIA with independent assurance that the Grant has been used for carrying out the Project Activities. To satisfy this requirement you must provide a statement showing that the use of the Grant has been certified by an independent and appropriately qualified auditor or accountant.

- 8.2 Subject to clause 11, ARIA and/or its authorised representative may, at any time during the Funding Period and for up to 7 years after the end of the Funding Period, conduct audits in relation to your use of the Grant and your compliance with the Grant Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.

8.3 You must:

- (a) maintain an appropriate system of financial management and controls, maintain detailed records in relation to those controls, and provide copies of those records to ARIA on request; and
- (b) retain, and procure that your Sub-Contractors retain and will provide to you on request, all relevant documentation relating to the Eligible Expenditure (including invoices, receipts and accounting records) during the Funding Period and for a period of 7 years thereafter.

9. FINANCIAL MANAGEMENT

9.1 You must:

- (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Grant; and
- (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project Activities as soon as they are identified, and keep ARIA informed of your remedial actions.

9.2 In the event of any actual or suspected fraud, theft or other financial irregularity (which includes use of the Grant for any purpose other than that envisaged by the Grant Agreement), ARIA may, at its absolute discretion:

- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
- (b) suspend the Project Activities and future payment of the Grant to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

10.1 You must inform ARIA promptly of any actual, perceived or potential conflicts between your and your Representatives' obligations under the Grant Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Funding Period.

10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that these conflicts are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you or your Representative to cease the conflicting activity and if that is not acceptable to you or your Representative, either party may terminate the Grant Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the provision of the Project Activities, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.

11.2 ARIA may publish a summary of the Grant Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Grant Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.

11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:

- (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;

- (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information necessary for the purpose concerned and obtains appropriate confidentiality undertakings in relation to such information;
- (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and where no exception to disclosure under them is applicable; or
- (d) where that party (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.

11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under the Grant Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

- 12.1 Each party must comply with its obligations under the Law, including where applicable the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.
- 12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.
- 12.3 You acknowledge that ARIA, acting in accordance with the Information Acts (other than the FOIA), may disclose information concerning you and the Grant Agreement without consulting you. ARIA must take reasonable steps to notify you of any request for information to the extent permissible and reasonably practical and will give you adequate opportunity to make representations before ARIA discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.
- 12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or the Grant Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.
- 12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.
- 12.6 You must take account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate

mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

- 13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.
- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with the Grant Agreement. If either party anticipates that the other will process any Personal Data on its behalf under the Grant Agreement it must notify the other party and the parties must agree a variation to the Grant Agreement under clause 26 to incorporate appropriate provisions (such as those set out in Schedule 4) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. SUBSIDY CONTROL AND STATE AID

- 14.1 ARIA intends that the Grant complies with the Subsidy Control Act 2022 on the basis that the Project Activities are not economic activities and do not give a specific advantage to one or more enterprises. You must take all reasonable steps to maintain this position and to assist ARIA to comply with the requirements of the Act and must cooperate with any investigations under the Act.
- 14.2 Where the EU state aid laws apply to the Grant (where the Project Activities will affect trade between Northern Ireland and the EU), you acknowledge that the Project Activities are designed and performed so they are compatible with state aid laws. You will take all reasonable steps to assist ARIA to comply with state aid law requirements and cooperate with any investigations by the European Commission into the Project Activities.
- 14.3 ARIA will immediately stop future payments of the Grant and may require repayment of some or all of the Grant if subsidy control or state aid laws so require for the funding to be compliant.

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and not seek to avoid their application by artificial means.

Background IP

- 15.2 The Grant Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Funding Period if any additional Background IP is required either to carry out the Project Activities or to exploit commercially any of the Results.

Foreground IP ownership

- 15.3 You will own all Foreground IP unless your policy is for individual researchers to own the Foreground IP they create, or you agree your Sub-Contractor (or another third party) will own all, or parts of, the

Foreground IP. Where your Sub-Contractor or individual researchers (or any other third party involved in the performance of the Project Activities) will own any of the Foreground IP you must impose on them the obligations relating to Foreground IP and Results contained in clauses 15 and 16. Where you assign any Foreground IP to a Third Party (including your technology transfer company) you must impose on that Third Party the obligations relating to Foreground IP and Results contained in clauses 15 and 16.

- 15.4 You must submit all (i) all patents within or covering the Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the [Future Proofing our Climate and Weather Intellectual Property Pledge promptly following creation or filing (as applicable) of such patents and/or data (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge. You hereby agree to comply and uphold the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.5 You must ensure that whenever any Results are used with or communicated to Third Parties or are exploited commercially, ARIA's funding of the Project Activities is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and publication

- 15.6 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.7 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.8 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to fund future prosecution and maintenance and/or request the assignment of the patents to ARIA or its nominee.

Inventor first preference

- 15.9 Subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge if any inventor or active participant in the Project Activities expresses interest in the exploitation of the Foreground IP they have developed, you must give them an opportunity to negotiate an assignment or commercial licence of the Foreground IP, on reasonable terms, prior to negotiating with any entity in which an inventor or active participant in the Project Activities is not involved as a shareholder or other key stakeholder.

16. COMMERCIALISATION OF RESULTS

- 16.1 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge, where they are capable of commercial exploitation you should seek to exploit the Results commercially. This should be done, where applicable, in accordance with the Commercialisation Hypothesis.
- 16.2 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge, if for any reason you choose not to exploit any such Results commercially within a reasonable timeframe (or, where applicable, the timeframe set out in the Commercialisation Hypothesis) you are encouraged to discuss the position with ARIA, and you may request that ARIA exploit them or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Non-UK Commercialisation

- 16.3 Save as set out in the Future Proofing our Climate and Weather Intellectual Property Pledge, to avoid any restriction on commercialisation, no consent is required from ARIA for any Non-UK commercialisation or any sale of Foreground IP to a Non-UK Entity. However, ARIA is set up to create value for the UK and therefore you must secure a fee payable to ARIA (**ARIA Non-UK Fee**) in each of the following circumstances:
- (a) where you are a Non-UK Entity;
 - (b) where you become a Non-UK Entity;
 - (c) where you assign or Commercially License any Foreground IP to a Non-UK Entity; or
 - (d) where you have assigned or Commercially Licensed any Foreground IP to a UK Entity that subsequently becomes a Non-UK Entity.
- 16.4 In order to avoid any unnecessary complexity, the ARIA Non-UK Fee will be based on the terms that you agree with any person to which you assign or Commercially License the relevant Foreground IP. This ARIA Non-UK Fee will amount to an additional twenty-five per cent (25%) of the value of the consideration (including upfronts, licence fees, milestone payments, royalties, shares or other securities, buyouts, exit fees and other consideration) that you receive from the exploitation of the relevant Foreground IP during any period that the above circumstances exist.
- 16.5 For example, if you would receive £100 (via royalty or royalty buyout), you must ensure your contractual mechanism enables you to collect an additional £25 and pay that additional amount to ARIA.
- 16.6 The ARIA Non-UK Fee is payable within 90 days after the end of each relevant Financial Year for receipts related to that calendar year. You are encouraged to use the clauses in Annex 1 in your Commercialisation Licences of Foreground IP.

Crown Body customers

- 16.7 You must ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no

higher than those offered to or agreed with any other customer for equivalent quantities, and in suitable quantities for the Crown Body's requirements.

Spin-outs

- 16.8 ARIA seeks to maximise future investment of entrepreneurial talent and capital in start-up companies commercialising the Results of its funded activities. To that end, having funded the full economic cost of the research, ARIA places restrictions on the level of equity stakes and royalties that you may negotiate in exchange for the assignment or Commercialisation Licence of any Foreground IP.
- 16.9 If you or your technology transfer company assign or licence any Foreground IP to any third party or to a start-up established for the purpose of commercially exploiting the Results (a NewCo) you together with any connected person (including any investment fund to which you may transfer any part of your stake) shall be entitled to:

EITHER

- (a) hold or have the right to hold no more than 10% in fully-dilutable shares or equity (pre investment) in the third party or NewCo (with no other preferential subscription rights), not including any shares or equity subscribed for cash on arm's length terms alongside other investors;

OR

- (b) charge a royalty, with no upfront payments, annual fees, milestone payments or minimum royalties, payable by the third party or NewCo under any licence or assignment of the Foreground IP at no more than the relevant rate, and on the other terms, set out in Schedule 3.

- 16.10 The provisions of clauses 16.9(a) and 16.9(b) shall not apply to any equity taken or royalty charged in consideration of:

- (a) IP other than Foreground IP licensed or assigned to the third party or NewCo; or
 - (b) facilities, equipment, personnel or other material support or services provided to the third party or NewCo independent of the Project Activities,
- with such equity or royalty limited to the proportion that reflects the contribution made by IP that is not Foreground IP.

- 16.11 You must notify ARIA in writing before any transaction completes of the overall equity stake or royalty percentages agreed under clause 16.8 (and any impact of clause 16.9, if relevant).

17. ASSETS

- 17.1 You must keep a register during the Funding Period and for up to 7 years after the end of the Funding Period of all Assets, with all relevant details about each Asset. You must use any Assets purchased with Grant monies for the Project Activities.

- 17.2 At the end of the Funding Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

- 18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Grant Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUBCONTRACTING

- 19.1 You may not transfer, assign, novate or otherwise dispose of the whole or any part of the Grant Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.
- 19.2 You shall not subcontract any of the Project Activities to a Third Party except to the extent permitted, and to the person or persons identified, in Schedule 2 Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractor as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Grant Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Grant Agreement.

20. BORROWING, LOSSES, GIFTS, SPECIAL PAYMENTS

- 20.1 You must obtain ARIA's prior written consent before:
- (a) borrowing or lending money from any source in connection with the Grant Agreement;
 - (b) giving any guarantee, indemnity, security over any Asset or letter of comfort in relation to the Grant Agreement;
 - (c) making any gift or writing off any debt or liability in connection with the Grant, and must keep a record of all gifts given and received in connection with the Grant.

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Grant and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Grant or publicise details of the Grant Agreement without the other's consent, except as required by Law.
- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events occur:

- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13, 15.5 or 25, or commit a material breach of any other term of the Grant Agreement in the reasonable opinion of ARIA;
- (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
- (c) you fail to improve the performance of the Project Activities, notwithstanding your having undertaken the remedial activity agreed with ARIA in the remedial plan under clause 6.2(d);
- (d) you or the researchers involved in the Project Activities obtain any funding from a Third Party that, in the opinion of ARIA, undertakes activities that are likely to bring the reputation of the Project Activities or ARIA into disrepute;
- (e) you provide ARIA with any materially misleading or inaccurate information in your grant application or in subsequent related correspondence;
- (f) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Third Party, immediately upon becoming aware of it;
- (g) you are subject to an Insolvency Event;
- (h) the Grant or any part of it is held by a court or competent authority to be a prohibited subsidy under the Subsidy Control Act 2022 or an illegal state aid;
- (i) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project Activities;
 - (ii) result in your being unable to receive the Grant; and/or
 - (iii) raises national security concerns.

Rights reserved for ARIA in relation to an Event of Default

22.2 If an Event of Default has or may have occurred, ARIA may by written notice to you take any one or more of the following actions:

- (a) suspend the Project Activities and payment of the whole or any part of the Grant for such period as ARIA may determine, acting reasonably;
- (b) reduce the Maximum Sum, in which case the payment of Grant will thereafter be made in accordance with the reduction and notified to you; and/or
- (c) subject to clause 22.4, terminate the Grant Agreement with immediate effect as from the date of service of the notice of that termination.

22.3 Where this Grant Agreement is terminated for an Event of Default described in clause 22.1(f) or 22.1(h), ARIA may require you to repay the entire amount of the Grant previously paid to you.

Opportunity for you to remedy an Event of Default

22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:

- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and
- (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

22.5 Without prejudice to any other provision of the Grant Agreement, you may terminate the Grant Agreement on written notice to ARIA if ARIA commits a material breach of the Grant Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

General Termination Rights

22.6 Notwithstanding ARIA's right to terminate the Grant Agreement under clause 22.2(c), either party may terminate the Grant Agreement (in whole or in part) at any time by giving at least 60 days' prior written notice to the other party.

22.7 You must promptly notify ARIA in writing if at any time the principal investigator or any key researcher(s) named in Schedule 2 working on the Project Activities is unable or unwilling to continue to be involved in the Project Activities or is moving to a new organisation without the desire to continue the research. Within 60 days after the date of that notice, you must either:

- (a) nominate one or more successors, subject to ARIA's approval; or
- (b) agree that the Grant is transferred to another organisation subject to your and the new organisation's agreement in writing and ARIA's approval of the transfer

If ARIA is unwilling to accept the nominated successor(s) or does not approve a request for transfer, it may terminate the Grant Agreement by at least 30 days' written notice to you.

Consequences of Termination

22.8 If the Grant Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.

22.9 Where ARIA terminates the Grant Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:

- (a) you taking all reasonable steps to mitigate such loss; and
- (b) the Unavoidable Costs being:
 - (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Grant Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA;

- (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you;
- (v) costs that would not have been incurred had this Grant Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period).

- 22.10 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Services, over £250,000 will terminate automatically and immediately upon termination of this Agreement.
- 22.11 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Grant Agreement in the event that the Grant Agreement was terminated (calculated on the basis described in clause 22.8).
- 22.12 ARIA's total liability under clause 22.9 shall be limited to the Maximum Sum under the Grant Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.13 If the Grant Agreement is terminated or expires ARIA will not be liable to pay any of your costs or those of any of your contractors or suppliers related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Grant Funding Letter and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Grant Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Grant Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the Grant Manager and the Project Representative.
- 23.3 If the dispute cannot be resolved between the Grant Manager and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to a formal meeting between the parties' Escalation Contacts.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:
- (a) fraudulent misrepresentation or any other fraudulent act or omission;
 - (b) payment of sums properly due and owing to the other in the normal course of performance of this Grant Agreement;
 - (c) a breach of clause 13;

- (d) liability arising under any indemnity in this Grant Agreement; or
- (e) liability which may not lawfully be excluded or limited.

24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Grant Agreement or for ARIA's breach of this Grant Agreement), whether arising directly or indirectly, that may arise in connection with:

- (a) your carrying out the Project Activities;
- (b) the use of the Grant by any person;
- (c) any reduction, suspension, withdrawal or request for repayment of the Grant in accordance with this Grant Agreement; or
- (d) termination of the Grant Agreement in accordance with this Grant Agreement.

24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:

- (a) loss of profit, sales or turnover;
- (b) loss of contracts or business opportunities;
- (c) loss of anticipated savings;
- (d) loss of goodwill or damage to reputation; or
- (e) any indirect, special or consequential loss or damage;

in each case arising out of or relating to the Grant Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.

24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to the Grant Agreement or its subject matter or anything which it has done or not done in connection with the Grant Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the amount of the Maximum Sum.

24.5 You shall under no circumstances in connection with this Grant Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.

24.6 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Grant Agreement.

25. RESEARCH ETHICS AND CODE OF CONDUCT

25.1 As a recipient of a Government grant you must operate in accordance with the Concordat.

25.2 All research data:

- (a) must be generated using sound scientific techniques and processes;
- (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and

(c) must be analysed appropriately, without bias and in accordance with good scientific practices.

25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.

25.4 You must comply with the Code of Conduct and ensure that your Representatives undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

26.1 Any variation to the Grant Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

27. GENERAL

27.1 Notices: All notices and other communications in relation to this Grant Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such communications will be deemed to have been given and received on the third Working Day following such mailing.

27.2 Change of control: You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(i) is likely to apply.

28. GOVERNING LAW

28.1 This Grant Agreement (including any non-contractual disputes or claims arising in connection with this Grant Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. NOT USED

30. DEFINITIONS AND INTERPRETATION

30.1 Where they appear in these Conditions or the Grant Agreement:

Adequate Insurance means the insurance requirements and amounts set out in the Grant Funding Letter.

Asset means any asset that is purchased, improved or developed using the Grant including equipment and fixed assets;

Background IP means IP that is:

(a) owned by or licensed to a party prior to the Commencement Date; or
(b) developed by or on behalf of a party during the Funding Period but not in connection with the Project Activities,

and is in either case used in connection with the Project Activities;

Bribery Act means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;

Change of Control means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Recipients of Government General Grants published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754555/2018-11-06_Code_of_Conduct_for_Grant_Recipients.pdf

including any subsequent updates from time to time;

Commencement Date means the date set out in the Grant Funding Letter;

Commercialisation Licence means a licence of IP other than a research or evaluation licence and/or subcontract manufacture (and **Commercially License** means to license under a Commercialisation Licence);

Commercialisation Hypothesis means the exploitation plan approved by ARIA and set out at Schedule 2 Part 2, as may be amended by agreement between the parties during and after the Funding Period;

Completion Date means the date set out in the Grant Funding Letter;

Concordat means the Concordat to Support Research Integrity which can be found at <https://ukrio.org/about-us/the-concordat-to-support-research-integrity/>

Conditions means these ARIA Grant Conditions;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Grant Agreement, that ought reasonably to be considered to be confidential (whether or not it is so marked), (a) including: (i) information relating to the business, affairs, customers, clients, suppliers or plans of the disclosing party; (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party; (iii) any information developed by the parties in the course of carrying out the Project Activities; (iv) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Grant Agreement; and (v) and any information derived from any of the above,

(b) but not including information which: (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11); (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party; (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or (iv) is independently developed without access to the Confidential Information; and (v) the content of this specific version of the Grant Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

Duplicate Funding means funding provided to you by a Third Party which is to fund the same activities as the Project Activities;

EA means the Equality Act 2000 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Eligible Expenditure means the payments made by you during the Funding Period for the purposes of carrying out the Project Activities which comply with clause 5 and ARIA's published eligibility rules (which provide for full economic cost reimbursement) and as agreed in the Grant Funding Letter;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Grant Funding Letter;

Event of Default means any of the events or circumstances set out in clause 22.1;

Financial Year means 1 April to 31 March;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means any IP in the Results;

Funding Period means the period commencing on the Commencement Date and ending on the Completion Date or such later date as may be agreed between the parties unless otherwise determined in accordance with the terms of the Grant Agreement;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification (operated by ARIA or by a third party), in the form set out at Annex A;

GDPR means Regulation (EU) 2016/679;

Go/No-Go Milestone means a decision point for ARIA to determine whether it wishes to proceed with or terminate the Project Activities (any decision regarding a Go/No-Go Milestone will be made at ARIA's sole discretion, following a Grant Review as outlined in Clause 6);

Grant means the sum or sums ARIA will pay to you up to the amount set out in the Grant Funding Letter, in accordance with clause 4 and subject to the provisions set out at clause 22.

Grant Agreement has the meaning given in the Grant Funding Letter;

Grant Claim means a request submitted by you to ARIA for payment of the Grant;

Grant Funding Letter means the letter from ARIA to you to which these Conditions are annexed;

Grant Manager means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Grant;

Grant Review means the process for reviewing the grant outlined in clause 6;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Ineligible Expenditure means expenditure incurred by you which is not Eligible Expenditure as set out in clause 5 and ARIA's published eligibility rules;

Information Acts means the Data Protection Legislation, FOIA and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property Rights or **IP** means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions, semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation;

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise;

Maximum Sum means the maximum amount of the Grant stated in the Grant Funding Letter;

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

NewCo has the meaning given in clause 16;

Non-UK Entity means a legal entity that is not a UK Entity;

Personal Data has the meaning given to it in the Data Protection Legislation as amended from time to time;

Prohibited Act means:

(a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Grant Agreement; and/or (ii) showing or not showing favour or disfavour to any person in relation to the Grant Agreement;

(b) committing any offence: (i) under the Bribery Act; (ii) under legislation creating offences in respect of fraudulent acts; and/or (iii) at common law in respect of fraudulent acts in relation to the Grant Agreement; and/or

(c) defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the activities to be carried out by you that are described in the Grant Funding Letter and in Schedule 2 Part 1;

Project Representative means the representative appointed by you, who at the Commencement Date will be the individual listed as such in the Grant Funding Letter;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means all information, data, techniques, inventions, discoveries, works, software and materials generated in the course of the Project Activities;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Project Activities or any part thereof or facilities or services necessary for the performance of the Project Activities or any part thereof or necessary for the management, direction or control of the Project Activities or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

UK Entity means a legal entity whose ultimate parent company has its headquarters and principal establishment in the United Kingdom;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Grant Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Funding Period because of termination or breach of the Grant Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination; and

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 In these Conditions and the Grant Agreement, unless the context otherwise requires:

- (a) references to "party" and "parties" are to the parties to the Grant Agreement;
- (b) the singular includes the plural and vice versa;
- (c) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (d) references to clauses and Schedules are to the clauses of these Conditions and to the Schedules to the Grant Agreement;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation"; and
- (g) the headings in the Grant Agreement are for ease of reference only and will not affect the interpretation or construction of the Grant Agreement.

PART 1 - PROJECT ACTIVITIES

1. Background

SAI is one of the most-studied forms of climate engineering, but research has virtually exclusively been limited to numerical simulations. Most of the studies investigating different strategies look at the effects of introducing sulphur dioxide (SO_2) into the stratosphere, which reacts to become sulphuric acid aerosol (H_2SO_4) and which reflects some of the radiation from the sun back into space increasing the planetary albedo (α in equation for T_{surf} in Programme Thesis). This has in part been inspired by observations from volcanic eruptions, especially the 1991 Mount Pinatubo eruption which lofted ~20 million tonnes of SO_2 into the stratosphere resulting in global cooling by approximately 0.5 °C for around a year. Injection of aerosols into the stratosphere rather than the troposphere reduces the required mass injection rate in part due to longer residence times. Depending on the latitude of injection, the aerosol cloud would be dispersed across the globe within a period of weeks. SAI is considered by a number of scientists as a potential way of actively cooling the earth.

2. Aims and objectives of the Project Activities

The aim of this project is to improve our understanding of Stratospheric Aerosol Injection (SAI) as a potential climate intervention improve our understanding.

The objectives are to expand our knowledge of different candidate particles by combining outdoor experiments, laboratory work and modelling to determine which materials could be effective at radiative forcing, while assessing what their effects could be on stratospheric composition and dynamics compared to SO_2 .

3. Project Activities

3.1

- 3.1.1 **WP1 - Stratospheric evolution of chemical and physical properties of Alternative SAI Materials (ASAIMs):** This Work Package will address the evolution of chemical and optical properties of ASAIMs through the preparation and conducting of stratospheric balloon flights and short duration science flights (~4 hour duration). No materials will be released to the stratosphere in these flights
- 3.1.2 **WP2 - Dispersal and deliverability of aerosols:** This WP will conduct laboratory (indoor) tests on potential dispersal systems, measuring particle size distribution using methods including optical and scanning mobility particle sizers.
- 3.1.3 **WP3 - Climate impact of non-sulphate aerosols:** The necessary context for WP1 and WP2 is provided by evaluating how findings change the overall efficacy of SAI using ASAIMs. Plume dynamics, efficient plume representation, ambient condition estimation and simulating plume effects at global scale are all investigated, analysed and modelled computationally.

3.2 The following Milestones will be used to monitor your delivery of the Project. The costs associated with completing these Milestones are estimated in the cost breakdown sheet [REDACTED]

ID	Milestones	Measure	Date	Notes
1	Flight plan submitted and agreed for balloon launch with no materials attached. This is a go/no go milestone	Evidence supplied that short duration, small balloon launches are compliant with applicable and required regulations/legislation. Draft communication and engagement plan agreed with ARIA and oversight committee. Small balloon launches likely to take place in locations TBC as part of the launch plan, . Launches must not commence until the communication and engagement plan has been agreed by ARIA, and until any required engagement activities have been undertaken.	Commencement Date + 3 months	
2	Short duration science flight plan submitted and agreed for balloon launch with materials attached. This is a go/no go milestone	Evidence supplied that short duration science flights are compliant with applicable and required regulations/legislation. Updated communication and engagement plan agreed with ARIA and oversight committee. Launches must not commence until the communication and engagement plan has been agreed by ARIA, and until any required engagement	Commencement Date + 6 months	

		activities have been undertaken.		
3	Design briefing for high-pressure slurry pump delivery system and for aerosol dispersion system complete (WP2)	Select the preferred options for pumping and dispersal for indoor tests based on initial findings from literature, patents, commercial products and calculations. Includes safety audit and risk assessment owing to high-pressure pumping.	Commencement Date + 6 months	
42	Vessel ready for science flights (WP1) with materials attached.	Select and mount ASAIM materials on grids; complete prototype vessel design, fabrication and thermal vacuum tests followed by short duration balloon engineering flight (first flight ~1 h in stratosphere; subsequently up to 4 h); all data for publication of vessel design collected. (First flights expected to take about 10 h total)	Commencement Date + 9 months	
5	Interim report on comms and engagement	Summary of the nature of comms and engagement undertaken to date supplied to ARIA and oversight committee. A description of these activities to date should be provided, as well as a discussion of how these activities have shaped experimental	Commencement Date + 12 months	

		work. A plan for ongoing comms and engagement should be included in the report.		
6	Flight plan submitted and agreed for long durations balloon launch with materials attached This is a go/no go milestone	Evidence supplied that these launches are compliant with applicable and required regulations/legislation Updated communication and engagement plan agreed with ARIA and oversight committee as appropriate. Readiness of system and science approach for longer duration flights (weeks, months, heavier launches) established.	Commencement Date + 18 months	Key considerations include: 1) Whether a consecutive sequence of 3 day flights can substitute for one long duration flight and achieve science goals and whether this is cost saving. If answer is yes, this approach will be taken and revised approach and budget presented to ARIA 2) Whether another funded Creator has developed a longer duration balloon system suitable for our payload and whether this is cost saving. If the answer is yes, the trade-offs with this approach will be evaluated with respect to science and budget, and presented to ARIA.
7	Batch prototype	System that can deliver a dispersed plume of	Commencement Date	

	dispersion and pumping systems available	aerosol in indoor tests is functioning; agglomeration and effects of electrostatics can be investigated. Order of few hundred grams of aerosol dispersed indoors in batch over a period of minutes is suggested as a target. Slurry pumping system can run indoors for a few seconds using a suitable medium (e.g. liquid nitrogen).	+ 24 months	
8	Mid term report on Project Progress (WP-All)	Series of flights completed and first detailed characterization of aging of ASAIMs in real environment over longer time representing key parameters for radiative and chemical impacts of ASAIMs (WP1); Design & Outcome of an indoor prototype dispersal system to deliver particles with narrow size distribution and without clumping together with experimental design to test pumping mechanisms (WP2); results from annual simulation (WP3). Concepts for potential follow on activities are presented to ARIA.	Commencement Date + 24 months	
98	Continuous indoor prototype pumping	Steady and continuous flow of slurry can be maintained indoors at high pressure (20+ bar)	Commencement Date	

	system available	using suitable medium (e.g. liquid nitrogen). Demonstrated indoors over multiple canisters of aerosol over several minutes of operation.	+ 36 months	
10	Final Report on Project completion (WP2&3)	Design and evaluation of a multi-phase (slurry) high-pressure pumping system and the indoor dispersal system (WP2); Results of annual simulation (WP3).	Commencement Date + 36 months Report delivery expected month 38	

In addition to the above Milestones, the following project plan will be used to track progress throughout the project and may be updated from time to time: [REDACTED]

3.3 The intended long-term outcomes are summarised below:

- Detailed understanding of the effects and potential impacts of ASAIMs on and in the stratosphere
- Using indoor tests to understand the technological challenges and opportunities for high pressure aerosol delivery systems
- Identification of materials that offer safer alternatives for SAI, whilst still maintaining key properties for effectiveness for extended periods in the stratosphere.

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement
Planning	• Roles and responsibilities • External communications • Vision • Project details

	• Code and data management • Project plan + project management
Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Key Learning, discoveries and decisions • Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • Invoicing and cost reporting Optional: • technical evidence saved to drive e.g. report or presentation as requested by PD • review meeting slide deck saved to drive as requested by PD
Annual	• ARIA impact metrics • Attendance at annual ARIA event
Ad hoc	• As required, Programme Director/ Programme Team may request additional information and evidence • Workshops - potential to be invited to ARIA workshops
Project closure	• Project closure report

5. Payment

5.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments quarterly in arrears.

For quarterly payments, the cadence of payments will align with ARIAs financial year beginning 1st April e.g Quarter 1 Grant Claims will be for the period of 1st April to 30 June, Quarter 2 Grant Claims will be for the period of 1st July to 30 Sept and so on.

5.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

5.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end

of the relevant period.

5.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

6. Principal investigator/key researchers

6.1 For the purposes of clause 22.7, the following principle investigators or key researchers have been identified:

Name	Role	Organisation
Frank Keutsch	WP1 Lead	Harvard University
Hugh Hunt	Overall Project Lead and WP2 Lead	University of Cambridge
Shaun Fitzgerald	Key Researcher of WP2	University of Cambridge
Sebastian Eastham	WP3 Lead	Imperial College London
[REDACTED]	Key Researcher of WP3	University of Cambridge
[REDACTED]	Key Researcher of WP3	University of Cambridge

7. Sub-Contractors

7.1 For the purposes of clause 19, the following Sub-Contractors have been ~~agreed~~ identified:

Name	Description of activity	Location of organisation
Aerostar	Conducting a 3 week stratospheric balloon flight with Aerostar's Thunderhead Balloon Systems.	South Dakota, USA

PART 2 - GRANT APPLICATION

Application titled "Novel Materials for Stratospheric Aerosol Injection" submitted 6 December 2025

SCHEDULE 3

Royalty Percentages

Royalties on the sale or supply of products or services that are covered by, use or incorporate the Foreground IP licensed to the NewCo will only become due on aggregate net sales derived from the Foreground IP exceeding £50 million.

The maximum headline percentage royalty rate (i.e. before any royalty stacking, step-down or other reduction and excluding any ARIA Non-UK Fee) for products or services that are covered by, use or incorporate the Foreground IP, and of sublicensing income, shall be one of the following:

Type of product	Applicable headline royalty percentage (up to)
Low margin	0.5% of net sales
Medium margin	1% of net sales
High margin	2% of net sales
Sublicensing royalty	10% of net receipts

ANNEX 1

Clause for inclusion in licences of Foreground IP

[] **ARIA NON-UK FEE**

[].1 In this clause:

“ARIA” means the Advanced Research and Invention Agency;

“Crown Body” means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

“UK Entity” means a legal entity that has or whose ultimate parent company has its headquarters and principal establishment in the United Kingdom.

[].2 The Foreground IP was developed with funding from ARIA. As a condition of its funding ARIA requires that a benefit is returned to the United Kingdom where the Foreground IP is licensed by the Licensor to any person that is not a UK Entity. Accordingly, in addition to any other sums payable by the Licensee to the Licensor under this Agreement, the Licensee shall pay to the Licensor within 90 days after the end of each calendar year during the Relevant Period (as defined below), and within 90 days after the end of the Relevant Period, a fee (**ARIA Non-UK Fee**) on all amounts (including upfronts, licence fees, milestone payments, royalties, shares or other securities, exit fees, buyout or other consideration) payable by the Licensee to the Licensor under this Agreement in relation to the exploitation of any Foreground IP (**Relevant Amount**) that accrues during, or relates to, any period of time that the Licensee is not a UK Entity (**Relevant Period**). The amount of the ARIA Non-UK Fee is 25% of the Relevant Amount, and is payable by the Licensee to the Licensor in addition to the amounts that would otherwise be payable under this Agreement. For example if the Relevant Amount is £100 the ARIA Non-UK Fee is an additional £25, which the Licensee shall pay to the Licensor and the Licensor shall remit to ARIA.

Crown Body customers

[].3 You must also ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities and in suitable quantities for the Crown Body's requirements.

[].4 ARIA shall have the right to enforce this clause [] under the Contracts (Rights of Third Parties) Act 1999. Neither party may amend this Agreement in a way that detracts from ARIA's right to enforce its rights under this clause without ARIA's prior written consent.

[1] When using this clause you may substitute the relevant defined terms used elsewhere in the agreement to capture the concept of "Foreground IP". Where the clause refers to the "Licensor" and "Licensee" please use the appropriate defined terms to include the licensor, licensee, assignor and assignee of the Foreground IP. This clause is not suitable for assignments of the Foreground IP in consideration of the payment of one or more lump sum payments. In those cases the Licensor needs to be informed, and potentially make an additional payment, if the Foreground IP is subsequently assigned to a non-UK Entity or if the Assignee ceases to be a UK Entity.

SCHEDULE 4: Data Protection

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Grant Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Grant Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Grant Agreement:
- 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are

relying on Domestic Law as the basis for processing Personal Data, you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;

- 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);
- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Grant Agreement unless required by Domestic Law to store the Personal Data; and

3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.

3.4. [[ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):

3.4.1. cancel its plans to change the affected sub-Processor;

3.4.2. offer an alternative which is acceptable to ARIA; or

3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.

3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Grant Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.

3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]

3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Grant agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it, storing it, retrieving it, consulting it, disseminating it or destroying it, etc.

	Note the definition of processing in the UK GDPR: <i>“any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction”]</i>
Duration of Processing:	Duration of this Grant Agreement (and any post termination processing that is permitted / required).
Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called “special categories” of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: <i>“data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation”]</i>
Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors,

	clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. You shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.
- 4.2. Any limitation of liability set out in this Grant Agreement will not apply to this Schedule's indemnity or reimbursement obligations.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

- 1.** Submission of Pledged Patents and Experimental Data
 - 1.1** The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
 - 1.2** The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.
- 2.** Experimental Data Licence
 - 2.1** Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
 - 2.2** The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
 - 2.3** The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
 - 2.4** The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).
- 3.** Research Licence
 - 3.1** Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
 - 3.2** The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
 - 3.3** Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.

3.5 The Research Licensee must:

- (a) at all times when using the Pledged Patents comply with all Laws; and
- (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).

4. Commercial Licence

4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.

4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.

4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.

5. Pledgor Know-How

At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.

6. Termination

6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:

- (a) materially breaches the terms of such licence or this Pledge; or
- (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).

7. Transfers of Pledged Patents and/or Experimental Data

The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.

8. No Warranty

The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and
Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

University of the Philippines Los Baños Foundation, Inc. **(Grant Recipient)**
567R+CPF, UPLBFI Bldg., Andres P. Aglibut Ave,
University of the Philippines Los Baños,
Los Baños, 4031, Laguna, Philippines

29 May 2025

Attention: Dr. Lorena L. Sabino

Dear Dr. Sabino,

FPCW-PR01-P011 - PULSE Project: Public Understanding, Leadership, and Social Ethics in the Governance of Earth Cooling Technologies in Communities Impacted by Volcanic Activity in the Philippine Context.– Standard Grant Funding Letter

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to Exploring Climate Cooling and ARIA is pleased to offer you a Grant for the performance of the Project Activities up to the Maximum Sum, subject to your agreement to, and compliance with, the terms and conditions set out in this Grant Funding Letter and its Schedules.

1. Overview of the Grant

Any reference in this letter to "you" or "your" means the Grant Recipient and any capitalised terms have the meanings given in the ARIA Grant Conditions (Conditions).

The key elements of the Grant are described in the table below:

Project Activities	PULSE Project: Public Understanding, Leadership, and Social Ethics in the Governance of Earth Cooling Technologies in Communities Impacted by Volcanic Activity in the Philippine Context. A more detailed description of the Project Activities is set out in Schedule 2 (Project Activities).
Maximum Sum of the Grant (inclusive of taxes)	£147,954 (inclusive of all taxes where applicable)
Commencement Date	The commencement date is 1 June 2025
Completion Date	The completion is 31 May 2027

Grant Review Intervals	ARIA will review the Grant at quarterly intervals using the process referred to in clause 6 of the Conditions	
Adequate Insurance	Employers' liability - At least £5 million (as required by the Employers' Liability (Compulsory Insurance Act 1969)) Public liability: £5 million (per year in aggregate)	
Monitoring and Reporting	The performance reports referred to in clause 7 of the Conditions shall be provided at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Project Representative	Lorena L. Sabino Project Principal Investigator [REDACTED] [REDACTED]	
Grant Manager	Mark Symes, Programme Director, [REDACTED]	
Escalation Contacts	ARIA	Grant Recipient
	Chief Product Officer [REDACTED]	[REDACTED] [REDACTED] [REDACTED] [REDACTED] [REDACTED] [REDACTED] [REDACTED]
Notices	ARIA Contracts [REDACTED]	Lorena L. Sabino Project Principal Investigator [REDACTED] [REDACTED] [REDACTED] Research Associate [REDACTED] [REDACTED]

2. Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Grant and return it to finance@aria.org.uk

3. The Grant Agreement

- 3.1. Once you sign a copy of this Grant Funding Letter in accordance with paragraph 6 (Acceptance) below, it will form a binding "**Grant Agreement**" between you and ARIA that includes and incorporates the following documents:

- 3.1.1. the **Grant Conditions** in Schedule 1;
- 3.1.2. the **Project Activities, Milestones** and **Grant Application** in Schedule 2;
- 3.1.3. the **Royalty percentages** (including annexes) in Schedule 3; and
- 3.1.4. the terms relating to Data Protection in Schedule 4.

- 3.2. The parties confirm that it is their intention to be legally bound by the Grant Agreement.

- 3.3. Not used

4. Warranties

- 4.1. By signing this Grant Funding Letter, you warrant and represent that:

- 4.1.1. your obligations under the Grant Agreement are legal, valid, binding and enforceable;
- 4.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Grant Agreement have been obtained;
- 4.1.3. the person signing the Grant Agreement is duly authorised to sign on your behalf; and
- 4.1.4. your Project Representative referenced in the table above is authorised to make decisions and provide information on your behalf.

5. Amendments to the Grant Conditions

- 5.1. Not used

6. Acceptance

- 6.1. To accept this Grant Funding Letter, please arrange for an authorised signatory to sign and date the duplicate copy of this Grant Funding Letter as indicated below, and return to ARIA as a complete signed original of the Grant Agreement including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Grant Agreement and to bind the Grant Recipient.
- 6.2. The offer of this Grant Funding Letter will expire on 01 June 2025.

Yours sincerely,

for and on behalf of ARIA

Name of ARIA signatory:

Position Held:

Date:

I confirm the agreement of University of the Philippines Los Baños Foundation, Inc. (UPLBFI) to the terms and conditions in this Grant Funding Letter and its Schedules.

Signature:

Name:

Position:

SCHEDULE 1 - GRANT CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up the Grant Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Grant Funding Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to the Grant Agreement with the exception of Schedule 2 Part 2 (the Grant Application);
 - (d) Schedule 2 Part 2 (the Grant Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, the Grant Agreement.

2. DURATION AND PURPOSE OF THE GRANT

- 2.1 The Grant Agreement will subsist for the duration of the Funding Period unless extended by written agreement signed by a duly authorised representative of the parties or terminated earlier in accordance with its terms. Any provision of the Grant Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Grant Agreement shall remain in full force and effect, including clauses 1, 2, 4, 7.4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.3, 22.7, 22.8, 22.11, 22.12, 23, 24, 26, 27, 28, and 30.
- 2.2 You may only use the Grant for carrying out the Project Activities. You may not make any changes to the Project Activities without ARIA's prior written agreement.
- 2.3 You may not unreasonably withhold, condition or delay your agreement to any changes requested by ARIA to the Project Activities or the amount of the Grant. Any agreed change will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

3. ENVIRONMENTAL AND SAFETY REQUIREMENTS

- 3.1 In performing the Project Activities, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. PAYMENT OF GRANT

- 4.1 Subject to the remainder of this clause 4, ARIA will pay the Grant to you:
- (a) up to the Maximum Sum;
 - (b) in pounds sterling (GBP) by wire transfer into your bank account, details of which you provided in the Confirmation of Bank Details form attached to the Grant Funding Letter; and
 - (c) if a tax is chargeable in respect of the Grant, all payments will be deemed to be inclusive of all such taxes and ARIA will not be obliged to pay any additional amount.
- 4.2 The bank account of which you provided details in your Confirmation of Bank Details form (and any alternative bank details nominated subsequently by you) must be an ordinary business bank account

with appropriate segregation of duties and control. During the Funding Period, you must notify ARIA of any change of bank account details as soon as reasonably practicable on the same form and signed by an approved signatory. You must notify ARIA of any change of signatory for approval, as soon as known.

- 4.3 You will be the sole recipient of the Grant and you will be responsible for managing the Grant as between you and any Third Parties involved in performing the Project Activities. This includes securing the repayment of the Grant if requested by ARIA in accordance with the Grant Conditions, including where the Grant has already been distributed to Third Parties.
- 4.4 You must promptly notify ARIA if any money is incorrectly paid to you for any reason, and must repay it as soon as reasonably practicable. Any amount not immediately repaid will be recoverable as a civil debt.
- 4.5 ARIA reserves the right not to pay any Grant Claims that are not submitted within the period set out in the Grant Funding Letter or that are incomplete, incorrect or not accompanied by full supporting documentation (including any documentation that ARIA reasonably requests).
- 4.6 You may not apply for or obtain Duplicate Funding for any Project Activities.
- 4.7 You may not retain any Unspent Monies and must repay them to ARIA within 30 days after ARIA's request for repayment.
- 4.8 You acknowledge the critical importance of cash flow for Sub-Contractors (including startups and small businesses) and commit to paying all valid and undisputed invoices relating to the Project within a maximum of 30 days from the date of receipt.
- 4.9 Where required, you will work with Sub-Contractors to arrange more frequent payment schedules (e.g., same day, weekly or milestone-based payments) to better support their cash flow needs.

5. ELIGIBLE AND INELIGIBLE EXPENDITURE

- 5.1 ARIA will only pay the Grant for Eligible Expenditure incurred by you in carrying out the Project Activities. You must provide ARIA with any evidence reasonably requested by ARIA (including receipts, invoices and other documentary evidence) that all Grant Claims relate to costs that are Eligible Expenditure.
- 5.2 You may not in any circumstance claim as Eligible Expenditure paid-for lobbying, which means using the Grant to fund lobbying (via an external firm or in-house staff) in order to undertake activities intended to influence or attempt to influence Parliament, government or political activity; or attempting to influence legislative or regulatory action.

6. GRANT REVIEW

- 6.1 ARIA will review the Grant at the intervals specified in the Grant Funding Letter. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.3.

- 6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:
- (a) consent to the Project Activities and the Grant Agreement continuing in line with existing plans;
 - (b) increase or decrease the Grant for the remainder of the Funding Period, as applicable;
 - (c) redefine the Milestones;
 - (d) require you to carry out remedial activity with the aim of improving delivery of the Project Activities; and/or
 - (e) terminate the Grant Agreement in accordance with clause 22.
- 6.3 Any change to these Grant Terms, the Project Activities, or the Grant pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

7. MONITORING AND REPORTING

- 7.1 You must closely monitor the carrying out of the Project Activities throughout the Funding Period and must notify ARIA as soon as reasonably practicable of any actual or potential failure to comply with any of your obligations under the Grant Agreement.
- 7.2 ARIA does not limit its engagement with you to purely administrative activities and will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project Activities. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.
- 7.3 You must provide ARIA with:
- (a) the Milestones and a report on your performance against the Milestones at the intervals and for the periods of time specified in the Grant Funding Letter. ARIA may copy and adapt the contents of any of the Milestones and those reports for ARIA's internal use to review, develop and shape ARIA's funded research programmes, but ARIA will treat those contents as your Confidential Information under clause 11;
 - (b) any assistance and information reasonably requested by ARIA to establish whether you have used the Grant in accordance with the Grant Agreement; and
 - (c) a quarterly report on the use of the Maximum Sum, details broken down in accordance with ARIA's prescribed form.
- 7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its funding activities and compliance with the terms of the Grant Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time after the end of the Funding Period

about the impact metrics, commercial exploitation or other dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Grant Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Grant Agreement.

8. AUDITING AND ASSURANCE

- 8.1 For Grants between £100k and £500k: At the end of the Funding Period you must provide ARIA with independent assurance that the Grant has been used for carrying out the Project Activities. To satisfy this requirement you must provide a statement showing that the use of the Grant has been certified by an independent and appropriately qualified auditor or accountant.
- 8.2 Subject to clause 11, ARIA and/or its authorised representative may, at any time during the Funding Period and for up to 7 years after the end of the Funding Period, conduct audits in relation to your use of the Grant and your compliance with the Grant Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.
- 8.3 You must:
- (a) maintain an appropriate system of financial management and controls, maintain detailed records in relation to those controls, and provide copies of those records to ARIA on request; and
 - (b) retain, and procure that your Sub-Contractors retain and will provide to you on request, all relevant documentation relating to the Eligible Expenditure (including invoices, receipts and accounting records) during the Funding Period and for a period of 7 years thereafter.

9. FINANCIAL MANAGEMENT

- 9.1 You must:
- (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Grant; and
 - (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project Activities as soon as they are identified, and keep ARIA informed of your remedial actions.
- 9.2 In the event of any actual or suspected fraud, theft or other financial irregularity (which includes use of the Grant for any purpose other than that envisaged by the Grant Agreement), ARIA may, at its absolute discretion:
- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
 - (b) suspend the Project Activities and future payment of the Grant to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

- 10.1 You must inform ARIA promptly of any actual, perceived or potential conflicts between your and your Representatives' obligations under the Grant Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Funding Period.
- 10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that these conflicts are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you or your Representative to cease the conflicting activity and if that is not acceptable to you or your Representative, either party may terminate the Grant Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

- 11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the provision of the Project Activities, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.
- 11.2 ARIA may publish a summary of the Grant Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Grant Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.
- 11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:
- (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;
 - (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information necessary for the purpose concerned and obtains appropriate confidentiality undertakings in relation to such information;
 - (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and where no exception to disclosure under them is applicable; or

- (d) where that party (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.

11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under the Grant Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

12.1 Each party must comply with its obligations under the Law, including where applicable the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.

12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.

12.3 You acknowledge that ARIA, acting in accordance with the Information Acts (other than the FOIA), may disclose information concerning you and the Grant Agreement without consulting you. ARIA must take reasonable steps to notify you of any request for information to the extent permissible and reasonably practical and will give you adequate opportunity to make representations before ARIA discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.

12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or the Grant Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.

12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.

12.6 You must take account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.

- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with the Grant Agreement. If either party anticipates that the other will process any Personal Data on its behalf under the Grant Agreement it must notify the other party and the parties must agree a variation to the Grant Agreement under clause 26 to incorporate appropriate provisions (such as those set out in Schedule 4) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. SUBSIDY CONTROL AND STATE AID

- 14.1 ARIA intends that the Grant complies with the Subsidy Control Act 2022 on the basis that the Project Activities are not economic activities and do not give a specific advantage to one or more enterprises. You must take all reasonable steps to maintain this position and to assist ARIA to comply with the requirements of the Act and must cooperate with any investigations under the Act.
- 14.2 Where the EU state aid laws apply to the Grant (where the Project Activities will affect trade between Northern Ireland and the EU), you acknowledge that the Project Activities are designed and performed so they are compatible with state aid laws. You will take all reasonable steps to assist ARIA to comply with state aid law requirements and cooperate with any investigations by the European Commission into the Project Activities.
- 14.3 ARIA will immediately stop future payments of the Grant and may require repayment of some or all of the Grant if subsidy control or state aid laws so require for the funding to be compliant.

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and not seek to avoid their application by artificial means.

Background IP

- 15.2 The Grant Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Funding Period if any additional Background IP is required either to carry out the Project Activities or to exploit commercially any of the Results.

Foreground IP ownership

- 15.3 You will own all Foreground IP unless your policy is for individual researchers to own the Foreground IP they create, or you agree your Sub-Contractor (or another third party) will own all, or parts of, the Foreground IP. Where your Sub-Contractor or individual researchers (or any other third party involved in the performance of the Project Activities) will own any of the Foreground IP you must impose on them the obligations relating to Foreground IP and Results contained in clauses 15 and 16. Where you assign any Foreground IP to a Third Party (including your technology transfer company) you must impose on that Third Party the obligations relating to Foreground IP and Results contained in clauses 15 and 16.
- 15.4 You must submit all (i) all patents within or covering the Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the Future Proofing our Climate and

Weather Intellectual Property Pledge promptly following creation or filing (as applicable) of such patents and/or data (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge. You hereby agree to comply and uphold the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.5 You must ensure that whenever any Results are used with or communicated to Third Parties or are exploited commercially, ARIA's funding of the Project Activities is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and publication

- 15.6 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.7 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.8 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to fund future prosecution and maintenance and/or request the assignment of the patents to ARIA or its nominee.

Inventor first preference

- 15.9 Subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge if any inventor or active participant in the Project Activities expresses interest in the exploitation of the Foreground IP they have developed, you must give them an opportunity to negotiate an assignment or commercial licence of the Foreground IP, on reasonable terms, prior to negotiating with any entity in which an inventor or active participant in the Project Activities is not involved as a shareholder or other key stakeholder.

16. COMMERCIALISATION OF RESULTS

- 16.1 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge, where they are capable of commercial exploitation you should seek to exploit the Results commercially. This should be done, where applicable, in accordance with the Commercialisation Hypothesis.
- 16.2 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge, if for any reason you choose not to exploit any such Results commercially

within a reasonable timeframe (or, where applicable, the timeframe set out in the Commercialisation Hypothesis) you are encouraged to discuss the position with ARIA, and you may request that ARIA exploit them or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Non-UK Commercialisation

- 16.3 Save as set out in the Future Proofing our Climate and Weather Intellectual Property Pledge, to avoid any restriction on commercialisation, no consent is required from ARIA for any Non-UK commercialisation or any sale of Foreground IP to a Non-UK Entity. However, ARIA is set up to create value for the UK and therefore you must secure a fee payable to ARIA (**ARIA Non-UK Fee**) in each of the following circumstances:
- (a) where you are a Non-UK Entity;
 - (b) where you become a Non-UK Entity;
 - (c) where you assign or Commercially License any Foreground IP to a Non-UK Entity; or
 - (d) where you have assigned or Commercially Licensed any Foreground IP to a UK Entity that subsequently becomes a Non-UK Entity.
- 16.4 In order to avoid any unnecessary complexity, the ARIA Non-UK Fee will be based on the terms that you agree with any person to which you assign or Commercially License the relevant Foreground IP. This ARIA Non-UK Fee will amount to an additional twenty-five per cent (25%) of the value of the consideration (including upfronts, licence fees, milestone payments, royalties, shares or other securities, buyouts, exit fees and other consideration) that you receive from the exploitation of the relevant Foreground IP during any period that the above circumstances exist.
- 16.5 For example, if you would receive £100 (via royalty or royalty buyout), you must ensure your contractual mechanism enables you to collect an additional £25 and pay that additional amount to ARIA.
- 16.6 The ARIA Non-UK Fee is payable within 90 days after the end of each relevant Financial Year for receipts related to that calendar year. You are encouraged to use the clauses in Annex 1 in your Commercialisation Licences of Foreground IP.

Crown Body customers

- 16.7 You must ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities, and in suitable quantities for the Crown Body's requirements.

Spin-outs

- 16.8 ARIA seeks to maximise future investment of entrepreneurial talent and capital in start-up companies commercialising the Results of its funded activities. To that end, having funded the full economic cost of the research, ARIA places restrictions on the level of equity stakes and royalties that you may negotiate in exchange for the assignment or Commercialisation Licence of any Foreground IP.

- 16.9 If you or your technology transfer company assign or licence any Foreground IP to any third party or to a start-up established for the purpose of commercially exploiting the Results (a NewCo) you together with any connected person (including any investment fund to which you may transfer any part of your stake) shall be entitled to:

EITHER

- (a) hold or have the right to hold no more than 10% in fully-dilutable shares or equity (pre investment) in the third party or NewCo (with no other preferential subscription rights), not including any shares or equity subscribed for cash on arm's length terms alongside other investors;

OR

- (b) charge a royalty, with no upfront payments, annual fees, milestone payments or minimum royalties, payable by the third party or NewCo under any licence or assignment of the Foreground IP at no more than the relevant rate, and on the other terms, set out in Schedule 3.

- 16.10 The provisions of clauses 16.9(a) and 16.9(b) shall not apply to any equity taken or royalty charged in consideration of:

- (a) IP other than Foreground IP licensed or assigned to the third party or NewCo; or
(b) facilities, equipment, personnel or other material support or services provided to the third party or NewCo independent of the Project Activities,
with such equity or royalty limited to the proportion that reflects the contribution made by IP that is not Foreground IP.

- 16.11 You must notify ARIA in writing before any transaction completes of the overall equity stake or royalty percentages agreed under clause 16.8 (and any impact of clause 16.9, if relevant).

17. ASSETS

- 17.1 You must keep a register during the Funding Period and for up to 7 years after the end of the Funding Period of all Assets, with all relevant details about each Asset. You must use any Assets purchased with Grant monies for the Project Activities.
- 17.2 At the end of the Funding Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

- 18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Grant Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUBCONTRACTING

- 19.1 You may not transfer, assign, novate or otherwise dispose of the whole or any part of the Grant Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.
- 19.2 You shall not subcontract any of the Project Activities to a Third Party except to the extent permitted, and to the person or persons identified, in Schedule 2 Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractor as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Grant Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Grant Agreement.

20. BORROWING, LOSSES, GIFTS, SPECIAL PAYMENTS

- 20.1 You must obtain ARIA's prior written consent before:
- (a) borrowing or lending money from any source in connection with the Grant Agreement;
 - (b) giving any guarantee, indemnity, security over any Asset or letter of comfort in relation to the Grant Agreement;
 - (c) making any gift or writing off any debt or liability in connection with the Grant, and must keep a record of all gifts given and received in connection with the Grant.

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Grant and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Grant or publicise details of the Grant Agreement without the other's consent, except as required by Law.
- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

- 22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events occur:
- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13, 15.5 or 25, or commit a material breach of any other term of the Grant Agreement in the reasonable opinion of ARIA;
 - (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
 - (c) you fail to improve the performance of the Project Activities, notwithstanding your having undertaken the remedial activity agreed with ARIA in the remedial plan under clause 6.2(d);

- (d) you or the researchers involved in the Project Activities obtain any funding from a Third Party that, in the opinion of ARIA, undertakes activities that are likely to bring the reputation of the Project Activities or ARIA into disrepute;
- (e) you provide ARIA with any materially misleading or inaccurate information in your grant application or in subsequent related correspondence;
- (f) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Third Party, immediately upon becoming aware of it;
- (g) you are subject to an Insolvency Event;
- (h) the Grant or any part of it is held by a court or competent authority to be a prohibited subsidy under the Subsidy Control Act 2022 or an illegal state aid;
- (i) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project Activities;
 - (ii) result in your being unable to receive the Grant; and/or
 - (iii) raises national security concerns.

Rights reserved for ARIA in relation to an Event of Default

22.2 If an Event of Default has or may have occurred, ARIA may by written notice to you take any one or more of the following actions:

- (a) suspend the Project Activities and payment of the whole or any part of the Grant for such period as ARIA may determine, acting reasonably;
- (b) reduce the Maximum Sum, in which case the payment of Grant will thereafter be made in accordance with the reduction and notified to you; and/or
- (c) subject to clause 22.4, terminate the Grant Agreement with immediate effect as from the date of service of the notice of that termination.

22.3 Where this Grant Agreement is terminated for an Event of Default described in clause 22.1(f) or 22.1(h), ARIA may require you to repay the entire amount of the Grant previously paid to you.

Opportunity for you to remedy an Event of Default

22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:

- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and
- (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

22.5 Without prejudice to any other provision of the Grant Agreement, you may terminate the Grant Agreement on written notice to ARIA if ARIA commits a material breach of the Grant Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

General Termination Rights

- 22.6 Notwithstanding ARIA's right to terminate the Grant Agreement under clause 22.2(c), either party may terminate the Grant Agreement (in whole or in part) at any time by giving at least 60 days' prior written notice to the other party.
- 22.7 You must promptly notify ARIA in writing if at any time the principal investigator or any key researcher(s) named in Schedule 2 working on the Project Activities is unable or unwilling to continue to be involved in the Project Activities or is moving to a new organisation without the desire to continue the research. Within 60 days after the date of that notice, you must either:
- (a) nominate one or more successors, subject to ARIA's approval; or
 - (b) agree that the Grant is transferred to another organisation subject to your and the new organisation's agreement in writing and ARIA's approval of the transfer

If ARIA is unwilling to accept the nominated successor(s) or does not approve a request for transfer, it may terminate the Grant Agreement by at least 30 days' written notice to you.

Consequences of Termination

- 22.8 If the Grant Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.
- 22.9 Where ARIA terminates the Grant Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:
- (a) you taking all reasonable steps to mitigate such loss; and
 - (b) the Unavoidable Costs being:
 - (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Grant Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA;
 - (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you;
 - (v) costs that would not have been incurred had this Grant Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period).
- 22.10 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Services, over £250,000 will terminate automatically and immediately upon termination of this Agreement.

- 22.11 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Grant Agreement in the event that the Grant Agreement was terminated (calculated on the basis described in clause 22.8).
- 22.12 ARIA's total liability under clause 22.9 shall be limited to the Maximum Sum under the Grant Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.13 If the Grant Agreement is terminated or expires ARIA will not be liable to pay any of your costs or those of any of your contractors or suppliers related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Grant Funding Letter and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Grant Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Grant Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the Grant Manager and the Project Representative.
- 23.3 If the dispute cannot be resolved between the Grant Manager and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to a formal meeting between the parties' Escalation Contacts.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:
- (a) fraudulent misrepresentation or any other fraudulent act or omission;
 - (b) payment of sums properly due and owing to the other in the normal course of performance of this Grant Agreement;
 - (c) a breach of clause 13;
 - (d) liability arising under any indemnity in this Grant Agreement; or
 - (e) liability which may not lawfully be excluded or limited.
- 24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Grant Agreement or for ARIA's breach of this Grant Agreement), whether arising directly or indirectly, that may arise in connection with:
- (a) your carrying out the Project Activities;
 - (b) the use of the Grant by any person;
 - (c) any reduction, suspension, withdrawal or request for repayment of the Grant in accordance with this Grant Agreement; or

(d) termination of the Grant Agreement in accordance with this Grant Agreement.

24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:

- (a) loss of profit, sales or turnover;
- (b) loss of contracts or business opportunities;
- (c) loss of anticipated savings;
- (d) loss of goodwill or damage to reputation; or
- (e) any indirect, special or consequential loss or damage;

in each case arising out of or relating to the Grant Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.

24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to the Grant Agreement or its subject matter or anything which it has done or not done in connection with the Grant Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the amount of the Maximum Sum.

24.5 You shall under no circumstances in connection with this Grant Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.

24.6 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Grant Agreement.

25. RESEARCH ETHICS AND CODE OF CONDUCT

25.1 As a recipient of a Government grant you must operate in accordance with the Concordat.

25.2 All research data:

- (a) must be generated using sound scientific techniques and processes;
- (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and
- (c) must be analysed appropriately, without bias and in accordance with good scientific practices.

25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.

25.4 You must comply with the Code of Conduct and ensure that your Representatives undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

- 26.1 Any variation to the Grant Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

27. GENERAL

- 27.1 Notices: All notices and other communications in relation to this Grant Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such communications will be deemed to have been given and received on the third Working Day following such mailing.
- 27.2 Change of control: You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(i) is likely to apply.

28. GOVERNING LAW

- 28.1 This Grant Agreement (including any non-contractual disputes or claims arising in connection with this Grant Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. NOT USED

30. DEFINITIONS AND INTERPRETATION

- 30.1 Where they appear in these Conditions or the Grant Agreement:
- Adequate Insurance** means the insurance requirements and amounts set out in the Grant Funding Letter.
- Asset** means any asset that is purchased, improved or developed using the Grant including equipment and fixed assets;
- Background IP** means IP that is:
- (a) owned by or licensed to a party prior to the Commencement Date; or
 - (b) developed by or on behalf of a party during the Funding Period but not in connection with the Project Activities,
- and is in either case used in connection with the Project Activities;
- Bribery Act** means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;
- Change of Control** means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Recipients of Government General Grants published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754555/2018-11-06_Code_of_Conduct_for_Grant_Recipients.pdf

including any subsequent updates from time to time;

Commencement Date means the date set out in the Grant Funding Letter;

Commercialisation Licence means a licence of IP other than a research or evaluation licence and/or subcontract manufacture (and **Commercially License** means to license under a Commercialisation Licence);

Commercialisation Hypothesis means the exploitation plan approved by ARIA and set out at Schedule 2 Part 2, as may be amended by agreement between the parties during and after the Funding Period;

Completion Date means the date set out in the Grant Funding Letter;

Concordat means the Concordat to Support Research Integrity which can be found at <https://ukrio.org/about-us/the-concordat-to-support-research-integrity/>

Conditions means these ARIA Grant Conditions;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Grant Agreement, that ought reasonably to be considered to be confidential (whether or not it is so marked), (a) including: (i) information relating to the business, affairs, customers, clients, suppliers or plans of the disclosing party; (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party; (iii) any information developed by the parties in the course of carrying out the Project Activities; (iv) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Grant Agreement; and (v) and any information derived from any of the above,

(b) but not including information which: (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11); (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party; (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or (iv) is independently developed without access to the Confidential Information; and (v) the content of this specific version of the Grant Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

Duplicate Funding means funding provided to you by a Third Party which is to fund the same activities as the Project Activities;

EA means the Equality Act 2000 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Eligible Expenditure means the payments made by you during the Funding Period for the purposes of carrying out the Project Activities which comply with clause 5 and ARIA's published eligibility rules (which provide for full economic cost reimbursement) and as agreed in the Grant Funding Letter;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Grant Funding Letter;

Event of Default means any of the events or circumstances set out in clause 22.1;

Financial Year means 1 April to 31 March;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means any IP in the Results;

Funding Period means the period commencing on the Commencement Date and ending on the Completion Date or such later date as may be agreed between the parties unless otherwise determined in accordance with the terms of the Grant Agreement;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification (operated by ARIA or by a third party), in the form set out at Annex A;

GDPR means Regulation (EU) 2016/679;

Grant means the sum or sums ARIA will pay to you up to the amount set out in the Grant Funding Letter, in accordance with clause 4 and subject to the provisions set out at clause 22.

Grant Agreement has the meaning given in the Grant Funding Letter;

Grant Claim means a request submitted by you to ARIA for payment of the Grant;

Grant Funding Letter means the letter from ARIA to you to which these Conditions are annexed;

Grant Manager means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Grant;

Grant Review means the process for reviewing the grant outlined in clause 6;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Ineligible Expenditure means expenditure incurred by you which is not Eligible Expenditure as set out in clause 5 and ARIA's published eligibility rules;

Information Acts means the Data Protection Legislation, FOIA and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property Rights or **IP** means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions, semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation;

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise;

Maximum Sum means the maximum amount of the Grant stated in the Grant Funding Letter;

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

NewCo has the meaning given in clause 16;

Non-UK Entity means a legal entity that is not a UK Entity;

Personal Data has the meaning given to it in the Data Protection Legislation as amended from time to time;

Prohibited Act means:

(a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Grant Agreement; and/or (ii) showing or not showing favour or disfavour to any person in relation to the Grant Agreement;

(b) committing any offence: (i) under the Bribery Act; (ii) under legislation creating offences in respect of fraudulent acts; and/or (iii) at common law in respect of fraudulent acts in relation to the Grant Agreement; and/or

(c) defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the activities to be carried out by you that are described in the Grant Funding Letter and in Schedule 2 Part 1;

Project Representative means the representative appointed by you, who at the Commencement Date will be the individual listed as such in the Grant Funding Letter;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means all information, data, techniques, inventions, discoveries, works, software and materials generated in the course of the Project Activities;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Project Activities or any part thereof or facilities or services necessary for the performance of the Project Activities or any part thereof or necessary for the management, direction or control of the Project Activities or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

UK Entity means a legal entity whose ultimate parent company has its headquarters and principal establishment in the United Kingdom;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Grant Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Funding Period because of termination or breach of the Grant Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination; and

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 In these Conditions and the Grant Agreement, unless the context otherwise requires:

- (a) references to "party" and "parties" are to the parties to the Grant Agreement;
- (b) the singular includes the plural and vice versa;
- (c) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (d) references to clauses and Schedules are to the clauses of these Conditions and to the Schedules to the Grant Agreement;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation"; and
- (g) the headings in the Grant Agreement are for ease of reference only and will not affect the interpretation or construction of the Grant Agreement.

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

The PULSE Project, titled "Public Understanding, Leadership, and Social Ethics in the Governance of Earth Cooling Technologies," focuses on the governance of Stratospheric Aerosol Injection (SAI). It explicitly targets communities within danger zones affected by volcanic activities, referred to as Volcanically Affected Communities in the Philippine context. This project aims to explore public opinion, ethical considerations, and the governance of SAI.

Communities impacted by volcanic activity are ideal sites for studies on Solar Radiation Management (SRM) because they offer natural analogs to SAI. For example, volcanic eruptions like the 1991 Mount Pinatubo event release materials into the stratosphere that cool the Earth by reflecting solar radiation, similar to proposed SAI methods. These communities are also inherently vulnerable to climate impacts, highlighting the need to understand how they perceive SRM in already at-risk populations, from both climate and natural calamities. Their historical experiences with volcanic activities also provide valuable insights into resilience and response strategies that could inform SRM governance. Local perceptions and ethical considerations in these communities are crucial. Their past experiences with natural calamities may significantly contribute to the development of the governance framework, ensuring that any future use of SRM technologies is managed ethically and inclusively.

The project will yield necessary insights through surveys and community group discussions situated around areas where volcanic eruptions have occurred in the Philippines, with an emphasis on Mt. Mayon (Albay), Mt. Kanlaon (Negros Island), Mt. Pinatubo (Pampanga, Tarlac, Zambales), Taal Volcano (Batangas), and Mt. Hibok-Hibok (Camiguin). The survey aims to determine the communities' stand on SAI, their awareness, knowledge, and concerns, and how this relates to their past experiences concerning volcanic eruptions, changing climate, and aspects of their environment. Focus group discussions and workshops on national-level engagement, including the youth sector, will also be conducted to complement policy analysis and governance frameworks and ensure that any SRM technologies are characterized by transparency and accountability concerning the welfare of vulnerable populations. The project aims to "gauge society's pulse" and ensure future climate interventions are grounded in ethical leadership, inclusive governance, and public accountability.

Study Objectives

The main focuses of the PULSE projects are

Study 1: Investigate the awareness, understanding, and perceptions of communities in the volcanic regions concerning Earth cooling technologies and the associated impacts and risks,

Study 2: Examine ethical issues and intergenerational perspectives of SRM, including equity, justice, and protection in communities prone to volcanic eruptions;

Study 3: Analyze leadership roles and governance frameworks for assuring transparency, accountability, and inclusivity in decision-making for Earth cooling approaches and

Study 4: Recommend structures of governance and other methods for making decision-making inclusive and ethical.

2. Aims and Objectives of the Project Activities

Project activities	Project Activity aim/objectives	Target
Work package 1: Project kick-off coordination, preparation, and procurement of supplies and materials.	- Establish a shared understanding of the project goals and deliverables among stakeholders - Introduce team members, roles, and responsibilities - Outline project work, milestones, and success indicators	2nd Quarter- April to June 2025
Work package 2: Project reconnaissance, survey, and focus group discussion (FGD) in Project sites: Taal Volcano (Batangas) and Mt. Pinatubo (Pampanga, Tarlac, Zambales). Work package 3: Project reconnaissance, survey, and FGD in Project sites: Mt. Mayon (Albay). Work package 4: Project reconnaissance, survey, and FGD in Project sites: Mt. Kanlaon (Negros Island). Work package 5: Project reconnaissance, survey, and FGD in Project sites: Mt. Hibok-hibok (Camiguin).	Visit 1: Reconnaissance - Conduct an on-site coordination and orientation about the project - Initial secondary data gathering (baseline data) (e.g., climate data, socio-economic and environmental-related profiles) - Analyze possible barriers and safety conditions, as well as establish rapport among local government units Visit 2: Survey and Focus Group Discussion - Conduct structured surveys to gather quantitative data - Facilitate focus group discussion - Analyze emerging trends from FGD themes and initial data processing Visit 3 - Workshop and Validation - Present preliminary findings from reconnaissance, survey, and FGDs - Facilitate participatory discussions to refine insights	3rd Quarter - July to September 2025: (Taal Volcano and Mt. Pinatubo) 4th Quarter - October to December 2025: (Mt. Mayon) 1st Quarter: January to March 2026 (Mt. Kanlaon) 2nd Quarter: April to June 2026 (Mt. Hibok-hibok)
Work Package 6. National-level leaders/policymakers and youth engagement	Key Informant Interview and Policymaker engagement Workshops	3rd Quarter: July to September 2026
Work Package 7. Data processing, management integration, and analyses	- Develop a structured workflow for data collection, cleaning, coding, and storage to ensure accuracy, consistency, and security - Establish a data management system	4th Quarter: October to December 2026

	that allows an efficient data organization, retrieval, and tracking of data from the surveys, key informant interviews (KII), and FGDs • Harmonize data from multiple sources • Apply appropriate statistical and qualitative analyses	
Work Package 8: Writeshop, Report Writing, Report Submission and Drafting of Publishable articles	• Organize write shop among team members • Prepare a comprehensive project report • Transform research findings into high-impact academic and more widely-oriented publications for journals, conferences, and other dissemination platforms	1st Quarter (January 2027 to April 2027)

3. Project Activities

3.1 The PULSE Project is structured into a series of coordinated work packages (WPs) that align closely with its goals, targets, and objectives. These work packages are designed to progress systematically from initial project setup and data collection to in-depth analysis and dissemination of findings.

WP1: Initiation and Planning

- **Objective:** Launch the project with planning, coordination, and preparations.
- **Activities:**
 - Conduct a project kick-off meeting to introduce team members and assign roles and responsibilities.
 - Prepare research protocols, including informed consent forms, survey instruments, key informant interview guides, and focus group discussion (FGD) guide questions.
 - Procure all necessary supplies and materials for the project.
- **Expected Outcome:**
 - Successful project initiation with clear guidelines and prepared team.
 - Submission of a quarterly progress report

WP2 to WP5: Data Collection at Mt. Mayon (Albay), Mt. Kanlaon (Negros Island), Mt. Pinatubo (Pampanga, Tarlac, Zambales), Taal Volcano (Batangas), and Mt. Hibok-Hibok (Camiguin).

- **Objective:** Complete site-specific reconnaissance, surveys, and FGDs
- **Activities:**
 - Conduct site-specific reconnaissance, surveys, and initial FGDs.
 - Data processing and initial analysis are needed to identify emerging trends.
- **Expected Outcome:**
 - Completion of data collection and initial analysis.
 - Submission of a quarterly progress report

WP6: National and Youth Engagement

- **Objective:** Engage national-level stakeholders and the youth in in-depth interviews and discussions to gauge perceptions of Solar Radiation Management (SRM).
- **Activities:**
 - Conduct in-depth interviews and discussions/workshops with policymakers, scientists, environmental activists, and industry leaders, as well as the youth sector
- **Expected Outcome:**
 - Comprehensive understanding of national perspectives on SRM.

WP7: Data Management and Analysis

- **Objective:** Systematically manage and analyze collected data.
- **Activities:**
 - Establish a robust data management system.
 - Harmonize data and apply statistical analyses to interpret findings.
- **Expected Outcome:**

- Integrated and analyzed data ready for reporting.

WP8: Reporting and Dissemination

- **Objective:** Draft and submit comprehensive project reports and scholarly articles.
- **Activities:**
 - Conduct a write shop to draft the final project report and prepare at least two publishable articles.
- **Expected Outcome:**
 - High-quality reports and articles that contribute to the academic and practical understanding of SRM.

3.2 The following Milestones will be used to monitor your delivery of the Project. The costs associated with completing these Milestones are estimated in the cost breakdown sheet:

ID	Milestones	Measure	Date
1	Project kick-off, planning, site coordination, preparation, and procurement of supplies and materials complete	● Project Kick-off meeting held ● Successful introduction of team members, roles, responsibilities, ● Completion of research project protocol such as informed consent, survey instrument, key informant interview guide, and focus group discussion guide questions. ●	Commencement date + 3 months
2	Project reconnaissance, Survey, and FGD in The sites of Taal Volcano and Mt. Pinatubo complete	Completion of surveys, initial FGD themes analyzed, and emerging trends identified in these regions ●	Commencement date + 6 months

3	Project reconnaissance, Survey, and FGD in Project site: Mt. Mayon complete	Completion of Reconnaissance, Survey, and FGD for Mt. Mayon	Commencement date + 9 months
4	Project reconnaissance, Survey, and FGD in Project sites: Mt. Kanlaon complete	Completion of Reconnaissance, Survey, and FGD for Mt. Kanlaon	Commencement date + 12 months
5	Project reconnaissance, Survey, and FGD in Project sites: Mt. Hibok-Hibok complete	Completion of Reconnaissance, Survey, and FGD for Mt. Hibok-Hibok	Commencement date + 15 months
6	Interviews and workshops complete	National-level and Youth engagement: In-depth interviews and discussions/workshops with policymakers, scientists, environmental activists, and industry leaders concerning perceptions of SRM's feasibility, safety, and potential role in global climate strategies. All planned in-depth interviews and policymakers/stakeholder discussions/workshops complete	Commencement date + 18 months
7	Data processing, management integration, and analyses complete	Data Management and Analysis Completed. Establishment of a data management system, data harmonization, and application of statistical analyses	Commencement date + 21 months

8	Writeshop, Report Writing, Report Submission, and Drafting of Publishable articles.	Submission of the comprehensive project report and draft articles for publication (At least two articles) Comprehensive report submission and draft publishable articles (at least two) Make data available on ARIA open-access repository.	Commencement date + 24 months

In addition to the above Milestones, the following project plan will be used to track progress throughout the project and may be updated from time to time:



3.3 The intended long-term outcomes are summarised below:

1. Increased Awareness and Understanding

- Study 1 may lead to a comprehensive report detailing the current awareness, understanding, perception, and acceptance of SRM as an earth-cooling approach among communities in volcanic regions. This report could include data on the perceived benefits, risks, and impacts, which could inform educational and communication strategies. Through systematic reconnaissance, surveys, key informant interviews, and focus group discussions/workshops conducted across various volcanic sites, Taal Volcano, Mt. Pinatubo, Mt. Mayon, Mt. Kanlaon, and Mt. Hibok-Hibok, the project aims to gather and analyze data concerning the perception/awareness, ethical issues, leaders, and governance issues of these areas. Additionally, the project activities are set to enhance the capacity of both project staff and local stakeholders, such as government officials, community leaders, and civil society organizations, enabling them to engage more effectively in discussions about SRM. This capacity-building component is crucial for fostering informed and active participation in governance processes related to earth-cooling technologies.

2. Ethical Framework Development

- Study 2 is expected to result in ethical guidelines or a framework addressing issues such as equity, justice, and protecting vulnerable communities. This framework could help ensure that any future use of SRM considers intergenerational impacts and ethical considerations.

3. Leadership and Governance Insights

- Study 3 could result in a detailed analysis of existing leadership roles and governance frameworks. This might include recommendations for improving transparency, accountability, and inclusivity in the decision-making processes associated with Earth

cooling technologies. Additionally, it could identify key leadership qualities or training needs for effective governance.

4. Governance Structures

- Study 4 will likely produce a set of proposed governance structures that prioritize ethical, inclusive decision-making. These could guide policymakers and local governments to reflect on what responsible governance of earth-cooling approaches in the future could look like.
- The engagement processes, including key informant interviews and stakeholder workshops, are designed to integrate the perspectives of policymakers, government representatives, youth, and local communities.

5. Knowledge dissemination

- The outcomes will be shared through conferences, widely-oriented publications, and academic journals.

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement
Kick off	• Roles and responsibilities • External communications • Project details
Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Invoicing and cost reporting Optional: • Key Learning, discoveries and decisions • Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • technical evidence saved to drive e.g. report or presentation as requested by PD • review meeting slide deck saved to drive as requested by PD

	Review meeting with ARIA Programme Team
Annual	• ARIA impact metrics • Attendance at annual ARIA event
Ad hoc	• As required, Programme Director/ Programme Team may request additional information and evidence • Workshops - potential to be invited to ARIA workshops
Project closure	• Project closure report

5. Payment

5.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments monthly in arrears. Monthly payments will align with the calendar month

5.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

5.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end of the relevant period.

5.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

6. Principal investigator/key researchers

6.1 For the purposes of clause 22.7, the following principle investigators or key researchers have been identified:

Name	Role	Organisation
Lorena L. Sabino	Project Leader- Sets the overall strategic direction of the project and leadership	University of the Philippines
	Full-time research assistant for the following role:	To be hired

	activities if available.	
██████████	Provides guidance and mentorship to research assistants Join the team to conduct activities if available.	Faculty, University of the Philippines
██████████	Provides guidance and mentorship to research assistants Join the team to conduct activities if available.	Faculty, University of the Philippines
██████████	Provides guidance and mentorship to research assistants Join the team to conduct activities if available. Guide in the data analysis of the research project	Faculty, University of the Philippines

7. Sub-Contractors

7.1 For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Location

PART 2 - GRANT APPLICATION

Application titled "Lorena L. Sabino" submitted 9 December 2024.

SCHEDULE 3

Royalty Percentages

Royalties on the sale or supply of products or services that are covered by, use or incorporate the Foreground IP licensed to the NewCo will only become due on aggregate net sales derived from the Foreground IP exceeding £50 million.

The maximum headline percentage royalty rate (i.e. before any royalty stacking, step-down or other reduction and excluding any ARIA Non-UK Fee) for products or services that are covered by, use or incorporate the Foreground IP, and of sublicensing income, shall be one of the following:

Type of product	Applicable headline royalty percentage (up to)
Low margin	0.5% of net sales
Medium margin	1% of net sales
High margin	2% of net sales
Sublicensing royalty	10% of net receipts

ANNEX 1

Clause for inclusion in licences of Foreground IP

[] **ARIA NON-UK FEE**

[].1 In this clause:

"ARIA" means the Advanced Research and Invention Agency;

"Crown Body" means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

"UK Entity" means a legal entity that has or whose ultimate parent company has its headquarters and principal establishment in the United Kingdom.

[].2 The Foreground IP was developed with funding from ARIA. As a condition of its funding ARIA requires that a benefit is returned to the United Kingdom where the Foreground IP is licensed by the Licensor to any person that is not a UK Entity. Accordingly, in addition to any other sums payable by the Licensee to the Licensor under this Agreement, the Licensee shall pay to the Licensor within 90 days after the end of each calendar year during the Relevant Period (as defined below), and within 90 days after the end of the Relevant Period, a fee (**ARIA Non-UK Fee**) on all amounts (including upfronts, licence fees, milestone payments, royalties, shares or other securities, exit fees, buyout or other consideration) payable by the Licensee to the Licensor under this Agreement in relation to the exploitation of any Foreground IP (**Relevant Amount**) that accrues during, or relates to, any period of time that the Licensee is not a UK Entity (**Relevant Period**). The amount of the ARIA Non-UK Fee is 25% of the Relevant Amount, and is payable by the Licensee to the Licensor in addition to the amounts that would otherwise be payable under this Agreement. For example if the Relevant Amount is £100 the ARIA Non-UK Fee is an additional £25, which the Licensee shall pay to the Licensor and the Licensor shall remit to ARIA.

Crown Body customers

[].3 You must also ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities and in suitable quantities for the Crown Body's requirements.

[].4 ARIA shall have the right to enforce this clause [] under the Contracts (Rights of Third Parties) Act 1999. Neither party may amend this Agreement in a way that detracts from ARIA's right to enforce its rights under this clause without ARIA's prior written consent.

[1] When using this clause you may substitute the relevant defined terms used elsewhere in the agreement to capture the concept of "Foreground IP". Where the clause refers to the "Licensor" and "Licensee" please use the appropriate defined terms to include the licensor, licensee, assignor and assignee of the Foreground IP. This clause is not suitable for assignments of the Foreground IP in consideration of the payment of one or more lump sum payments. In those cases the Licensor needs to be informed, and potentially make an additional payment, if the Foreground IP is subsequently assigned to a non-UK Entity or if the Assignee ceases to be a UK Entity.

SCHEDULE 4: Data Protection

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Grant Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Grant Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Grant Agreement:
- 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are

relying on Domestic Law as the basis for processing Personal Data, you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;

- 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);
- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Grant Agreement unless required by Domestic Law to store the Personal Data; and

- 3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.
- 3.4. [[ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):
- 3.4.1. cancel its plans to change the affected sub-Processor;
- 3.4.2. offer an alternative which is acceptable to ARIA; or
- 3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.
- 3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Grant Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.
- 3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]
- 3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Grant agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it, storing it, retrieving it, consulting it, disseminating it or destroying it, etc.

	Note the definition of processing in the UK GDPR: <i>“any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction”]</i>
Duration of Processing:	Duration of this Grant Agreement (and any post termination processing that is permitted / required).
Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called “special categories” of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: <i>“data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation”]</i>
Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors,

	clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. You shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.
- 4.2. Any limitation of liability set out in this Grant Agreement will not apply to this Schedule's indemnity or reimbursement obligations.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

1. Submission of Pledged Patents and Experimental Data
 - 1.1 The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
 - 1.2 The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.
2. Experimental Data Licence
 - 2.1 Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
 - 2.2 The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
 - 2.3 The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
 - 2.4 The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).
3. Research Licence
 - 3.1 Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
 - 3.2 The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
 - 3.3 Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

- 3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.
- 3.5 The Research Licensee must:
- (a) at all times when using the Pledged Patents comply with all Laws; and
 - (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).
4. Commercial Licence
- 4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.
- 4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.
- 4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.
5. Pledgor Know-How
- At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.
6. Termination
- 6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:
- (a) materially breaches the terms of such licence or this Pledge; or
 - (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).
7. Transfers of Pledged Patents and/or Experimental Data
- The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.
8. No Warranty
- The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and
Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

The Chancellor, Masters, and Scholars of the University of Cambridge **(Grant Recipient)**

The Old Schools, Trinity Lane, Cambridge, CB2 1TN

29th May 2025

Attention: Shaun Fitzgerald

Dear Shaun,

FPCW-PR01-P015 - Re-thickening Arctic Sea Ice— Standard Grant Funding Letter

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to Exploring Climate Cooling and ARIA is pleased to offer you a Grant for the performance of the Project Activities up to the Maximum Sum, subject to your agreement to, and compliance with, the terms and conditions set out in this Grant Funding Letter and its Schedules.

1. Overview of the Grant

Any reference in this letter to "you" or "your" means the Grant Recipient and any capitalised terms have the meanings given in the ARIA Grant Conditions (Conditions).

The key elements of the Grant are described in the table below:

Project Activities	Re-thickening Arctic Sea Ice. A more detailed description of the Project Activities is set out in Schedule 2 (Project Activities).
Maximum Sum of the Grant (inclusive of taxes)	£9,907,841 (inclusive of all taxes where applicable)
Commencement Date	The commencement date is 2 June 2025
Completion Date	The completion is 1 December 2028
Grant Review Intervals	ARIA will review the Grant at quarterly intervals using the process referred to in clause 6 of the Conditions
Adequate Insurance	Employers' liability - At least £5 million (as required by the Employers' Liability (Compulsory Insurance Act 1969))

	Public liability: £10 million (per year in aggregate)	
Monitoring and Reporting	The performance reports referred to in clause 7 of the Conditions shall be provided at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Project Representative	Shaun Fitzgerald, Project Lead, [REDACTED]	
Grant Manager	Mark Symes, Programme Director, [REDACTED]	
Escalation Contacts	ARIA	Grant Recipient
	Chief Product Officer [REDACTED]	[REDACTED] Research Support Manager, School of Technology University of Cambridge, [REDACTED] [REDACTED] [REDACTED] [REDACTED] [REDACTED]
Notices	ARIA Contracts [REDACTED]	Assistant Director, School of Technology University of Cambridge, Research Operations Office, [REDACTED] [REDACTED] [REDACTED] [REDACTED]

2. Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Grant and return it to finance@aria.org.uk

3. The Grant Agreement

3.1. Once you sign a copy of this Grant Funding Letter in accordance with paragraph 6 (Acceptance) below, it will form a binding "**Grant Agreement**" between you and ARIA that includes and incorporates the following documents:

3.1.1. the **Grant Conditions** in Schedule 1;

3.1.2. the **Project Activities, Milestones** and **Grant Application** in Schedule 2;

3.1.3. the **Royalty percentages** (including annexes) in Schedule 3; and

3.1.4. the terms relating to Data Protection in Schedule 4.

3.2. The parties confirm that it is their intention to be legally bound by the Grant Agreement.

3.3. Not used.

4. Warranties

4.1. By signing this Grant Funding Letter, you warrant and represent that:

4.1.1. your obligations under the Grant Agreement are legal, valid, binding and enforceable;

4.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Grant Agreement have been obtained;

4.1.3. the person signing the Grant Agreement is duly authorised to sign on your behalf; and

4.1.4. your Project Representative referenced in the table above is authorised to make decisions and provide information on your behalf.

5. Amendments to the Grant Conditions

5.1. Not used

6. Acceptance

6.1. To accept this Grant Funding Letter, please arrange for an authorised signatory to sign and date the duplicate copy of this Grant Funding Letter as indicated below, and return to ARIA as a complete signed original of the Grant Agreement including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Grant Agreement and to bind the Grant Recipient.

6.2. The offer of this Grant Funding Letter will expire on 02 June 2025.

Yours sincerely

for and on behalf of ARIA

Name of ARIA signatory:

Position Held:

Date:

I confirm the agreement of The Chancellor, Masters, and Scholars of the University of Cambridge to the terms and conditions in this Grant Funding Letter and its Schedules.

Signature:

Name:

Position:

Date:

SCHEDULE 1 - GRANT CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up the Grant Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Grant Funding Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to the Grant Agreement with the exception of Schedule 2 Part 2 (the Grant Application);
 - (d) Schedule 2 Part 2 (the Grant Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, the Grant Agreement.

2. DURATION AND PURPOSE OF THE GRANT

- 2.1 The Grant Agreement will subsist for the duration of the Funding Period unless extended by written agreement signed by a duly authorised representative of the parties or terminated earlier in accordance with its terms. Any provision of the Grant Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Grant Agreement shall remain in full force and effect, including clauses 1, 2, 4, 7.4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.3, 22.7, 22.8, 22.11, 22.12, 23, 24, 26, 27, 28, and 30.
- 2.2 You may only use the Grant for carrying out the Project Activities. You may not make any changes to the Project Activities without ARIA's prior written agreement.
- 2.3 You may not unreasonably withhold, condition or delay your agreement to any changes requested by ARIA to the Project Activities or the amount of the Grant. Any agreed change will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

3. ENVIRONMENTAL AND SAFETY REQUIREMENTS

- 3.1 In performing the Project Activities, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. PAYMENT OF GRANT

- 4.1 Subject to the remainder of this clause 4, ARIA will pay the Grant to you:
- (a) up to the Maximum Sum;
 - (b) in pounds sterling (GBP) by wire transfer into your bank account, details of which you provided in the Confirmation of Bank Details form attached to the Grant Funding Letter; and
 - (c) if a tax is chargeable in respect of the Grant, all payments will be deemed to be inclusive of all such taxes and ARIA will not be obliged to pay any additional amount.
- 4.2 The bank account of which you provided details in your Confirmation of Bank Details form (and any alternative bank details nominated subsequently by you) must be an ordinary business bank account

with appropriate segregation of duties and control. During the Funding Period, you must notify ARIA of any change of bank account details as soon as reasonably practicable on the same form and signed by an approved signatory. You must notify ARIA of any change of signatory for approval, as soon as known.

- 4.3 You will be the sole recipient of the Grant and you will be responsible for managing the Grant as between you and any Third Parties involved in performing the Project Activities. This includes securing the repayment of the Grant if requested by ARIA in accordance with the Grant Conditions, including where the Grant has already been distributed to Third Parties.
- 4.4 You must promptly notify ARIA if any money is incorrectly paid to you for any reason, and must repay it as soon as reasonably practicable. Any amount not immediately repaid will be recoverable as a civil debt.
- 4.5 ARIA reserves the right not to pay any Grant Claims that are not submitted within the period set out in the Grant Funding Letter or that are incomplete, incorrect or not accompanied by full supporting documentation (including any documentation that ARIA reasonably requests).
- 4.6 You may not apply for or obtain Duplicate Funding for any Project Activities.
- 4.7 You may not retain any Unspent Monies and must repay them to ARIA within 30 days after ARIA's request for repayment.
- 4.8 You acknowledge the critical importance of cash flow for Sub-Contractors (including startups and small businesses) and commit to paying all valid and undisputed invoices relating to the Project within a maximum of 30 days from the date of receipt.
- 4.9 Where required, you will work with Sub-Contractors to arrange more frequent payment schedules (e.g., same day, weekly or milestone-based payments) to better support their cash flow needs.

5. ELIGIBLE AND INELIGIBLE EXPENDITURE

- 5.1 ARIA will only pay the Grant for Eligible Expenditure incurred by you in carrying out the Project Activities. You must provide ARIA with any evidence reasonably requested by ARIA (including receipts, invoices and other documentary evidence) that all Grant Claims relate to costs that are Eligible Expenditure.
- 5.2 You may not in any circumstance claim as Eligible Expenditure paid-for lobbying, which means using the Grant to fund lobbying (via an external firm or in-house staff) in order to undertake activities intended to influence or attempt to influence Parliament, government or political activity; or attempting to influence legislative or regulatory action.

6. GRANT REVIEW

- 6.1 ARIA will review the Grant at the intervals specified in the Grant Funding Letter. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.3.

- 6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:
- (a) consent to the Project Activities and the Grant Agreement continuing in line with existing plans;
 - (b) increase or decrease the Grant for the remainder of the Funding Period, as applicable;
 - (c) redefine the Milestones;
 - (d) require you to carry out remedial activity with the aim of improving delivery of the Project Activities; and/or
 - (e) terminate the Grant Agreement in accordance with clause 22.
- 6.3 Any change to these Grant Terms, the Project Activities, or the Grant pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Grant Agreement in accordance with clause 26.
- 6.4 For the avoidance of doubt any decision to terminate the Grant Agreement as a result of a Go/No Go Milestone will be made at ARIA's sole discretion and done so in accordance with clause 22.6.

7. MONITORING AND REPORTING

- 7.1 You must closely monitor the carrying out of the Project Activities throughout the Funding Period and must notify ARIA as soon as reasonably practicable of any actual or potential failure to comply with any of your obligations under the Grant Agreement.
- 7.2 ARIA does not limit its engagement with you to purely administrative activities and will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project Activities. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.
- 7.3 You must provide ARIA with:
- (a) the Milestones and a report on your performance against the Milestones at the intervals and for the periods of time specified in the Grant Funding Letter. ARIA may copy and adapt the contents of any of the Milestones and those reports for ARIA's internal use to review, develop and shape ARIA's funded research programmes, but ARIA will treat those contents as your Confidential Information under clause 11;
 - (b) any assistance and information reasonably requested by ARIA to establish whether you have used the Grant in accordance with the Grant Agreement; and
 - (c) a quarterly report on the use of the Maximum Sum, details broken down in accordance with ARIA's prescribed form.

- 7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its funding activities and compliance with the terms of the Grant Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time after the end of the Funding Period about the impact metrics, commercial exploitation or other dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Grant Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Grant Agreement.

8. AUDITING AND ASSURANCE

- 8.1 For Grants over £500k: Annually, and on each anniversary of the Commencement Date and at the end of the Funding Period you must provide ARIA with independent assurance that the Grant has been used for carrying out the Project Activities. To satisfy this requirement you must provide a statement showing that the use of the Grant has been certified by an independent and appropriately qualified auditor or accountant.
- 8.2 Subject to clause 11, ARIA and/or its authorised representative may, at any time during the Funding Period and for up to 7 years after the end of the Funding Period, conduct audits in relation to your use of the Grant and your compliance with the Grant Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.
- 8.3 You must:
- (a) maintain an appropriate system of financial management and controls, maintain detailed records in relation to those controls, and provide copies of those records to ARIA on request; and
 - (b) retain, and procure that your Sub-Contractors retain and will provide to you on request, all relevant documentation relating to the Eligible Expenditure (including invoices, receipts and accounting records) during the Funding Period and for a period of 7 years thereafter.

9. FINANCIAL MANAGEMENT

- 9.1 You must:
- (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Grant; and
 - (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project Activities as soon as they are identified, and keep ARIA informed of your remedial actions.

9.2 In the event of any actual or suspected fraud, theft or other financial irregularity (which includes use of the Grant for any purpose other than that envisaged by the Grant Agreement), ARIA may, at its absolute discretion:

- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
- (b) suspend the Project Activities and future payment of the Grant to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

10.1 You must inform ARIA promptly of any actual, perceived or potential conflicts between your and your Representatives' obligations under the Grant Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Funding Period.

10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that these conflicts are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you or your Representative to cease the conflicting activity and if that is not acceptable to you or your Representative, either party may terminate the Grant Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the provision of the Project Activities, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.

11.2 ARIA may publish a summary of the Grant Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Grant Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.

11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:

- (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;

- (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information necessary for the purpose concerned and obtains appropriate confidentiality undertakings in relation to such information;
- (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and where no exception to disclosure under them is applicable; or
- (d) where that party (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.

11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under the Grant Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

- 12.1 Each party must comply with its obligations under the Law, including where applicable the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.
- 12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.
- 12.3 You acknowledge that ARIA, acting in accordance with the Information Acts (other than the FOIA), may disclose information concerning you and the Grant Agreement without consulting you. ARIA must take reasonable steps to notify you of any request for information to the extent permissible and reasonably practical and will give you adequate opportunity to make representations before ARIA discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.
- 12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or the Grant Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.
- 12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.
- 12.6 You must take account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate

mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

- 13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.
- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with the Grant Agreement. If either party anticipates that the other will process any Personal Data on its behalf under the Grant Agreement it must notify the other party and the parties must agree a variation to the Grant Agreement under clause 26 to incorporate appropriate provisions (such as those set out in Schedule 4) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. SUBSIDY CONTROL AND STATE AID

- 14.1 ARIA intends that the Grant complies with the Subsidy Control Act 2022 on the basis that the Project Activities are not economic activities and do not give a specific advantage to one or more enterprises. You must take all reasonable steps to maintain this position and to assist ARIA to comply with the requirements of the Act and must cooperate with any investigations under the Act.
- 14.2 Where the EU state aid laws apply to the Grant (where the Project Activities will affect trade between Northern Ireland and the EU), you acknowledge that the Project Activities are designed and performed so they are compatible with state aid laws. You will take all reasonable steps to assist ARIA to comply with state aid law requirements and cooperate with any investigations by the European Commission into the Project Activities.
- 14.3 ARIA will immediately stop future payments of the Grant and may require repayment of some or all of the Grant if subsidy control or state aid laws so require for the funding to be compliant.

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and not seek to avoid their application by artificial means.

Background IP

- 15.2 The Grant Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Funding Period if any additional Background IP is required either to carry out the Project Activities or to exploit commercially any of the Results.

Foreground IP ownership

- 15.3 You will own all Foreground IP unless your policy is for individual researchers to own the Foreground IP they create, or you agree your Sub-Contractor (or another third party) will own all, or parts of, the

Foreground IP. Where your Sub-Contractor or individual researchers (or any other third party involved in the performance of the Project Activities) will own any of the Foreground IP you must impose on them the obligations relating to Foreground IP and Results contained in clauses 15 and 16. Where you assign any Foreground IP to a Third Party (including your technology transfer company) you must impose on that Third Party the obligations relating to Foreground IP and Results contained in clauses 15 and 16.

- 15.4 You must submit all (i) all patents within or covering the Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the Future Proofing our Climate and Weather Intellectual Property Pledge promptly following creation or filing (as applicable) of such patents and/or data (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge. You hereby agree to comply and uphold the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.5 You must ensure that whenever any Results are used with or communicated to Third Parties or are exploited commercially, ARIA's funding of the Project Activities is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and publication

- 15.6 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.7 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.8 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to fund future prosecution and maintenance and/or request the assignment of the patents to ARIA or its nominee.

Inventor first preference

- 15.9 Subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge] if any inventor or active participant in the Project Activities expresses interest in the exploitation of the Foreground IP they have developed, you must give them an opportunity to negotiate an assignment or commercial licence of the Foreground IP, on reasonable terms, prior to negotiating with any entity in which an inventor or active participant in the Project Activities is not involved as a shareholder or other key stakeholder.

16. COMMERCIALISATION OF RESULTS

- 16.1 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge], where they are capable of commercial exploitation you should seek to exploit the Results commercially. This should be done, where applicable, in accordance with the Commercialisation Hypothesis.
- 16.2 Save for Results that are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge, if for any reason you choose not to exploit any such Results commercially within a reasonable timeframe (or, where applicable, the timeframe set out in the Commercialisation Hypothesis) you are encouraged to discuss the position with ARIA, and you may request that ARIA exploit them or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Non-UK Commercialisation

- 16.3 Save as set out in the Future Proofing our Climate and Weather Intellectual Property Pledge, to avoid any restriction on commercialisation, no consent is required from ARIA for any Non-UK commercialisation or any sale of Foreground IP to a Non-UK Entity. However, ARIA is set up to create value for the UK and therefore you must secure a fee payable to ARIA (**ARIA Non-UK Fee**) in each of the following circumstances:
- (a) where you are a Non-UK Entity;
 - (b) where you become a Non-UK Entity;
 - (c) where you assign or Commercially License any Foreground IP to a Non-UK Entity; or
 - (d) where you have assigned or Commercially Licensed any Foreground IP to a UK Entity that subsequently becomes a Non-UK Entity.
- 16.4 In order to avoid any unnecessary complexity, the ARIA Non-UK Fee will be based on the terms that you agree with any person to which you assign or Commercially License the relevant Foreground IP. This ARIA Non-UK Fee will amount to an additional twenty-five per cent (25%) of the value of the consideration (including upfronts, licence fees, milestone payments, royalties, shares or other securities, buyouts, exit fees and other consideration) that you receive from the exploitation of the relevant Foreground IP during any period that the above circumstances exist.
- 16.5 For example, if you would receive £100 (via royalty or royalty buyout), you must ensure your contractual mechanism enables you to collect an additional £25 and pay that additional amount to ARIA.
- 16.6 The ARIA Non-UK Fee is payable within 90 days after the end of each relevant Financial Year for receipts related to that calendar year. You are encouraged to use the clauses in Annex 1 in your Commercialisation Licences of Foreground IP.

Crown Body customers

- 16.7 You must ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no

higher than those offered to or agreed with any other customer for equivalent quantities, and in suitable quantities for the Crown Body's requirements.

Spin-outs

- 16.8 ARIA seeks to maximise future investment of entrepreneurial talent and capital in start-up companies commercialising the Results of its funded activities. To that end, having funded the full economic cost of the research, ARIA places restrictions on the level of equity stakes and royalties that you may negotiate in exchange for the assignment or Commercialisation Licence of any Foreground IP.
- 16.9 If you or your technology transfer company assign or licence any Foreground IP to any third party or to a start-up established for the purpose of commercially exploiting the Results (a NewCo) you together with any connected person (including any investment fund to which you may transfer any part of your stake) shall be entitled to:

EITHER

- (a) hold or have the right to hold no more than 10% in fully-dilutable shares or equity (pre investment) in the third party or NewCo (with no other preferential subscription rights), not including any shares or equity subscribed for cash on arm's length terms alongside other investors;

OR

- (b) charge a royalty, with no upfront payments, annual fees, milestone payments or minimum royalties, payable by the third party or NewCo under any licence or assignment of the Foreground IP at no more than the relevant rate, and on the other terms, set out in Schedule 3.

- 16.10 The provisions of clauses 16.9(a) and 16.9(b) shall not apply to any equity taken or royalty charged in consideration of:

- (a) IP other than Foreground IP licensed or assigned to the third party or NewCo; or
(b) facilities, equipment, personnel or other material support or services provided to the third party or NewCo independent of the Project Activities,
with such equity or royalty limited to the proportion that reflects the contribution made by IP that is not Foreground IP.

- 16.11 You must notify ARIA in writing before any transaction completes of the overall equity stake or royalty percentages agreed under clause 16.8 (and any impact of clause 16.9, if relevant).

17. ASSETS

- 17.1 You must keep a register during the Funding Period and for up to 7 years after the end of the Funding Period of all Assets, with all relevant details about each Asset. You must use any Assets purchased with Grant monies for the Project Activities.

- 17.2 At the end of the Funding Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

- 18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Grant Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUBCONTRACTING

- 19.1 You may not transfer, assign, novate or otherwise dispose of the whole or any part of the Grant Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.
- 19.2 You shall not subcontract any of the Project Activities to a Third Party except to the extent permitted, and to the person or persons identified, in Schedule 2 Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractor as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Grant Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Grant Agreement.

20. BORROWING, LOSSES, GIFTS, SPECIAL PAYMENTS

- 20.1 You must obtain ARIA's prior written consent before:
- (a) borrowing or lending money from any source in connection with the Grant Agreement;
 - (b) giving any guarantee, indemnity, security over any Asset or letter of comfort in relation to the Grant Agreement;
 - (c) making any gift or writing off any debt or liability in connection with the Grant, and must keep a record of all gifts given and received in connection with the Grant.

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Grant and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Grant or publicise details of the Grant Agreement without the other's consent, except as required by Law.
- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events occur:

- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13, 15.5 or 25, or commit a material breach of any other term of the Grant Agreement in the reasonable opinion of ARIA;
- (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
- (c) you fail to improve the performance of the Project Activities, notwithstanding your having undertaken the remedial activity agreed with ARIA in the remedial plan under clause 6.2(d);
- (d) you or the researchers involved in the Project Activities obtain any funding from a Third Party that, in the opinion of ARIA, undertakes activities that are likely to bring the reputation of the Project Activities or ARIA into disrepute;
- (e) you provide ARIA with any materially misleading or inaccurate information in your grant application or in subsequent related correspondence;
- (f) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Third Party, immediately upon becoming aware of it;
- (g) you are subject to an Insolvency Event;
- (h) the Grant or any part of it is held by a court or competent authority to be a prohibited subsidy under the Subsidy Control Act 2022 or an illegal state aid;
- (i) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project Activities;
 - (ii) result in your being unable to receive the Grant; and/or
 - (iii) raises national security concerns.

Rights reserved for ARIA in relation to an Event of Default

22.2 If an Event of Default has or may have occurred, ARIA may by written notice to you take any one or more of the following actions:

- (a) suspend the Project Activities and payment of the whole or any part of the Grant for such period as ARIA may determine, acting reasonably;
- (b) reduce the Maximum Sum, in which case the payment of Grant will thereafter be made in accordance with the reduction and notified to you; and/or
- (c) subject to clause 22.4, terminate the Grant Agreement with immediate effect as from the date of service of the notice of that termination.

22.3 Where this Grant Agreement is terminated for an Event of Default described in clause 22.1(f) or 22.1(h), ARIA may require you to repay the entire amount of the Grant previously paid to you.

Opportunity for you to remedy an Event of Default

22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:

- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and
- (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

22.5 Without prejudice to any other provision of the Grant Agreement, you may terminate the Grant Agreement on written notice to ARIA if ARIA commits a material breach of the Grant Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

General Termination Rights

22.6 Notwithstanding ARIA's right to terminate the Grant Agreement under clause 22.2(c), either party may terminate the Grant Agreement (in whole or in part) at any time by giving at least 60 days' prior written notice to the other party.

22.7 You must promptly notify ARIA in writing if at any time the principal investigator or any key researcher(s) named in Schedule 2 working on the Project Activities is unable or unwilling to continue to be involved in the Project Activities or is moving to a new organisation without the desire to continue the research. Within 60 days after the date of that notice, you must either:

- (a) nominate one or more successors, subject to ARIA's approval; or
- (b) agree that the Grant is transferred to another organisation subject to your and the new organisation's agreement in writing and ARIA's approval of the transfer

If ARIA is unwilling to accept the nominated successor(s) or does not approve a request for transfer, it may terminate the Grant Agreement by at least 30 days' written notice to you.

Consequences of Termination

22.8 If the Grant Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.

22.9 Where ARIA terminates the Grant Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:

- (a) you taking all reasonable steps to mitigate such loss; and
- (b) the Unavoidable Costs being:
 - (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Grant Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA;

- (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you;
- (v) costs that would not have been incurred had this Grant Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period).

- 22.10 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Services, over £250,000 will terminate automatically and immediately upon termination of this Agreement.
- 22.11 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Grant Agreement in the event that the Grant Agreement was terminated (calculated on the basis described in clause 22.8).
- 22.12 ARIA's total liability under clause 22.9 shall be limited to the Maximum Sum under the Grant Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.13 If the Grant Agreement is terminated or expires ARIA will not be liable to pay any of your costs or those of any of your contractors or suppliers related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Grant Funding Letter and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Grant Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Grant Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the Grant Manager and the Project Representative.
- 23.3 If the dispute cannot be resolved between the Grant Manager and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to a formal meeting between the parties' Escalation Contacts.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:
- (a) fraudulent misrepresentation or any other fraudulent act or omission;
 - (b) payment of sums properly due and owing to the other in the normal course of performance of this Grant Agreement;
 - (c) a breach of clause 13;

- (d) liability arising under any indemnity in this Grant Agreement; or
- (e) liability which may not lawfully be excluded or limited.

24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Grant Agreement or for ARIA's breach of this Grant Agreement), whether arising directly or indirectly, that may arise in connection with:

- (a) your carrying out the Project Activities;
- (b) the use of the Grant by any person;
- (c) any reduction, suspension, withdrawal or request for repayment of the Grant in accordance with this Grant Agreement; or
- (d) termination of the Grant Agreement in accordance with this Grant Agreement.

24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:

- (a) loss of profit, sales or turnover;
- (b) loss of contracts or business opportunities;
- (c) loss of anticipated savings;
- (d) loss of goodwill or damage to reputation; or
- (e) any indirect, special or consequential loss or damage;

in each case arising out of or relating to the Grant Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.

24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to the Grant Agreement or its subject matter or anything which it has done or not done in connection with the Grant Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the amount of the Maximum Sum.

24.5 You shall under no circumstances in connection with this Grant Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.

24.6 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Grant Agreement.

25. RESEARCH ETHICS AND CODE OF CONDUCT

25.1 As a recipient of a Government grant you must operate in accordance with the Concordat.

25.2 All research data:

- (a) must be generated using sound scientific techniques and processes;
- (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and

(c) must be analysed appropriately, without bias and in accordance with good scientific practices.

25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.

25.4 You must comply with the Code of Conduct and ensure that your Representatives undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

26.1 Any variation to the Grant Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

27. GENERAL

27.1 Notices: All notices and other communications in relation to this Grant Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such communications will be deemed to have been given and received on the third Working Day following such mailing.

27.2 Change of control: You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(i) is likely to apply.

28. GOVERNING LAW

28.1 This Grant Agreement (including any non-contractual disputes or claims arising in connection with this Grant Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. NOT USED

30. DEFINITIONS AND INTERPRETATION

30.1 Where they appear in these Conditions or the Grant Agreement:

Adequate Insurance means the insurance requirements and amounts set out in the Grant Funding Letter.

Asset means any asset that is purchased, improved or developed using the Grant including equipment and fixed assets;

Background IP means IP that is:

(a) owned by or licensed to a party prior to the Commencement Date; or
(b) developed by or on behalf of a party during the Funding Period but not in connection with the Project Activities,

and is in either case used in connection with the Project Activities;

Bribery Act means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;

Change of Control means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Recipients of Government General Grants published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754555/2018-11-06_Code_of_Conduct_for_Grant_Recipients.pdf

including any subsequent updates from time to time;

Commencement Date means the date set out in the Grant Funding Letter;

Commercialisation Licence means a licence of IP other than a research or evaluation licence and/or subcontract manufacture (and **Commercially License** means to license under a Commercialisation Licence);

Commercialisation Hypothesis means the exploitation plan approved by ARIA and set out at Schedule 2 Part 2, as may be amended by agreement between the parties during and after the Funding Period;

Completion Date means the date set out in the Grant Funding Letter;

Concordat means the Concordat to Support Research Integrity which can be found at <https://ukrio.org/about-us/the-concordat-to-support-research-integrity/>

Conditions means these ARIA Grant Conditions;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Grant Agreement, that ought reasonably to be considered to be confidential (whether or not it is so marked), (a) including: (i) information relating to the business, affairs, customers, clients, suppliers or plans of the disclosing party; (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party; (iii) any information developed by the parties in the course of carrying out the Project Activities; (iv) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Grant Agreement; and (v) and any information derived from any of the above,

(b) but not including information which: (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11); (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party; (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or (iv) is independently developed without access to the Confidential Information; and (v) the content of this specific version of the Grant Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

Duplicate Funding means funding provided to you by a Third Party which is to fund the same activities as the Project Activities;

EA means the Equality Act 2000 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Eligible Expenditure means the payments made by you during the Funding Period for the purposes of carrying out the Project Activities which comply with clause 5 and ARIA's published eligibility rules (which provide for full economic cost reimbursement) and as agreed in the Grant Funding Letter;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Grant Funding Letter;

Event of Default means any of the events or circumstances set out in clause 22.1;

Financial Year means 1 April to 31 March;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means any IP in the Results;

Funding Period means the period commencing on the Commencement Date and ending on the Completion Date or such later date as may be agreed between the parties unless otherwise determined in accordance with the terms of the Grant Agreement;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification (operated by ARIA or by a third party), in the form set out at Annex A;

GDPR means Regulation (EU) 2016/679;

Go/No-Go Milestone means a decision point for ARIA to determine whether it wishes to proceed with or terminate the Project Activities (any decision regarding a Go/No-Go Milestone will be made at ARIA's sole discretion, following a Grant Review as outlined in Clause 6);

Grant means the sum or sums ARIA will pay to you up to the amount set out in the Grant Funding Letter, in accordance with clause 4 and subject to the provisions set out at clause 22.

Grant Agreement has the meaning given in the Grant Funding Letter;

Grant Claim means a request submitted by you to ARIA for payment of the Grant;

Grant Funding Letter means the letter from ARIA to you to which these Conditions are annexed;

Grant Manager means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Grant;

Grant Review means the process for reviewing the grant outlined in clause 6;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Ineligible Expenditure means expenditure incurred by you which is not Eligible Expenditure as set out in clause 5 and ARIA's published eligibility rules;

Information Acts means the Data Protection Legislation, FOIA and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property Rights or **IP** means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions, semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation;

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise;

Maximum Sum means the maximum amount of the Grant stated in the Grant Funding Letter;

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

NewCo has the meaning given in clause 16;

Non-UK Entity means a legal entity that is not a UK Entity;

Personal Data has the meaning given to it in the Data Protection Legislation as amended from time to time;

Prohibited Act means:

(a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Grant Agreement; and/or (ii) showing or not showing favour or disfavour to any person in relation to the Grant Agreement;

(b) committing any offence: (i) under the Bribery Act; (ii) under legislation creating offences in respect of fraudulent acts; and/or (iii) at common law in respect of fraudulent acts in relation to the Grant Agreement; and/or

(c) defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the activities to be carried out by you that are described in the Grant Funding Letter and in Schedule 2 Part 1;

Project Representative means the representative appointed by you, who at the Commencement Date will be the individual listed as such in the Grant Funding Letter;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means all information, data, techniques, inventions, discoveries, works, software and materials generated in the course of the Project Activities;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Project Activities or any part thereof or facilities or services necessary for the performance of the Project Activities or any part thereof or necessary for the management, direction or control of the Project Activities or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

UK Entity means a legal entity whose ultimate parent company has its headquarters and principal establishment in the United Kingdom;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Grant Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Funding Period because of termination or breach of the Grant Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination; and

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 In these Conditions and the Grant Agreement, unless the context otherwise requires:

- (a) references to "party" and "parties" are to the parties to the Grant Agreement;
- (b) the singular includes the plural and vice versa;
- (c) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (d) references to clauses and Schedules are to the clauses of these Conditions and to the Schedules to the Grant Agreement;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation"; and
- (g) the headings in the Grant Agreement are for ease of reference only and will not affect the interpretation or construction of the Grant Agreement.

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

The Arctic is currently warming 3-4 times faster than the global average. While rapidly decarbonizing the global economy is crucial, implementing methods to specifically cool the Arctic region could significantly extend the time needed to avoid temperature-induced climate tipping points. To explore the feasibility of purposefully cooling the Arctic, we propose investigating whether sea ice re-thickening could offer a viable solution. Ice re-thickening is primarily achieved by drawing seawater onto existing sea ice to increase its thickness. By enhancing ice thickness, sea ice can endure longer during warmer seasons, thereby enhancing the reflectivity of a geographic area compared to seawater. This would reduce not only solar warming of the region but also global temperatures. Alongside direct re-thickening, our project aims to explore how thickening key portions of sea ice can be used to help limit sea ice export out of the Arctic Ocean.

2. Aims and objectives of the Project Activities

The aim of this project is to develop the essential knowledge, technology and impact assessments required for sea ice thickening to mitigate the significant loss of sea ice coverage in the Arctic Ocean.

This will be done by integrating large-scale climate and sea ice modelling validated by field and laboratory tests to assess:

- a) The feasibility of large-scale Regional Application of Arctic Ice Thickening.
- b) The feasibility of a targeted approach involving Ice Arch Strengthening, so as to limit the export of Arctic sea ice.

Alongside each of these approaches, we will also address the scalability of developed technologies.

3. Project Activities

3.1

3.1.1 **WP1 - Satellite Analysis:** This WP aims to identify the most vulnerable areas of ice thinning that would benefit from ice thickening, providing crucial input for the modelling work. We will use high-resolution satellite imagery to monitor the timing and location of ice arch formation and disintegration. Additionally, we will review data to identify areas in the Arctic, away from the ice arches, that are experiencing annual ice loss. This will help determine regions that could benefit most from winter sea ice thickening.

3.1.2 **WP2 - Ice modelling:** A suite of analytical and numerical models will be used to enhance our understanding of how sea ice grows and strengthens when seawater is pumped onto its surface. This work will provide crucial input for the larger-scale modelling efforts of WP3. Models for water flow through snow will help establish the areal extent of water coverage required based on snow depth, temperature, flow rate, and ice surface morphology. By developing end-member models of channel and radial flow, we aim to

better predict the physical characteristics of sea ice that grows faster through seawater pumping.

- 3.1.3 **WP3 - Regional and Arctic basin scale modelling:** The outputs of the detailed ice modelling undertaken in WP2 will be utilised in conjunction with the results from the small-scale laboratory experiments (WP5), and field tests (WP6) to inform the regional and Arctic basin model parameters. The impact of re-icing will be modelled using two fully-coupled climate models: the Community Earth System Model version 2 (CESM2) and the UK Earth Systems Model (UKESM).
 - 3.1.4 **WP4 - Impact upon Arctic Albedo:** Using the results of WP2, WP3 and observations planned in WP6, we will calculate the potential change in Arctic albedo (and therefore global warming contribution) for a range of climate scenarios. The different levels of albedo of normal sea ice, flooded sea ice, and snow covered sea ice will be assessed.
 - 3.1.5 **WP5 - Laboratory Experiments:** Laboratory tests will be conducted to validate the models developed in WP2, which will be critical for building our understanding of the evolution of the ice. A series of non-flow experiments to investigate the freezing of saltwater on top of fresh ice and the subsequent migration of brine will be conducted and the evolving ice thickness and temperature profiles will be compared with theoretical predictions.
 - 3.1.6 **WP6 - Field Experiments:** Two field test programs running in parallel will be undertaken, each lasting at most three winters (2025/26 to 2027/28), operating in different locations in the Arctic. These experiments will be informed by and inform our modelling work on ice growth (WP2). They will also help inform our larger scale modelling (WP3), our assessment of the impact on albedo (WP4), and our work on scalability (WP7).
 - 3.1.7 **WP7 - Engineering Development:** There will be an investigation into two different technological approaches to ice thickening and the potential for scaling up to areas of approximately 1 million square kilometers.
 - 3.1.8 **WP8 - Project Management, Coordination and Synthesis:** This project involves a number of teams in different locations. Regular project controls meetings will take place on the project and field experiments as well as an annual all-team in-person workshop.
- 3.2 The following Milestones will be used to monitor delivery of the Project. The costs associated with completing these Milestones are estimated in the cost breakdown sheet [REDACTED]

ID	Milestones	Measure	Date	Notes
1	Update on preparations for outdoor experiments	Engagement and permitting plans and progress to date shared with ARIA and the oversight committee for feedback. Framework for agreeing process for approval for outdoor experiment agreed between team, ARIA and oversight committee.	Commencement Date + 4 months	
2	Permits & local support obtained in each location for 2025/26 winter (WP6) This is a Go/No Go Milestone	Permits (including EIA) will be obtained for Real Ice and Arctic Reflections ice thickening field tests (locations TBC). Evidence supplied to ARIA and oversight committee of ongoing community engagement activities in proposed regions	Commencement Date + 8 months	(i.e. by 1st Feb) (Real Ice expect permit by 6 months)
3a	Initial report on sea ice characteristics for input to regional model in WP3 (WP1)	Report detailing sea ice thickness data analysis from airborne and satellite measurements with sea ice drift data to calculate ice fluxes in both area extent and ice volume	Commencement Date + 12 months	
3b	Initial report on modelling of Regional and	Report synthesising the initial modelling output of WP2, small-scale lab experiment	Commencement Date + 12 months	

	Basin-scale ice thickening (WP3)	(WP5) and field tests (WP6) to inform model parameters.		
4	Engagement documentation reviewed, lessons learned	Development of community and stakeholder engagement strategy submitted to ARIA programme team and Oversight Committee. Evidence of community engagement and codesign provided to ARIA team and oversight committee ahead of second season of outdoor experiments	Commencement Date + 16 months	
5a	Completion of design, delivery and testing/operation of first underwater drone before funding for manufacture of subsequent test drones (WP7a) This is a Go/No Go Milestone	Development of individual drone functions: Drones will be capable of completing a pre-programmed automated mission, consisting of navigating to a target location at least 1 km away from the base, pumping sea water for at least 1 hour at a flow rate of at least 10 m³ per hour, and then returning to base. These capabilities will be tested in temperate climate sea locations, with no sea ice. Drones will also be capable of drilling a hole through ice at least 50 cm thick. Testing of this capability will be undertaken in a laboratory environment.	Commencement Date + 18 months	

5b	Completion of design, delivery and testing of first autonomous-ready icemaker (WP7b) This is a Go/No Go Milestone	Developed and tested fully mechanical functioning icemaker (automation-ready) with the ability to move 5km over the ice per day, and the ability to drill holes through ice of up to 1m thick, and pump for at least 2 hours per day with a pump flow rate of at least 500 m³/hour (Arctic Reflections)	Commencement Date + 18 months	
6	Confirmation of permits & local support obtained in each location for 2026/27 winter (WP6) This is a Go/No Go Milestone	Permits (including EIA) will be obtained for Real Ice and Arctic Reflections' field tests on ice thickening and ice arch strengthening (locations TBD). Evidence supplied to ARIA and oversight committee of ongoing community engagement activities in proposed regions	Commencement Date + 20 months	
7	Interim report on sea ice mechanics from discrete/continuous FDEM model (WP2) and Lab experiments (WP5)	Report detailing FDEM model findings using water flow through snow modelling output and results from laboratory experiments in WP5	Commencement Date + 24 months	
8	Interim report on the evaluation of modelling ice flow through Nares Strait (WP3)	Report detailing the initial observations of the impact and risks on the Arctic ocean of extended ice coverage in the Nares Strait.	Commencement Date + 24 months	

9	Engagement documentation reviewed, lessons learned	Development of community and stakeholder engagement strategy submitted to ARIA programme team and Oversight Committee. Evidence of ongoing community engagement and codesign provided to ARIA team and oversight committee ahead of third season of outdoor experiments	Commencement Date + 28 months	
10	Permits & local support obtained in each location for 2027/28 winter (WP6) This is a Go/No Go Milestone	Permits (including EIA) will be obtained for the ice thickening field test locations. Evidence supplied to ARIA and oversight committee of ongoing community engagement activities in proposed regions	Commencement Date + 32 months	
11	Report highlighting target areas for Ice Thickening (Ice Arches and Regional) (WP1)	Following data analysis, a report detailing identified areas experiencing ice loss for field experiments.	Commencement Date + 36 months	
12	Final report on modelling of Regional- and Basin-scale ice thickening (WP3)	Report synthesising the final modelling output of WP2, small-scale lab experiment (WP5) and field tests (WP6) to inform model parameters.	Commencement Date + 36 months	
13a	Successful design, manufacturing and operational test in Arctic conditions of the hub & spoke model, and a full	Testing of up to four drones in the Arctic to test scalability and robustness in real-world conditions. System wide automation will be demonstrated, consisting in	Commencement Date + 36 months	

	feasibility study detailing a realistic pathway to scaleup, including the relevant operational parameters and required number of units for the ultimate ambition (WP7a)	orchestrating 4 drones in a coherent ice thickening strategy to cover a sea ice area of at least 100,000 m² over the duration of a field test. The drones would independently and autonomously complete missions as instructed by a central system, and regularly return to base to recharge their batteries. An underwater communication and positioning system would allow drones to regularly share their status (location, depth, remaining energy, pumping time and rate, ice thickness, obstacles identified, etc.) and acquire updated plans from the base. The drones will also implement safety features such as obstacle avoidance and natural buoyancy to support recoverability. The system will be tested in Arctic conditions with temperatures of -30C or below and sea ice up to 1 meter thick.		
13b	Successful design, manufacturing and operational test in Arctic conditions of the hub & spoke model, and a full feasibility study detailing a realistic pathway to scaleup, including the	Tested in Arctic conditions (-30 C) an automatically functioning icemaker with ability to move 10km over the ice per day, and ability of thickening 50 hectares during a field test, and designed a system with a central hub enabling autonomous deployment of	Commencement Date + 36 months	

	relevant operational parameters and required number of units for the ultimate ambition (WP7b)	several of these large icemakers		
14	Final project report (WP2-5)	Final report detailing modelling output for Ice Thickening and structural integrity of ice arches (WP2); the concluded overall impact and risks on the Arctic ocean of extended ice coverage in the Nares Strait (WP3); potential changes in Arctic albedo under differing climate conditions (WP4); laboratory results of the flow of water through a snow layer on top of ice (WP5) Experimental and modelling data gathered throughout the project submitted to ARIA open access repository.	Commencement Date + 42 months	

In addition to the above Milestones, the following project plan will be used to track progress throughout the project and may be updated from time to time: [REDACTED]

3.3 The intended long-term outcomes are summarised below:

- For both regional and targeted ice thickening, feasibility or otherwise of ice thickening as an effective climate intervention to preserve and restore Arctic sea ice is known
- For any ice thickening approach which is shown to be feasible, pathways for scalability are identified
- The integrated approach with multiple disciplines working together across large scale modeling, lab testing, field testing and prototyping with short feedback loops and

frequent interactions has served as a crucial accelerator in determining the feasibility or otherwise of ice thickening in the Arctic

- Community and Stakeholder involvement was conducted in such a way that co-design and co-execution of activities was possible, and the approach was documented so that it could be used as a blueprint for similar future endeavours.

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement
Planning	• Roles and responsibilities • External communications • Vision • Project details • Code and data management • Project plan + project management
Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Key Learning, discoveries and decisions • Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • Invoicing and cost reporting Optional: • technical evidence saved to drive e.g. report or presentation as requested by PD • review meeting slide deck saved to drive as requested by PD
Annual	• ARIA impact metrics • Attendance at annual ARIA event
Ad hoc	• As required, Programme Director/ Programme Team may request additional information and evidence • Workshops - potential to be invited to ARIA workshops

Project closure	Project closure report

5. Payment

5.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments quarterly in arrears.

For quarterly payments, the cadence of payments will align with ARIAs financial year beginning 1st April e.g Quarter 1 Grant Claims will be for the period of 1st April to 30 June, Quarter 2 Grant Claims will be for the period of 1st July to 30 Sept and so on.

5.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

5.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end of the relevant period.

5.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

6. Principal investigator/key researchers

6.1 For the purposes of clause 22.7, the following principle investigators or key researchers have been identified:

Name	Role	Organisation
Dr Shaun Fitzgerald	Lead	University of Cambridge
Dr Geoff Evatt	Deputy Lead	University of Manchester
Dr Michel Tsamados	Key Researcher	University College London
[REDACTED]	Key Researcher	University of Washington
Prof Steven Desch	Key Researcher	Arizona State University
Dr Einar Ólason	Key Researcher	Nansen Environmental and Remote Sensing Center
Andrea Ceccolini	Key Researcher	Real Ice
Fonger Ypma	Key Researcher	Arctic Reflections

7. Sub-Contractors

7.1 For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Location
The Interdisciplinary Center on Sustainability and Climate - Sant'Anna School of Advanced Studies	Design and development of autonomous underwater vehicle prototypes for ice thickening operations	Pisa, Italy

PART 2 - GRANT APPLICATION

Application titled "Re-thickening Arctic Sea Ice" submitted 6 December 2024.

SCHEDULE 3

Royalty Percentages

Royalties on the sale or supply of products or services that are covered by, use or incorporate the Foreground IP licensed to the NewCo will only become due on aggregate net sales derived from the Foreground IP exceeding £50 million.

The maximum headline percentage royalty rate (i.e. before any royalty stacking, step-down or other reduction and excluding any ARIA Non-UK Fee) for products or services that are covered by, use or incorporate the Foreground IP, and of sublicensing income, shall be one of the following:

Type of product	Applicable headline royalty percentage (up to)
Low margin	0.5% of net sales
Medium margin	1% of net sales
High margin	2% of net sales
Sublicensing royalty	10% of net receipts

ANNEX 1

Clause for inclusion in licences of Foreground IP

[] **ARIA NON-UK FEE**

[].1 In this clause:

"ARIA" means the Advanced Research and Invention Agency;

"Crown Body" means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

"UK Entity" means a legal entity that has or whose ultimate parent company has its headquarters and principal establishment in the United Kingdom.

[].2 The Foreground IP was developed with funding from ARIA. As a condition of its funding ARIA requires that a benefit is returned to the United Kingdom where the Foreground IP is licensed by the Licensor to any person that is not a UK Entity. Accordingly, in addition to any other sums payable by the Licensee to the Licensor under this Agreement, the Licensee shall pay to the Licensor within 90 days after the end of each calendar year during the Relevant Period (as defined below), and within 90 days after the end of the Relevant Period, a fee (**ARIA Non-UK Fee**) on all amounts (including upfronts, licence fees, milestone payments, royalties, shares or other securities, exit fees, buyout or other consideration) payable by the Licensee to the Licensor under this Agreement in relation to the exploitation of any Foreground IP (**Relevant Amount**) that accrues during, or relates to, any period of time that the Licensee is not a UK Entity (**Relevant Period**). The amount of the ARIA Non-UK Fee is 25% of the Relevant Amount, and is payable by the Licensee to the Licensor in addition to the amounts that would otherwise be payable under this Agreement. For example if the Relevant Amount is £100 the ARIA Non-UK Fee is an additional £25, which the Licensee shall pay to the Licensor and the Licensor shall remit to ARIA.

Crown Body customers

[].3 You must also ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities and in suitable quantities for the Crown Body's requirements.

[].4 ARIA shall have the right to enforce this clause [] under the Contracts (Rights of Third Parties) Act 1999. Neither party may amend this Agreement in a way that detracts from ARIA's right to enforce its rights under this clause without ARIA's prior written consent.

[1] When using this clause you may substitute the relevant defined terms used elsewhere in the agreement to capture the concept of "Foreground IP". Where the clause refers to the "Licensor" and "Licensee" please use the appropriate defined terms to include the licensor, licensee, assignor and assignee of the Foreground IP. This clause is not suitable for assignments of the Foreground IP in consideration of the payment of one or more lump sum payments. In those cases the Licensor needs to be informed, and potentially make an additional payment, if the Foreground IP is subsequently assigned to a non-UK Entity or if the Assignee ceases to be a UK Entity.

SCHEDULE 4: Data Protection

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Grant Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Grant Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Grant Agreement:
 - 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are

relying on Domestic Law as the basis for processing Personal Data, you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;

- 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);
- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Grant Agreement unless required by Domestic Law to store the Personal Data; and

- 3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.
- 3.4. [[ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):
- 3.4.1. cancel its plans to change the affected sub-Processor;
- 3.4.2. offer an alternative which is acceptable to ARIA; or
- 3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.
- 3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Grant Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.
- 3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]
- 3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Grant agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it, storing it, retrieving it, consulting it, disseminating it or destroying it, etc.

	Note the definition of processing in the UK GDPR: <i>“any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction”</i>]
Duration of Processing:	Duration of this Grant Agreement (and any post termination processing that is permitted / required).
Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called “special categories” of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: <i>“data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation”</i>]
Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors,

	clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. You shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.
- 4.2. Any limitation of liability set out in this Grant Agreement will not apply to this Schedule's indemnity or reimbursement obligations.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

- 1.** Submission of Pledged Patents and Experimental Data
 - 1.1** The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
 - 1.2** The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.
- 2.** Experimental Data Licence
 - 2.1** Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
 - 2.2** The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
 - 2.3** The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
 - 2.4** The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).
- 3.** Research Licence
 - 3.1** Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
 - 3.2** The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
 - 3.3** Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.

3.5 The Research Licensee must:

- (a) at all times when using the Pledged Patents comply with all Laws; and
- (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).

4. Commercial Licence

4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.

4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.

4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.

5. Pledgor Know-How

At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.

6. Termination

6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:

- (a) materially breaches the terms of such licence or this Pledge; or
- (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).

7. Transfers of Pledged Patents and/or Experimental Data

The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.

8. No Warranty

The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and
Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

The Energy and Resources Institute (**Grant Recipient**)

Darbari Seth Block, IHC Complex, Lodhi Road, New Delhi-110003, India

17 June 2025

Attention: Mr K Venkatramana

Dear Mr K Venkatramana,

FPCW-PR01-P017 - Simulating the Effects of Earth Cooling Approaches on the Dynamics and Thermodynamics of Monsoon and Precipitation Extremes– Basic Research Grant Funding Letter

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to Exploring Climate Cooling and ARIA is pleased to offer you a Grant for the performance of the Basic Research Project Activities up to the Maximum Sum, subject to your agreement to, and compliance with, the terms and conditions set out in this Grant Funding Letter and its Schedules.

This Basic Research Funding Letter is offered to you on the basis the activity being funded is considered experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.

1. Overview of the Grant

Any reference in this letter to "you" or "your" means the Grant Recipient and any capitalised terms have the meanings given in the ARIA Grant Conditions (Conditions).

The key elements of the Grant are described in the table below:

Project Activities	Simulating the Effects of Earth Cooling Approaches on the Dynamics and Thermodynamics of Monsoon and Precipitation Extremes. A more detailed description of the Project Activities is set out in Schedule 2 (Project Activities).
Maximum Amount of the Grant	£142,024 (inclusive of all taxes where applicable)
Commencement Date	The commencement date is 17 June 2025
Completion Date	The completion is 16 June 2027
Grant Review Intervals	ARIA will review the Grant at quarterly intervals using the process referred to in clause 6 of the Conditions
Adequate Insurance	Employers' liability - At least £5 million (as required by the Employers' Liability (compulsory Insurance Act 1969) Public liability: £5 million (per year in aggregate)
Monitoring and Reporting	The performance reports referred to in clause 7 of the Conditions shall

	be provided by you at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Project Representative	Mr K Venkatramana, Associate Fellow & AC, TERI. [REDACTED] [REDACTED]	
Grant Manager	Mark Symes, Programme Director, [REDACTED]	
Escalation Contacts	ARIA	Grant Recipient
	Chief Product Officer [REDACTED]	[REDACTED], Senior Fellow and Director, TERI. [REDACTED]
Notices	ARIA Contracts [REDACTED]	[REDACTED], Senior Manager-PMU, TERI. [REDACTED] [REDACTED] [REDACTED]

2. Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Grant and return it to finance@aria.org.uk

3. The Grant Agreement

- 3.1. Once you sign a copy of this Grant Funding Letter in accordance with paragraph 6 (Acceptance) below, it will form a binding "**Grant Agreement**" between you and ARIA that includes and incorporates the following documents:
- 3.1.1. the **Grant Conditions** in Schedule 1;
 - 3.1.2. the **Project Activities, Milestones** and **Grant Application** in Schedule 2;
 - 3.1.3. the **Commercial Exploitation Terms** (including annexes) in Schedule 3 - Although the parties do not envisage any commercial application of the Results, this schedule sets out your obligations if commercial exploitation of the Results does occur, and
 - 3.1.4. the terms relating to **Data Protection** in Schedule 4.
- 3.2. Not used.
- 3.3. The parties confirm that it is their intention to be legally bound by the Grant Agreement.

4. Warranties

- 4.1. By signing this Grant Funding Letter, you warrant and represent that:
- 4.1.1. your obligations under the Grant Agreement are legal, valid, binding and enforceable;

- 4.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Grant Agreement have been obtained;
- 4.1.3. the person signing the Grant Agreement is duly authorised to sign on your behalf; and
- 4.1.4. your Project Representative referenced in the table above is authorised to make decisions and provide information on your behalf.

5. Amendments to the Grant Conditions

- 5.1. Not used.

6. Acceptance

- 6.1. To accept this Grant Funding Letter, please arrange for an authorised signatory to sign and date the duplicate copy of this Grant Funding Letter as indicated below, and return to ARIA as a complete signed original of the Grant Agreement including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Grant Agreement and to bind the Grant Recipient.

- 6.2. The offer of this Grant Funding Letter will expire on 19 June 2025.

Yours sincerely

for and on behalf of ARIA

Name of ARIA signatory:

Position Held:

Date:

I confirm the agreement of The Energy and Resources Institute to the terms and conditions in this Grant Funding Letter and its Schedules.

Signature:

Name:

Position:

Date:

SCHEDULE 1 - GRANT CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up the Grant Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Grant Funding Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to the Grant Agreement with the exception of Schedule 2 Part 2 (the Grant Application);
 - (d) Schedule 2 Part 2 (the Grant Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, the Grant Agreement.

2. DURATION AND PURPOSE OF THE GRANT

- 2.1 The Grant Agreement will subsist for the duration of the Funding Period unless extended by written agreement signed by a duly authorised representative of the parties or terminated earlier in accordance with its terms. Any provision of the Grant Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Grant Agreement shall remain in full force and effect, including clauses 1, 2, 4, 7.4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.3, 22.7, 22.8, 22.11, 22.12, 23, 24, 26, 27, 28, and 29.
- 2.2 You may only use the Grant for carrying out the Project Activities. You may not make any changes to the Project Activities without ARIA's prior written agreement.
- 2.3 You may not unreasonably withhold, condition or delay your agreement to any changes requested by ARIA to the Project Activities or the amount of the Grant. Any agreed change will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

3. ENVIRONMENTAL AND SAFETY REQUIREMENTS

- 3.1 In performing the Project Activities, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. PAYMENT OF GRANT

- 4.1 Subject to the remainder of this clause 4 ARIA will pay the Grant to you:
- (a) up to the Maximum Sum;
 - (b) in pounds sterling (GBP) by wire transfer into your bank account details of which you provided in the Confirmation of Bank Details form attached to the Grant Funding Letter; and
 - (c) if a tax is chargeable in respect of the Grant, all payments will be deemed to be inclusive of all such taxes and ARIA will not be obliged to pay any additional amount.
- 4.2 The bank account of which you provided details in your Confirmation of Bank Details form (and any alternative bank details nominated subsequently by you) must be an ordinary business bank account with appropriate segregation of duties and control. During the Funding Period, you must notify ARIA of any change of bank account details as soon as reasonably practicable on the same form and signed by an approved signatory. You must notify ARIA of any change of signatory for approval, as soon as known.

- 4.3 You will be the sole recipient of the Grant and you will be responsible for managing the Grant as between you and any Third Parties involved in performing the Project Activities. This includes securing the repayment of the Grant if requested by ARIA in accordance with the Grant Conditions, including where the Grant has already been distributed to Third Parties.
- 4.4 You must promptly notify ARIA if any money is incorrectly paid to you for any reason, and must repay it as soon as reasonably practicable. Any amount not immediately repaid will be recoverable as a civil debt.
- 4.5 ARIA reserves the right not to pay any Grant Claims that are not submitted within the period set out in the Grant Funding Letter or that are incomplete, incorrect or not accompanied by full supporting documentation (including any documentation that ARIA reasonably requests).
- 4.6 You may not apply for or obtain Duplicate Funding for any Project Activities.
- 4.7 You may not retain any Unspent Monies and must repay them to ARIA within 30 days after ARIA's request for repayment.
- 4.8 You acknowledge the critical importance of cash flow for Sub-Contractors (including startups and small businesses) and commit to paying all valid and undisputed invoices relating to the Project within a maximum of 30 days from the date of receipt.
- 4.9 Where required, you will work with Sub-Contractors to arrange more frequent payment schedules (e.g., same day, weekly or milestone-based payments) to better support their cash flow needs.

5. ELIGIBLE AND INELIGIBLE EXPENDITURE

- 5.1 ARIA will only pay the Grant for Eligible Expenditure incurred by you in carrying out the Project Activities. You must provide ARIA with any evidence reasonably requested by ARIA (including receipts, invoices and other documentary evidence) that all Grant Claims relate to costs that are Eligible Expenditure.
- 5.2 You may not in any circumstance claim as Eligible Expenditure paid-for lobbying, which means using the Grant to fund lobbying (via an external firm or in-house staff) in order to undertake activities intended to influence or attempt to influence Parliament, government or political activity; or attempting to influence legislative or regulatory action.

6. GRANT REVIEW

- 6.1 ARIA will review the Grant at the intervals specified in the Grant Funding Letter. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.3.
- 6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:
 - (a) consent to the Project Activities and the Grant Agreement continuing in line with existing plans;
 - (b) increase or decrease the Grant for the remainder of the Funding Period, as applicable;
 - (c) redefine the Milestones;
 - (d) require you to carry out remedial activity with the aim of improving delivery of the Project Activities; and/or
 - (e) terminate the Grant Agreement in accordance with clause 22.

- 6.3 Any change to these Grant Terms, the Project Activities, or the Grant pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

7. MONITORING AND REPORTING

- 7.1 You must closely monitor the carrying out of the Project Activities throughout the Funding Period and must notify ARIA as soon as reasonably practicable of any actual or potential failure to comply with any of your obligations under the Grant Agreement.
- 7.2 ARIA does not limit its engagement with you to purely administrative activities and will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project Activities. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.
- 7.3 You must provide ARIA with:
- (a) the Milestones and a report on your performance against the Milestones at the intervals and for the periods of time specified in the Grant Funding Letter. ARIA may copy and adapt the contents of any of the Milestones and those reports for ARIA's internal use to review, develop and shape ARIA's funded research programmes, but ARIA will treat those contents as your Confidential Information under clause 11;
 - (b) any assistance and information reasonably requested by ARIA to establish whether you have used the Grant in accordance with the Grant Agreement; and
 - (c) a quarterly report on your use of the Maximum Sum, with details broken down in accordance with ARIA's prescribed form.
- 7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its funding activities and compliance with the terms of the Grant Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time after the end of the Funding Period about the dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Grant Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Grant Agreement.

8. AUDITING AND ASSURANCE

- 8.1 For Grants between £100k and £500k: At the end of the Funding Period you must provide ARIA with independent assurance that the Grant has been used for carrying out the Project Activities. To satisfy this requirement you must provide a statement showing that the use of the Grant has been certified by an independent and appropriately qualified auditor or accountant.
- 8.2 Subject to clause 11, ARIA and/or its authorised representative may, at any time during the Funding Period and for up to 7 years after the end of the Funding Period, conduct audits in relation to your use of the Grant and your compliance with the Grant Agreement. You must act

reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.

8.3 You must:

- (a) maintain an appropriate system of financial management and controls, maintain detailed records in relation to those controls, and provide copies of those records to ARIA on request; and
- (b) retain, and procure that your Sub-Contractors retain and will provide to you on request, all relevant documentation relating to the Eligible Expenditure (including invoices, receipts and accounting records) during the Funding Period and for a period of 7 years thereafter.

9. FINANCIAL MANAGEMENT

9.1 You must:

- (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Grant; and
- (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project Activities as soon as they are identified, and keep ARIA informed of your remedial actions.

9.2 In the event of any actual or suspected fraud, theft or other financial irregularity (which includes use of the Grant for any purpose other than that envisaged by the Grant Agreement), ARIA may, at its absolute discretion:

- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
- (b) suspend the Project Activities and future payment of the Grant to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft, or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

10.1 You must inform ARIA promptly of any actual, perceived or potential conflicts between your and your Representatives' obligations under the Grant Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Funding Period.

10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that these conflicts are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you or your Representative to cease the conflicting activity and if that is not acceptable to you or your Representative, either party may terminate the Grant Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other

party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the provision of the Project Activities, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.

- 11.2 ARIA may publish a summary of the Grant Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Grant Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.
- 11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:
- (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;
 - (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information necessary for the purpose concerned and obtains appropriate confidentiality undertakings in relation to such information;
 - (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and where no exception to disclosure under them is applicable; or
 - (d) where that party (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.
- 11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under the Grant Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

- 12.1 Each party must comply with its obligations under the Law, including where applicable the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.
- 12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.
- 12.3 You acknowledge that ARIA, acting in accordance with the Information Acts (other than the FOIA), may disclose information concerning you and the Grant Agreement without consulting you. ARIA must notify you of any request for information to the extent permissible and reasonably practical and will give you adequate opportunity to make representations before ARIA discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.
- 12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or the Grant Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.

- 12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.
- 12.6 You must take account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

- 13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.
- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with the Grant Agreement. If either party anticipates that the other will process any Personal Data on its behalf under the Grant Agreement it must notify the other party and the parties must agree a variation to the Grant Agreement under clause 26 to incorporate appropriate provisions (such as those set out in Schedule 4) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. SUBSIDY CONTROL AND STATE AID

- 14.1 ARIA intends that the Grant complies with the Subsidy Control Act 2022 on the basis that the Project Activities constitute basic research and have no commercial application in view, notwithstanding that they may be carried out with the intention of contributing to a knowledge base which may form the basis of a solution to a recognised or expected problem. If during the Funding Period you plan to take any concrete action regarding any current or future commercial application of the Results, you must promptly inform ARIA. You must assist ARIA to comply with the requirements of the Act and must cooperate with any investigations under the Act.
- 14.2 Where the EU state aid laws apply to the Grant (where the Project Activities will affect trade between Northern Ireland and the EU), you acknowledge that the Project Activities are designed and performed so they are compatible with state aid laws. You will take all reasonable steps to assist ARIA to comply with state aid law requirements and cooperate with any investigations by the European Commission into the Project Activities.
- 14.3 ARIA will immediately stop future payments of the Grant and may require repayment of some or all of the Grant if subsidy control or state aid laws so require for the funding to be compliant.

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and where applicable, the terms of Schedule 3, and not seek to avoid their application by artificial means.

Background IP

- 15.2 The Grant Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Funding Period if any additional Background IP is required to carry out the Project Activities.

Foreground IP ownership and dissemination

- 15.3 You will own all Foreground IP and, subject to clauses 15.5 and 15.7, you must publish or report publicly on the outcomes of the Project Activities within 18 months after the end of the Funding Period unless:
- (a) a delay in publication is reasonably necessary to protect any Confidential Information or Foreground IP; or
 - (b) there is some other substantial reason to delay or suspend publication and you have obtained ARIA's written consent to do so.
- 15.4 Where you assign any Foreground IP to a Third Party you must impose on the assignee the obligations relating to Foreground IP and Results contained in clauses 15 and 16.
- 15.5 You must submit all (i) all patents within or covering the Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the Future Proofing our Climate and Weather Intellectual Property Pledge promptly following creation or filing (as applicable) of such patents and/or data (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge. You hereby agree to comply and uphold the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.6 You must ensure that whenever any Results are used with or communicated to Third Parties, ARIA's funding of the Project Activities is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and publication

- 15.7 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.8 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.9 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to fund future prosecution and maintenance and/or request the assignment of the patents to ARIA or its nominee.

16. COMMERCIALISATION

- 16.1 As stated at 14.1 above, the Project Activities will consist of basic research with no commercial application in view. However, if commercial exploitation of the Results does arise, such commercial exploitation shall be carried out in accordance with Schedule 3.

17. ASSETS

- 17.1 You must keep a register during the Funding Period and for up to 7 years after the end of the Funding Period of all Assets, with all relevant details about each Asset. You must use any Assets purchased with Grant monies for the Project Activities.
- 17.2 At the end of the Funding Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

- 18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Grant Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUBCONTRACTING

- 19.1 You may not transfer, assign, novate or otherwise dispose of the whole or any part of the Grant Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.
- 19.2 You shall not subcontract any of the Project Activities to a Third Party except to the extent permitted, and to the person or persons identified, in Schedule 2 Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractor as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Grant Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Grant Agreement.

20. BORROWING, LOSSES, GIFTS, SPECIAL PAYMENTS

- 20.1 You must obtain ARIA's prior written consent before:
- (a) borrowing or lending money from any source in connection with the Grant Agreement;
 - (b) giving any guarantee, indemnity, security over any Asset or letter of comfort in relation to the Grant Agreement;
 - (c) making any gift or writing off any debt or liability in connection with the Grant, and must keep a record of all gifts given and received in connection with the Grant.

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Grant and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Grant or publicise details of the Grant Agreement without the other's consent, except as required by Law.
- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events occur:

- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13 or 25, or commit a material breach of any other term of the Grant Agreement in the reasonable opinion of ARIA;
- (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
- (c) you fail to improve the performance of the Project Activities, notwithstanding you having undertaken the remedial activity agreed with ARIA in the remedial plan under clause 6.2(d);
- (d) you obtain any funding from a Third Party that, in the opinion of ARIA, undertakes activities that are likely to bring the reputation of the Project Activities or ARIA into disrepute;
- (e) you provide ARIA with any materially misleading or inaccurate information in your grant application or in subsequent related correspondence;
- (f) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Third Party, immediately upon becoming aware of it;
- (g) you are subject to an Insolvency Event;
- (h) the Grant or any part of it is held by a court or competent authority to be a prohibited subsidy under the Subsidy Control Act 2022 or an illegal state aid;
- (i) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project Activities;
 - (ii) result in your being unable to receive the Grant; and/or
 - (iii) raises national security concerns.

Rights reserved for ARIA in relation to an Event of Default

22.2 If an Event of Default has occurred, ARIA may by written notice to you take any one or more of the following actions:

- (a) suspend the Project Activities and payment of the whole or any part of the Grant for such period as ARIA may determine, acting reasonably;
- (b) reduce the Maximum Sum, in which case the payment of Grant will thereafter be made in accordance with the reduction and notified to you; and/or
- (c) subject to clause 22.4, terminate the Grant Agreement with immediate effect as from the date of service of the notice of that termination.

22.3 Where this Grant Agreement is terminated for an Event of Default described in clause 22.1(f) or 22.1(h), ARIA may require you to repay the entire amount of the Grant previously paid to you.

Opportunity for you to remedy an Event of Default

22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:

- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and
- (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

- 22.5 Without prejudice to any other provision of the Grant Agreement, you may terminate the Grant Agreement immediately on written notice to ARIA if ARIA commits a material breach of the Grant Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

General Termination Rights

- 22.6 Notwithstanding ARIA's right to terminate the Grant Agreement under clause 22.2(c), either party may terminate the Grant Agreement (in whole or in part) at any time by giving at least 60 days' prior written notice to the other party.
- 22.7 You must promptly notify ARIA in writing if at any time the principal investigator or any key researcher(s) named in Schedule 2 working on the Project Activities is unable or unwilling to continue to be involved in the Project Activities or is moving to a new organisation without the desire to continue the research. Within 60 days after the date of that notice, you must either:
- (a) nominate one or more successors, subject to ARIA's approval; or
 - (b) agree that the Grant is transferred to another organisation subject to your and the new organisation's agreement in writing and ARIA's approval of the transfer.

If ARIA is unwilling to accept the nominated successor(s) or does not approve a request for transfer, it may terminate the Grant Agreement by at least 30 days' written notice to you.

Consequences of Termination

- 22.8 If the Grant Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.
- 22.9 Where ARIA terminates the Grant Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:
- (a) you taking all reasonable steps to mitigate such loss; and
 - (b) the Unavoidable Costs being:
 - (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Grant Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA;
 - (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you; and
 - (v) costs that would not have been incurred had this Grant Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period).
- 22.10 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Project Activities, over £250,000 will terminate automatically and immediately upon termination of this Grant Agreement.

- 22.11 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Agreement in the event that the Grant Agreement was terminated (calculated on the basis described in clause 22.8).
- 22.12 ARIA's total liability under clause 22.9 shall be limited to the Maximum Sum under the Grant Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.13 If the Grant Agreement is terminated or expires ARIA will not be liable to pay any of your costs or those of any of your contractors or suppliers related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Grant Funding Letter and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Grant Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Grant Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the Grant Manager and the Project Representative.
- 23.3 If the dispute cannot be resolved between the Grant Manager and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to a formal meeting between the parties' Escalation Contacts.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:
- (a) fraudulent misrepresentation or any other fraudulent act or omission;
 - (b) payment of sums properly due and owing to the other in the normal course of performance of this Grant Agreement;
 - (c) a breach of clause 13;
 - (d) liability arising under any indemnity in this Grant Agreement; or
 - (e) liability which may not lawfully be excluded or limited.
- 24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Grant Agreement or for ARIA's breach of this Grant Agreement), whether arising directly or indirectly, that may arise in connection with:
- (a) your carrying out the Project Activities;
 - (b) the use of the Grant by any person;
 - (c) any reduction, suspension, withdrawal or request for repayment of the Grant in accordance with this Grant Agreement; or
 - (d) termination of the Grant Agreement in accordance with this Grant Agreement.
- 24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:

- (a) loss of profit, sales or turnover;
- (b) loss of contracts or business opportunities;
- (c) loss of anticipated savings;
- (d) loss of goodwill or damage to reputation; or
- (e) any indirect, special or consequential loss or damage;

in each case arising out of or relating to the Grant Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.

- 24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to the Grant Agreement or its subject matter or anything which it has done or not done in connection with the Grant Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the amount of the Maximum Sum.
- 24.5 You shall under no circumstances in connection with this Grant Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.
- 24.6 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Grant Agreement.

25. RESEARCH ETHICS AND CODE OF CONDUCT

- 25.1 Recipients who are research institutions must operate in accordance with the Concordat.
- 25.2 All research data:
 - (a) must be generated using sound scientific techniques and processes;
 - (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and
 - (c) must be analysed appropriately, without bias and in accordance with good scientific practices.
- 25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.
- 25.4 You must comply with the Code of Conduct and ensure that your Representatives undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

- 26.1 Any variation to the Grant Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

27. GENERAL

- 27.1 Notices: All notices and other communications in relation to this Grant Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such

communications will be deemed to have been given and received on the third Working Day following such mailing.

- 27.2 Change of control: You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(i) is likely to apply.

28. GOVERNING LAW

- 28.1 This Grant Agreement (including any non-contractual disputes or claims arising in connection with this Grant Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. NOT USED

30. DEFINITIONS AND INTERPRETATION

- 30.1 Where they appear in these Conditions or the Grant Agreement:

Adequate Insurance means the insurance requirements and amounts set out in the Grant Funding Letter.

Asset means any asset that is purchased, improved or developed using the Grant including equipment and fixed assets;

Background IP means IP that is:

- (a) owned by or licensed to a party prior to the Commencement Date; or
- (b) developed by or on behalf of a party during the Funding Period but not in connection with the Project Activities;

and is in either case used in connection with the Project Activities;

Bribery Act means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;

Change of Control means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Recipients of Government General Grants published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754555/2018-11-06_Code_of_Conduct_for_Grant_Recipients.pdf

including any subsequent updates from time to time;

Commencement Date means the date set out in the Grant Funding Letter;

Concordat means the Concordat to Support Research Integrity which can be found at <https://ukrio.org/about-us/the-concordat-to-support-research-integrity/>

Conditions means these ARIA Grant Conditions;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Grant

Agreement that ought reasonably to be considered to be confidential (whether or not it is so marked), including:

- (a) any information relating to:
 - (i) the business, affairs, customers, clients, suppliers or plans of the disclosing party; or
 - (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party;
 - (b) any information developed by the parties in the course of carrying out the Project Activities;
 - (c) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Grant Agreement; and
 - (d) any information derived from any of the above,
- but not including:
- (e) information which:
 - (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11);
 - (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party;
 - (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or
 - (iv) is independently developed without access to the Confidential Information; and
 - (f) the content of this specific version of the Grant Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

Duplicate Funding means funding provided to you by a Third Party which is to fund the same activities as the Project Activities;

EA means the Equality Act 2000 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Eligible Expenditure means the payments made by you during the Funding Period for the purposes of carrying out the Project Activities which comply with clause 5 and ARIA's published eligibility rules (which provide for full economic cost reimbursement) and as agreed in the Grant Funding Letter;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Grant Funding Letter;

Event of Default means any of the events or circumstances set out in clause 22.1;

Financial Year means 1 April to 31 March;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means any IP in the Results;

Funding Period means the period for which the Grant is awarded as set out in the Grant Funding Letter;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to approaches for actively cooling the earth operated by ARIA/a third party in the form at Annex A;

GDPR means Regulation (EU) 2016/679;

Grant means the sum or sums ARIA will pay to you up to the amount set out in the Grant Funding Letter, in accordance with clause 4 and subject to the provisions set out at clause 22.

Grant Agreement has the meaning given in the Grant Funding Letter;

Grant Claim means a request submitted by you to ARIA for payment of the Grant;

Grant Funding Letter means the letter from ARIA to you to which these Conditions are annexed;

Grant Manager means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Grant;

Grant Review means the process for reviewing the grant outlined in clause 6;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Ineligible Expenditure means expenditure incurred by you which is not Eligible Expenditure as set out in clause 5 and ARIA's published eligibility rules;

Information Acts means the Data Protection Legislation, FOIA and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property Rights or **IP** means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation;

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise;

Maximum Sum means the maximum amount of the Grant stated in the Grant Funding Letter;

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

Personal Data has the meaning given to it in the Data Protection Legislation as amended from time to time;

Prohibited Act means:

- (a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for:
 - (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Grant Agreement; and/or
 - (ii) showing or not showing favour or disfavour to any person in relation to the Grant Agreement;
- (b) committing any offence:
 - (i) under the Bribery Act;
 - (ii) under legislation creating offences in respect of fraudulent acts; and/or
 - (iii) at common law in respect of fraudulent acts in relation to the Grant Agreement; and/or
- (c) defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the activities to be carried out by you that are described in the Grant Funding Letter and in Schedule 2 Part 1;

Project Representative means the representative appointed by you, who at the Commencement Date will be the individual listed as such in the Grant Funding Letter;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means all information, data, techniques, inventions, discoveries, works, software and materials generated in the course of the Project Activities;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Project Activities or any part thereof or facilities or services necessary for the performance of the Project Activities or any part thereof or necessary for the management, direction or control of the Project Activities or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Grant Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Funding Period because of termination or breach of the Grant Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination;

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 In these Conditions and the Grant Agreement, unless the context otherwise requires:

- (a) references to "party" and "parties" are to the parties to the Grant Agreement;
- (b) the singular includes the plural and vice versa;
- (c) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (d) references to clauses and Schedules are to the clauses of these Conditions and to the Schedules to the Grant Agreement;

- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation"; and
- (g) the headings in the Grant Agreement are for ease of reference only and will not affect the interpretation or construction of the Grant Agreement.

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

The ongoing warming of the planet significantly influences precipitation patterns and extremes, which is a critical consideration when evaluating SRM strategies aimed at cooling the Earth. Climate change could exacerbate these patterns, leading to a scenario where wet regions could become wetter and dry areas could experience increased aridity. Specifically, numerical models suggest that under the Shared Socioeconomic Pathway (SSP) 5-8.5 scenario (high-emission), many regions will experience more intense monsoon precipitation compared to the SSP2-4.5 scenario (middle of the road). This trend is attributed to an increase in the frequency and intensity of extreme daily events associated with climate change.

A critical factor in these extreme precipitation events is the enhanced vertical moisture ascent, often referred to as the dynamic component. This vertical motion, linked to local convection and low-level convergence, elevates atmospheric moisture, triggering latent heating and subsequent heavy rainfall. While thermodynamic factors contribute to overall precipitation increases, dynamic processes play a pivotal role in local-scale intensification, particularly in monsoon regions. Similar findings have emerged from studies in the UK, where an extreme winter event in 2014 was linked to stronger vertical motions that increased atmospheric moisture and promoted convection. Recent research, including your own work (Byju et al., 2024), highlights the dominance of this dynamic component (>70%) in driving extreme precipitation during monsoon seasons. However, projections suggest a potential decline of its contribution (10-35%) under future high-emission scenarios, possibly due to increased tropospheric stability resulting from warming.

In response to the growing impacts of climate change, SRM strategies have been proposed as potential method to mitigate these effects and cool the planet. Current research indicates that while SRM strategies may effectively cool the planet, they could also present significant drawbacks by disrupting the planet's energy balance and potentially affecting the climate system. Additionally, uncontrolled termination of SRM interventions could lead to rapid climatic changes. The nature and magnitude of these drawbacks are contingent upon specific SRM approaches.

Climate modelling studies available in this area are mainly focused on stratospheric aerosol injection (SAI), which is a proposed method to inject reflecting aerosols into the stratosphere, which can lead to a reduction in global and tropical precipitation. Several recent studies indicate that planned simultaneous injections at multiple locations can effectively help maintain large-scale temperature metrics in a nearly stable state. Climate modelling studies such as the Geoengineering Large Ensemble (GLENS) experiment involved injection of sulphur dioxide (SO₂) at various latitudes with an adaptive feedback-control algorithm, revealing that such injections suppress tropical precipitation, particularly affecting monsoon regions in India and the Americas. In contrast, Arctic aerosol injection is thought to have a lesser impact on tropical climates due to its shorter aerosol lifespan and smaller coverage area. Studies have also indicated that both tropical and Arctic injections could decrease precipitation over monsoon regions in Asia and Africa. Specifically, research has shown that Arctic SAI and the resulting inter-hemispheric temperature difference can shift the Intertropical Convergence Zone southward, altering precipitation patterns in the Northern and Southern

Hemispheres. However, differences in injection intensities between tropical and Arctic SAI experiments complicate the assessment of their respective contributions to climate changes. While thermodynamic and nonlinear terms contribute to a decrease in global mean precipitation under Arctic SAI, dynamic terms may counteract this effect.

The Indian Summer Monsoon (ISM), a critical system for regional sustenance, is particularly sensitive to SAI. Research indicates that the location and intensity of aerosol injections can significantly impact ISM precipitation, potentially leading to substantial reductions. Even when large-scale temperature metrics are stabilized, factors such as upper tropospheric warming and circulation changes can lead to a weakening of the monsoon precipitation. Given the complexity of the Asian monsoon system and its numerous feedback mechanisms, establishing clear cause-and-effect relationships remains challenging. Nevertheless, considering that a significant portion of the population depends on the ISM for sustenance, these studies carry substantial regional implications—not only for SRM outcomes but also for intermediate climatic conditions during its implementation.

Although proposed SRM methods may lead to planetary cooling, their impacts on the pattern of precipitation will vary. SAI, for instance, has been shown to reduce extreme precipitation in tropical areas, while GeoMIP solar dimming scenario may be more effective in extra-tropical regions. Further, SRM could significantly compensate for the change in seasonality, peak precipitation timing and duration associated with enhanced warming. Several such studies also show that regional variability of precipitation responses to SRM is significant, but it is not uniform. Moreover, at the termination of climate interventions, climatic conditions such as temperature, precipitation, winds, and moisture would abruptly revert to what they would have been under a global warming scenario. This potential shift must also be considered when evaluating methods aimed at cooling the planet.

Overall, while the proposed methods of SRM could cool the planet, SRM carries complex implications for global and regional precipitation and requires careful consideration of the undesirable side effects, even after the termination. The impacts of SRM on extreme precipitation can be multifaceted and can lead to both reductions and increases in precipitation extremes depending on the method used and the regional climatic conditions. Further, the relationship between warming/cooling and extreme precipitation is complex due to the interplay between dynamic and thermodynamic factors.

This project aims to leverage moisture budget decomposition methodologies, building upon your previous research, to explore the impacts of SRM methods on regional precipitation, particularly focusing on the dynamic and thermodynamic drivers of extreme events. The proposed project will offer valuable insights into regional variations and potential climate extremes and thereby provide policymakers, researchers, and stakeholders with meaningful information for decision-making processes on the impacts of SRM.

2. Aims and objectives of the Project Activities

Precipitation is a critical component of the Earth's climate system, essential for sustaining ecosystems and supporting agricultural productivity. However, climate change is projected to significantly alter global precipitation patterns. Additionally, alterations in atmospheric circulation patterns driven by warming will further modulate the intensity and distribution of extreme precipitation events.

SRM has gained attention as a potential approach for mitigating climate change impacts. Although the existing SRM methods, such as Stratospheric Aerosol Injection (SAI), Marine Cloud Brightening (MCB), and Cirrus Cloud Thinning (CCT), may lead to planetary cooling, their impacts on the processes controlling precipitation will vary. People are very much concerned about the changes in precipitation that SRM would bring because of their broader societal implications, particularly concerning agriculture and thus on the economy.

A moisture budget decomposition of precipitation would help you to identify the different factors, such as dynamic, thermodynamic, evaporation and nonlinear processes, that impacts the total rainfall as well as extremes. Warming would alter the contribution of those factors in shaping the precipitation patterns. In this project you aim to explore through modelling how the cooling of the planet with the existing SRM methods could alter the factors that drive precipitation and extreme weather events. You aim to gain valuable insights into regional variations and potential climate extremes in this study, thereby providing policymakers, researchers, and stakeholders with meaningful information for decision-making processes on SRM.

The main objectives of this project are to:

1. Conduct a comprehensive assessment of SRM's impact on monsoon and precipitation extremes across India and the UK—factors directly influencing agricultural practices and food production and economy.
2. Elucidate how the factors influencing precipitation frequency, intensity and seasonality such as atmospheric dynamics, thermodynamics, evaporation processes, and nonlinear physics are altered due to climate interventions.
3. Investigate how these changes manifest in the precipitation and moisture budget terms following the termination of such interventions

3. Project Activities

Your primary objective of this proposal is to understand how the changes in different factors contribute to changes in precipitation patterns. To address this, you will decompose the anomalous precipitation into different moisture budget components into dynamic, thermodynamic and nonlinear components. Analysing the results would provide insights into the physical components that are most sensitive to climate intervention methods resulting in anomalous precipitation. Furthermore, analysing changes across different regions and distinct geographical contexts, while utilising various climate model data for different SRM approaches, will enhance your understanding of the sensitivity of these interventions regionally.

Further, the project also aims to understand whether the warming or cooling of the planet will lead to changes in seasonality, which is crucial, as these changes can significantly influence local ecological and social dynamics. Seasonality changes can be assessed using matrices that include dimensionless relative

entropy, dimensionless seasonality index, timing of the peak rainy season, and duration of the peak rainy season (Feng et al., 2013).

You will use data from models participating in the Coupled Model Intercomparison Project phase-6 (CMIP6) under historical, intermediate (SSP2-4.5), and high-emission (SSP5-8.5) scenarios to investigate characteristic changes in precipitation, extremes and seasonality in global warming scenarios. A comprehensive analysis of the characteristic changes in precipitation under climate interventions to cool the planet is proposed here by analysing existing GeoMIP model simulations. A wide range of climate models, including global climate models and Earth system models, participate in GeoMIP. This diversity helps capture a range of potential climate responses to SRM. It explores a variety of SRM scenarios, such as different implementation strategies, intensities, and durations. This allows for a comprehensive understanding of the potential range of outcomes.

3.1 A detailed timeframe of the project activity is given below as Work Packages (WP).

Work Packages and detailed plan of implementation with month wise timelines and targets time

WP1: Assess precipitation pattern over India and the UK

Objective: Understand the changes in precipitation patterns and moisture budget components over India and the UK.

Month 1-3: WP1.1 Project Setup, Data Acquisition and Quality Analysis

Establish project team and communication protocols.

Plan and acquire available CMIP6 (historical, SSP2-4.5, SSP5-8.5) model data and ERA5 reanalysis data for India and the UK.

Set up data processing and analysis environments. Complete Quality check of the data and understand the biases.

Deliverable: Project setup complete, data acquisition initiated and ready for analysis.

Month 4-9: WP1.2 Historical analysis of precipitation changes over India and United Kingdom

Analyse precipitation patterns and calculate the moisture budget components (dynamic, thermodynamic, nonlinear) using CMIP6 historical data and ERA5 over India and the United Kingdom.

Investigate regional (tropical vs. midlatitude) responses in a planet warming situation.

Focus on extreme precipitation and its moisture budget. How is it changing spatially and temporally?

Deliverable: Completion of historical precipitation and moisture budget analysis for India and the UK. Understand the pattern changes under the current warming phase.

Month 7-12: WP1.3 Changes under different climate change scenarios

Analyse future precipitation patterns and moisture budget components using CMIP6 SSP2-4.5 and SSP5-8.5 scenarios.

Assess sensitivity of extreme precipitation to different emission scenarios.

Compare tropical and midlatitude impacts.

Deliverable: Completion of precipitation analysis under SSP2-4.5 and SSP5-8.5 scenarios, and comparative study to historical data.

Month 11-14: WP1.4 Presentation and Initial Reporting

Prepare and present preliminary findings from WP1.

Draft initial report on historical and future climate change impacts on precipitation. Publish the findings in a peer reviewed journal.

Milestone 1 (Month 11 –14): Achieve a comprehensive understanding of how global warming influences precipitation patterns, moisture budget components (dynamic, thermodynamic, nonlinear), and extremes in India and the UK. Disseminate initial findings through scientific publication.

WP2: Assess the impact of climate interventions on moisture budget

Objective: To quantify the impact of various SRM methods on precipitation and large excess precipitation events. How does the cooling of planet Earth modulate the dynamics and thermodynamics of precipitation? What are the precipitation responses following the termination of different SRM interventions?

Month 1-3: WP2.1 Data Acquisition and Quality Analysis

Acquire available GeoMIP simulation data. Primary focus will be for the variants of G4 simulations. Data of G3, G6sulfur and G7cirrus simulations could also be acquired if available.

Conduct feasibility of the data for analysis and processing it.

A thorough literature review about the impact of SRM on precipitation.

Deliverable: Acquisition of GeoMIP model data for the analysis.

Month 6-18: WP2.2 SRM Impacts

Analyse precipitation changes across various SRM scenarios. Comparative analysis of SRM techniques will pinpoint impact hotspots and inform optimised intervention strategies.

Decompose and analyse anomalies in precipitation and extremes to dynamic, thermodynamic and nonlinear components. This would reveal the sensitivity of each component to different SRM techniques.

Study the changes after the termination of the interventions.

Compare and contrast results from WP1 and WP2 to identify climate response to climate warming and SRM induced cooling of the planet.

Deliverable: A comprehensive understanding of the impacts and sensitivities of various SRM techniques on precipitation, extreme events, and moisture budget components, including a comparative analysis of SRM's effectiveness versus continued warming and an assessment of termination risks.

Month 17–20: WP2.3 Presentation and Publishing the results

Present the findings in a conference or draft it for peer review publication.

Milestone 2 (Month 17 –20): Develop a comprehensive scientific understanding of the mechanisms by which SRM techniques influence precipitation patterns, moisture budget components, and extreme events, including post-termination effects. A comprehensive understanding of the factors contributing to the precipitation changes in global warming and SRM scenarios. Disseminate these findings through scientific publications.

WP3: Analyse the changes in precipitation seasonality

Objective: Analyse the changes in seasonality, timing and duration of precipitation due to SRM interventions and after their termination.

Month 13-22: WP3.1 Seasonality Analysis

Analyse changes in precipitation seasonality using metrics like dimensionless relative entropy, seasonality index, peak rainy season timing, and duration.

Compare seasonality changes under SRM scenarios with historical and warming scenarios.

Analyse seasonality changes at the termination of climate interventions.

Deliverable: Completion of seasonality analysis under climate change and SRM scenarios, including termination effects.

Month 20-24: WP3.2 Publish the findings

Prepare a manuscript detailing the findings of the seasonality analysis for submission to peer-reviewed journal.

Milestone 3 (Month 22 –24): This project will deliver a comprehensive analysis of how SRM impacts precipitation patterns over India and the United Kingdom. By decomposing moisture budgets and analyzing seasonality changes using climate model data, you will quantify the effectiveness and risks of various SRM techniques. The project will produce peer-reviewed publications and inform policy makers, ultimately contributing to a better understanding of SRM's potential and limitations in mitigating climate change impacts on regional climate.

3.2 The following Milestones will be used to monitor your delivery of the Project. The costs associated with completing these Milestones are estimated in the cost breakdown sheet [REDACTED]

ID	Milestones	Measure	Date
1	Data Acquisition and Quality Analysis of CMIP and ERA5	Plan and acquire available CMIP6 (historical, SSP2-4.5, SSP5-8.5) model data and ERA5 reanalysis data for India and the UK. Set up data processing and analysis environments. Complete Quality check of the data and understand the biases.	Commencement Date + 3 months
2	Data Acquisition and Quality Analysis of geoMIP data	Acquire available GeoMIP simulation data. Primary focus will be for the variants of G4 simulations. Data of G3, G6sulfur and G7cirrus simulations could also be acquired if available. Conduct feasibility of the data for analysis and processing it.	Commencement Date + 6 months
3	Completion of data analysis for historical precipitation for India and the UK.	Completion of historical precipitation and moisture budget analysis for India and the UK. Understand the pattern changes under the current warming phase.	Commencement Date + 12
4	Submission to scientific journal	Achieve a comprehensive understanding of how global warming influences precipitation patterns, moisture budget components and extremes in India and the UK. Improved understanding of how the warming impacts dynamics and thermodynamics of regional precipitation.	Commencement Date + 15 months

ID	Milestones	Measure	Date
5	Submission to scientific journal	Develop a comprehensive scientific understanding of the mechanisms by which SRM techniques influence precipitation patterns, moisture budget components, and extreme events, including post-termination effects. A comprehensive understanding of the factors contributing to the precipitation changes in global warming and SRM scenarios. An improved understanding of the sensitivity of different moisture budget components to SRM induced cooling using GeoMIP scenarios.	Commencement Date + 21 months
6	Submission to scientific journal	A comprehensive understanding of how SRM affects the seasonality of precipitation and a final report. Output data for publications are made available in ARIA public repository.	Commencement Date + 24 months

In addition to the above Milestones, the following project plan will be used to track progress throughout the project and may be updated from time to time:



3.3 The intended long-term outcomes are summarised below:

By pinpointing the sensitivities of moisture budget components and seasonality to SRM techniques, this project will allow for a more nuanced debate on intervention strategies, minimizing disruptions to natural climate processes and ensuring that the benefits of any intervention are realized with minimal adverse impacts on precipitation and regional water cycles. The long-term outcomes aim to translate the project's scientific findings into actionable knowledge that can inform climate debate, enhance climate resilience, and guide responsible research and implementation. In a nutshell, the outcomes stemming from the findings contribute to:

- **Enhanced Understanding of Climate Dynamics:** A deeper understanding of the complex interactions between dynamic and thermodynamic processes in the climate system, particularly in

relation to precipitation extremes and seasonality, under both global warming and intervention scenarios.

- **Refined Theoretical Frameworks:** Contribution to the development of refined theoretical frameworks for understanding the impacts of SRM on the hydrological cycle, incorporating dynamic, thermodynamic, and seasonality considerations.
- **Evidence-Based Information for Policy Makers:** Provision of critical scientific evidence to inform policy makers regarding climate change mitigation and potential intervention strategies, minimizing unintended consequences.
- **Optimized intervention Strategies:** Development of optimized strategies that minimize negative impacts on regional precipitation and seasonality, while maximizing climate cooling benefits.

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement
Kick off	Roles and responsibilities External communications Project details
Quarterly	Reporting: Technical status - Red/Amber/Green Delivery status - Red/Amber/Green The latest progress against milestone(s) from last quarter Invoicing and cost reporting Optional: Key Learning, discoveries and decisions Stories to highlight Priorities for the next quarter Challenges Changes to team and new collaborations technical evidence saved to drive e.g. report or presentation as requested by PD review meeting slide deck saved to drive as requested by PD Review meeting with ARIA Programme Team
Annual	ARIA impact metrics Attendance at annual ARIA event

Frequency	Requirement
Ad hoc	As required, Programme Director/ Programme Team may request additional information and evidence Workshops - potential to be invited to ARIA workshops
Project closure	Project closure report

5. Payment

5.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments quarterly in arrears based on actual costs incurred.

For quarterly payments, the cadence of payments will align with ARIA's financial year beginning 1st April e.g. Quarter 1 Grant Claims will be for the period of 1st April to 30 June, Quarter 2 Grant Claims will be for the period of 1st July to 30 Sept and so on.

5.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

5.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end of the relevant period.

5.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

6. Principle investigator/key researchers

6.1 For the purposes of clause 22.7, the following principle investigators or key researchers have been identified:

Name	Role	Organisation
Dr. Byju Pookkandy	- Principal Investigator - Oversee the overall coordination and execution of the project. - Lead WP1 (Assess precipitation patterns over India and the UK) and WP3 (Analyse changes in precipitation seasonality). - Contribute significantly to WP2 (Assess the impact of geoengineering methods).	The Energy and Resources Institute, New Delhi, India
[REDACTED]	- SRM Expert - Lead/Supervise WP2 (Assess the impact of SRM SRM methods). - Contribute to WP1 and WP3 interpretation and discussions.	The Energy and Resources Institute, New Delhi, India

Name	Role	Organisation
Mr.Kaagita Venkatramana	- Co-Principal Investigator - Contribute to all three research work packages (WP1, WP2, and WP3). - Support the PI in project coordination and execution.	The Energy and Resources Institute, New Delhi, India
██████████ ██████████	- Provide strategic guidance on climate change impacts and risks. - Contribute to the interpretation of results in the context of global climate change.	The Energy and Resources Institute, New Delhi, India
██████████████████ ██████████	- Provide expertise on SRM policies and implementation. - Contribute to the interpretation of results in the context of environmental policy and governance.	The Energy and Resources Institute, New Delhi, India

7. Sub-Contractors

7.1 For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Location

PART 2 - GRANT APPLICATION

Application titled "The Energy and Resources Institute" submitted 9 December 2024.

SCHEDULE 3: Commercial Exploitation

Although the parties do not envisage any commercial application of the Results, this schedule sets out your obligations if commercial exploitation of the Results does occur.

1. LICENCES and ROYALTIES

1.1. In this Schedule:

Commercialisation Licence means a licence of IP other than a research or evaluation licence and/or subcontract manufacture (and **Commercially License** means to license under a Commercialisation Licence);

First Sale Date means the date on which you (or your affiliate or sublicensee) first bill an amount to a customer in respect of the sale of goods or services (or any other transaction) which use or incorporate Foreground IP;

Gross Sales means total invoiced value of sales made during a specific period, including all amounts billed to customers such as from the sale of goods, services, licence income, royalty income, franchise fees, commissions, subscription fees, before any deductions;

Group means in relation to a company, that company, any subsidiary or holding company from time to time of that company;

Net Sales means Gross Sales after relevant accounting deductions, such as sales tax, packaging, insurance, carriage and freight, trade discounts and credits, returns and allowances, import taxes and similar applicable government levies;

Non-UK Entity means a legal entity that is not a UK Entity; and

UK Entity means a legal entity or group of legal entities that has its headquarters and principal establishment in the United Kingdom.

1.2. If you consider that commercial exploitation of any of the Results has become or may become viable, you are encouraged to discuss the position with ARIA. Under clause 14.1 of the Conditions you are required to inform ARIA if during the Funding Period you plan to take any concrete action regarding any current or future commercial application of the Results.

1.3. You may request that ARIA exploit the Results or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Crown Body customers

1.4. You must ensure under any agreement for Commercial Licensing or assignment of Foreground IP, that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period, at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities, and in suitable quantities for the Crown Body's requirements.

Non-UK Commercialisation

- 1.5. A royalty of 0.25% of your Net Sales which use or incorporate Foreground IP shall be payable to ARIA if you are incorporated outside of the United Kingdom (the "ARIA Non-UK Fee"). For the avoidance of doubt, the ARIA Non-UK Fee shall be calculated solely in respect of the share of the Net Sales which corresponds to the value resulting directly from the Foreground IP.
- 1.6. The ARIA Non-UK Fee shall be payable within 90 days following the end of each relevant calendar year, for a period of ten (10) years from the First Sale Date, up to an aggregate total equal to 20 times the Maximum Sum.
- 1.7. In the event that:
 - (a) there is a change of control of the Foreground IP, such that you assign or grant an exclusive licence to the Foreground IP to another person; or
 - (b) you extend rights to the Foreground IP within your Group, such that you grant another entity within your Group a licence to the Foreground IP,
then,
 - (c) you must notify ARIA immediately; and
 - (d) include clauses 1.5 and 1.6 in the relevant instrument and ensure that it expressly provides that the provisions are intended to be enforceable by ARIA by virtue of the Contracts (Rights of Third Parties) Act 1999 (or any equivalent in any jurisdiction) and take any other step required to ensure that the ARIA Non-UK Fee is payable by the transferee or licensee (as applicable).
- 1.8. For the avoidance of doubt, in respect of:
 - (a) clause 1.7(a), provided that you have complied with clause 1.7(d), your obligation to pay the ARIA Non-UK Fee shall cease and pass to the transferee or licensee (until, in the case of an exclusive licence, the termination or expiry of such licence); and
 - (b) clause 1.7(d) the transferee or licensee shall only be liable to pay the ARIA Non-UK Fee to ARIA for the remainder of the aggregated total amount and the ten (10) year period specified in clause 1.7 prorated from the date of the relevant instrument.

SCHEDULE 4: Data Protection

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Grant Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Grant Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Grant Agreement:
- 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are relying on Domestic Law as the basis for processing Personal Data,

you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;

- 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);
- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Grant Agreement unless required by Domestic Law to store the Personal Data; and
- 3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated

auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.

3.4. [[ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):

3.4.1. cancel its plans to change the affected sub-Processor;

3.4.2. offer an alternative which is acceptable to ARIA; or

3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.

3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Grant Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.

3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]

3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Grant agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it, storing it, retrieving it, consulting it, disseminating it or destroying it, etc. Note the definition of processing in the UK GDPR: "<i>any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration,</i>

Scope and purpose of Processing:	Provision of the Project Activities by you under this Grant agreement.
	<i>retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction”]</i>
Duration of Processing:	Duration of this Grant Agreement (and any post termination processing that is permitted / required).
Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called “special categories” of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: “<i>data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation</i>”]
Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors, clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. You shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in

connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.

- 4.2. Any limitation of liability set out in this Grant Agreement will not apply to this Schedule's indemnity or reimbursement obligations.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

1. Submission of Pledged Patents and Experimental Data

- 1.1 The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.

- 1.2 The Pledgor undertakes to:
- (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.

2. Experimental Data Licence

- 2.1 Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
- 2.2 The licence granted under Clause 2.1:
- (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
- 2.3 The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
- 2.4 The Experimental Data Licensee must:
- (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).

3. Research Licence

- 3.1 Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
- 3.2 The licence granted under Clause 3.1:
- (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
- 3.3 Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.
- 3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.
- 3.5 The Research Licensee must:
- (a) at all times when using the Pledged Patents comply with all Laws; and

- (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).

4. Commercial Licence

- 4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.
- 4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.
- 4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.

5. Pledgor Know-How

At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.

6. Termination

- 6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:
 - (a) materially breaches the terms of such licence or this Pledge; or
 - (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).

7. Transfers of Pledged Patents and/or Experimental Data

The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.

8. No Warranty

The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and
Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

Planetary Sunshade Foundation **(Grant Recipient)**

5730 Vineland Ave Unit 110,

North Hollywood, CA 91601

30 May 2025

Attention: Morgan Goodwin

Dear Morgan,

FPCW-PR01-P003 - Planetary Sunshade Baseline Survey – Basic Research Grant Funding Letter

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to Exploring Climate Cooling and ARIA is pleased to offer you a Grant for the performance of the Basic Research Project Activities up to the Maximum Sum, subject to your agreement to, and compliance with, the terms and conditions set out in this Grant Funding Letter and its Schedules.

This Basic Research Funding Letter is offered to you on the basis the activity being funded is considered experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view.

1. Overview of the Grant

Any reference in this letter to "you" or "your" means the Grant Recipient and any capitalised terms have the meanings given in the ARIA Grant Conditions (Conditions).

The key elements of the Grant are described in the table below:

Project Activities	Planetary Sunshade Baseline Survey. A more detailed description of the Project Activities is set out in Schedule 2 (Project Activities).
Maximum Amount of the Grant	£395,427(inclusive of all taxes where applicable)
Commencement Date	The commencement date is 1 June 2025
Completion Date	The completion is 31 July 2026
Grant Review Intervals	ARIA will review the Grant at quarterly intervals using the process referred to in clause 6 of the Conditions
Adequate Insurance	General Liability \$2,000,000 aggregate / \$1,000,000 per occurrence Professional Liability (E&O) \$2,000,000 aggregate / \$1,000,000 per

	occurrence Directors & Officers (D&O) \$1,000,000	
Monitoring and Reporting	The performance reports referred to in clause 7 of the Conditions shall be provided by you at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Project Representative	Morgan Goodwin Executive Director, Planetary Sunshade Foundation [REDACTED] [REDACTED]	
Grant Manager	Mark Symes, Programme Director [REDACTED]	
Escalation Contacts	ARIA	Grant Recipient
	Chief Product Officer [REDACTED]	[REDACTED] Chair of Planetary Sunshade Foundation [REDACTED] [REDACTED]
Notices	ARIA Contracts [REDACTED]	Morgan Goodwin, Executive Director, [REDACTED] [REDACTED]

2. Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Grant and return it to finance@aria.org.uk

3. The Grant Agreement

- 3.1. Once you sign a copy of this Grant Funding Letter in accordance with paragraph 6 (Acceptance) below, it will form a binding "**Grant Agreement**" between you and ARIA that includes and incorporates the following documents:
- 3.1.1. the **Grant Conditions** in Schedule 1;
 - 3.1.2. the **Project Activities, Milestones** and **Grant Application** in Schedule 2;

- 3.1.3. the **Commercial Exploitation Terms** (including annexes) in Schedule 3 - Although the parties do not envisage any commercial application of the Results, this schedule sets out your obligations if commercial exploitation of the Results does occur, and
- 3.1.4. the terms relating to **Data Protection** in Schedule 4.

3.2. Not used

3.3. The parties confirm that it is their intention to be legally bound by the Grant Agreement.

4. Warranties

4.1. By signing this Grant Funding Letter, you warrant and represent that:

- 4.1.1. your obligations under the Grant Agreement are legal, valid, binding and enforceable;
- 4.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Grant Agreement have been obtained;
- 4.1.3. the person signing the Grant Agreement is duly authorised to sign on your behalf; and
- 4.1.4. your Project Representative referenced in the table above is authorised to make decisions and provide information on your behalf.

5. Amendments to the Grant Conditions

5.1. Not used

6. Acceptance

6.1. To accept this Grant Funding Letter, please arrange for an authorised signatory to sign and date the duplicate copy of this Grant Funding Letter as indicated below, and return to ARIA as a complete signed original of the Grant Agreement including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Grant Agreement and to bind the Grant Recipient.

6.2. The offer of this Grant Funding Letter will expire on 01 June 2025.

Yours sincerely

for and on behalf of ARIA

Name of ARIA signatory:

Position Held:

Date:

I confirm the agreement of the Planetary Sunshade Foundation to the terms and conditions in this Grant Funding Letter and its Schedules.

Signature:

Name:

Position:

Date:

SCHEDULE 1 - GRANT CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up the Grant Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Grant Funding Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to the Grant Agreement with the exception of Schedule 2 Part 2 (the Grant Application);
 - (d) Schedule 2 Part 2 (the Grant Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, the Grant Agreement.

2. DURATION AND PURPOSE OF THE GRANT

- 2.1 The Grant Agreement will subsist for the duration of the Funding Period unless extended by written agreement signed by a duly authorised representative of the parties or terminated earlier in accordance with its terms. Any provision of the Grant Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Grant Agreement shall remain in full force and effect, including clauses 1, 2, 4, 7.4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.3, 22.7, 22.8, 22.11, 22.12, 23, 24, 26, 27, 28, and 29.
- 2.2 You may only use the Grant for carrying out the Project Activities. You may not make any changes to the Project Activities without ARIA's prior written agreement.
- 2.3 You may not unreasonably withhold, condition or delay your agreement to any changes requested by ARIA to the Project Activities or the amount of the Grant. Any agreed change will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

3. ENVIRONMENTAL AND SAFETY REQUIREMENTS

- 3.1 In performing the Project Activities, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. PAYMENT OF GRANT

- 4.1 Subject to the remainder of this clause 4 ARIA will pay the Grant to you:
- (a) up to the Maximum Sum;
 - (b) in pounds sterling (GBP) by wire transfer into your bank account details of which you provided in the Confirmation of Bank Details form attached to the Grant Funding Letter; and
 - (c) if a tax is chargeable in respect of the Grant, all payments will be deemed to be inclusive of all such taxes and ARIA will not be obliged to pay any additional amount.
- 4.2 The bank account of which you provided details in your Confirmation of Bank Details form (and any alternative bank details nominated subsequently by you) must be an ordinary business bank account with appropriate segregation of duties and control. During the Funding Period, you must notify ARIA of any change of bank account details as soon as reasonably practicable on the same

form and signed by an approved signatory. You must notify ARIA of any change of signatory for approval, as soon as known.

- 4.3 You will be the sole recipient of the Grant and you will be responsible for managing the Grant as between you and any Third Parties involved in performing the Project Activities. This includes securing the repayment of the Grant if requested by ARIA in accordance with the Grant Conditions, including where the Grant has already been distributed to Third Parties.
- 4.4 You must promptly notify ARIA if any money is incorrectly paid to you for any reason, and must repay it as soon as reasonably practicable. Any amount not immediately repaid will be recoverable as a civil debt.
- 4.5 ARIA reserves the right not to pay any Grant Claims that are not submitted within the period set out in the Grant Funding Letter or that are incomplete, incorrect or not accompanied by full supporting documentation (including any documentation that ARIA reasonably requests).
- 4.6 You may not apply for or obtain Duplicate Funding for any Project Activities.
- 4.7 You may not retain any Unspent Monies and must repay them to ARIA within 30 days after ARIA's request for repayment.
- 4.8 You acknowledge the critical importance of cash flow for Sub-Contractors (including startups and small businesses) and commit to paying all valid and undisputed invoices relating to the Project within a maximum of 30 days from the date of receipt.
- 4.9 Where required, you will work with Sub-Contractors to arrange more frequent payment schedules (e.g., same day, weekly or milestone-based payments) to better support their cash flow needs.

5. ELIGIBLE AND INELIGIBLE EXPENDITURE

- 5.1 ARIA will only pay the Grant for Eligible Expenditure incurred by you in carrying out the Project Activities. You must provide ARIA with any evidence reasonably requested by ARIA (including receipts, invoices and other documentary evidence) that all Grant Claims relate to costs that are Eligible Expenditure.
- 5.2 You may not in any circumstance claim as Eligible Expenditure paid-for lobbying, which means using the Grant to fund lobbying (via an external firm or in-house staff) in order to undertake activities intended to influence or attempt to influence Parliament, government or political activity; or attempting to influence legislative or regulatory action.

6. GRANT REVIEW

- 6.1 ARIA will review the Grant at the intervals specified in the Grant Funding Letter. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.3.
- 6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:
 - (a) consent to the Project Activities and the Grant Agreement continuing in line with existing plans;
 - (b) increase or decrease the Grant for the remainder of the Funding Period, as applicable;
 - (c) redefine the Milestones;

- (d) require you to carry out remedial activity with the aim of improving delivery of the Project Activities; and/or
 - (e) terminate the Grant Agreement in accordance with clause 22.
- 6.3 Any change to these Grant Terms, the Project Activities, or the Grant pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

7. MONITORING AND REPORTING

- 7.1 You must closely monitor the carrying out of the Project Activities throughout the Funding Period and must notify ARIA as soon as reasonably practicable of any actual or potential failure to comply with any of your obligations under the Grant Agreement.
- 7.2 ARIA does not limit its engagement with you to purely administrative activities and will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project Activities. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.
- 7.3 You must provide ARIA with:
 - (a) the Milestones and a report on your performance against the Milestones at the intervals and for the periods of time specified in the Grant Funding Letter. ARIA may copy and adapt the contents of any of the Milestones and those reports for ARIA's internal use to review, develop and shape ARIA's funded research programmes, but ARIA will treat those contents as your Confidential Information under clause 11;
 - (b) any assistance and information reasonably requested by ARIA to establish whether you have used the Grant in accordance with the Grant Agreement; and
 - (c) a quarterly report on your use of the Maximum Sum, with details broken down in accordance with ARIA's prescribed form.
- 7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its funding activities and compliance with the terms of the Grant Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time after the end of the Funding Period about the dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Grant Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Grant Agreement.

8. AUDITING AND ASSURANCE

- 8.1 At the end of the Funding Period you must provide ARIA with independent assurance that the Grant has been used for carrying out the Project Activities. To satisfy this requirement you must

provide a statement showing that the use of the Grant has been certified by an independent and appropriately qualified auditor or accountant.

8.2 Subject to clause 11, ARIA and/or its authorised representative may, at any time during the Funding Period and for up to 7 years after the end of the Funding Period, conduct audits in relation to your use of the Grant and your compliance with the Grant Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.

8.3 You must:

- (a) maintain an appropriate system of financial management and controls, maintain detailed records in relation to those controls, and provide copies of those records to ARIA on request; and
- (b) retain, and procure that your Sub-Contractors retain and will provide to you on request, all relevant documentation relating to the Eligible Expenditure (including invoices, receipts and accounting records) during the Funding Period and for a period of 7 years thereafter.

9. FINANCIAL MANAGEMENT

9.1 You must:

- (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Grant; and
- (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project Activities as soon as they are identified, and keep ARIA informed of your remedial actions.

9.2 In the event of any actual or suspected fraud, theft or other financial irregularity (which includes use of the Grant for any purpose other than that envisaged by the Grant Agreement), ARIA may, at its absolute discretion:

- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
- (b) suspend the Project Activities and future payment of the Grant to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft, or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

10.1 You must inform ARIA promptly of any actual, perceived or potential conflicts between your and your Representatives' obligations under the Grant Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Funding Period.

10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that these conflicts are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you or your

Representative to cease the conflicting activity and if that is not acceptable to you or your Representative, either party may terminate the Grant Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

- 11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the provision of the Project Activities, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.
- 11.2 ARIA may publish a summary of the Grant Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Grant Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.
- 11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:
- (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;
 - (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information necessary for the purpose concerned and obtains appropriate confidentiality undertakings in relation to such information;
 - (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and where no exception to disclosure under them is applicable; or
 - (d) where that party (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.
- 11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under the Grant Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

- 12.1 Each party must comply with its obligations under the Law, including where applicable the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.
- 12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.
- 12.3 You acknowledge that ARIA, acting in accordance with the Information Acts (other than the FOIA), may disclose information concerning you and the Grant Agreement without consulting you. ARIA

must notify you of any request for information to the extent permissible and reasonably practical and will give you adequate opportunity to make representations before ARIA discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.

- 12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or the Grant Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.
- 12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.
- 12.6 You must take account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

- 13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.
- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with the Grant Agreement. If either party anticipates that the other will process any Personal Data on its behalf under the Grant Agreement it must notify the other party and the parties must agree a variation to the Grant Agreement under clause 26 to incorporate appropriate provisions (such as those set out in Schedule 4) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. SUBSIDY CONTROL AND STATE AID

- 14.1 ARIA intends that the Grant complies with the Subsidy Control Act 2022 on the basis that the Project Activities constitute basic research and have no commercial application in view, notwithstanding that they may be carried out with the intention of contributing to a knowledge base which may form the basis of a solution to a recognised or expected problem. If during the Funding Period you plan to take any concrete action regarding any current or future commercial application of the Results, you must promptly inform ARIA. You must assist ARIA to comply with the requirements of the Act and must cooperate with any investigations under the Act.
- 14.2 Where the EU state aid laws apply to the Grant (where the Project Activities will affect trade between Northern Ireland and the EU), you acknowledge that the Project Activities are designed and performed so they are compatible with state aid laws. You will take all reasonable steps to assist ARIA to comply with state aid law requirements and cooperate with any investigations by the European Commission into the Project Activities.

- 14.3 ARIA will immediately stop future payments of the Grant and may require repayment of some or all of the Grant if subsidy control or state aid laws so require for the funding to be compliant.

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and where applicable, the terms of Schedule 3, and not seek to avoid their application by artificial means.

Background IP

- 15.2 The Grant Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Funding Period if any additional Background IP is required to carry out the Project Activities.

Foreground IP ownership and dissemination

- 15.3 You will own all Foreground IP and, subject to clauses 15.5 and 15.7, you must publish or report publicly on the outcomes of the Project Activities within 18 months after the end of the Funding Period unless:
- (a) a delay in publication is reasonably necessary to protect any Confidential Information or Foreground IP; or
 - (b) there is some other substantial reason to delay or suspend publication and you have obtained ARIA's written consent to do so.
- 15.4 Where you assign any Foreground IP to a Third Party you must impose on the assignee the obligations relating to Foreground IP and Results contained in clauses 15 and 16.
- 15.5 You must submit all (i) all patents within or covering the Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the Future Proofing our Climate and Weather Intellectual Property Pledge promptly following creation or filing (as applicable) of such patents and/or data (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge. You hereby agree to comply and uphold the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.6 You must ensure that whenever any Results are used with or communicated to Third Parties, ARIA's funding of the Project Activities is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and publication

- 15.7 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.8 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss

with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.

- 15.9 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to fund future prosecution and maintenance and/or request the assignment of the patents to ARIA or its nominee.

16. COMMERCIALISATION

- 16.1 As stated at 14.1 above, the Project Activities will consist of basic research with no commercial application in view. However, if commercial exploitation of the Results does arise, such commercial exploitation shall be carried out in accordance with Schedule 3.

17. ASSETS

- 17.1 You must keep a register during the Funding Period and for up to 7 years after the end of the Funding Period of all Assets, with all relevant details about each Asset. You must use any Assets purchased with Grant monies for the Project Activities.
- 17.2 At the end of the Funding Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

- 18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Grant Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUBCONTRACTING

- 19.1 You may not transfer, assign, novate or otherwise dispose of the whole or any part of the Grant Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.
- 19.2 You shall not subcontract any of the Project Activities to a Third Party except to the extent permitted, and to the person or persons identified, in Schedule 2 Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractor as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Grant Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Grant Agreement.

20. BORROWING, LOSSES, GIFTS, SPECIAL PAYMENTS

- 20.1 You must obtain ARIA's prior written consent before:
- (a) borrowing or lending money from any source in connection with the Grant Agreement;
 - (b) giving any guarantee, indemnity, security over any Asset or letter of comfort in relation to the Grant Agreement;

- (c) making any gift or writing off any debt or liability in connection with the Grant, and must keep a record of all gifts given and received in connection with the Grant.

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Grant and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Grant or publicise details of the Grant Agreement without the other's consent, except as required by Law.
- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

- 22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events occur:
 - (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13 or 25, or commit a material breach of any other term of the Grant Agreement in the reasonable opinion of ARIA;
 - (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
 - (c) you fail to improve the performance of the Project Activities, notwithstanding you having undertaken the remedial activity agreed with ARIA in the remedial plan under clause 6.2(d);
 - (d) you obtain any funding from a Third Party that, in the opinion of ARIA, undertakes activities that are likely to bring the reputation of the Project Activities or ARIA into disrepute;
 - (e) you provide ARIA with any materially misleading or inaccurate information in your grant application or in subsequent related correspondence;
 - (f) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Third Party, immediately upon becoming aware of it;
 - (g) you are subject to an Insolvency Event;
 - (h) the Grant or any part of it is held by a court or competent authority to be a prohibited subsidy under the Subsidy Control Act 2022 or an illegal state aid;
 - (i) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project Activities;
 - (ii) result in your being unable to receive the Grant; and/or
 - (iii) raises national security concerns.

Rights reserved for ARIA in relation to an Event of Default

- 22.2 If an Event of Default has occurred, ARIA may by written notice to you take any one or more of the following actions:
 - (a) suspend the Project Activities and payment of the whole or any part of the Grant for such period as ARIA may determine, acting reasonably;

- (b) reduce the Maximum Sum, in which case the payment of Grant will thereafter be made in accordance with the reduction and notified to you; and/or
- (c) subject to clause 22.4, terminate the Grant Agreement with immediate effect as from the date of service of the notice of that termination.

22.3 Where this Grant Agreement is terminated for an Event of Default described in clause 22.1(f) or 22.1(h), ARIA may require you to repay the entire amount of the Grant previously paid to you.

Opportunity for you to remedy an Event of Default

22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:

- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and
- (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

22.5 Without prejudice to any other provision of the Grant Agreement, you may terminate the Grant Agreement immediately on written notice to ARIA if ARIA commits a material breach of the Grant Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

General Termination Rights

22.6 Notwithstanding ARIA's right to terminate the Grant Agreement under clause 22.2(c), either party may terminate the Grant Agreement (in whole or in part) at any time by giving at least 60 days' prior written notice to the other party.

22.7 You must promptly notify ARIA in writing if at any time the principal investigator or any key researcher(s) named in Schedule 2 working on the Project Activities is unable or unwilling to continue to be involved in the Project Activities or is moving to a new organisation without the desire to continue the research. Within 60 days after the date of that notice, you must either:

- (a) nominate one or more successors, subject to ARIA's approval; or
- (b) agree that the Grant is transferred to another organisation subject to your and the new organisation's agreement in writing and ARIA's approval of the transfer.

If ARIA is unwilling to accept the nominated successor(s) or does not approve a request for transfer, it may terminate the Grant Agreement by at least 30 days' written notice to you.

Consequences of Termination

22.8 If the Grant Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.

22.9 Where ARIA terminates the Grant Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:

- (a) you taking all reasonable steps to mitigate such loss; and

- (b) the Unavoidable Costs being:
- (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Grant Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA;
 - (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you; and
 - (v) costs that would not have been incurred had this Grant Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period).

- 22.10 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Project Activities, over £250,000 will terminate automatically and immediately upon termination of this Grant Agreement.
- 22.11 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Agreement in the event that the Grant Agreement was terminated (calculated on the basis described in clause 22.8).
- 22.12 ARIA's total liability under clause 22.9 shall be limited to the Maximum Sum under the Grant Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.13 If the Grant Agreement is terminated or expires ARIA will not be liable to pay any of your costs or those of any of your contractors or suppliers related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Grant Funding Letter and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Grant Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Grant Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the Grant Manager and the Project Representative.
- 23.3 If the dispute cannot be resolved between the Grant Manager and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to a formal meeting between the parties' Escalation Contacts.

24. LIMITATION OF LIABILITY

24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:

- (a) fraudulent misrepresentation or any other fraudulent act or omission;
- (b) payment of sums properly due and owing to the other in the normal course of performance of this Grant Agreement;
- (c) a breach of clause 13;
- (d) liability arising under any indemnity in this Grant Agreement; or
- (e) liability which may not lawfully be excluded or limited.

24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Grant Agreement or for ARIA's breach of this Grant Agreement), whether arising directly or indirectly, that may arise in connection with:

- (a) your carrying out the Project Activities;
- (b) the use of the Grant by any person;
- (c) any reduction, suspension, withdrawal or request for repayment of the Grant in accordance with this Grant Agreement; or
- (d) termination of the Grant Agreement in accordance with this Grant Agreement.

24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:

- (a) loss of profit, sales or turnover;
- (b) loss of contracts or business opportunities;
- (c) loss of anticipated savings;
- (d) loss of goodwill or damage to reputation; or
- (e) any indirect, special or consequential loss or damage;

in each case arising out of or relating to the Grant Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.

24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to the Grant Agreement or its subject matter or anything which it has done or not done in connection with the Grant Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the amount of the Maximum Sum.

24.5 You shall under no circumstances in connection with this Grant Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.

24.6 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Grant Agreement.

25. RESEARCH ETHICS AND CODE OF CONDUCT

25.1 Recipients who are research institutions must operate in accordance with the Concordat.

25.2 All research data:

- (a) must be generated using sound scientific techniques and processes;

- (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and
 - (c) must be analysed appropriately, without bias and in accordance with good scientific practices.
- 25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.
- 25.4 You must comply with the Code of Conduct and ensure that your Representatives undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

- 26.1 Any variation to the Grant Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

27. GENERAL

- 27.1 Notices: All notices and other communications in relation to this Grant Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such communications will be deemed to have been given and received on the third Working Day following such mailing.
- 27.2 Change of control: You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(i) is likely to apply.

28. GOVERNING LAW

- 28.1 This Grant Agreement (including any non-contractual disputes or claims arising in connection with this Grant Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. NOT USED

30. DEFINITIONS AND INTERPRETATION

- 30.1 Where they appear in these Conditions or the Grant Agreement:

Adequate Insurance means the insurance requirements and amounts set out in the Grant Funding Letter.

Asset means any asset that is purchased, improved or developed using the Grant including equipment and fixed assets;

Background IP means IP that is:

- (a) owned by or licensed to a party prior to the Commencement Date; or
- (b) developed by or on behalf of a party during the Funding Period but not in connection with the Project Activities;

and is in either case used in connection with the Project Activities;

Bribery Act means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;

Change of Control means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Recipients of Government General Grants published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754555/2018-11-06_Code_of_Conduct_for_Grant_Recipients.pdf

including any subsequent updates from time to time;

Commencement Date means the date set out in the Grant Funding Letter;

Concordat means the Concordat to Support Research Integrity which can be found at

<https://ukrio.org/about-us/the-concordat-to-support-research-integrity/>

Conditions means these ARIA Grant Conditions;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Grant Agreement that ought reasonably to be considered to be confidential (whether or not it is so marked), including:

- (a) any information relating to:
 - (i) the business, affairs, customers, clients, suppliers or plans of the disclosing party; or
 - (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party;
 - (b) any information developed by the parties in the course of carrying out the Project Activities;
 - (c) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Grant Agreement; and
 - (d) any information derived from any of the above,
- but not including:
- (e) information which:
 - (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11);
 - (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party;
 - (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or
 - (iv) is independently developed without access to the Confidential Information; and
 - (f) the content of this specific version of the Grant Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

Duplicate Funding means funding provided to you by a Third Party which is to fund the same activities as the Project Activities;

EA means the Equality Act 2000 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Eligible Expenditure means the payments made by you during the Funding Period for the purposes of carrying out the Project Activities which comply with clause 5 and ARIA's published eligibility rules (which provide for full economic cost reimbursement) and as agreed in the Grant Funding Letter;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Grant Funding Letter;

Event of Default means any of the events or circumstances set out in clause 22.1;

Financial Year means 1 April to 31 March;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means any IP in the Results;

Funding Period means the period for which the Grant is awarded as set out in the Grant Funding Letter;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to [approaches for actively cooling the earth operated by ARIA/a third party in the form at Annex A;

GDPR means Regulation (EU) 2016/679;

Grant means the sum or sums ARIA will pay to you up to the amount set out in the Grant Funding Letter, in accordance with clause 4 and subject to the provisions set out at clause 22.

Grant Agreement has the meaning given in the Grant Funding Letter;

Grant Claim means a request submitted by you to ARIA for payment of the Grant;

Grant Funding Letter means the letter from ARIA to you to which these Conditions are annexed;

Grant Manager means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Grant;

Grant Review means the process for reviewing the grant outlined in clause 6;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Ineligible Expenditure means expenditure incurred by you which is not Eligible Expenditure as set out in clause 5 and ARIA's published eligibility rules;

Information Acts means the Data Protection Legislation, FOIA and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property Rights or **IP** means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation;

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise;

Maximum Sum means the maximum amount of the Grant stated in the Grant Funding Letter;

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

Personal Data has the meaning given to it in the Data Protection Legislation as amended from time to time;

Prohibited Act means:

- (a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for:
 - (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Grant Agreement; and/or
 - (ii) showing or not showing favour or disfavour to any person in relation to the Grant Agreement;
- (b) committing any offence:
 - (i) under the Bribery Act;
 - (ii) under legislation creating offences in respect of fraudulent acts; and/or
 - (iii) at common law in respect of fraudulent acts in relation to the Grant Agreement; and/or
- (c) defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the activities to be carried out by you that are described in the Grant Funding Letter and in Schedule 2 Part 1;

Project Representative means the representative appointed by you, who at the Commencement Date will be the individual listed as such in the Grant Funding Letter;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means all information, data, techniques, inventions, discoveries, works, software and materials generated in the course of the Project Activities;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Project Activities or any part thereof or facilities or services necessary for the performance of the Project Activities or any part thereof or necessary for the management, direction or control of the Project Activities or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Grant Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Funding Period because of termination or breach of the Grant Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination;

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 In these Conditions and the Grant Agreement, unless the context otherwise requires:

- (a) references to "party" and "parties" are to the parties to the Grant Agreement;
- (b) the singular includes the plural and vice versa;
- (c) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (d) references to clauses and Schedules are to the clauses of these Conditions and to the Schedules to the Grant Agreement;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation"; and
- (g) the headings in the Grant Agreement are for ease of reference only and will not affect the interpretation or construction of the Grant Agreement.

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

The Planetary Sunshade Baseline Project aims to advance understanding of space-based Solar Radiation Modification (SRM) architectures. Your work will involve developing and comparing various SRM options, assessing key factors, and conducting climate modeling. While conducting an outdoor experiment—specifically a spacecraft-based test—is beyond the scope of ARIA’s funding, there is an urgent need to advance space-based SRM to a level of understanding comparable to existing in-atmosphere SRM interventions. At the conclusion of your project, you will propose a space-based experiment, deliver a rigorously modeled set of potential space interventions, and establish a comprehensive baseline for ARIA and the global community for space based SRM.

2. Aims and objectives of the Project Activities

This project will study the practical feasibility and predicted climate impacts of the set of all plausible space based SRM solutions. To understand a plausible intervention, you need to consider the full range of possible architectures from both engineering and climate modeling perspectives. You will design 6 representative architectures, run climate models on them, and iterate with both the engineering and modeling teams.

By organising the engineering and modeling work in a unified project, you will create a ‘baseline’ for future discussions of space SRM and for how to compare space SRM to other methods.

3. Project Activities

- 3.1 You will create two intersecting workstreams for the modeling and engineering teams. Each architecture will be scaled to match the same level of global cooling, and described in terms of latitudes, ramp-up time, wavelengths and other factors relevant to modeling. While the engineering teams continue to develop their concepts at deeper levels of engineering detail, the climate modeling team will run iterative analysis, from simple to intermediate models to the most complex.

Work Package	Description	Deliverables
1. Engineering Architecture Development & Iteration	Conceptual design and tech specs for our 6 architectures, with feedback and iteration	1.1 Literature review of existing work 1.2 Standard set of parameters for a likely version of each architecture 1.3 Shade file for modeling teams to use 1.4 Preliminary feasibility assessment 1.5 Preliminary design review assessment & priority for advanced modeling 1.6 Prototype mission recommendation

2. Climate Modeling	Run Community Earth Systems Model (CESM) for the 6 architectures	2.1 First round - simple model results 2.2 Second round - intermediate model results 2.3 Third round - full earth system model results (for most promising 1 or 2 architectures)
3. Publishing Results	Sharing our findings with both the SRM and aerospace community in a way that is maximally helpful.	3.1 Research paper(s) submitted for publication 3.2 PSF creates a web portal for open access to modeling and engineering work 3.3 Publish policy briefing materials

3.2 The following Milestones will be used to monitor your delivery of the Project. The costs associated with completing these Milestones are estimated in the [REDACTED]

ID	Milestones	Measure	Date
1	Model scoping and first round engineering architectures complete	Commonly formatted report on first round engineering architectures available to share with modelers. Modeling presentation at quarterly check in in the first round of intermediate-complexity results of all the architectures and makes recommendations/suggestions for iterative designs. Outline architecture downselect framework available for review. The team will convene prior to this milestone to review work thus far, investing in cross-discipline education and learnings.	Commencement date + 6 months

2	Second Round modeling & engineering round conclusion.	Commonly formatted report on second-round engineering architectures, including iterations based on the modeling results thus far. Modeling essentially complete and report with analysis of results from overall project and full complexity model runs. Results compiled and start to create PSF interactive web interface.	Commencement date + 12 months
3	Project Complete & results ready for publication	Research Paper(s) fully drafted. Preprint published online. Engineering design review deck available. Defined mission requirements for prototype mission. Published PSF interactive web interface. Data publicly available (as part of open-access paper submission) as well as stored in a central ARIA public repository.	Commencement date + 14 months

In addition to the above Milestones, the following project plan will be used to track progress throughout the project and may be updated from time to time: [REDACTED].

3.3 The intended long-term outcomes are summarised below:

- The establishment of a baseline study for space based SRM. If successful, this project will be referenced by the upcoming IPCC report, and similar scientific forums, as defining the possibilities for space based SRM. Team members will be called upon as experts in further SRM discussions.
- Briefing to the UN's Committee on the Peaceful Uses of Outer Space and related space governance agencies.
- The project will allow a prototype space mission to be developed that identifies the highest value propositions to test.
- The project could serve as the groundwork for a FRO in this area.

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement
Kick off	• Roles and responsibilities • External communications • Project details
Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Invoicing and cost reporting Optional: • Key Learning, discoveries and decisions • Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • technical evidence saved to drive e.g. report or presentation as requested by PD • review meeting slide deck saved to drive as requested by PD Review meeting with ARIA Programme Team
Annual	• ARIA impact metrics • Attendance at annual ARIA event
Ad hoc	• As required, Programme Director/ Programme Team may request additional information and evidence • Workshops - potential to be invited to ARIA workshops
Project closure	• Project closure report

5. Payment

5.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments monthly in arrears.

Monthly payments will align with the calendar month.

5.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

5.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end of the relevant period.

5.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

6. Principal investigator/key researchers

6.1 For the purposes of clause 22.7, the following principle investigators or key researchers have been identified:

Name	Role	Organisation
Morgan Goodwin	Primary Investigator	Planetary Sunshade Foundation
Jeff Overbeek	Technical Director	Planetary Sunshade Foundation
[REDACTED]	Project Manager	Planetary Sunshade Foundation

7. Sub-Contractors

7.1 For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Location
Cornell University	Daniele Vioni and [REDACTED] Climate Modeling	Ithaca, New York
U. of Nottingham	Chantel Cappelletti, [REDACTED] [REDACTED] Engineering Design & Review	Nottingham, UK

PART 2 - GRANT APPLICATION

Application titled "Planetary Sunshade Baseline Survey" submitted 9 December 2024

SCHEDULE 3: Commercial Exploitation

Although the parties do not envisage any commercial application of the Results, this schedule sets out your obligations if commercial exploitation of the Results does occur.

1. LICENCES and ROYALTIES

1.1. In this Schedule:

Commercialisation Licence means a licence of IP other than a research or evaluation licence and/or subcontract manufacture (and **Commercially License** means to license under a Commercialisation Licence);

First Sale Date means the date on which you (or your affiliate or sublicensee) first bill an amount to a customer in respect of the sale of goods or services (or any other transaction) which use or incorporate Foreground IP;

Gross Sales means total invoiced value of sales made during a specific period, including all amounts billed to customers such as from the sale of goods, services, licence income, royalty income, franchise fees, commissions, subscription fees, before any deductions;

Group means in relation to a company, that company, any subsidiary or holding company from time to time of that company;

Net Sales means Gross Sales after relevant accounting deductions, such as sales tax, packaging, insurance, carriage and freight, trade discounts and credits, returns and allowances, import taxes and similar applicable government levies;

Non-UK Entity means a legal entity that is not a UK Entity; and

UK Entity means a legal entity or group of legal entities that has its headquarters and principal establishment in the United Kingdom.

1.2. If you consider that commercial exploitation of any of the Results has become or may become viable, you are encouraged to discuss the position with ARIA. Under clause 14.1 of the Conditions you are required to inform ARIA if during the Funding Period you plan to take any concrete action regarding any current or future commercial application of the Results.

1.3. You may request that ARIA exploit the Results or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Crown Body customers

1.4. You must ensure under any agreement for Commercial Licensing or assignment of Foreground IP, that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period, at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities, and in suitable quantities for the Crown Body's requirements.

Non-UK Commercialisation

1.5. A royalty of 0.25% of your Net Sales which use or incorporate Foreground IP shall be payable to ARIA if you are incorporated outside of the United Kingdom (the "ARIA Non-UK Fee"). For the

avoidance of doubt, the ARIA Non-UK Fee shall be calculated solely in respect of the share of the Net Sales which corresponds to the value resulting directly from the Foreground IP.

1.6. The ARIA Non-UK Fee shall be payable within 90 days following the end of each relevant calendar year, for a period of ten (10) years from the First Sale Date, up to an aggregate total equal to 20 times the Maximum Sum.

1.7. In the event that:

- (a) there is a change of control of the Foreground IP, such that you assign or grant an exclusive licence to the Foreground IP to another person; or
- (b) you extend rights to the Foreground IP within your Group, such that you grant another entity within your Group a licence to the Foreground IP,

then,
- (c) you must notify ARIA immediately; and
- (d) include clauses 1.5 and 1.6 in the relevant instrument and ensure that it expressly provides that the provisions are intended to be enforceable by ARIA by virtue of the Contracts (Rights of Third Parties) Act 1999 (or any equivalent in any jurisdiction) and take any other step required to ensure that the ARIA Non-UK Fee is payable by the transferee or licensee (as applicable).

1.8 For the avoidance of doubt, in respect of:

- (a) clause 1.7(a), provided that you have complied with clause 1.7(d), your obligation to pay the ARIA Non-UK Fee shall cease and pass to the transferee or licensee (until, in the case of an exclusive licence, the termination or expiry of such licence); and
- (b) clause 1.7(d) the transferee or licensee shall only be liable to pay the ARIA Non-UK Fee to ARIA for the remainder of the aggregated total amount and the ten (10) year period specified in clause 1.7 prorated from the date of the relevant instrument.

SCHEDULE 4: Data Protection

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Grant Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Grant Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Grant Agreement:
- 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are relying on Domestic Law as the basis for processing Personal Data, you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;

- 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);
- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Grant Agreement unless required by Domestic Law to store the Personal Data; and
- 3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.
- 3.4. [[ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this

Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):

- 3.4.1. cancel its plans to change the affected sub-Processor;
- 3.4.2. offer an alternative which is acceptable to ARIA; or
- 3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.

3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Grant Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.

3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]

3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Grant agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it, storing it, retrieving it, consulting it, disseminating it or destroying it, etc. Note the definition of processing in the UK GDPR: "<i>any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction</i>"
Duration of Processing:	Duration of this Grant Agreement (and any post termination processing that is permitted / required).

Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called “special categories” of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: “<i>data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation</i>”]
Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors, clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. You shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.
- 4.2. Any limitation of liability set out in this Grant Agreement will not apply to this Schedule’s indemnity or reimbursement obligations.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

1. Submission of Pledged Patents and Experimental Data
 - 1.1 The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
 - 1.2 The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.
2. Experimental Data Licence
 - 2.1 Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
 - 2.2 The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
 - 2.3 The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
 - 2.4 The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).
3. Research Licence
 - 3.1 Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
 - 3.2 The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
 - 3.3 Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.

3.5 The Research Licensee must:

- (a) at all times when using the Pledged Patents comply with all Laws; and
- (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).

4. Commercial Licence

4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.

4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.

4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.

5. Pledgor Know-How

At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.

6. Termination

6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:

- (a) materially breaches the terms of such licence or this Pledge; or
- (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).

7. Transfers of Pledged Patents and/or Experimental Data

The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.

8. No Warranty

The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and
Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

Stichting Centre for Future Generations (CFG) (**Grant Recipient**)

Hof van Zevenbergen 1 A

5211HB 's Hertogenbosch

Netherlands

30th May 2025

Attention: [REDACTED]

Dear [REDACTED]

FPCW-PR01-P012 - SAFEGEOGOV – Standard Grant Funding Letter

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to **Exploring Climate Cooling** and ARIA is pleased to offer you a Grant for the performance of the Project Activities up to the Maximum Sum, subject to your agreement to, and compliance with, the terms and conditions set out in this Grant Funding Letter and its Schedules.

1. Overview of the Grant

Any reference in this letter to "you" or "your" means the Grant Recipient and any capitalised terms have the meanings given in the ARIA Grant Conditions (Conditions).

The key elements of the Grant are described in the table below:

Project Activities	SAFEGEOGOV. A more detailed description of the Project Activities is set out in Schedule 2 (Project Activities).
Maximum Sum of the Grant (inclusive of taxes)	£1,255,090 (inclusive of all taxes where applicable)
Commencement Date	The commencement date is 1 June 2025
Completion Date	The completion is 1 November 2026
Grant Review Intervals	ARIA will review the Grant at quarterly intervals using the process referred to in clause 6 of the Conditions

Adequate Insurance	Employers' liability - At least £5 million (as required by the Employers' Liability (Compulsory Insurance Act 1969)) Public liability: £5 million (per year in aggregate)	
Monitoring and Reporting	The performance reports referred to in clause 7 of the Conditions shall be provided at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Project Representative	Matthias Honegger, Program Director [REDACTED] [REDACTED]	
Grant Manager	Mark Symes, Programme Director, [REDACTED]	
Escalation Contacts	ARIA	Grant Recipient
	Chief Product Officer [REDACTED]	[REDACTED] Chief Program Officer [REDACTED] [REDACTED]
Notices	ARIA Contracts [REDACTED]	Matthias Honegger, Program Director [REDACTED] [REDACTED]



Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Grant and return it to finance@aria.org.uk

3. The Grant Agreement

- 3.1. Once you sign a copy of this Grant Funding Letter in accordance with paragraph 6 (Acceptance) below, it will form a binding "**Grant Agreement**" between you and ARIA that includes and incorporates the following documents:

- 3.1.1. the **Grant Conditions** in Schedule 1;

- 3.1.2. the **Project Activities, Milestones** and **Grant Application** in Schedule 2;
- 3.1.3. the **Royalty percentages** (including annexes) in Schedule 3; and
- 3.1.4. the terms relating to Data Protection in Schedule 4.
- 3.2. The parties confirm that it is their intention to be legally bound by the Grant Agreement.
- 3.3. Not used.

4. Warranties

- 4.1. By signing this Grant Funding Letter, you warrant and represent that:
 - 4.1.1. your obligations under the Grant Agreement are legal, valid, binding and enforceable;
 - 4.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Grant Agreement have been obtained;
 - 4.1.3. the person signing the Grant Agreement is duly authorised to sign on your behalf;
 - 4.1.4. in relation to the Project activities, you are not an 'enterprise' within the definition of the Subsidy Control Act 2022; and
 - 4.1.5. your Project Representative referenced in the table above is authorised to make decisions and provide information on your behalf.

5. Amendments to the Grant Conditions

- 5.1. Not used.

6. Acceptance

- 6.1. To accept this Grant Funding Letter, please arrange for an authorised signatory to sign and date the duplicate copy of this Grant Funding Letter as indicated below, and return to ARIA as a complete signed original of the Grant Agreement including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Grant Agreement and to bind the Grant Recipient.
- 6.2. The offer of this Grant Funding Letter will expire on 1 June 2025.

Yours sincerely

for and on behalf of ARIA

Name of ARIA signatory:

Position Held:

Date:

I confirm the agreement of Stichting Centre for Future Generations to the terms and conditions in this Grant Funding Letter and its Schedules.

Signature:

Name:

Position:

Date:

SCHEDULE 1 - GRANT CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up the Grant Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Grant Funding Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to the Grant Agreement with the exception of Schedule 2 Part 2 (the Grant Application);
 - (d) Schedule 2 Part 2 (the Grant Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, the Grant Agreement.

2. DURATION AND PURPOSE OF THE GRANT

- 2.1 The Grant Agreement will subsist for the duration of the Funding Period unless extended by written agreement signed by a duly authorised representative of the parties or terminated earlier in accordance with its terms. Any provision of the Grant Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Grant Agreement shall remain in full force and effect, including clauses 1, 2, 4, 7.4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.3, 22.7, 22.8, 22.11, 22.12, 23, 24, 26, 27, 28, and 30.
- 2.2 You may only use the Grant for carrying out the Project Activities. You may not make any changes to the Project Activities without ARIA's prior written agreement.
- 2.3 You may not unreasonably withhold, condition or delay your agreement to any changes requested by ARIA to the Project Activities or the amount of the Grant. Any agreed change will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

3. ENVIRONMENTAL AND SAFETY REQUIREMENTS

- 3.1 In performing the Project Activities, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. PAYMENT OF GRANT

- 4.1 Subject to the remainder of this clause 4, ARIA will pay the Grant to you:
- (a) up to the Maximum Sum;
 - (b) in pounds sterling (GBP) by wire transfer into your bank account, details of which you provided in the Confirmation of Bank Details form attached to the Grant Funding Letter; and
 - (c) if a tax is chargeable in respect of the Grant, all payments will be deemed to be inclusive of all such taxes and ARIA will not be obliged to pay any additional amount.
- 4.2 The bank account of which you provided details in your Confirmation of Bank Details form (and any alternative bank details nominated subsequently by you) must be an ordinary business bank account

with appropriate segregation of duties and control. During the Funding Period, you must notify ARIA of any change of bank account details as soon as reasonably practicable on the same form and signed by an approved signatory. You must notify ARIA of any change of signatory for approval, as soon as known.

- 4.3 You will be the sole recipient of the Grant and you will be responsible for managing the Grant as between you and any Third Parties involved in performing the Project Activities. This includes securing the repayment of the Grant if requested by ARIA in accordance with the Grant Conditions, including where the Grant has already been distributed to Third Parties.
- 4.4 You must promptly notify ARIA if any money is incorrectly paid to you for any reason, and must repay it as soon as reasonably practicable. Any amount not immediately repaid will be recoverable as a civil debt.
- 4.5 ARIA reserves the right not to pay any Grant Claims that are not submitted within the period set out in the Grant Funding Letter or that are incomplete, incorrect or not accompanied by full supporting documentation (including any documentation that ARIA reasonably requests).
- 4.6 You may not apply for or obtain Duplicate Funding for any Project Activities.
- 4.7 You may not retain any Unspent Monies and must repay them to ARIA within 30 days after ARIA's request for repayment.
- 4.8 You acknowledge the critical importance of cash flow for Sub-Contractors (including startups and small businesses) and commit to paying all valid and undisputed invoices relating to the Project within a maximum of 30 days from the date of receipt.
- 4.9 Where required, you will work with Sub-Contractors to arrange more frequent payment schedules (e.g., same day, weekly or milestone-based payments) to better support their cash flow needs.

5. ELIGIBLE AND INELIGIBLE EXPENDITURE

- 5.1 ARIA will only pay the Grant for Eligible Expenditure incurred by you in carrying out the Project Activities. You must provide ARIA with any evidence reasonably requested by ARIA (including receipts, invoices and other documentary evidence) that all Grant Claims relate to costs that are Eligible Expenditure.
- 5.2 You may not in any circumstance claim as Eligible Expenditure paid-for lobbying, which means using the Grant to fund lobbying (via an external firm or in-house staff) in order to undertake activities intended to influence or attempt to influence Parliament, government or political activity; or attempting to influence legislative or regulatory action.

6. GRANT REVIEW

- 6.1 ARIA will review the Grant at the intervals specified in the Grant Funding Letter. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.3.

- 6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:
- (a) consent to the Project Activities and the Grant Agreement continuing in line with existing plans;
 - (b) increase or decrease the Grant for the remainder of the Funding Period, as applicable;
 - (c) redefine the Milestones;
 - (d) require you to carry out remedial activity with the aim of improving delivery of the Project Activities; and/or
 - (e) terminate the Grant Agreement in accordance with clause 22.
- 6.3 Any change to these Grant Terms, the Project Activities, or the Grant pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

7. MONITORING AND REPORTING

- 7.1 You must closely monitor the carrying out of the Project Activities throughout the Funding Period and must notify ARIA as soon as reasonably practicable of any actual or potential failure to comply with any of your obligations under the Grant Agreement.
- 7.2 ARIA does not limit its engagement with you to purely administrative activities and will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project Activities. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.
- 7.3 You must provide ARIA with:
- (a) the Milestones and a report on your performance against the Milestones at the intervals and for the periods of time specified in the Grant Funding Letter. ARIA may copy and adapt the contents of any of the Milestones and those reports for ARIA's internal use to review, develop and shape ARIA's funded research programmes, but ARIA will treat those contents as your Confidential Information under clause 11;
 - (b) any assistance and information reasonably requested by ARIA to establish whether you have used the Grant in accordance with the Grant Agreement; and
 - (c) a quarterly report on the use of the Maximum Sum, details broken down in accordance with ARIA's prescribed form.
- 7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its funding activities and compliance with the terms of the Grant Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time after the end of the Funding Period

about the impact metrics, commercial exploitation or other dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Grant Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Grant Agreement.

8. AUDITING AND ASSURANCE

- 8.1 For Grants over £500k: Annually, and on each anniversary of the Commencement Date and at the end of the Funding Period you must provide ARIA with independent assurance that the Grant has been used for carrying out the Project Activities. To satisfy this requirement you must provide a statement showing that the use of the Grant has been certified by an independent and appropriately qualified auditor or accountant.
- 8.2 Subject to clause 11, ARIA and/or its authorised representative may, at any time during the Funding Period and for up to 7 years after the end of the Funding Period, conduct audits in relation to your use of the Grant and your compliance with the Grant Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.
- 8.3 You must:
- (a) maintain an appropriate system of financial management and controls, maintain detailed records in relation to those controls, and provide copies of those records to ARIA on request; and
 - (b) retain, and procure that your Sub-Contractors retain and will provide to you on request, all relevant documentation relating to the Eligible Expenditure (including invoices, receipts and accounting records) during the Funding Period and for a period of 7 years thereafter.

9. FINANCIAL MANAGEMENT

- 9.1 You must:
- (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Grant; and
 - (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project Activities as soon as they are identified, and keep ARIA informed of your remedial actions.
- 9.2 In the event of any actual or suspected fraud, theft or other financial irregularity (which includes use of the Grant for any purpose other than that envisaged by the Grant Agreement), ARIA may, at its absolute discretion:
- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
 - (b) suspend the Project Activities and future payment of the Grant to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

- 10.1 You must inform ARIA promptly of any actual, perceived or potential conflicts between your and your Representatives' obligations under the Grant Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Funding Period.
- 10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that these conflicts are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you or your Representative to cease the conflicting activity and if that is not acceptable to you or your Representative, either party may terminate the Grant Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

- 11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the provision of the Project Activities, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.
- 11.2 ARIA may publish a summary of the Grant Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Grant Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.
- 11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:
- (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;
 - (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information necessary for the purpose concerned and obtains appropriate confidentiality undertakings in relation to such information;
 - (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and where no exception to disclosure under them is applicable; or

- (d) where that party (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.

11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under the Grant Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

12.1 Each party must comply with its obligations under the Law, including where applicable the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.

12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.

12.3 You acknowledge that ARIA, acting in accordance with the Information Acts (other than the FOIA), may disclose information concerning you and the Grant Agreement without consulting you. ARIA must take reasonable steps to notify you of any request for information to the extent permissible and reasonably practical and will give you adequate opportunity to make representations before ARIA discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.

12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or the Grant Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.

12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.

12.6 You must take account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.

- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with the Grant Agreement. If either party anticipates that the other will process any Personal Data on its behalf under the Grant Agreement it must notify the other party and the parties must agree a variation to the Grant Agreement under clause 26 to incorporate appropriate provisions (such as those set out in Schedule 4) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. SUBSIDY CONTROL AND STATE AID

- 14.1 ARIA intends that the Grant complies with the Subsidy Control Act 2022 on the basis that the Project Activities are not economic activities and do not give a specific advantage to one or more enterprises. You must take all reasonable steps to maintain this position and to assist ARIA to comply with the requirements of the Act and must cooperate with any investigations under the Act.
- 14.2 Where the EU state aid laws apply to the Grant (where the Project Activities will affect trade between Northern Ireland and the EU), you acknowledge that the Project Activities are designed and performed so they are compatible with state aid laws. You will take all reasonable steps to assist ARIA to comply with state aid law requirements and cooperate with any investigations by the European Commission into the Project Activities.
- 14.3 ARIA will immediately stop future payments of the Grant and may require repayment of some or all of the Grant if subsidy control or state aid laws so require for the funding to be compliant.

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and not seek to avoid their application by artificial means.

Background IP

- 15.2 The Grant Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Funding Period if any additional Background IP is required either to carry out the Project Activities or to exploit commercially any of the Results.

Foreground IP ownership

- 15.3 You will own all Foreground IP unless your policy is for individual researchers to own the Foreground IP they create, or you agree your Sub-Contractor (or another third party) will own all, or parts of, the Foreground IP. Where your Sub-Contractor or individual researchers (or any other third party involved in the performance of the Project Activities) will own any of the Foreground IP you must impose on them the obligations relating to Foreground IP and Results contained in clauses 15 and 16. Where you assign any Foreground IP to a Third Party (including your technology transfer company) you must impose on that Third Party the obligations relating to Foreground IP and Results contained in clauses 15 and 16.
- 15.4 You must submit all (i) all patents within or covering the Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the [Future Proofing our Climate and

Weather Intellectual Property Pledge promptly following creation or filing (as applicable) of such patents and/or data (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge. You hereby agree to comply and uphold the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.5 You must ensure that whenever any Results are used with or communicated to Third Parties or are exploited commercially, ARIA's funding of the Project Activities is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and publication

- 15.6 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.7 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.8 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to fund future prosecution and maintenance and/or request the assignment of the patents to ARIA or its nominee.

Inventor first preference

- 15.9 Subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge if any inventor or active participant in the Project Activities expresses interest in the exploitation of the Foreground IP they have developed, you must give them an opportunity to negotiate an assignment or commercial licence of the Foreground IP, on reasonable terms, prior to negotiating with any entity in which an inventor or active participant in the Project Activities is not involved as a shareholder or other key stakeholder.

16. COMMERCIALISATION OF RESULTS

- 16.1 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge, where they are capable of commercial exploitation you should seek to exploit the Results commercially. This should be done, where applicable, in accordance with the Commercialisation Hypothesis.
- 16.2 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge, if for any reason you choose not to exploit any such Results commercially within a reasonable timeframe (or, where applicable, the timeframe set out in the Commercialisation Hypothesis) you are encouraged to discuss the position with ARIA, and you may request that ARIA exploit them or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Non-UK Commercialisation

- 16.3 Save as set out in the Future Proofing our Climate and Weather Intellectual Property Pledge, to avoid any restriction on commercialisation, no consent is required from ARIA for any Non-UK commercialisation or any sale of Foreground IP to a Non-UK Entity. However, ARIA is set up to create value for the UK and therefore you must secure a fee payable to ARIA (**ARIA Non-UK Fee**) in each of the following circumstances:
- (a) where you are a Non-UK Entity;
 - (b) where you become a Non-UK Entity;
 - (c) where you assign or Commercially License any Foreground IP to a Non-UK Entity; or
 - (d) where you have assigned or Commercially Licensed any Foreground IP to a UK Entity that subsequently becomes a Non-UK Entity.
- 16.4 In order to avoid any unnecessary complexity, the ARIA Non-UK Fee will be based on the terms that you agree with any person to which you assign or Commercially License the relevant Foreground IP. This ARIA Non-UK Fee will amount to an additional twenty-five per cent (25%) of the value of the consideration (including upfronts, licence fees, milestone payments, royalties, shares or other securities, buyouts, exit fees and other consideration) that you receive from the exploitation of the relevant Foreground IP during any period that the above circumstances exist.
- 16.5 For example, if you would receive £100 (via royalty or royalty buyout), you must ensure your contractual mechanism enables you to collect an additional £25 and pay that additional amount to ARIA.
- 16.6 The ARIA Non-UK Fee is payable within 90 days after the end of each relevant Financial Year for receipts related to that calendar year. You are encouraged to use the clauses in Annex 1 in your Commercialisation Licences of Foreground IP.

Crown Body customers

- 16.7 You must ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities, and in suitable quantities for the Crown Body's requirements.

Spin-outs

- 16.8 ARIA seeks to maximise future investment of entrepreneurial talent and capital in start-up companies commercialising the Results of its funded activities. To that end, having funded the full economic cost of the research, ARIA places restrictions on the level of equity stakes and royalties that you may negotiate in exchange for the assignment or Commercialisation Licence of any Foreground IP.
- 16.9 If you or your technology transfer company assign or licence any Foreground IP to any third party or to a start-up established for the purpose of commercially exploiting the Results (a NewCo) you together with any connected person (including any investment fund to which you may transfer any part of your stake) shall be entitled to:

EITHER

- (a) hold or have the right to hold no more than 10% in fully-dilutable shares or equity (pre investment) in the third party or NewCo (with no other preferential subscription rights), not including any shares or equity subscribed for cash on arm's length terms alongside other investors;

OR

- (b) charge a royalty, with no upfront payments, annual fees, milestone payments or minimum royalties, payable by the third party or NewCo under any licence or assignment of the Foreground IP at no more than the relevant rate, and on the other terms, set out in Schedule 3.

- 16.10 The provisions of clauses 16.9(a) and 16.9(b) shall not apply to any equity taken or royalty charged in consideration of:
- (a) IP other than Foreground IP licensed or assigned to the third party or NewCo; or
- (b) facilities, equipment, personnel or other material support or services provided to the third party or NewCo independent of the Project Activities,
- with such equity or royalty limited to the proportion that reflects the contribution made by IP that is not Foreground IP.
- 16.11 You must notify ARIA in writing before any transaction completes of the overall equity stake or royalty percentages agreed under clause 16.8 (and any impact of clause 16.9, if relevant).

17. ASSETS

- 17.1 You must keep a register during the Funding Period and for up to 7 years after the end of the Funding Period of all Assets, with all relevant details about each Asset. You must use any Assets purchased with Grant monies for the Project Activities.
- 17.2 At the end of the Funding Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

- 18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Grant Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUBCONTRACTING

- 19.1 You may not transfer, assign, novate or otherwise dispose of the whole or any part of the Grant Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.
- 19.2 You shall not subcontract any of the Project Activities to a Third Party except to the extent permitted, and to the person or persons identified, in Schedule 2 Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractor as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Grant Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Grant Agreement.

20. BORROWING, LOSSES, GIFTS, SPECIAL PAYMENTS

- 20.1 You must obtain ARIA's prior written consent before:
- (a) borrowing or lending money from any source in connection with the Grant Agreement;
 - (b) giving any guarantee, indemnity, security over any Asset or letter of comfort in relation to the Grant Agreement;
 - (c) making any gift or writing off any debt or liability in connection with the Grant, and must keep a record of all gifts given and received in connection with the Grant.

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Grant and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Grant or publicise details of the Grant Agreement without the other's consent, except as required by Law.
- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

- 22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events occur:

- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13, 15.5 or 25, or commit a material breach of any other term of the Grant Agreement in the reasonable opinion of ARIA;
- (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
- (c) you fail to improve the performance of the Project Activities, notwithstanding your having undertaken the remedial activity agreed with ARIA in the remedial plan under clause 6.2(d);
- (d) you or the researchers involved in the Project Activities obtain any funding from a Third Party that, in the opinion of ARIA, undertakes activities that are likely to bring the reputation of the Project Activities or ARIA into disrepute;
- (e) you provide ARIA with any materially misleading or inaccurate information in your grant application or in subsequent related correspondence;
- (f) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Third Party, immediately upon becoming aware of it;
- (g) you are subject to an Insolvency Event;
- (h) the Grant or any part of it is held by a court or competent authority to be a prohibited subsidy under the Subsidy Control Act 2022 or an illegal state aid;
- (i) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project Activities;
 - (ii) result in your being unable to receive the Grant; and/or
 - (iii) raises national security concerns.

Rights reserved for ARIA in relation to an Event of Default

- 22.2 If an Event of Default has or may have occurred, ARIA may by written notice to you take any one or more of the following actions:
- (a) suspend the Project Activities and payment of the whole or any part of the Grant for such period as ARIA may determine, acting reasonably;
 - (b) reduce the Maximum Sum, in which case the payment of Grant will thereafter be made in accordance with the reduction and notified to you; and/or
 - (c) subject to clause 22.4, terminate the Grant Agreement with immediate effect as from the date of service of the notice of that termination.
- 22.3 Where this Grant Agreement is terminated for an Event of Default described in clause 22.1(f) or 22.1(h), ARIA may require you to repay the entire amount of the Grant previously paid to you.

Opportunity for you to remedy an Event of Default

- 22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:
- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and

- (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

22.5 Without prejudice to any other provision of the Grant Agreement, you may terminate the Grant Agreement on written notice to ARIA if ARIA commits a material breach of the Grant Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

General Termination Rights

22.6 Notwithstanding ARIA's right to terminate the Grant Agreement under clause 22.2(c), either party may terminate the Grant Agreement (in whole or in part) at any time by giving at least 60 days' prior written notice to the other party.

22.7 You must promptly notify ARIA in writing if at any time the principal investigator or any key researcher(s) named in Schedule 2 working on the Project Activities is unable or unwilling to continue to be involved in the Project Activities or is moving to a new organisation without the desire to continue the research. Within 60 days after the date of that notice, you must either:

- (a) nominate one or more successors, subject to ARIA's approval; or
- (b) agree that the Grant is transferred to another organisation subject to your and the new organisation's agreement in writing and ARIA's approval of the transfer

If ARIA is unwilling to accept the nominated successor(s) or does not approve a request for transfer, it may terminate the Grant Agreement by at least 30 days' written notice to you.

Consequences of Termination

22.8 If the Grant Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.

22.9 Where ARIA terminates the Grant Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:

- (a) you taking all reasonable steps to mitigate such loss; and
- (b) the Unavoidable Costs being:
 - (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Grant Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA;

- (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you;
- (v) costs that would not have been incurred had this Grant Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period).

- 22.10 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Services, over £250,000 will terminate automatically and immediately upon termination of this Agreement.
- 22.11 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Grant Agreement in the event that the Grant Agreement was terminated (calculated on the basis described in clause 22.8).
- 22.12 ARIA's total liability under clause 22.9 shall be limited to the Maximum Sum under the Grant Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.13 If the Grant Agreement is terminated or expires ARIA will not be liable to pay any of your costs or those of any of your contractors or suppliers related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Grant Funding Letter and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Grant Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Grant Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the Grant Manager and the Project Representative.
- 23.3 If the dispute cannot be resolved between the Grant Manager and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to a formal meeting between the parties' Escalation Contacts.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:
- (a) fraudulent misrepresentation or any other fraudulent act or omission;
 - (b) payment of sums properly due and owing to the other in the normal course of performance of this Grant Agreement;
 - (c) a breach of clause 13;

- (d) liability arising under any indemnity in this Grant Agreement; or
- (e) liability which may not lawfully be excluded or limited.

24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Grant Agreement or for ARIA's breach of this Grant Agreement), whether arising directly or indirectly, that may arise in connection with:

- (a) your carrying out the Project Activities;
- (b) the use of the Grant by any person;
- (c) any reduction, suspension, withdrawal or request for repayment of the Grant in accordance with this Grant Agreement; or
- (d) termination of the Grant Agreement in accordance with this Grant Agreement.

24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:

- (a) loss of profit, sales or turnover;
- (b) loss of contracts or business opportunities;
- (c) loss of anticipated savings;
- (d) loss of goodwill or damage to reputation; or
- (e) any indirect, special or consequential loss or damage;

in each case arising out of or relating to the Grant Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.

24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to the Grant Agreement or its subject matter or anything which it has done or not done in connection with the Grant Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the amount of the Maximum Sum.

24.5 You shall under no circumstances in connection with this Grant Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.

24.6 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Grant Agreement.

25. RESEARCH ETHICS AND CODE OF CONDUCT

25.1 As a recipient of a Government grant you must operate in accordance with the Concordat.

25.2 All research data:

- (a) must be generated using sound scientific techniques and processes;
- (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and

(c) must be analysed appropriately, without bias and in accordance with good scientific practices.

25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.

25.4 You must comply with the Code of Conduct and ensure that your Representatives undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

26.1 Any variation to the Grant Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

27. GENERAL

27.1 Notices: All notices and other communications in relation to this Grant Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such communications will be deemed to have been given and received on the third Working Day following such mailing.

27.2 Change of control: You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(i) is likely to apply.

28. GOVERNING LAW

28.1 This Grant Agreement (including any non-contractual disputes or claims arising in connection with this Grant Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. NOT USED.

30. DEFINITIONS AND INTERPRETATION

30.1 Where they appear in these Conditions or the Grant Agreement:

Adequate Insurance means the insurance requirements and amounts set out in the Grant Funding Letter.

Asset means any asset that is purchased, improved or developed using the Grant including equipment and fixed assets;

Background IP means IP that is:

(a) owned by or licensed to a party prior to the Commencement Date; or
(b) developed by or on behalf of a party during the Funding Period but not in connection with the Project Activities,

and is in either case used in connection with the Project Activities;

Bribery Act means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;

Change of Control means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Recipients of Government General Grants published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754555/2018-11-06_Code_of_Conduct_for_Grant_Recipients.pdf

including any subsequent updates from time to time;

Commencement Date means the date set out in the Grant Funding Letter;

Commercialisation Licence means a licence of IP other than a research or evaluation licence and/or subcontract manufacture (and **Commercially License** means to license under a Commercialisation Licence);

Commercialisation Hypothesis means the exploitation plan approved by ARIA and set out at Schedule 2 Part 2, as may be amended by agreement between the parties during and after the Funding Period;

Completion Date means the date set out in the Grant Funding Letter;

Concordat means the Concordat to Support Research Integrity which can be found at <https://ukrio.org/about-us/the-concordat-to-support-research-integrity/>

Conditions means these ARIA Grant Conditions;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Grant Agreement, that ought reasonably to be considered to be confidential (whether or not it is so marked), (a) including: (i) information relating to the business, affairs, customers, clients, suppliers or plans of the disclosing party; (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party; (iii) any information developed by the parties in the course of carrying out the Project Activities; (iv) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Grant Agreement; and (v) and any information derived from any of the above,

(b) but not including information which: (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11); (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party; (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or (iv) is independently developed without access to the Confidential Information; and (v) the content of this specific version of the Grant Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

Duplicate Funding means funding provided to you by a Third Party which is to fund the same activities as the Project Activities;

EA means the Equality Act 2000 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Eligible Expenditure means the payments made by you during the Funding Period for the purposes of carrying out the Project Activities which comply with clause 5 and ARIA's published eligibility rules (which provide for full economic cost reimbursement) and as agreed in the Grant Funding Letter;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Grant Funding Letter;

Event of Default means any of the events or circumstances set out in clause 22.1;

Financial Year means 1 April to 31 March;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means any IP in the Results;

Funding Period means the period commencing on the Commencement Date and ending on the Completion Date or such later date as may be agreed between the parties unless otherwise determined in accordance with the terms of the Grant Agreement;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification (operated by ARIA or by a third party), in the form set out at Annex A;

GDPR means Regulation (EU) 2016/679;

Grant means the sum or sums ARIA will pay to you up to the amount set out in the Grant Funding Letter, in accordance with clause 4 and subject to the provisions set out at clause 22.

Grant Agreement has the meaning given in the Grant Funding Letter;

Grant Claim means a request submitted by you to ARIA for payment of the Grant;

Grant Funding Letter means the letter from ARIA to you to which these Conditions are annexed;

Grant Manager means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Grant;

Grant Review means the process for reviewing the grant outlined in clause 6;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Ineligible Expenditure means expenditure incurred by you which is not Eligible Expenditure as set out in clause 5 and ARIA's published eligibility rules;

Information Acts means the Data Protection Legislation, FOIA and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property Rights or **IP** means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions, semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation;

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise;

Maximum Sum means the maximum amount of the Grant stated in the Grant Funding Letter;

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

NewCo has the meaning given in clause 16;

Non-UK Entity means a legal entity that is not a UK Entity;

Personal Data has the meaning given to it in the Data Protection Legislation as amended from time to time;

Prohibited Act means:

(a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Grant Agreement; and/or (ii) showing or not showing favour or disfavour to any person in relation to the Grant Agreement;

(b) committing any offence: (i) under the Bribery Act; (ii) under legislation creating offences in respect of fraudulent acts; and/or (iii) at common law in respect of fraudulent acts in relation to the Grant Agreement; and/or

(c) defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the activities to be carried out by you that are described in the Grant Funding Letter and in Schedule 2 Part 1;

Project Representative means the representative appointed by you, who at the Commencement Date will be the individual listed as such in the Grant Funding Letter;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means all information, data, techniques, inventions, discoveries, works, software and materials generated in the course of the Project Activities;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Project Activities or any part thereof or facilities or services necessary for the performance of the Project Activities or any part thereof or necessary for the management, direction or control of the Project Activities or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

UK Entity means a legal entity whose ultimate parent company has its headquarters and principal establishment in the United Kingdom;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Grant Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Funding Period because of termination or breach of the Grant Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination; and

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 In these Conditions and the Grant Agreement, unless the context otherwise requires:

- (a) references to "party" and "parties" are to the parties to the Grant Agreement;
- (b) the singular includes the plural and vice versa;
- (c) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (d) references to clauses and Schedules are to the clauses of these Conditions and to the Schedules to the Grant Agreement;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation"; and
- (g) the headings in the Grant Agreement are for ease of reference only and will not affect the interpretation or construction of the Grant Agreement.

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

As global temperatures continue to rise beyond 1.5°C, there is increasing concern that interest in solar radiation modification (SRM) could surge without sufficient scientific knowledge, governance frameworks, or informed policymaking. This project examines plausible futures of SRM deployment by 2035, developing a baseline and four geopolitical SRM scenarios and outlines the contours of a global governance framework responding to the governance needs identified in the scenarios. The project is a collaboration between the Centre for Future Generations, the Organisation for Economic Co-operation and Development (OECD), the University of Leeds, and the Australian National University.

2. Aims and objectives of the Project Activities

The project SAFEGEOGOV (Strategic Foresight on Climate and Geopolitics: Toward Governance of Solar Radiation Modification) explores and produces scenarios informed by scientific and policy experts. These scenarios will make the potential risks, benefits, and uncertainties of SRM deployment more tangible. They will also offer insights into how SRM could intersect with geopolitical tensions, security concerns, migration, human rights, and similar issues.

The scenarios will explore various possibilities, from unilateral deployment by major powers to multilateral SRM initiatives led by climate-vulnerable nations. The project will also examine critical governance challenges, such as transparency in SRM research, public engagement, and international coordination and outline the contours of a global governance approach that meets key needs.

Through participatory scenario-building, briefings, and policy engagement, the project bridges the science-policy divide and places SRM governance on the policy agenda. Vice versa, the project strengthens academic work on governance by providing an understanding of real-world political dynamics. Both contributions will help advance concrete governance options grounded in strategic decision-making and institutional feasibility and thus reduce the risks of poorly informed SRM decisions – regardless of whether SRM is pursued or prevented.

3. Project Activities

A note on publication dates, policy engagements and the (sub-)project structure: SAFEGEOGOV is aiming to deliver impact by engaging different stakeholders, including senior officials. To achieve its agenda-setting ambition, it may be important for the project partners to coordinate the timing of publications. This could mean that key documents are not published before the project team brings them jointly to the attention of the OECD's Global Strategy Group (GSG) meeting in October 2026.

For the same reason, it will be important to ensure that sufficient support can be garnered from key members and partner experts before online publication. This could require some flexibility regarding the final publication date. A similar process conducted in 2024 led to the final publication of reports in late February.

The SAFEGEOGOV project partners endeavour to have the key publications ready by June 2026, including having already undertaken some of the necessary consultations by then. However, you cannot rule out the possibility that further consultations may be necessary in the months following the presentation of materials in October until a final publication by January 2027. Since the main body of work will be concluded within 12 months – followed by engagements (see Work Package D), SAFEGEOGOV runs formally for 17 Months. Yet in the case that further consultations are required, all project partners are committed to seeing the work through to final publication, including by contributing to any necessary revisions upon important feedback during that time.

You also would like to reserve flexibility regarding the most suitable branding of individual publications, including to brand some of them as publications merely by the leading project partner or – if suitable for the envisaged impact – jointly by several partners. The approach may be adapted inter alia depending on the level of political buy-in the partners are observing.

3.1 Description of Project Activities

The project activities comprise a) data generation through Delphi interviews, bi- and minilateral stakeholder consultations, and deliberative workshops, b) baseline and scenario development, c) global governance framework development, and d) engagements and dissemination.

Work Package A) Data generation: Interviews, consultations and workshops

Data generation includes Delphi interviews, workshops, and symposia. These will involve relevant practitioners and experts from a range of fields (including game theory, international relations, behavioural economics, and/or risk communications). This data will provide the analytical base for the scenario development and the anticipatory governance framework.

A1: Delphi interviews (led by Trish Lavery)

A1 comprises the design and conduct of a series of Delphi interviews under Trish Lavery's lead. The interviews will include SRM, technology, climate policy, geopolitical, governance, and foresight experts. The interviews will serve the later scenario development by mapping the analytical background and create a long list of factors that are defining aspects of SRM presently and in the future. The interviews will be led mainly by the foresight practitioner Trish Lavery (ANU) in collaboration with the CFG for subject matter expertise and access to international SRM or governance experts and practitioners.

The ANU-led work on A1 will thus result in:

- A 1-page briefing note introducing the project goals and structure to stakeholders and prospective interviewees (to be approved by all partners).
- A series of interviews conducted in the first 6-8 months of the project
- Interview protocols including summaries as data input into (B).

A2: Workshops and (online) symposia (led by Danielle Young)

A2 comprises three in-person workshops and numerous online symposia led by Danielle Young. These discussions will provide rich data input into the scenario development and identification of governance needs. A series of open-ended, research-driven simulation workshops will investigate

decision-making in non-ideal scenarios and shed light on the global geopolitical challenges SRM poses. An international research network of 25 participants will include a mix of scientists, social scientists with policy portfolios relevant to SRM, and policymakers. These workshops will focus specifically on developing and running scenarios that examine the potential geopolitical implications of SRM research and deployment in which its potential as a climate intervention is secondary to its potential as a source of competition. This sub-project work program will complement the broader SAFEGEOGOV project by providing higher-resolution data on competitive or non-cooperative mindsets and approaches that may inform the behaviour of decision-makers. It will also highlight the risks for SAFEGEOGOV project partners of non-ideal research and deployment scenarios in broader socio-political dynamics. This will contribute to forecasting exercises for anticipatory governance frameworks. The discussions will allow us to overlay and compare draft scenarios (B) with the simulation space framework to identify similarities and differences in assumptions and policy/technology implications.

The Leeds-led A2 work will thus result in:

- 3 simulation-based white papers and a report on the outcomes of the project to inform domestic and international SRM governance discussions.
- Inputs into the CFG-led scenario report and the OECD-led governance report.
- 3 presentations in different academic-policy fora to report interim results after each scenario workshop, (i) The Net Zero Regulation and Policy Hub at the Blavatnik School in Oxford, (ii) The Norwegian Institute of International Affairs (NUPI) in Oslo, and (iii) the Mile End Institute, Queen Mary University of London;
- An extensive interdisciplinary research matrix to identify areas for continuing interdisciplinary research and collaboration (led by Colleen Golja in Danielle Young's team).

Work Package B) Scenario Development (ANU and CFG-lead)

The strategic foresight process for scenario development is a structured way to think about the future through the eyes of multiple stakeholders, each of whom can bring distinct insights to broaden or deepen the range of considerations. Its purpose is to equip governments, societies, and researchers with the capacity to explore and prepare for multiple plausible futures, risks, opportunities and challenges to guide decision-making today.

The strategic foresight methodology used in this project is a comprehensive deductive approach that allows for generating evidence-based, defensible and robust SRM future scenarios. It mirrors processes employed by other International Organisations, including the UNIDIR, and is widely considered one of the most rigorous strategic foresight processes. ScMI software will be used for structured data analysis that supports the scenarios.

The scenario development, led by ANU and CFG jointly, will be informed by data input from the prior Delphi interviews and the notes from workshops and consultations. The scenario development follows the following four steps:

1. Prioritising a shortlist of the most impactful factors and assessing possible future projections for each to develop the reference scenario;

2. Assessing the consistency between projections to elucidate groups of factors that are logically most likely to co-occur;
3. Developing four reference scenarios about the future of SRM to explore tensions, trade-offs and potentially fitting (global) governance arrangements;
4. Modelling of the broad geopolitical and socio-economic-environmental implications of SRM future scenarios with an international set of thematic and policy experts.

The ANU and CFG-led work on (B) thus results in:

- A (primarily) CFG and ANU branded **scenario (synthesis) report** – showing and explaining the four 2035 SRM scenarios in a clear and concise format. For each scenario, the governance implications – including opportunities and challenges that might have to be anticipated and managed by policymakers – will be clearly articulated.
- Optional: One or more **research articles** (targeting the research community may complement the report (produced jointly with co-authorship contributions from all partners where appropriate).
- At least 5 customised **briefings** (meetings or phone calls) for specific actors (policymakers, NGOs, the media).
- **1-3 written briefing notes:** These will not initially be published but used to introduce the project in private conversations and upon approaching interviewees. One (or two) will introduce the project (and the University of Leeds-led subproject). More briefing notes may be developed later to support engagement activities (see D) including to introduce specific governance opportunities, including potential multilateral and international measures for anticipating and minimising risks and research funding design options for responsible and transparent SRM research, testing, and monitoring. Used in support of consultation meetings, these may help with inviting feedback to inform the work on the global governance framework (C). All notes will likely only be published at the time of publishing the two major reports to enhance the agenda-setting effect (upon coordination between the project partners).

Work Package C) Global Governance Framework (OECD lead)

The development of a proposed global governance framework runs parallel to and in close exchange with the above project activities. The objective is that the contours outlined match the governance needs that are unearthed through the data generation and scenario development process.

The first step is to identify the “so what” implications of the observations provided by interviewees, experts, workshop participants and other counterparts involved in the data generation (A). The second step is to identify the “so what” implications of observations flowing from the use/non-use scenarios as they are being developed (B). The third step is to compare the two lists of implications derived from data generation (A) and scenarios (B) so as to identify the totality of governance needs or functions, which would need to be met collectively in any successful global governance framework – capable of dealing with ideally all eventualities outlined in the scenarios and all concerns raised by the stakeholders and experts.

Work Package D) Engagements and Dissemination (CFG lead)

The project team will endeavor to clarify the respective roles and responsibilities for coordinated and coherent engagements with specific targets. This may start on selected aspects already from the project beginning (including at the in-person kick-off meeting in June). From the beginning, the project scope and objectives will be communicated coherently in consultation and interview meetings including through the use of the note(s) jointly developed (see A1) to ensure clarity, stakeholder interest and buy-in. The workshop engagements and those facing broader (academic) audiences may utilize a dedicated note that outlines the University of Leeds-led subproject.

The project partners will also regularly exchange information to ensure a targeted media outreach to help create an impact by informing NGO and public discussions especially around the publication date. The aim is to stimulate and broaden balanced (risk-risk) reflections on the future contexts in which SRM might be tested or deployed and the consequences - socio-economic, environmental, geopolitical and social (in)stability of each. This will include the range of climate change-related impacts and the associated governance needs, as well as potential SRM field tests or deployments and the potential geopolitical, socio-economic and environmental consequences thereof.

D1: OECD-led engagements and dissemination will include the internal coordination among OECD directorates and with key OECD stakeholders and member government counterparts as well as the dissemination of the global governance framework, including via a high-level conference (likely in October 2026) and other dedicated meetings. This will be led by the OECD’s Strategic Foresight Unit in the Office of the Secretary-General.

D2: CFG-led global engagements and dissemination: global engagements to gather input to the scenario report and disseminate its implications for governance. The synthesis report and its key findings will be presented in research and policy contexts and multiple tailored briefings to senior policymakers and their advisors in the EU and other major economies, as well as with climate-vulnerable countries and civil society networks. Relevant policy fora may include the Climate Vulnerable Forum, G7, G20 and World Bank annual preparatory meetings, Arctic Council’s Arctic Monitoring and Assessment Programme (AMAP) working group meetings, and more. Relevant international research conferences may include AGU, DEGREES’ Global Forum, and Gordon Research Conferences. Relevant science-policy contexts may include WCRP, IPCC, and IPBES

meetings or those by the Ozone Secretariat's science panels. Relevant multilateral contexts include UN venues such as UNEP, WMO, UNFCCC, UNCBD, or Montreal Protocol.

D3: Leeds-led engagements and dissemination includes engagements with other ARIA-funded groups and broader scientific communities, and takes place in parallel. Where appropriate this may refer to the more limited-scope subproject so as to avoid interfering with the diplomatic engagements led by the OECD (D1) or CFG (D2). Corresponding talking points (and perhaps a (sub-)project description) may be prepared and jointly agreed by the project partners for this purpose. You primarily seek to mobilise experts' feedback on key scientific, technical, geopolitical and governance aspects of the scenarios, including the pace and scale of potential deployment, hardware development bottlenecks and the plausible pace of development under varying assumptions, as well as the pace and scale of earth system responses, including in cases of tipping points.

3.2 The following **Milestones** will be used to monitor delivery of the Project. The costs associated with completing these Milestones are estimated in the [REDACTED].

ID	Milestones	Measure	Date
1	Collaboration operational, start of interviews, first workshop delivered	Collaboration agreements, interview- and workshop records	01 December 2025
2	Scenario and governance outlines complete and ready for engagements	Two documents complete and available for consultations and engagements	01 January 2026
3	Project completed	Key engagement activities concluded leading to publication of the 2 reports - subject to OECD Member Country approval	01 November 2026

In addition to the above Milestones, the following project [REDACTED] will be used to track progress throughout the project and may be updated from time to time:

Note: the GANTT Chart linked above follows this list:

- Kick-off meeting in Paris, early June
- The panel of experts and stakeholders for Workshop series established (Leeds) - August
- Data management plan (Leeds) - August
- Annotated outline of scenario report to align on rough structure - Sept
- Monthly online network meetings to facilitate simulation development and design (Leeds) - months 3-12
- Introductory note(s) outlining the project (and sub-project) jointly developed and agreed upon between all partners (not for publication) - October
- Thematic and policy experts identified for Delphi interview series (ANU) - August
- Start of Delphi interviews (ANU) - September
- First in-person intensive simulation workshop on SRM decision-making challenges posed by geopolitical dilemmas (Leeds) - September
- First in-person engagement (in London) to co-create scenarios and identify governance needs (CFG and ANU) - September (back-to-back with and right before or after the above)
- First ARIA project milestone (commencement date plus 6 months - 1. December)
- Simulation space framework (integrating geopolitical, security and social science) (Leeds) - December
- Factors and projections for reference scenario developed (ANU) - November
- Second in-person intensive simulation workshop on SRM decision-making challenges posed by geopolitical dilemmas (Leeds & CFG) - Jan
- Second in-person engagement (in London) to co-create scenarios and identify governance needs (CFG and ANU) - Jan
- Third in-person intensive simulation workshop on SRM decision-making challenges posed by geopolitical dilemmas (Leeds) - April
- Third in-person engagement (in London) to co-create scenarios and identify governance needs (CFG and ANU) - April
- Fourth in-person engagement (in London) to co-create scenarios and identify governance needs (CFG and ANU) - May
- Scenario report drafted – for preparation of launch and dissemination - Sept 2026
- Governance report drafted for publication - Sept 2026
- Publication of scenario report and governance report at OECD high-level policy forum - October 2026
- Briefings and engagements based on published reports - December (CFG would continue dissemination activities as an in-kind contribution beyond the project end date in Oct. 2026)

- (approximately) quarterly project team meetings (in-person where possible, hybrid where necessary to ensure smooth scheduling). The work will be conducted in Brussels, New York, Australia, and Paris, with regular meetings held at CFG's headquarters and the OECD's office in Paris. Additional regular meetings can be arranged with ARIA, ARIA-funded researchers, and other UK-based stakeholders to inform this project and, vice versa, convey insights to other projects.

3.3 Long-term Outcomes

The **intended long-term outcomes** are summarised below:

1. Improved governance capabilities on climate and SRM, enabling informed decisions on SRM research funding and domestic and international policy action
2. Embedding of geopolitical dimensions in governance research
3. Reduced risk of unilateral action on SRM

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement
Planning	• Roles and responsibilities • External communications • Vision • Project details • Code and data management • Project plan + project management
Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Key Learning, discoveries and decisions • Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • Invoicing and cost reporting Optional: • technical evidence saved to drive e.g. report or presentation as requested by PD

	review meeting slide deck saved to drive as requested by PD
Annual	- ARIA impact metrics - Attendance at annual ARIA event
Ad hoc	- As required, Programme Director/ Programme Team may request additional information and evidence - Workshops - potential to be invited to ARIA workshops
Project closure	Project closure report

4. Payment

4.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments quarterly in arrears based on actual costs incurred.

The cadence of quarterly payments will align with ARIAs financial year beginning 1st April e.g. Quarter 1 Grant Claims will be for the period of 1st April to 30 June, Quarter 2 Grant Claims will be for the period of 1st July to 30 Sept and so on.

4.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

4.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end of the relevant period.

4.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

5. Principal investigator/key researchers

For the purposes of clause 22.7, the following principle investigators or key researchers have been identified:

Name	Role	Organisation
Matthias Honegger	Program Director	CFG
Cynthia Scharf	Senior Fellow	CFG
Giulia Neri	Policy Officer	CFG
Roxane Cordier	Researcher	CFG

TBD	Assistant Project Manager	CFG

6. Sub-Contractors

For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Location
Trish Lavery (affiliated with ANU)	Lead on interviews and scenario development process	Canberra
Strategic Foresight Unit, Office of the Sec-Gen, OECD	Governance Framework development and associated policy outreach, coordination of inputs from OECD Directorates	Paris
Leeds University	Workshops and (online) symposia, short reports on workshop findings	Leeds, London

PART 2 - GRANT APPLICATION

Application titled "SAFE GEOGOV – Strategic Foresight on Climate and Geopolitics: Toward Governance of Solar Radiation Modification" submitted 8 December 2024.

SCHEDULE 3

Royalty Percentages

Royalties on the sale or supply of products or services that are covered by, use or incorporate the Foreground IP licensed to the NewCo will only become due on aggregate net sales derived from the Foreground IP exceeding £50 million.

The maximum headline percentage royalty rate (i.e. before any royalty stacking, step-down or other reduction and excluding any ARIA Non-UK Fee) for products or services that are covered by, use or incorporate the Foreground IP, and of sublicensing income, shall be one of the following:

Type of product	Applicable headline royalty percentage (up to)
Low margin	0.5% of net sales
Medium margin	1% of net sales
High margin	2% of net sales
Sublicensing royalty	10% of net receipts

ANNEX 1

Clause for inclusion in licences of Foreground IP

[] **ARIA NON-UK FEE**

[].1 In this clause:

"ARIA" means the Advanced Research and Invention Agency;

"Crown Body" means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

"UK Entity" means a legal entity that has or whose ultimate parent company has its headquarters and principal establishment in the United Kingdom.

[].2 The Foreground IP was developed with funding from ARIA. As a condition of its funding ARIA requires that a benefit is returned to the United Kingdom where the Foreground IP is licensed by the Licensor to any person that is not a UK Entity. Accordingly, in addition to any other sums payable by the Licensee to the Licensor under this Agreement, the Licensee shall pay to the Licensor within 90 days after the end of each calendar year during the Relevant Period (as defined below), and within 90 days after the end of the Relevant Period, a fee (**ARIA Non-UK Fee**) on all amounts (including upfronts, licence fees, milestone payments, royalties, shares or other securities, exit fees, buyout or other consideration) payable by the Licensee to the Licensor under this Agreement in relation to the exploitation of any Foreground IP (**Relevant Amount**) that accrues during, or relates to, any period of time that the Licensee is not a UK Entity (**Relevant Period**). The amount of the ARIA Non-UK Fee is 25% of the Relevant Amount, and is payable by the Licensee to the Licensor in addition to the amounts that would otherwise be payable under this Agreement. For example if the Relevant Amount is £100 the ARIA Non-UK Fee is an additional £25, which the Licensee shall pay to the Licensor and the Licensor shall remit to ARIA.

Crown Body customers

[].3 You must also ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities and in suitable quantities for the Crown Body's requirements.

[].4 ARIA shall have the right to enforce this clause [] under the Contracts (Rights of Third Parties) Act 1999. Neither party may amend this Agreement in a way that detracts from ARIA's right to enforce its rights under this clause without ARIA's prior written consent.

- [1] When using this clause you may substitute the relevant defined terms used elsewhere in the agreement to capture the concept of "Foreground IP". Where the clause refers to the "Licensor" and "Licensee" please use the appropriate defined terms to include the licensor, licensee, assignor and assignee of the Foreground IP. This clause is not suitable for assignments of the Foreground IP in consideration of the payment of one or more lump sum payments. In those cases the Licensor needs to be informed, and potentially make an additional payment, if the Foreground IP is subsequently assigned to a non-UK Entity or if the Assignee ceases to be a UK Entity.

SCHEDULE 4: Data Protection

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Grant Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Grant Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Grant Agreement:
- 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are

relying on Domestic Law as the basis for processing Personal Data, you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;

- 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);
- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Grant Agreement unless required by Domestic Law to store the Personal Data; and

- 3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.
- 3.4. [[ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):
- 3.4.1. cancel its plans to change the affected sub-Processor;
- 3.4.2. offer an alternative which is acceptable to ARIA; or
- 3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.
- 3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Grant Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.
- 3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]
- 3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Grant agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it, storing it, retrieving it, consulting it, disseminating it or destroying it, etc.

	Note the definition of processing in the UK GDPR: <i>“any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction”]</i>
Duration of Processing:	Duration of this Grant Agreement (and any post termination processing that is permitted / required).
Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called “special categories” of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: <i>“data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation”]</i>
Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors,

	clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. You shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.
- 4.2. Any limitation of liability set out in this Grant Agreement will not apply to this Schedule's indemnity or reimbursement obligations.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

1. Submission of Pledged Patents and Experimental Data
 - 1.1 The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
 - 1.2 The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.
2. Experimental Data Licence
 - 2.1 Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
 - 2.2 The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
 - 2.3 The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
 - 2.4 The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).
3. Research Licence
 - 3.1 Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
 - 3.2 The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
 - 3.3 Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.

3.5 The Research Licensee must:

- (a) at all times when using the Pledged Patents comply with all Laws; and
- (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).

4. Commercial Licence

4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.

4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.

4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.

5. Pledgor Know-How

At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.

6. Termination

6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:

- (a) materially breaches the terms of such licence or this Pledge; or
- (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).

7. Transfers of Pledged Patents and/or Experimental Data

The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.

8. No Warranty

The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and

Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

Voltitude Limited (**Contractor**)

Cody Technology Park,

Old Ively Road,

Farnborough, GU14 0LX

17 June 2025

Attention: [REDACTED]

Dear [REDACTED]

FPCW-PR01-P001 StratoGuard - Global Monitoring of Geoengineering using Micro High-Altitude Balloons— Research Contract Agreement - Offer Letter

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to Exploring Climate Cooling. We are pleased to confirm that ARIA wishes to appoint you to deliver the contract research services as described in the Project for ARIA, subject to the terms and conditions set out in this Offer Letter and its Schedules.

1. Overview of the Agreement

- 1.1. Any reference in this Offer Letter to you or your means the Contractor and any capitalised terms have the meanings given in Schedule 1 below).

Certain variables of the Agreement are set out in the table below:

Project	The project entitled 'StratoGuard - Global Monitoring of Geoengineering using Micro High-Altitude Balloons' details of which can be found in Schedule 2.
Maximum Approved Cost (inclusive of taxes)	Maximum Approved Cost (inclusive of all taxes where applicable) is: £601,987
Commencement Date	The commencement date is 06 July 2025
Completion Date	The completion is 05 March 2028
Adequate Insurance	Employers' liability - At least £5 million (as required by the Employers' Liability (Compulsory Insurance Act 1969)) Public liability: At least minimum £5 million (per year in aggregate) Balloon Operator Insurance with Public Liability Insurance that is compliant with EC 785/2004.

Monitoring and Reporting	The performance reports referred to in clause 7 of Schedule 1 shall be provided by you at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Contractor's Representative	 Role: Voltitude Ltd Chief Operating Officer 	
ARIA's Representative	Mark Symes, Programme Director	
Escalation Contacts	ARIA	Contractor
	Chief Product Officer 	Mr Paul Stevens Role: Voltitude Ltd CEO
Notices	ARIA Contracts 	 Role: Voltitude Ltd Chief Operating Officer

2. Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Contract and return it to finance@aria.org.uk.

3. Obligations

- 3.1. You will undertake the Project as a contract research and development project carried out at the direction of and for the benefit of ARIA's programmes.
- 3.2. ARIA will pay you the Approved Cost as set out in Schedule 2 for undertaking the Project in accordance with Offer Letter and its Schedules.

4. The Agreement

- 4.1. Once you sign a copy of this Offer Letter in accordance with paragraph 7 (Acceptance) below, it will form a binding **Agreement** between you and ARIA that includes and incorporates the following documents:
 - 4.1.1. the **Conditions** in Schedule 1;
 - 4.1.2. the **Project Activities, Milestones** and **Application** in Schedule 2; and
 - 4.1.3. the terms relating to Data Protection in Schedule 3.
- 4.2. The contract effected by the signing of this Offer Letter constitutes the whole agreement between the parties and supersedes all prior negotiations, agreements, representations or understandings between them relating to the subject matter of this Agreement.
- 4.3. Each party acknowledges that, in entering into the Agreement, it does not rely on any statement, representation, assurance or warranty (Representation) of any person (whether a party to this Agreement or not) other than as expressly set out in the Agreement. Each party agrees that the only remedies available to it arising out of or in connection with a Representation shall be for breach of contract.

5. Warranties

- 5.1. By signing this Offer Letter, you warrant and represent that:
 - 5.1.1. your obligations under the Agreement are legal, valid, binding and enforceable;
 - 5.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Agreement have been obtained;
 - 5.1.3. the person signing the Agreement is duly authorised to sign on your behalf;
 - 5.1.4. there are no actions, suits or proceedings pending or, to your knowledge, threatened against or affecting you before any court or administrative body or tribunal that might affect the ability of you to meet and carry out your obligations under this Agreement;
 - 5.1.5. the Project will be carried out by appropriately experienced, qualified and trained personnel with all due skill, care and diligence;
 - 5.1.6. you will discharge your obligations hereunder with all due skill, care and diligence, including, but not limited to, good industry practice and (without limiting the generality of the foregoing) in accordance with your own established internal procedures; and
 - 5.1.7. the provision of the Project and ARIA's use of the Intellectual Property rights in the Foreground IP granted shall not infringe any Intellectual Property rights of any Third Party.

6. Amendments to Schedule 1

Not Used

7. Acceptance

7.1. To confirm your acceptance of the Agreement please arrange for an authorised signatory to sign and date the duplicate copy of this Offer Letter as indicated below and return to ARIA as a complete signed original of the Offer Letter including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Agreement and to bind the Contractor.

7.2. This Offer Letter expires on 20 June 2025 and any acceptance received after this date will not be valid.

Yours sincerely

Signed by the duly authorised signatory of ARIA:

Signature

Name

Position

Date

Signed by the duly authorised signatory of Voltitude Limited

Signature

Name

Position

Date

SCHEDULE 1 - CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up this Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Offer Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to this Agreement with the exception of Schedule 2 Part 2 (the Application);
 - (d) Schedule 2 Part 2 (the Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, this Agreement.

2. DURATION AND OBLIGATIONS OF THE PARTIES

- 2.1 The Agreement will subsist for the duration of the Project Period unless extended by agreement or terminated earlier in accordance with its terms. Any provision of the Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Agreement shall remain in full force and effect.
- 2.2 You shall manage and complete the Project in accordance with the specification as set out in Schedule 2 Part 1 and shall allocate sufficient resources to the Project to enable you to comply with this obligation.
- 2.3 ARIA may request changes to the Project Activities (including changing the Approved Cost and/or the scope of the Project Activities) by providing at least 30 days written notice to you of such changes and the rationale. ARIA will agree with you the terms of any variation to the Agreement requested by ARIA to implement such changes subject to clause 26 with your agreement to the variation not to be unreasonably withheld, delayed or conditioned.
- 2.4 You shall use reasonable endeavours to meet any performance dates specified in Schedule 2 Part 1 or elsewhere in the Agreement and the obligations of this clause 2.
- 2.5 You shall:
- (a) reasonably co-operate with ARIA in all matters relating to the Project; and
 - (b) promptly inform ARIA of the absence of the Contractor's Representative and/or Key Staff and you must provide a suitably qualified replacement approved by ARIA (such approval not to be unreasonably withheld or delayed);
 - (c) observe, and ensure that all member of your Staff observe, all rules and regulations and any other reasonable requirements of ARIA that ARIA has provided to you; this shall include and not be limited to ensuring that the Approved Cost shall be utilised in accordance with the Project cost breakdown (referred to in Schedule 2) covering all Project materials, equipment and any applicable Sub-Contractor costs;
 - (d) notify ARIA as soon as you become aware of any issues which arise in relation to the Project; and

- (e) before the Commencement Date obtain, and at all times maintain, all necessary licences and consents and comply with all relevant legislation in relation to your obligations under the Agreement.

3. ENVIRONMENTAL REQUIREMENTS

- 3.1 In performing the Project, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. ACCOUNTING AND PAYMENTS

- 4.1 The total amount to be paid by ARIA to you shall not exceed the Approved Cost. Invoices raised by you for Milestone Payments shall be paid by ARIA in accordance with the Agreement (including Schedule 2).
- 4.2 Payments to third parties including Sub-Contractors shall remain your responsibility and you shall ensure that such payments are made promptly within 30 days from the receipt of a valid invoice.
- 4.3 ARIA may suspend payment at any time if (i) in the view of ARIA, acting reasonably, satisfactory progress on the Project has not been maintained (but suspension shall be limited to the affected portions of the activities), or (ii) reports have not been submitted as required under Clause 7. In the event that ARIA suspends payment under (i), you may suspend performance of the Project Activities (and ARIA's corresponding payment obligations shall also suspend) until the parties have agreed, acting in a good faith, a course of action to progress the Project Activities, in which case you shall reinstate your performance of the Project Activities and ARIA shall resume payment (including, as agreed, in respect of any missed payments) in accordance with the provisions of this Agreement. If the parties are unable to agree a course of action and/or ARIA's payment suspension lasts for two (2) months, this Agreement shall automatically terminate.
- 4.4 On completion of the Project Period, the final payment in respect of costs properly incurred under the Agreement will be paid by ARIA to you within 30 (thirty) days, provided that:
 - (a) the Project has been completed in accordance with the Agreement;
 - (b) the reports required under clause 7 have been submitted by you; and
 - (c) an agreement has been reached in respect of any items remaining for disposal.
- 4.5 If at any time an overpayment has been made to you for any reason whatsoever, the amount of such overpayment shall be taken into account in the assessing of any further payments or shall be recoverable from you at ARIA's discretion.
- 4.6 You shall keep and maintain until seven years after this Agreement has been completed, or as long a period as may be agreed between the Parties, full and accurate records of the Project including:
 - (a) all aspects of the Project;
 - (b) all expenditure reimbursed by ARIA; and
 - (c) all payments made by ARIA;

and you shall on request afford ARIA or ARIA's representatives such access to those records as may be required in connection with the Agreement.

4.7 You shall make any payments due to ARIA without any deduction whether by way of set-off, counterclaim, discount, abatement or otherwise, unless you have a valid court order requiring an amount equal to such deduction to be paid by ARIA to you.

4.8 If any sum of money shall be due from you to ARIA or any other government department, the same may be deducted from any sum due now or in future to you under this Agreement or any other agreement with ARIA or with any other Crown Body.

5. NOT USED

6. PROJECT REVIEW

6.1 ARIA will review the Project at the intervals specified in Schedule 2 Part 1. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.

6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:

- (a) consent to the Services and the Project continuing in line with existing plans;
- (b) increase or decrease the Approved Cost for the remainder of the Project Period, as applicable;
- (c) redefine the Milestones;
- (d) require you to carry out remedial activity with the aim of improving delivery of the Services; and/or
- (e) terminate the Agreement in accordance with clause 22.

6.3 Any change to these Agreement terms, Project Activities, or Approved Cost pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Agreement in accordance with clause 26.

6.4 For the avoidance of doubt any decision to terminate the Agreement as a result of a Go/No Go Milestone will be made at ARIA's sole discretion and done so in accordance with clause 22.6.

7. MONITORING AND REPORTING

7.1 NOT USED

7.2 ARIA will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project against the specifications detailed in Schedule 2 Part 1. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.

7.3 You must provide ARIA with:

- (a) the Milestones and a report on your performance against them at the intervals and for the periods of time specified in Schedule 2 Part 1 and otherwise in compliance with the request of ARIA's Representative and shall detail all Data, methods, Results and provisional conclusions together with management information and any other information relating to the Project;
- (b) verbal or written reports and ad hoc meetings or discussions as reasonably required by ARIA on any aspect of the Project; and.
- (c) a quarterly report on your use of the Approved Costs, with details broken down in accordance with ARIA's prescribed form.

7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its Project activities and compliance with the terms of the Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time after the end of the Project about any commercial exploitation or other dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Agreement.

8. AUDITING AND ASSURANCE

- 8.1 You must provide supporting evidence as ARIA may reasonably require to prove that you have used the Approved Costs to carry out the Project and provide the Services in accordance with Schedule 2. The supporting evidence shall clearly identify all Project and associated overhead costs. You shall maintain proper financial records relating to the Project at all times during the Project Period and for a period of seven years after the end of the Project Period.
- 8.2 Subject to clause 11, ARIA and/or its authorised representative or any statutory or regulatory auditors may, at any time during the Project Period and for up to 7 years after the end of the Project Period, conduct audits in relation to your financial records for the Project and your compliance with this Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.

9. FINANCIAL MANAGEMENT

- 9.1 You must:
 - (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Project; and
 - (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project as soon as they are identified, and keep ARIA informed of your remedial actions.

9.2 In the event of any actual or suspected fraud, theft or other financial irregularity ARIA may, at its absolute discretion:

- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
- (b) suspend the Project and future Milestone Payments to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

10.1 You must inform ARIA promptly of any actual, perceived or potential conflict of interest between your and your Representatives obligations under the Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Project Period.

10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that they are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you to cease the conflicting activity and if that is not acceptable to you, either party may terminate this Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the Project, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.

11.2 ARIA may publish a summary of this Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.

11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:

- (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;
- (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information that is necessary for the

- purpose concerned and obtains appropriate confidentiality undertakings in relation to such information;
- (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and to the extent that no exception to disclosure under them is applicable; or
 - (d) where ARIA (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.
- 11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under this Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

- 12.1 Each party must comply with its obligations under the Law, including where applicable, the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.
- 12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.
- 12.3 You acknowledge that ARIA, acting in accordance with the codes of practice issued and revised from time to time under the Information Acts (other than the FOIA), may disclose information concerning you and this Agreement without consulting you. ARIA must notify you of any request for information to the extent that it is permissible and reasonably practical for it to do so and will give you adequate opportunity to make representations to ARIA before it discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.
- 12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or this Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.
- 12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.
- 12.6 You must take account of the account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

- 13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.
- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with this Agreement. Where either party anticipates that the other will process any Personal Data on its behalf under this Agreement it must notify the other party and the parties must agree a variation to this Agreement to incorporate appropriate provisions (such as those set out in Schedule 3) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. NOT USED

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and not seek to avoid their application by artificial means.

Background IP

- 15.2 This Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Term if any additional Background IP is required either to carry out the Project Activities or to exploit commercially any of the Results.

Foreground IP ownership and licensing

- 15.3 Subject to Clauses 15.4 and 16.2, the Foreground IP shall belong to you and:
- (a) you hereby grant to ARIA a royalty-free non-exclusive licence to use the Foreground IP for internal non-commercial purposes in ARIA's programmes; and
 - (b) you will cooperate with ARIA to facilitate collaborations and future licensing arrangements with Third Parties, including by participating in confidential discussions with ARIA and other Third Parties participating in ARIA's programme, in order to develop and commercialise the Foreground IP, subject to an appropriate agreement being in place with the Third Party. The foregoing shall not require you to enter into any agreement with, or license the Foreground IP to, any Third Party.
- 15.4 Where you assign or grant an exclusive or sole license the Foreground IP to a Third Party, you must impose on that Third Party all of the obligations set out in clause 15 and 16.
- 15.5 You must submit all (i) all patents within or covering the Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the Future Proofing our Climate and Weather Intellectual Property Pledge promptly following creation or filing (as applicable) of such patents and/or data (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge. You hereby agree to comply and uphold the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.6 You must ensure that whenever any Results are used with or communicated to Third Parties or are exploited commercially, ARIA's funding of the Project is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and Publication

- 15.7 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.8 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.9 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to request the assignment of the patents to ARIA or its nominee.

16. COMMERCIALISATION OF FOREGROUND IP AND RESULTS

- 16.1 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge], where they are capable of exploitation you should use all reasonable endeavours to exploit the Results. This should be done in accordance with the Commercialisation Hypothesis.
- 16.2 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge], if for any reason you choose not to exploit any such Results within a reasonable timeframe (or, where applicable, the timeframe set out in the Commercialisation Hypothesis) you are encouraged to discuss the position with ARIA, and you may request that ARIA exploit them or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Non-UK Commercialisation

- 16.3 A royalty of 0.25% of your Net Sales which use or incorporate Foreground IP shall be payable to ARIA if you are incorporated outside of the United Kingdom (the "**ARIA Non-UK Fee**"). For the avoidance of doubt, the ARIA Non-UK Fee shall be calculated solely in respect of the share of the Net Sales which corresponds to the value resulting directly from the Foreground IP.
- 16.4 The ARIA Non-UK Fee shall be payable within 90 days following the end of each relevant calendar year, for a period of ten (10) years from the First Sale Date, up to an aggregate total equal to 20 times the Approved Cost.
- 16.5 In the event that:

- (a) there is a change of control of the Foreground IP, such that you assign or grant an exclusive licence to the Foreground IP to another person; or
- (b) you extend rights to the Foreground IP within your Group, such that you grant another entity within your Group a licence to the Foreground IP,
then,
- (c) you must notify ARIA immediately; and
- (d) include clauses 16.3 to 16.5 in the relevant instrument and ensure that it expressly provides that the provisions are intended to be enforceable by ARIA by virtue of the Contracts (Rights of Third Parties) Act 1999 (or any equivalent in any jurisdiction) and take any other step required to ensure that the ARIA Non-UK Fee is payable by the transferee or licensee (as applicable).

16.6 For the avoidance of doubt, in respect of:

- (a) clause 16.5(a), provided that you have complied with clause 16.5(d), your obligation to pay the ARIA Non-UK Fee shall cease and pass to the transferee or licensee (until, in the case of an exclusive licence, the termination or expiry of such licence); and
- (b) clause 16.5(d) the transferee or licensee shall only be liable to pay the ARIA Non-UK Fee to ARIA for the remainder of the aggregated total amount and the ten (10) year period specified in clause 16.4 prorated from the date of the relevant instrument.

Assignment of IP

16.7 You must, on written request by ARIA, promptly assign any Foreground IP to ARIA (or to a Third Party nominated by ARIA) if you do not:

- (a) undertake further research and development work in respect of that Foreground IP; or
- (b) commercially exploit (and you are not using reasonable endeavours to commercially exploit) that Foreground IP,

within eight years of its creation, and each party shall bear its own costs in relation to any such assignment.

Pricing for Crown Body customers

16.8 You must ensure that any Crown Body is able to procure, in a reasonable timeframe and in suitable quantities for its requirements, any products and services that are covered by, use or incorporate the relevant Foreground IP:

- (a) at the Crown Discount price until the total Crown Discount given to all Crown Bodies equals two times the Approved Cost; and
- (b) thereafter at the Most Favoured Nation Price; and

you must provide details of the yearly amount of Crown Discount being provided to ARIA within 90 days after the end of each calendar year. You must use reasonable endeavours to reach the total set out in clause 16.9(a) within 10 years after the first sale to a Crown Body.

17. ASSETS

- 17.1 You must take all practical steps to purchase all materials and equipment at a fair and reasonable price and provide invoices issued to you for assets purchased in connection with the Project as part of the Approved Cost.
- 17.2 At the end of the Project Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

- 18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUB-CONTRACTING

- 19.1 You may not, transfer, assign, novate or otherwise dispose of the whole or any part of the Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.
- 19.2 You may only subcontract any of the Services or Project Activities except to the extent permitted, and to the Sub-Contractors identified, in Schedule 2, Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractors as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Agreement.

20. NOT USED

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Project and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Project or publicise details of the Agreement without the other's consent, except as required by Law.
- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

- 22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events (**Events of Default**) occur:

- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13 or 25, or commit a material breach of any other term of this Agreement in the reasonable opinion of ARIA;
- (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
- (c) you fail to improve the performance of the Project Activities, notwithstanding your having undertaken the remedial activity agreed with ARIA under clause 6.2;
- (d) you provide ARIA with any materially misleading or inaccurate information in the specification for the Project as detailed in Schedule 2 or in subsequent related correspondence;
- (e) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Sub-Contractor, immediately upon becoming aware of it;
- (f) you are subject to an Insolvency Event;
- (g) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project;
 - (ii) result in your being unable to undertake the Project; and/or
 - (iii) raise national security concerns.

Rights reserved for ARIA in relation to an Event of Default

22.2 If an Event of Default has or may have occurred, ARIA may by written notice to you take any one or more of the following actions:

- (a) suspend the Project and the payment of the whole or any part of Milestone Payments for such period as ARIA may determine, acting reasonably;
- (b) reduce the Approved Cost, in which case the Milestone Payments will thereafter be made in accordance with the reduction and notified to you; and/or
- (c) subject to clause 22.4, terminate this Agreement with immediate effect as from the date of service of the notice of that termination.

22.3 Where this Agreement is terminated for an Event of Default that is or includes a Prohibited Act, ARIA may require you to repay the entire amount of the Milestone Payments previously paid to you.

Opportunity for you to remedy an Event of Default

22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:

- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and
- (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

22.5 Without prejudice to any other provision of the Agreement, you may terminate the Agreement on written notice to ARIA if ARIA commits a material breach of the Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

Notwithstanding anything to the contrary in the Agreement, termination of the Agreement under this Clause 22.5 also results in the automatic termination of the licence granted to ARIA under Clause 15.3(a).

General Termination Rights

- 22.6 Without prejudice to any other provision of the Agreement, either party may terminate the Agreement at any time by giving at least 60 days' prior written notice to the other party.
- 22.7 Pursuant to clause 2.5, if ARIA is unwilling to accept a nominated successor(s) to Key Staff on it may terminate the Agreement by at least 30 days' written notice to you.

Consequences of Termination

- 22.8 Termination of this Agreement, however caused, shall not:
- (a) release either party from any duty or obligation of confidence which falls on such party or its servants, agents, employees or former employees under this Agreement or under the general law governing confidential information;
 - (b) prejudice or affect any rights, action or remedy which shall have accrued before termination or shall accrue thereafter to any party; or
 - (c) affect the continuing obligations of the parties under this Agreement.
- 22.9 If the Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.
- 22.10 Where ARIA terminates the Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:
- (a) you taking all reasonable steps to mitigate such loss; and
 - (b) the Unavoidable Costs being:
 - (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA; and
 - (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you.
 - (v) costs that would not have been incurred had this Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period);
- 22.11 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Services, over £250,000 will terminate automatically and immediately upon termination of this Agreement.

- 22.12 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Agreement in the event that the Agreement was terminated (calculated on the basis described in clause 22.10).
- 22.13 ARIA's total liability under clause 22.10 shall be limited to the Maximum Approved Cost under the Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.14 If the Agreement is terminated or expires ARIA will not be liable to pay any of your costs (or those of any of your contractors or suppliers) related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Offer Letter, and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the ARIA Representative and the Contractor's Representative.
- 23.3 If the dispute cannot be resolved between the ARIA Representative and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to senior officers of the parties for resolution.
- 23.4 If within a further 10 Working Days after such meeting the dispute has not been resolved, the dispute may be referred, by either party, to mediation. The parties shall agree the mediator within 10 Working Days. The fee for the appointed mediator shall be shared equally between the parties.
- 23.5 Nothing in this Clause 23 shall preclude either party from commencing proceedings.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:
- (a) fraudulent misrepresentation or any other fraudulent act or omission;
 - (b) payment of sums properly due and owing to the other in the normal course of performance of this Agreement;
 - (c) a breach of clause 13;
 - (d) liability arising under any indemnity in this Agreement; or
 - (e) liability which may not lawfully be excluded or limited.
- 24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Agreement or for ARIA's breach of this Agreement), whether arising directly or indirectly, that may arise in connection with:
- (a) your carrying out the Project Activities;
 - (b) any reduction, suspension, withdrawal or request for repayment of the Approved Cost in accordance with this Agreement; or

- (c) termination of the Agreement in accordance with this Agreement.
- 24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:
- (a) loss of profit, sales or turnover;
 - (b) loss of contracts or business opportunities;
 - (c) loss of anticipated savings;
 - (d) loss of goodwill or damage to reputation; or
 - (e) any indirect, special or consequential loss or damage;
- in each case arising out of or relating to this Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.
- 24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to this Agreement or its subject matter or anything which it has done or not done in connection with this Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the Approved Cost.
- 24.5 You shall indemnify and defend ARIA against all Losses (including but not limited to any direct, indirect or consequential losses, loss of profit, loss of reputation and all interest, penalties and reasonable legal costs (calculated on a full indemnity basis) and all other reasonable professional costs and expenses) suffered or incurred by ARIA arising out of or in connection with:
- (a) any claim brought against ARIA for actual or alleged infringement of a Third Party's intellectual property rights arising out of, or in connection with, the receipt, use or supply of the Services; and
 - (b) any claim made against ARIA by a Third Party arising out of, or in connection with, the supply of the Services,
- provided that the foregoing shall not apply to the extent that a claim arises as a result of ARIA's negligence or breach of this Agreement.
- 24.6 If ARIA receives a claim which falls within the scope of the indemnity at clause 24.5 (**Claim**), ARIA shall:
- (a) notify you without unreasonable delay in writing of the Claim;
 - (b) allow you, at your own cost, to conduct all negotiations and proceedings and to settle the Claim, always provided that you shall obtain ARIA's prior approval of any settlement terms, such approval not to be unreasonably withheld;
 - (c) provide you with such reasonable assistance regarding the Claim as is required by you, subject to reimbursement by you of ARIA's costs so incurred; and
 - (d) not, without prior consultation with you, make any admission relating to the Claim or attempt to settle it, provided that you consider and defend the Claim diligently, using competent counsel and in such a way so as not to bring the reputation of ARIA into disrepute.

24.7 You shall under no circumstances in connection with this Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.

24.8 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Agreement.

25. RESEARCH ETHICS AND INTEGRITY

25.1 Not Used

25.2 All research data:

- (a) must be generated using sound scientific techniques and processes;
- (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and
- (c) must be analysed appropriately, without bias and in accordance with good scientific practices.

25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.

25.4 You must comply with the Code of Conduct and ensure that your Staff undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

26.1 Any variation to this Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

26.2 You may request a variation to the Agreement or the Project at any time giving full details of the justification of the request and ARIA may agree to vary the Agreement or refuse the request and require the continuation of the Project in accordance with the Agreement.

27. GENERAL

27.1 **Force majeure:** Neither party shall be in breach of this Agreement nor liable for delay in performing, or failure to perform, any obligations under this Agreement to the extent such delay or failure result from events, circumstances or causes beyond its reasonable control. In such circumstances the affected party shall be entitled to a reasonable extension of the time for performing such obligations. If the period of delay or non-performance continues for 3 months, the party not affected may terminate this agreement by giving 30 days' written notice to the affected party.

27.2 **Notices:** All notices and other communications in relation to this Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer

Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such communications will be deemed to have been given and received on the third Working Day following such mailing.

- 27.3 **Change of control:** You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(g) is likely to apply.
- 27.4 **Severability:** If any provision of this Agreement is held invalid, illegal or unenforceable for any reason by any court of competent jurisdiction, such provision shall be severed and the remainder of the provisions shall continue in full force and effect as if this Agreement had been executed with the invalid provisions eliminated.
- 27.5 **Waiver:** The waiver by either party of any right or remedy in respect of any breach of any term or condition or requirement of this Agreement shall not prevent the subsequent enforcement and shall not be deemed to be a waiver of any right or remedy in respect of any subsequent breach.
- 27.6 **Relationships:** Nothing in this Agreement shall be construed as to make any party the employee, agent, partner or legal representative of the other party for any purpose whatsoever. No party is granted any right to assume or create any obligation or responsibility, expressed or implied, on behalf of or in the name of the other party. In fulfilling obligations pursuant to this Agreement, you will be acting as an independent contractor at arm's length from ARIA.
- 27.7 **Contracts (Rights of Third Parties) Act 1999:** A person who is not a party to this Agreement shall have no right to enforce any terms of it which confer a benefit on him.

28. GOVERNING LAW

This Agreement (including any non-contractual disputes or claims arising in connection with this Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. Not Used

30. DEFINITIONS AND INTERPRETATION

- 30.1 As used in this Agreement the following terms and expressions shall have the meaning ascribed to them below:

Adequate Insurance means the insurance requirements and amounts set out in the Offer Letter;

Approved Cost means the total cost agreed between the parties for the Project as set out in Offer Letter, inclusive of VAT or other sales tax;

ARIA's Representative means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Project as set out in clause 2.1 of the Offer Letter;

Background IP means IP that is:

(a) owned by or licensed to a party prior to the Commencement Date; or
(b) developed by or on behalf of a party during the Project Period but not in connection with the Project Activities,

and is in either case used in connection with the Project;

Bribery Act means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;

Change of Control means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Suppliers published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at https://assets.publishing.service.gov.uk/media/648c3ab5b32b9e000ca968c3/Supplier_Code_of_Conduct_v3.pdf, including any subsequent updates from time to time;

Commencement Date means the date set out in the Offer Letter;

Commercialisation Hypothesis means the exploitation plan set out in Schedule 2 Part 2, as may be amended by agreement between the parties during and after the Project Period;

Completion Date means the date set out in the Offer Letter;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Agreement, that ought reasonably to be considered to be confidential (whether or not it is so marked),

(a) including: (i) information relating to the business, affairs, customers, clients, suppliers or plans of the disclosing party; (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party; (iii) any information developed by the parties in the course of carrying out the Project Activities; (iv) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Agreement; and (v) and any information derived from any of the above,

(b) but not including information which: (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11); (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party; (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or (iv) is independently developed without access to the Confidential Information; and (v) the content of this specific version of the Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Contractor's Representative means a person authorised to represent you in respect of this Agreement and who shall have the authority to bind you in all matters under this Agreement as set out in clause 2.1 of the Offer Letter;

Crown or Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Crown Discount means the monetary value of the discount from the Most Favoured Nation Price given to a Crown Body;

Data means information collected and/or used for the purposes of the Project, which can be processed manually, electronically or by other means;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version

of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

EA means the Equality Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Offer Letter;

First Sale Date means the date on which you first bill an amount to a customer in respect of the sale of goods or services (or any other transaction) which use or incorporate Foreground IP;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means the Intellectual Property developed during and in connection with the Project;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to approaches for actively cooling the earth operated by ARIA/a third party in the form at Annex A;

Go/No-Go Milestone means a decision point for ARIA to determine whether it wishes to proceed with or terminate the Project Activities (any decision regarding a Go/No-Go Milestone will be made at ARIA's sole discretion, following a Grant Review as outlined in Clause 6

Gross Sales means total invoiced value of sales made during a specific period, including all amounts billed to customers such as from the sale of goods, services, licence income, royalty income, franchise fees, commissions, subscription fees, before any deductions;

Group in relation to a company, that company, any subsidiary or holding company from time to time of that company;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation.

Information Acts means the Data Protection Legislation and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property or IP means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions, semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade

secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Key Staff means the persons named in Schedule 2 Part 1;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation.

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise.

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

Milestone Payments means the payments made based on progress towards the Milestones as set out in Schedule 2 of this Agreement;

Most Favoured Nation Price means a price that is no higher than that offered to or agreed with any other customer for equivalent quantities of equivalent products or services;

Net Sales means Gross Sales after relevant accounting deductions, such as sales tax, packaging, insurance, carriage and freight, trade discounts and credits, returns and allowances, import taxes and similar applicable government levies;

Non-UK Entity means a legal entity that is not a UK Entity;

Personal Data has the meaning as defined in the Data Protection Act 2018 or successor legislation;

Prohibited Act means:

(a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for: (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Services; and/or (ii) showing or not showing favour or disfavour to any person in relation to the Agreement; or

(b) committing any offence: (i) under the Bribery Act; (ii) under legislation creating offences in respect of fraudulent acts; and/or (iii) at common law in respect of fraudulent acts in relation to this Agreement; and/or defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the scope specified in Schedule 2 Part 1;

Project Period means the period commencing on the Commencement Date and ending on the Completion Date or such later date as may be agreed between the parties unless otherwise determined in accordance with the terms of the Agreement;

Project Review means the process for reviewing the Project outlined in clause 6;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means any Data, reports or information or other material generated by the Project;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Services means the services being provided by you to enable fulfilment of the Project;

Staff means your Representative and all employees, consultants agents and Sub-Contractors which you engage in relation to the Project;

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Services or any part thereof or facilities or services necessary for the provision of the Services or any part thereof or necessary for the management,

direction or control of the Services or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

UK Entity means a legal entity that has or whose ultimate parent company has, its headquarters and principal establishment in the United Kingdom;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Project Period because of termination or breach of the Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination; and

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 The interpretation and construction of the Agreement shall be subject to the following provisions:

- (a) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (b) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (c) the headings to Clauses are for ease of reference only and shall not affect the interpretation or construction of the Clauses;
- (d) references to Clauses are references to Clauses in the part of the Agreement (i.e. the Offer Letter or particular Schedule or Annex as the case may be) in which they appear, unless otherwise stated;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time; and
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation".

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

The world is striving towards net zero, but current forecasts by the IPCC make for grim reading. A 1.1°C of global temperature rise has already occurred, with climate effects directly attributed to this change. While limiting global increases to 1.5 °C is possible, an overshoot is likely, potentially causing irreversible changes, including the activation of climate tipping points.

As scientists become more adept at predicting these events, mitigation solutions must be approached with caution. If tipping point limits are exceeded and if climate change begins to affect the global order, it is crucial that any response is well-prepared rather than last-minute and 'knee jerk'.

One possible technique, both in terms of technical feasibility, political will, and timely implementation, may be a form of aerosol injection into the tropical tropopause. However, it is vitally important that, were this scenario to arise, robust tools are available for monitoring the effects and measuring the impacts relative to long-term fiducial reference measurements. The primary focus must remain on ensuring that any actions taken are safe, sustainable, and beneficial for the environment.

Ultra-persistent, solar powered, micro-High-Altitude Balloons (mHABs), stationed primarily in the stratosphere, present a scientific and technological breakthrough in monitoring climate cooling mechanisms (and other atmospheric research areas), over large scales, at high resolution and for long durations, whilst offering an extremely low regulatory barrier to world-wide operation and adoption. The low-cost, long endurance mHAB system concept will unlock a 'cube sat' style capability in the stratosphere for the scientific community, using networks of mHABs which can be readily operationalised. Without a better baseline monitoring system, any active cooling interventions would be unethical at large scale, before their effects could even be detected. You believe this could also act as a global warning system to detect and highlight rogue scenarios – hence 'StratoGuard'.

2. Aims and objectives of the Project Activities

Project StratoGuard aims to develop core technologies to enable a global low cost, long endurance sensing system of multiweek endurance mHABs and be able to recover the systems at the end of life for re-use or responsible disposal and allow a payload to be steered during descent through sample areas of interest.

Aim 1: Assess the scientific and technological breakthrough potential of mHABs to provide climate intervention monitoring in the UTLS over remote and inaccessible regions, through the following project objectives.

Objective 1.1: Through trade space analysis, sub-system qualification and ground testing - define and validate the target specification and mission profile of the mHAB system against the StratoGuard role and other potential monitoring use cases from other ARIA projects.

Objective 1.2: Demonstrate an optimised super pressure balloon with a novel netting solution against the target specification and assess effectiveness.

Aim 2: Accelerate the research of other ARIA projects which require stratospheric access through the following objectives.

Objective 2.1: Integrate and demonstrate a micro-optical particle counter dropsonde and develop an in-situ payload controller to manage power, data and thermal requirements relevant to other ARIA payloads to allow in situ payload testing on any type of light category high altitude balloon.

Objective 2.2: Develop and demonstrate a steerable payload recovery system to allow reliable recovery of high value payloads, or atmospheric samples such as Frost Point Hygrometers (FPH), Electrochemical Concentration Cells (ECC), Portable Optical Particle Spectrometers (POPS) and be able to accurately sample areas of interest, such as contrails, volcanic plumes, or cirrus cloud.

Project StratoGuard is an ambitious 32-month project with planned start date 6th May 2025 with completion 31st December 2027. The project will be managed through the following four Work Packages (WP). The project schedule is attached and includes several risk mitigation activities. The project plan has been designed to allow quarterly monitoring and reporting of progress with proposed milestones selected to provide real measures of actual progress versus effort approximately every 6 months.

Work package descriptions:

WP1 – Project Management and Engineering Management: The project manager (PM) will be [REDACTED], Voltitude COO. This work package is responsible for overall project delivery and will hold weekly project team reviews, manage the schedule, risks and opportunities and is responsible for quarterly reporting and delivery of milestones. The PM will be supported by CEO Paul Stevens as engineering manager with a view to identifying technology exploitation and commercialisation opportunities and ensuring that appropriate engineering review gates are held within the project.

WP2 – Flight tests: Delivery and trials manager [REDACTED] will lead this work package which is responsible for planning and delivering all flight test activity. This includes flight planning, logistics and approvals. To offer maximum flexibility, 3 flight windows have been selected which covers Voltitude's normal operating seasons, to maximise synergy and offer additional 'slots' for alternative payloads or projects with minimal additional cost. Each window starts in ~July where UK weather allows reasonable station keeping for multiple days over the UK, while being potentially able to recover payloads and is a great opportunity for subsystem testing. If Voltitude are performing our normal operations from Cabo Verde in the Autumn, this offers an additional window for test flying e.g. if the tropical environment is needed for payload validation. M5 and M7 will ultimately lead into a stratospheric demonstration of the balloons system and payload and achieve M8.

WP3 – Platform Development: Voltitude lead systems engineer is Richard Nash who will manage this work package and manage the design life cycle. This work package is responsible for all technical aspects of the project including trade space analysis, performance modelling and monitoring, architectural design process, sub-system requirements and coordination of sub-system detailed design activity, system acceptance testing and flight test analysis and synthetic simulation. This work package contributes significantly into each milestone and is responsible for preparing the project's final report.

Within this work package there are four sub system work packages which are carried out in series:

WP3.1 The power system energy density and solar array performance will dictate the altitude range and navigation performance of a super pressure balloon. This WP will produce a solar array and

max power point tracker linked to a custom high specific energy density rechargeable battery optimised for the discharge rates needed on a stratospheric compressor. A low-pressure test will be carried out on the battery to ensure it operates at altitude, before a multi-day stratospheric test is performed to gather real world energy performance. This is an early de-risking activity as the power available and the mass of this subsystem is so influential in optimising the envelope while still meeting the ICAO light balloon category. This leads to M2.

WP3.2 concerns the super pressure envelope design and netting solution. After an initial architecting phase and optimisation study, which will include exploring the altitude ranges needed to navigate and size the balloon, the practicality of available netting and balloon manufacturing capability, and the likely thermal ranges will produce an overpressure requirement to maintain altitude and give first indications of required mass budgets, alongside the outputs from M2. This WP will then move to procurement of balloons and netting, and integration phase and a full-size ground test which will demonstrate the required overpressure, and aim to measure the effusion rate over multiple days. This may be split into two ground tests, a scaled test first to ensure modelling is correct before proceeding with an optimised net order. This achieves milestone M3 which will be a decision point for whether a super pressure mHAB is possible. If determined not to be possible, this would be a potential pivot point, where the project could move towards higher dynamic range single use latex balloons, but the focus would need to move towards increasing biodegradability in the marine environment, as in remote regions the probability of payload return drastically reduces. This WP will directly answer Aim 1 of the project.

WP3.3 /4 concerns the compressor and ballonnet. These subsystems will only be worked on once the proceed criteria has been met for the super pressure envelope. This WP will initially carry out mechanical design of the compressor, and manufacturing ready for a volume flow rate test in a partial vacuum chamber, to simulate the performance in the stratosphere. This will also validate the power consumption. The ballonnet design will be scaled based on the output of M3, and the results of the compressor optimisation. For instance, if the compressor can only run for 2 hours per day there would be little point in having a ballonnet which takes 4 hours to fill. These WP culminate with integrating them into the super pressure balloon and performing a full ground test leading to M7. If M3 decision point results in a do not proceed with SP balloon decision, this WP, which is essentially mechanical design, will be moved towards biodegradability of a single use system.

WP4 – Payload Development and Integration: Voltitude lead systems engineer is Richard Nash will also manage this work package. This WP is separated from the core super pressure balloon WP as it is the main interface to other ARIA programmes and sub-contractors, and its outputs are applicable to any balloon system. This WP is split into three further sub-WPs: -

WP4.1 Payload controller. This is development of a PCB which will be used to offer an array of power, data and thermal management interfaces to additional payloads. Initially it will be based on supporting the University of Hertfordshire (UoH) Optical Particle Counter (OPC) but will aim to identify additional requirements from other ARIA projects. There will be a small optimisation study covering if it is more efficient to provide power locally with a dedicated solar regenerative system or if power should be provided from the main balloon. This WP will lead to M5 using a pre-existing Voltitude balloon system to test this controller in the stratosphere.

WP4.2 A micro-OPC requires a very specific flow regime to operate optimally. This work package will focus on a mechanical design and aerodynamic analysis to integrate the micro-OPC into a physical package which will be optimal when falling from the stratosphere. This will involve CFD analysis and

consultation with UoH. The antenna design will also need to be redesigned to be more aerodynamic. This WP will directly lead to M4 where a prototype micro-OPC dropsonde will be dropped from the stratosphere to sea level.

WP4.3 This WP concerns developing a steerable form of a recovery parachute to allow the payload to be recovered in a 50 m x 50 m area, subject to wind conditions. This will involve architectural analysis to ensure correct parachute sizing, control design and operation methodology in the stratosphere. This will then lead to flight controller selection and integration with the balloon manager to allow control from the stratosphere. The operation method will be tested at low level repeatedly along with tuning the flight controller to maximise trajectory control. This WP will directly feed into M6 which will attempt to test the parachute, over a remote region in case of technical failure, and demonstrate flight path control relative to an un-steered parachute but with the same safe descent rate. The first use case for this scenario will be to attempt to steer the in situ optical particle counter through a body of interest such as a cirrus cloud.

3. Project Activities

The following Milestones will be used to monitor your delivery of the Project. The costs associated with completing these Milestones are estimated in the cost breakdown sheet: [REDACTED]

ID	Milestones	Measure	Date	Notes
1	Balloon launch plan agreed	Evidence supplied to internal ARIA team and Oversight Committee that launches are compliant with local regulations	Commencement Date	
2	Stratospheric Qualification of Solar Regenerative Power System	Test Completed, this informs the mass budgets of the whole system and indicates how many navigation manoeuvres can be made	Commencement date + 6 months	

ID	Milestones	Measure	Date	Notes
3	Ground Test of Optimised Super Pressure (SP) Envelope This is a Go/No-Go milestone	Test Completed, this is a SP go/no-go Milestone for if the SP concept is valid or a refocus on shorter endurance balloons is needed. Includes demonstrating that the: • Altitude control over all use cases validated through testing that the maximum sustained over pressure can be maintained. • multi-week endurance requirements can be met with proposed design, validated through effusion tests to verify daily buoyancy reduction rate assumptions. Objective 1.1	Commencement date + 12 months	This go/no go is related to the Super Pressure only, in the event of a 'no go' an alternative balloon would be used by agreement with ARIA.

ID	Milestones	Measure	Date	Notes
4	Stratospheric test of Micro-OPC Dropsonde	Testing completed demonstrating micro OPC dropsonde capability and specifically validating: • antenna/data link performant through descent to surface. • descent is stable and validates modelling predictions. • thermal and power budgets validated with dropsonde optimally powered to landing/splash down. • particulates spectra detected showing agreement with independent observations e.g. forecast, spacebased, or in situ observations during initial HAB ascent.	Commencement date + 15 months	

ID	Milestones	Measure	Date	Notes
5	Upper Tropospheric Lower Stratospheric (UTLS) in-situ profiling test of OPC	Test completed demonstrating UTLS in-situ observation profiling capability and specifically: • OPC sensor support functions from payload controller (PLC) tested and optimal provision of power, thermal control, data transfer from OPC sensor via SATCOM. • Particulates spectra detected showing good agreement with forecasted altitudes and positions. • Multiple day/night targeted UTLS profiling capability demonstrated. Objective 2.1	Commencement date + 18 months	
6	Stratospheric Test of Payload Recovery System	Test completed, demonstrating controlled recovery to an area specified in flight. Objective 2.2	Commencement date + 18 months	
7	Full System Ground Test of mHAB	Test completed, full inflation and all systems tested.	Commencement date + 24 months	

ID	Milestones	Measure	Date	Notes
8	Stratospheric Flight Test of Super Pressure (SP) Balloon	Test completed demonstrating SP balloon system capability: • Successful ascent to level-off at target altitude in the stratosphere. • SP balloon rate of change of pressure agrees with modelling predictions over >3-day period. • Altitude manoeuvres performed and validate min to max altitude modelled prediction and altitude control fidelity. • Power budgets and compressor design validated and agrees with modelled efficiency to confirm altitude range per day for profiling and navigation. Objective 1.2	Commencement date + 27 months	In the event of a 'no go' for Milestones ID 3, this Milestone 8 would be revised and agreed with ARIA.
9	Final Report	Report detailing all successes / failures of project Data from tests and campaigns and technical know-how submitted to open-access ARIA data repository.	Commencement date + 32 months	

In addition to the above Milestones, the following project plan will be used to track progress throughout the project and may be updated from time to time: [REDACTED]

3.1 The intended long-term outcomes are summarised below:

Project StratoGuard aims to develop core technologies to enable a global low cost, long endurance sensing system of long duration mHABs and be able to recover the systems at the end of life for re-use or responsible disposal.

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement
Kick off	• Roles and responsibilities • External communications • Project details
Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Invoicing and cost reporting Optional: • Key Learning, discoveries and decisions • Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • technical evidence saved to drive e.g. report or presentation as requested by PD • review meeting slide deck saved to drive as requested by PD Review meeting with ARIA Programme Team
Annual	• ARIA impact metrics • Attendance at annual ARIA event
Ad hoc	• As required, Programme Director/ Programme Team may request additional information and evidence • Workshops - potential to be invited to ARIA workshops

Project closure	Project closure report

5. Payment

5.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments quarterly in arrears.

For quarterly payments, the cadence of payments will align with ARIAs financial year beginning 1st April e.g Quarter 1 Grant Claims will be for the period of 1st April to 30 June, Quarter 2 Grant Claims will be for the period of 1st July to 30 Sept and so on.

5.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

5.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end of the relevant period.

5.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

6. Principle investigator/key researchers

6.1 For the purposes of clause 2.5, the following principle investigators or key researchers have been identified:

Name	Role	Organisation
Steven Tate	Principle Investigator	Voltitude
Paul Stevens	Engineering Manager	Voltitude
	Project Manager	Voltitude
Richard Nash	Systems Engineer	Voltitude

7. Sub-Contractors

7.1 For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Location
University of Hertfordshire	Provision of Optical Particle Counter sensor and calibration services; consultation on sensing requirements & capability for atmospheric aerosols, optimisation & analysis of combined flight opportunities, ensuring interoperability with satellite-based data, and modelling/data validation activities.	UK

PART 2: APPLICATION FORM

Application titled "StratoGuard - Global Monitoring of Geoengineering using Micro High-Altitude Balloons" submitted 09 December 2024

SCHEDULE 3: Data Protection

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Agreement:
- 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are relying on Domestic Law as the basis for processing Personal Data, you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;
- 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of

Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);

- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Agreement unless required by Domestic Law to store the Personal Data; and
- 3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.

- 3.4. [ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an

opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):

3.4.1. cancel its plans to change the affected sub-Processor;

3.4.2. offer an alternative which is acceptable to ARIA; or

3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.

3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.

3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]

3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it, storing it, retrieving it, consulting it, disseminating it or destroying it, etc. Note the definition of processing in the UK GDPR: "any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction"]
Duration of Processing:	Duration of this Agreement (and any post termination processing that is permitted / required).

Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called “special categories” of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: “data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation”]
Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors, clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. You shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.
- 4.2. Any limitation of liability set out in this Agreement will not apply to this Schedule’s indemnity or reimbursement obligations.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

1. Submission of Pledged Patents and Experimental Data
 - 1.1 The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
 - 1.2 The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.
2. Experimental Data Licence
 - 2.1 Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
 - 2.2 The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
 - 2.3 The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
 - 2.4 The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).
3. Research Licence
 - 3.1 Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
 - 3.2 The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
 - 3.3 Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.

3.5 The Research Licensee must:

- (a) at all times when using the Pledged Patents comply with all Laws; and
- (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).

4. Commercial Licence

4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.

4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.

4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.

5. Pledgor Know-How

At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.

6. Termination

6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:

- (a) materially breaches the terms of such licence or this Pledge; or
- (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).

7. Transfers of Pledged Patents and/or Experimental Data

The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.

8. No Warranty

The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and
Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

Institut Teknologi Sepuluh Nopember (ITS) **(Grant Recipient)**

Jl. Teknik Kimia, Keputih, Kec. Sukolilo,

Surabaya, East Java, 60111

Indonesia

28 May 2025

Attention: Prof. Heri Kuswanto

Dear Heri,

FPCW-PR01-P002 Towards Robust and Unbiased Validation of SAI Simulations (TRUSS) – Standard Grant Funding Letter

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to the Exploring Climate Cooling call and ARIA is pleased to offer you a Grant for the performance of the Project Activities up to the Maximum Sum, subject to your agreement to, and compliance with, the terms and conditions set out in this Grant Funding Letter and its Schedules.

1. Overview of the Grant

Any reference in this letter to "you" or "your" means the Grant Recipient and any capitalised terms have the meanings given in the ARIA Grant Conditions (Conditions).

The key elements of the Grant are described in the table below:

Project Activities	Towards Robust and Unbiased Validation of SAI Simulations (TRUSS). A more detailed description of the Project Activities is set out in Schedule 2 (Project Activities).
Maximum Sum of the Grant (inclusive of taxes)	£ 345,188 (inclusive of all taxes where applicable)
Commencement Date	The commencement date is 02 June 2025
Completion Date	The completion is 01 June 2028
Grant Review Intervals	ARIA will review the Grant at quarterly intervals using the process

	referred to in clause 6 of the Conditions	
Adequate Insurance	Employers' liability - At least £5 million (as required by the Employers' Liability (Compulsory Insurance Act 1969)) Public liability: £5 million (per year in aggregate)	
Monitoring and Reporting	The performance reports referred to in clause 7 of the Conditions shall be provided at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Project Representative	Heri Kuswanto, Professor in Statistics Phone: [REDACTED] Email: [REDACTED]	
Grant Manager	Mark Symes, Programme Director [REDACTED]	
Escalation Contacts	ARIA	Grant Recipient
	Chief Product Officer [REDACTED]	[REDACTED] Director of Research and Community Service – ITS [REDACTED] [REDACTED] [REDACTED]
Notices	ARIA Contracts [REDACTED]	[REDACTED] Director of Research and Community Service – ITS [REDACTED] [REDACTED] [REDACTED]

2. Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Grant and return it to finance@aria.org.uk

3. The Grant Agreement

- 3.1. Once you sign a copy of this Grant Funding Letter in accordance with paragraph 6 (Acceptance) below, it will form a binding "**Grant Agreement**" between you and ARIA that includes and incorporates the following documents:

- 3.1.1. the **Grant Conditions** in Schedule 1;
- 3.1.2. the **Project Activities, Milestones** and **Grant Application** in Schedule 2;
- 3.1.3. the **Royalty percentages** (including annexes) in Schedule 3; and
- 3.1.4. the terms relating to Data Protection in Schedule 4.

- 3.2. The parties confirm that it is their intention to be legally bound by the Grant Agreement.

4. Warranties

- 4.1. By signing this Grant Funding Letter, you warrant and represent that:
- 4.1.1. your obligations under the Grant Agreement are legal, valid, binding and enforceable;
 - 4.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Grant Agreement have been obtained;
 - 4.1.3. the person signing the Grant Agreement is duly authorised to sign on your behalf; and
 - 4.1.4. your Project Representative referenced in the table above is authorised to make decisions and provide information on your behalf.

5. Amendments to the Grant Conditions

- 5.1. Not used

6. Acceptance

- 6.1. To accept this Grant Funding Letter, please arrange for an authorised signatory to sign and date the duplicate copy of this Grant Funding Letter as indicated below, and return to ARIA as a complete signed original of the Grant Agreement including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Grant Agreement and to bind the Grant Recipient.
- 6.2. The offer of this Grant Funding Letter will expire on 01 June 2025.

Yours sincerely

for and on behalf of ARIA

Name of ARIA signatory:

Position Held:

Date:

I confirm the agreement of Institut Teknologi Sepuluh Nopember to the terms and conditions in this Grant Funding Letter and its Schedules.

Signature:

Name:

Position:

Date:

SCHEDULE 1 - GRANT CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up the Grant Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Grant Funding Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to the Grant Agreement with the exception of Schedule 2 Part 2 (the Grant Application);
 - (d) Schedule 2 Part 2 (the Grant Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, the Grant Agreement.

2. DURATION AND PURPOSE OF THE GRANT

- 2.1 The Grant Agreement will subsist for the duration of the Funding Period unless extended by written agreement signed by a duly authorised representative of the parties or terminated earlier in accordance with its terms. Any provision of the Grant Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Grant Agreement shall remain in full force and effect, including clauses 1, 2, 4, 7.4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.3, 22.7, 22.8, 22.11, 22.12, 23, 24, 26, 27, 28, and 30.
- 2.2 You may only use the Grant for carrying out the Project Activities. You may not make any changes to the Project Activities without ARIA's prior written agreement.
- 2.3 You may not unreasonably withhold, condition or delay your agreement to any changes requested by ARIA to the Project Activities or the amount of the Grant. Any agreed change will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

3. ENVIRONMENTAL AND SAFETY REQUIREMENTS

- 3.1 In performing the Project Activities, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. PAYMENT OF GRANT

- 4.1 Subject to the remainder of this clause 4, ARIA will pay the Grant to you:
- (a) up to the Maximum Sum;
 - (b) in pounds sterling (GBP) by wire transfer into your bank account, details of which you provided in the Confirmation of Bank Details form attached to the Grant Funding Letter; and
 - (c) if a tax is chargeable in respect of the Grant, all payments will be deemed to be inclusive of all such taxes and ARIA will not be obliged to pay any additional amount.
- 4.2 The bank account of which you provided details in your Confirmation of Bank Details form (and any alternative bank details nominated subsequently by you) must be an ordinary business bank account

with appropriate segregation of duties and control. During the Funding Period, you must notify ARIA of any change of bank account details as soon as reasonably practicable on the same form and signed by an approved signatory. You must notify ARIA of any change of signatory for approval, as soon as known.

- 4.3 You will be the sole recipient of the Grant and you will be responsible for managing the Grant as between you and any Third Parties involved in performing the Project Activities. This includes securing the repayment of the Grant if requested by ARIA in accordance with the Grant Conditions, including where the Grant has already been distributed to Third Parties.
- 4.4 You must promptly notify ARIA if any money is incorrectly paid to you for any reason, and must repay it as soon as reasonably practicable. Any amount not immediately repaid will be recoverable as a civil debt.
- 4.5 ARIA reserves the right not to pay any Grant Claims that are not submitted within the period set out in the Grant Funding Letter or that are incomplete, incorrect or not accompanied by full supporting documentation (including any documentation that ARIA reasonably requests).
- 4.6 You may not apply for or obtain Duplicate Funding for any Project Activities.
- 4.7 You may not retain any Unspent Monies and must repay them to ARIA within 30 days after ARIA's request for repayment.
- 4.8 You acknowledge the critical importance of cash flow for Sub-Contractors (including startups and small businesses) and commit to paying all valid and undisputed invoices relating to the Project within a maximum of 30 days from the date of receipt.
- 4.9 Where required, you will work with Sub-Contractors to arrange more frequent payment schedules (e.g., same day, weekly or milestone-based payments) to better support their cash flow needs.

5. ELIGIBLE AND INELIGIBLE EXPENDITURE

- 5.1 ARIA will only pay the Grant for Eligible Expenditure incurred by you in carrying out the Project Activities. You must provide ARIA with any evidence reasonably requested by ARIA (including receipts, invoices and other documentary evidence) that all Grant Claims relate to costs that are Eligible Expenditure.
- 5.2 You may not in any circumstance claim as Eligible Expenditure paid-for lobbying, which means using the Grant to fund lobbying (via an external firm or in-house staff) in order to undertake activities intended to influence or attempt to influence Parliament, government or political activity; or attempting to influence legislative or regulatory action.

6. GRANT REVIEW

- 6.1 ARIA will review the Grant at the intervals specified in the Grant Funding Letter. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.3.

- 6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:
- (a) consent to the Project Activities and the Grant Agreement continuing in line with existing plans;
 - (b) increase or decrease the Grant for the remainder of the Funding Period, as applicable;
 - (c) redefine the Milestones;
 - (d) require you to carry out remedial activity with the aim of improving delivery of the Project Activities; and/or
 - (e) terminate the Grant Agreement in accordance with clause 22.
- 6.3 Any change to these Grant Terms, the Project Activities, or the Grant pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

7. MONITORING AND REPORTING

- 7.1 You must closely monitor the carrying out of the Project Activities throughout the Funding Period and must notify ARIA as soon as reasonably practicable of any actual or potential failure to comply with any of your obligations under the Grant Agreement.
- 7.2 ARIA does not limit its engagement with you to purely administrative activities and will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project Activities. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.
- 7.3 You must provide ARIA with:
- (a) the Milestones and a report on your performance against the Milestones at the intervals and for the periods of time specified in the Grant Funding Letter. ARIA may copy and adapt the contents of any of the Milestones and those reports for ARIA's internal use to review, develop and shape ARIA's funded research programmes, but ARIA will treat those contents as your Confidential Information under clause 11;
 - (b) any assistance and information reasonably requested by ARIA to establish whether you have used the Grant in accordance with the Grant Agreement; and
 - (c) a quarterly report on the use of the Maximum Sum, details broken down in accordance with ARIA's prescribed form.

- 7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its funding activities and compliance with the terms of the Grant Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time after the end of the Funding Period about the impact metrics, commercial exploitation or other dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Grant Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Grant Agreement.

8. AUDITING AND ASSURANCE

- 8.1 At the end of the Funding Period you must provide ARIA with independent assurance that the Grant has been used for carrying out the Project Activities. To satisfy this requirement you must provide a statement showing that the use of the Grant has been certified by an independent and appropriately qualified auditor or accountant.
- 8.2 Subject to clause 11, ARIA and/or its authorised representative may, at any time during the Funding Period and for up to 7 years after the end of the Funding Period, conduct audits in relation to your use of the Grant and your compliance with the Grant Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.
- 8.3 You must:
- (a) maintain an appropriate system of financial management and controls, maintain detailed records in relation to those controls, and provide copies of those records to ARIA on request; and
 - (b) retain, and procure that your Sub-Contractors retain and will provide to you on request, all relevant documentation relating to the Eligible Expenditure (including invoices, receipts and accounting records) during the Funding Period and for a period of 7 years thereafter.

9. FINANCIAL MANAGEMENT

- 9.1 You must:
- (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Grant; and
 - (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project Activities as soon as they are identified, and keep ARIA informed of your remedial actions.
- 9.2 In the event of any actual or suspected fraud, theft or other financial irregularity (which includes use of the Grant for any purpose other than that envisaged by the Grant Agreement), ARIA may, at its absolute discretion:

- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
- (b) suspend the Project Activities and future payment of the Grant to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

- 10.1 You must inform ARIA promptly of any actual, perceived or potential conflicts between your and your Representatives' obligations under the Grant Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Funding Period.
- 10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that these conflicts are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you or your Representative to cease the conflicting activity and if that is not acceptable to you or your Representative, either party may terminate the Grant Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

- 11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the provision of the Project Activities, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.
- 11.2 ARIA may publish a summary of the Grant Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Grant Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.
- 11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:
 - (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;
 - (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information necessary for the purpose

concerned and obtains appropriate confidentiality undertakings in relation to such information;

- (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and where no exception to disclosure under them is applicable; or
- (d) where that party (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.

- 11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under the Grant Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

- 12.1 Each party must comply with its obligations under the Law, including where applicable the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.
- 12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.
- 12.3 You acknowledge that ARIA, acting in accordance with the Information Acts (other than the FOIA), may disclose information concerning you and the Grant Agreement without consulting you. ARIA must take reasonable steps to notify you of any request for information to the extent permissible and reasonably practical and will give you adequate opportunity to make representations before ARIA discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.
- 12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or the Grant Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.
- 12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.
- 12.6 You must take account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

- 13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.
- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with the Grant Agreement. If either party anticipates that the other will process any Personal Data on its behalf under the Grant Agreement it must notify the other party and the parties must agree a variation to the Grant Agreement under clause 26 to incorporate appropriate provisions (such as those set out in Schedule 4) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. SUBSIDY CONTROL AND STATE AID

- 14.1 ARIA intends that the Grant complies with the Subsidy Control Act 2022 on the basis that the Project Activities are not economic activities and do not give a specific advantage to one or more enterprises. You must take all reasonable steps to maintain this position and to assist ARIA to comply with the requirements of the Act and must cooperate with any investigations under the Act.
- 14.2 Where the EU state aid laws apply to the Grant (where the Project Activities will affect trade between Northern Ireland and the EU), you acknowledge that the Project Activities are designed and performed so they are compatible with state aid laws. You will take all reasonable steps to assist ARIA to comply with state aid law requirements and cooperate with any investigations by the European Commission into the Project Activities.
- 14.3 ARIA will immediately stop future payments of the Grant and may require repayment of some or all of the Grant if subsidy control or state aid laws so require for the funding to be compliant.

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and not seek to avoid their application by artificial means.

Background IP

- 15.2 The Grant Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Funding Period if any additional Background IP is required either to carry out the Project Activities or to exploit commercially any of the Results.

Foreground IP ownership

- 15.3 You will own all Foreground IP unless your policy is for individual researchers to own the Foreground IP they create, or you agree your Sub-Contractor (or another third party) will own all, or parts of, the Foreground IP. Where your Sub-Contractor or individual researchers (or any other third party involved in the performance of the Project Activities) will own any of the Foreground IP you must impose on them the obligations relating to Foreground IP and Results contained in clauses 15 and 16. Where you

assign any Foreground IP to a Third Party (including your technology transfer company) you must impose on that Third Party the obligations relating to Foreground IP and Results contained in clauses 15 and 16.

- 15.4 You must submit all (i) all patents within or covering the Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the Future Proofing our Climate and Weather Intellectual Property Pledge promptly following creation or filing (as applicable) of such patents and/or data (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge. You hereby agree to comply and uphold the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.5 You must ensure that whenever any Results are used with or communicated to Third Parties or are exploited commercially, ARIA's funding of the Project Activities is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and publication

- 15.6 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.7 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.8 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to fund future prosecution and maintenance and/or request the assignment of the patents to ARIA or its nominee.

Inventor first preference

- 15.9 Subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge if any inventor or active participant in the Project Activities expresses interest in the exploitation of the Foreground IP they have developed, you must give them an opportunity to negotiate an assignment or commercial licence of the Foreground IP, on reasonable terms, prior to negotiating with any entity in which an inventor or active participant in the Project Activities is not involved as a shareholder or other key stakeholder.

16. COMMERCIALISATION OF RESULTS

- 16.1 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge, where they are capable of commercial exploitation you should seek to exploit the Results commercially. This should be done, where applicable, in accordance with the Commercialisation Hypothesis.
- 16.2 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge, if for any reason you choose not to exploit any such Results commercially within a reasonable timeframe (or, where applicable, the timeframe set out in the Commercialisation Hypothesis) you are encouraged to discuss the position with ARIA, and you may request that ARIA exploit them or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Non-UK Commercialisation

- 16.3 Save as set out in the [Future Proofing our Climate and Weather Intellectual Property Pledge, to avoid any restriction on commercialisation, no consent is required from ARIA for any Non-UK commercialisation or any sale of Foreground IP to a Non-UK Entity. However, ARIA is set up to create value for the UK and therefore you must secure a fee payable to ARIA (**ARIA Non-UK Fee**) in each of the following circumstances:
- (a) where you are a Non-UK Entity;
 - (b) where you become a Non-UK Entity;
 - (c) where you assign or Commercially License any Foreground IP to a Non-UK Entity; or
 - (d) where you have assigned or Commercially Licensed any Foreground IP to a UK Entity that subsequently becomes a Non-UK Entity.
- 16.4 In order to avoid any unnecessary complexity, the ARIA Non-UK Fee will be based on the terms that you agree with any person to which you assign or Commercially License the relevant Foreground IP. This ARIA Non-UK Fee will amount to an additional twenty-five per cent (25%) of the value of the consideration (including upfronts, licence fees, milestone payments, royalties, shares or other securities, buyouts, exit fees and other consideration) that you receive from the exploitation of the relevant Foreground IP during any period that the above circumstances exist.
- 16.5 For example, if you would receive £100 (via royalty or royalty buyout), you must ensure your contractual mechanism enables you to collect an additional £25 and pay that additional amount to ARIA.
- 16.6 The ARIA Non-UK Fee is payable within 90 days after the end of each relevant Financial Year for receipts related to that calendar year. You are encouraged to use the clauses in Annex 1 in your Commercialisation Licences of Foreground IP.

Crown Body customers

- 16.7 You must ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities, and in suitable quantities for the Crown Body's requirements.

Spin-outs

- 16.8 ARIA seeks to maximise future investment of entrepreneurial talent and capital in start-up companies commercialising the Results of its funded activities. To that end, having funded the full economic cost of the research, ARIA places restrictions on the level of equity stakes and royalties that you may negotiate in exchange for the assignment or Commercialisation Licence of any Foreground IP.
- 16.9 If you or your technology transfer company assign or licence any Foreground IP to any third party or to a start-up established for the purpose of commercially exploiting the Results (a NewCo) you together with any connected person (including any investment fund to which you may transfer any part of your stake) shall be entitled to:

EITHER

- (a) hold or have the right to hold no more than 10% in fully-dilutable shares or equity (pre investment) in the third party or NewCo (with no other preferential subscription rights), not including any shares or equity subscribed for cash on arm's length terms alongside other investors;

OR

- (b) charge a royalty, with no upfront payments, annual fees, milestone payments or minimum royalties, payable by the third party or NewCo under any licence or assignment of the Foreground IP at no more than the relevant rate, and on the other terms, set out in Schedule 3.

- 16.10 The provisions of clauses 16.9(a) and 16.9(b) shall not apply to any equity taken or royalty charged in consideration of:
- (a) IP other than Foreground IP licensed or assigned to the third party or NewCo; or
- (b) facilities, equipment, personnel or other material support or services provided to the third party or NewCo independent of the Project Activities,
- with such equity or royalty limited to the proportion that reflects the contribution made by IP that is not Foreground IP.
- 16.11 You must notify ARIA in writing before any transaction completes of the overall equity stake or royalty percentages agreed under clause 16.8 (and any impact of clause 16.9, if relevant).

17. ASSETS

- 17.1 You must keep a register during the Funding Period and for up to 7 years after the end of the Funding Period of all Assets, with all relevant details about each Asset. You must use any Assets purchased with Grant monies for the Project Activities.
- 17.2 At the end of the Funding Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

- 18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Grant Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUBCONTRACTING

- 19.1 You may not transfer, assign, novate or otherwise dispose of the whole or any part of the Grant Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.
- 19.2 You shall not subcontract any of the Project Activities to a Third Party except to the extent permitted, and to the person or persons identified, in Schedule 2 Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractor as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Grant Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Grant Agreement.

20. BORROWING, LOSSES, GIFTS, SPECIAL PAYMENTS

- 20.1 You must obtain ARIA's prior written consent before:
- (a) borrowing or lending money from any source in connection with the Grant Agreement;
 - (b) giving any guarantee, indemnity, security over any Asset or letter of comfort in relation to the Grant Agreement;
 - (c) making any gift or writing off any debt or liability in connection with the Grant, and must keep a record of all gifts given and received in connection with the Grant.

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Grant and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Grant or publicise details of the Grant Agreement without the other's consent, except as required by Law.
- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

- 22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events occur:

- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13, 15.5 or 25, or commit a material breach of any other term of the Grant Agreement in the reasonable opinion of ARIA;
- (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
- (c) you fail to improve the performance of the Project Activities, notwithstanding your having undertaken the remedial activity agreed with ARIA in the remedial plan under clause 6.2(d);
- (d) you or the researchers involved in the Project Activities obtain any funding from a Third Party that, in the opinion of ARIA, undertakes activities that are likely to bring the reputation of the Project Activities or ARIA into disrepute;
- (e) you provide ARIA with any materially misleading or inaccurate information in your grant application or in subsequent related correspondence;
- (f) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Third Party, immediately upon becoming aware of it;
- (g) you are subject to an Insolvency Event;
- (h) the Grant or any part of it is held by a court or competent authority to be a prohibited subsidy under the Subsidy Control Act 2022 or an illegal state aid;
- (i) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project Activities;
 - (ii) result in your being unable to receive the Grant; and/or
 - (iii) raises national security concerns.

Rights reserved for ARIA in relation to an Event of Default

- 22.2 If an Event of Default has or may have occurred, ARIA may by written notice to you take any one or more of the following actions:
- (a) suspend the Project Activities and payment of the whole or any part of the Grant for such period as ARIA may determine, acting reasonably;
 - (b) reduce the Maximum Sum, in which case the payment of Grant will thereafter be made in accordance with the reduction and notified to you; and/or
 - (c) subject to clause 22.4, terminate the Grant Agreement with immediate effect as from the date of service of the notice of that termination.
- 22.3 Where this Grant Agreement is terminated for an Event of Default described in clause 22.1(f) or 22.1(h), ARIA may require you to repay the entire amount of the Grant previously paid to you.

Opportunity for you to remedy an Event of Default

- 22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:
- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and

- (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

22.5 Without prejudice to any other provision of the Grant Agreement, you may terminate the Grant Agreement on written notice to ARIA if ARIA commits a material breach of the Grant Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

General Termination Rights

22.6 Notwithstanding ARIA's right to terminate the Grant Agreement under clause 22.2(c), either party may terminate the Grant Agreement (in whole or in part) at any time by giving at least 60 days' prior written notice to the other party.

22.7 You must promptly notify ARIA in writing if at any time the principal investigator or any key researcher(s) named in Schedule 2 working on the Project Activities is unable or unwilling to continue to be involved in the Project Activities or is moving to a new organisation without the desire to continue the research. Within 60 days after the date of that notice, you must either:

- (a) nominate one or more successors, subject to ARIA's approval; or
- (b) agree that the Grant is transferred to another organisation subject to your and the new organisation's agreement in writing and ARIA's approval of the transfer

If ARIA is unwilling to accept the nominated successor(s) or does not approve a request for transfer, it may terminate the Grant Agreement by at least 30 days' written notice to you.

Consequences of Termination

22.8 If the Grant Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.

22.9 Where ARIA terminates the Grant Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:

- (a) you taking all reasonable steps to mitigate such loss; and
- (b) the Unavoidable Costs being:
 - (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Grant Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA;

- (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you;
- (v) costs that would not have been incurred had this Grant Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period).

- 22.10 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Services, over £250,000 will terminate automatically and immediately upon termination of this Agreement.
- 22.11 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Grant Agreement in the event that the Grant Agreement was terminated (calculated on the basis described in clause 22.8).
- 22.12 ARIA's total liability under clause 22.9 shall be limited to the Maximum Sum under the Grant Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.13 If the Grant Agreement is terminated or expires ARIA will not be liable to pay any of your costs or those of any of your contractors or suppliers related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Grant Funding Letter and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Grant Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Grant Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the Grant Manager and the Project Representative.
- 23.3 If the dispute cannot be resolved between the Grant Manager and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to a formal meeting between the parties' Escalation Contacts.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:
- (a) fraudulent misrepresentation or any other fraudulent act or omission;
 - (b) payment of sums properly due and owing to the other in the normal course of performance of this Grant Agreement;
 - (c) a breach of clause 13;

- (d) liability arising under any indemnity in this Grant Agreement; or
- (e) liability which may not lawfully be excluded or limited.

24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Grant Agreement or for ARIA's breach of this Grant Agreement), whether arising directly or indirectly, that may arise in connection with:

- (a) your carrying out the Project Activities;
- (b) the use of the Grant by any person;
- (c) any reduction, suspension, withdrawal or request for repayment of the Grant in accordance with this Grant Agreement; or
- (d) termination of the Grant Agreement in accordance with this Grant Agreement.

24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:

- (a) loss of profit, sales or turnover;
- (b) loss of contracts or business opportunities;
- (c) loss of anticipated savings;
- (d) loss of goodwill or damage to reputation; or
- (e) any indirect, special or consequential loss or damage;

in each case arising out of or relating to the Grant Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.

24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to the Grant Agreement or its subject matter or anything which it has done or not done in connection with the Grant Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the amount of the Maximum Sum.

24.5 You shall under no circumstances in connection with this Grant Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.

24.6 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Grant Agreement.

25. RESEARCH ETHICS AND CODE OF CONDUCT

25.1 As a recipient of a Government grant you must operate in accordance with the Concordat.

25.2 All research data:

- (a) must be generated using sound scientific techniques and processes;
- (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and

(c) must be analysed appropriately, without bias and in accordance with good scientific practices.

25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.

25.4 You must comply with the Code of Conduct and ensure that your Representatives undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

26.1 Any variation to the Grant Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

27. GENERAL

27.1 Notices: All notices and other communications in relation to this Grant Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such communications will be deemed to have been given and received on the third Working Day following such mailing.

27.2 Change of control: You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(i) is likely to apply.

28. GOVERNING LAW

28.1 This Grant Agreement (including any non-contractual disputes or claims arising in connection with this Grant Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. Not used

30. DEFINITIONS AND INTERPRETATION

30.1 Where they appear in these Conditions or the Grant Agreement:

Adequate Insurance means the insurance requirements and amounts set out in the Grant Funding Letter.

Asset means any asset that is purchased, improved or developed using the Grant including equipment and fixed assets;

Background IP means IP that is:

(a) owned by or licensed to a party prior to the Commencement Date; or
(b) developed by or on behalf of a party during the Funding Period but not in connection with the Project Activities,

and is in either case used in connection with the Project Activities;

Bribery Act means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;

Change of Control means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Recipients of Government General Grants published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754555/2018-11-06_Code_of_Conduct_for_Grant_Recipients.pdf

including any subsequent updates from time to time;

Commencement Date means the date set out in the Grant Funding Letter;

Commercialisation Licence means a licence of IP other than a research or evaluation licence and/or subcontract manufacture (and **Commercially License** means to license under a Commercialisation Licence);

Commercialisation Hypothesis means the exploitation plan approved by ARIA and set out at Schedule 2 Part 2, as may be amended by agreement between the parties during and after the Funding Period;

Completion Date means the date set out in the Grant Funding Letter;

Concordat means the Concordat to Support Research Integrity which can be found at <https://ukrio.org/about-us/the-concordat-to-support-research-integrity/>

Conditions means these ARIA Grant Conditions;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Grant Agreement, that ought reasonably to be considered to be confidential (whether or not it is so marked), (a) including: (i) information relating to the business, affairs, customers, clients, suppliers or plans of the disclosing party; (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party; (iii) any information developed by the parties in the course of carrying out the Project Activities; (iv) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Grant Agreement; and (v) and any information derived from any of the above,

(b) but not including information which: (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11); (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party; (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or (iv) is independently developed without access to the Confidential Information; and (v) the content of this specific version of the Grant Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

Duplicate Funding means funding provided to you by a Third Party which is to fund the same activities as the Project Activities;

EA means the Equality Act 2000 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Eligible Expenditure means the payments made by you during the Funding Period for the purposes of carrying out the Project Activities which comply with clause 5 and ARIA's published eligibility rules (which provide for full economic cost reimbursement) and as agreed in the Grant Funding Letter;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Grant Funding Letter;

Event of Default means any of the events or circumstances set out in clause 22.1;

Financial Year means 1 April to 31 March;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means any IP in the Results;

Funding Period means the period commencing on the Commencement Date and ending on the Completion Date or such later date as may be agreed between the parties unless otherwise determined in accordance with the terms of the Grant Agreement;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification (operated by ARIA or by a third party), in the form set out at Annex A;

GDPR means Regulation (EU) 2016/679;

Grant means the sum or sums ARIA will pay to you up to the amount set out in the Grant Funding Letter, in accordance with clause 4 and subject to the provisions set out at clause 22.

Grant Agreement has the meaning given in the Grant Funding Letter;

Grant Claim means a request submitted by you to ARIA for payment of the Grant;

Grant Funding Letter means the letter from ARIA to you to which these Conditions are annexed;

Grant Manager means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Grant;

Grant Review means the process for reviewing the grant outlined in clause 6;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Ineligible Expenditure means expenditure incurred by you which is not Eligible Expenditure as set out in clause 5 and ARIA's published eligibility rules;

Information Acts means the Data Protection Legislation, FOIA and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property Rights or **IP** means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions, semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation;

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise;

Maximum Sum means the maximum amount of the Grant stated in the Grant Funding Letter;

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

NewCo has the meaning given in clause 16;

Non-UK Entity means a legal entity that is not a UK Entity;

Personal Data has the meaning given to it in the Data Protection Legislation as amended from time to time;

Prohibited Act means:

(a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Grant Agreement; and/or (ii) showing or not showing favour or disfavour to any person in relation to the Grant Agreement;

(b) committing any offence: (i) under the Bribery Act; (ii) under legislation creating offences in respect of fraudulent acts; and/or (iii) at common law in respect of fraudulent acts in relation to the Grant Agreement; and/or

(c) defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the activities to be carried out by you that are described in the Grant Funding Letter and in Schedule 2 Part 1;

Project Representative means the representative appointed by you, who at the Commencement Date will be the individual listed as such in the Grant Funding Letter;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means all information, data, techniques, inventions, discoveries, works, software and materials generated in the course of the Project Activities;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Project Activities or any part thereof or facilities or services necessary for the performance of the Project Activities or any part thereof or necessary for the management, direction or control of the Project Activities or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

UK Entity means a legal entity whose ultimate parent company has its headquarters and principal establishment in the United Kingdom;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Grant Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Funding Period because of termination or breach of the Grant Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination; and

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 In these Conditions and the Grant Agreement, unless the context otherwise requires:

- (a) references to "party" and "parties" are to the parties to the Grant Agreement;
- (b) the singular includes the plural and vice versa;
- (c) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (d) references to clauses and Schedules are to the clauses of these Conditions and to the Schedules to the Grant Agreement;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation"; and
- (g) the headings in the Grant Agreement are for ease of reference only and will not affect the interpretation or construction of the Grant Agreement.

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

This project, Towards Robust and Unbiased Validation of SAI Simulations (TRUSS): Advancing Ensemble Calibration for Reliable Geoengineering Impact Analysis, is funded under the ARIA Exploring Climate Cooling programme. It addresses a critical gap in the validation of Stratospheric Aerosol Injection (SAI) ensemble simulations by refining climate intervention models. Many existing studies focus on ensemble means while often overlooking variability and uncertainties, which are essential for assessing the robustness of SAI models, particularly at regional scales. By leveraging Bayesian ensemble calibration and machine learning-based corrections, this project aims to enhance the reliability of SAI ensemble outputs and improve climate intervention impact assessments.

2. Aims and objectives of the Project Activities

The primary Research Objectives (ROs) of this project are:

- **(RO1)** To quantify and reduce uncertainty in ensemble outputs from SAI simulations (e.g., ARISE, GLENS).
- **(RO2)** To develop advanced calibration techniques that enhance the predictive power and reliability of ensemble simulations.
- **(RO3)** To validate the calibration techniques using observational data and alternative simulations.
- **(RO4)** To utilize the calibrated ensemble outputs for regional and local SAI impact analysis

3. Project Activities

3.1 The project is structured into three key work packages:

- WP1: Uncertainty Quantification and Calibration
 - Conduct statistical analyses to quantify variability in ensemble outputs.
 - Develop Bayesian calibration and machine learning-based methods to refine ensemble predictions.
 - Deliverable: Calibrated ensemble simulation outputs with quantified uncertainty.

Milestone relevance - This work package lays the foundation for the project. It directly supports:

- Milestone 1 (Month 6): Initial Uncertainty Quantification & Model Selection
 - You will complete data acquisition from ARISE and GLENS, conduct an initial analysis of ensemble variability, and document the selection of statistical and machine learning calibration methods.
- Milestone 2 (Month 18): Development of Prototype Calibration Models

- This covers the design and testing of both Bayesian ensemble calibration models and adaptive machine learning-based bias correction approaches, using selected datasets
- WP2: Validation
 - Validate calibrated outputs using historical climate data and observational comparisons.
 - Conduct sensitivity tests to assess model robustness.
 - Deliverable: A comprehensive publication detailing the reliability of calibrated ensembles.

Milestone relevance - This focuses on testing the robustness of your calibration techniques and supports:

- Milestone 3 (Month 24): Validation of Calibrated SAI Simulations
 - Involves benchmarking calibrated outputs against historical climate data, completing sensitivity analyses, and submitting findings for peer-reviewed publication.
- WP3: Impact Analysis
 - Utilize calibrated ensemble data to evaluate regional and local SAI impacts.
 - Assess variability within the calibrated ensembles for improved decision-making.
 - Deliverable: Regional impact assessments and reports.

Milestone relevance - This applies validated ensemble outputs to regional SAI impact assessments and supports:

Milestone 4 (Month 33): Regional Climate Impact Analysis & Open-Source Tool Development

This includes generating region-specific impact reports and releasing a reproducible open-source calibration and analysis toolkit.

Milestone 5 (Month 36): Final Project Completion & Submission of Reports & Publications

You will finalize all deliverables, submit additional publications, and deposit outputs in ARIA's open-access repository along with our final project report. Deliverable: Regional impact assessments and reports

3.2 The following Milestones will be used to monitor your delivery of the Project. The costs associated with completing these Milestones are estimated in the cost breakdown sheet

ID	Milestones	Measure	Date

1	Initial Uncertainty Quantification & Model Selection	Data acquisition from ARISE and GLENS completed; Initial uncertainty quantification and method selection documented.	Commencement Date + 6 months
2	Development of Prototype Calibration Models	Bayesian ensemble calibration and machine learning bias correction models developed and tested on initial datasets.	Commencement Date + 18 months
3	Validation of Calibrated SAI Simulations	Calibrated outputs tested against historical climate data; Sensitivity analysis completed. Publication submitted.	Commencement Date + 24 months
4	Regional Climate Impact Analysis & Open-Source Tool Development	Application of calibrated ensembles for regional impact analysis; Finalized calibration methodologies released as an open-source tool.	Commencement Date + 33 months
5	Final Project Completion & Submission of Reports & Publications	Project results submitted to peer-reviewed journals, and output data made available in ARIA open access repository; Final report and brief completed.	Commencement Date + 36 months

In addition to the above Milestones, the following project plan will be used to track progress throughout the project and may be updated from time to time: [REDACTED]

3.3 The intended long-term outcomes are summarised below:

The long-term outcome of this project is to establish a robust and unbiased framework for validating Stratospheric Aerosol Injection (SAI) simulations, enhancing their reliability for climate impact assessments. By integrating Bayesian ensemble calibration and machine learning techniques, the project aims to significantly improve uncertainty quantification and predictive accuracy in SAI models, ensuring they provide more reliable and actionable insights for decision-makers.

In the long run, this research will:

1. Support Informed Climate debate – By providing validated, uncertainty-aware SAI ensemble outputs, policymakers and climate scientists will be better equipped to assess the feasibility, risks, and benefits of climate interventions.
2. Enable Scalable Validation Methods – The calibration and validation methodologies developed in this project will be applicable to future climate simulations, including smaller ensembles and new scenarios such as those in GeoMIP.
3. Advance Open-Source Climate Modeling Tools – The project’s results, including calibration methods and datasets, will be made publicly accessible to support the broader climate science community, enhancing transparency and reproducibility.
4. Strengthen International Collaboration – The research outcomes will foster continued engagement between academia, policymakers, and climate modeling centers, paving the way for further interdisciplinary research on climate intervention strategies.

Ultimately, this project will set a new standard for the validation of SAI models, reduce overconfidence in ensemble-based climate projections, and contribute to responsible and scientifically sound discussions on climate interventions.

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement
Kick off	• Roles and responsibilities • External communications • Project details

Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Invoicing and cost reporting Optional: • Key Learning, discoveries and decisions • Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • technical evidence saved to drive e.g. report or presentation as requested by PD • review meeting slide deck saved to drive as requested by PD Review meeting with ARIA Programme Team
Annual	• ARIA impact metrics • Attendance at annual ARIA event
Ad hoc	• As required, Programme Director/ Programme Team may request additional information and evidence • Workshops - potential to be invited to ARIA workshops
Project closure	• Project closure report

5. Payment

5.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments monthly in arrears. Monthly payments will align with the calendar month

5.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

5.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end of the relevant period.

5.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

6. Principal investigator/key researchers

6.1 For the purposes of clause 22.7, the following principle investigators or key researchers have

been identified:

Name	Role	Organisation
Heri Kuswanto	Principal Investigator (PI)	Institut Teknologi Sepuluh Nopember (ITS)
Kartika Fithriasari	Co-PI	Institut Teknologi Sepuluh Nopember (ITS)
	Postdoctoral Researcher	Institut Teknologi Sepuluh Nopember (ITS)
PhD Student (TBA)	Research Assistant (Early Career)	Institut Teknologi Sepuluh Nopember (ITS)
	Research Assistant	Institut Teknologi Sepuluh Nopember (ITS)
	Researcher Assistant	Institut Teknologi Sepuluh Nopember (ITS)
	Research Assistant	Institut Teknologi Sepuluh Nopember (ITS)
	Research Assistant	Institut Teknologi Sepuluh Nopember (ITS)
	Research Collaborator	Cornell University - USA
	Research Collaborator	Exeter University - UK

7. Sub-Contractors

7.1 For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Location

PART 2 - GRANT APPLICATION

Application titled “Towards Robust and Unbiased Validation of SAI Simulations (TRUSS): Advancing Ensemble Calibration for Reliable Geoengineering Impact Analysis” dated 30 November 2024.

SCHEDULE 3

Royalty Percentages

Royalties on the sale or supply of products or services that are covered by, use or incorporate the Foreground IP licensed to the NewCo will only become due on aggregate net sales derived from the Foreground IP exceeding £50 million.

The maximum headline percentage royalty rate (i.e. before any royalty stacking, step-down or other reduction and excluding any ARIA Non-UK Fee) for products or services that are covered by, use or incorporate the Foreground IP, and of sublicensing income, shall be one of the following:

Type of product	Applicable headline royalty percentage (up to)
Low margin	0.5% of net sales
Medium margin	1% of net sales
High margin	2% of net sales
Sublicensing royalty	10% of net receipts

ANNEX 1

Clause for inclusion in licences of Foreground IP

[] **ARIA NON-UK FEE**

[].1 In this clause:

“ARIA” means the Advanced Research and Invention Agency;

“Crown Body” means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

“UK Entity” means a legal entity that has or whose ultimate parent company has its headquarters and principal establishment in the United Kingdom.

[].2 The Foreground IP was developed with funding from ARIA. As a condition of its funding ARIA requires that a benefit is returned to the United Kingdom where the Foreground IP is licensed by the Licensor to any person that is not a UK Entity. Accordingly, in addition to any other sums payable by the Licensee to the Licensor under this Agreement, the Licensee shall pay to the Licensor within 90 days after the end of each calendar year during the Relevant Period (as defined below), and within 90 days after the end of the Relevant Period, a fee (**ARIA Non-UK Fee**) on all amounts (including upfronts, licence fees, milestone payments, royalties, shares or other securities, exit fees, buyout or other consideration) payable by the Licensee to the Licensor under this Agreement in relation to the exploitation of any Foreground IP (**Relevant Amount**) that accrues during, or relates to, any period of time that the Licensee is not a UK Entity (**Relevant Period**). The amount of the ARIA Non-UK Fee is 25% of the Relevant Amount, and is payable by the Licensee to the Licensor in addition to the amounts that would otherwise be payable under this Agreement. For example if the Relevant Amount is £100 the ARIA Non-UK Fee is an additional £25, which the Licensee shall pay to the Licensor and the Licensor shall remit to ARIA.

Crown Body customers

[].3 You must also ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities and in suitable quantities for the Crown Body's requirements.

[].4 ARIA shall have the right to enforce this clause [] under the Contracts (Rights of Third Parties) Act 1999. Neither party may amend this Agreement in a way that detracts from ARIA's right to enforce its rights under this clause without ARIA's prior written consent.

[1] When using this clause you may substitute the relevant defined terms used elsewhere in the agreement to capture the concept of "Foreground IP". Where the clause refers to the "Licensor" and "Licensee" please use the appropriate defined terms to include the licensor, licensee, assignor and assignee of the Foreground IP. This clause is not suitable for assignments of the Foreground IP in consideration of the payment of one or more lump sum payments. In those cases the Licensor needs to be informed, and potentially make an additional payment, if the Foreground IP is subsequently assigned to a non-UK Entity or if the Assignee ceases to be a UK Entity.

SCHEDULE 4: Data Protection

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Grant Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Grant Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Grant Agreement:
 - 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are

relying on Domestic Law as the basis for processing Personal Data, you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;

- 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);
- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Grant Agreement unless required by Domestic Law to store the Personal Data; and

3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.

3.4. [[ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):

3.4.1. cancel its plans to change the affected sub-Processor;

3.4.2. offer an alternative which is acceptable to ARIA; or

3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.

3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Grant Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.

3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]

3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Grant agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it, storing it, retrieving it, consulting it, disseminating it or destroying it, etc.

	Note the definition of processing in the UK GDPR: <i>“any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction”]</i>
Duration of Processing:	Duration of this Grant Agreement (and any post termination processing that is permitted / required).
Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called “special categories” of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: <i>“data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation”]</i>
Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors,

	clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. You shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.
- 4.2. Any limitation of liability set out in this Grant Agreement will not apply to this Schedule's indemnity or reimbursement obligations.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

1. Submission of Pledged Patents and Experimental Data

- 1.1 The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
- 1.2 The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.

2. Experimental Data Licence

- 2.1 Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
- 2.2 The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
- 2.3 The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
- 2.4 The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).

3. Research Licence

- 3.1 Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
- 3.2 The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
- 3.3 Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

- 3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.
- 3.5 The Research Licensee must:
- (a) at all times when using the Pledged Patents comply with all Laws; and
 - (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).

4. Commercial Licence

- 4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.
- 4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.
- 4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.

5. Pledgor Know-How

At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.

6. Termination

- 6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:
- (a) materially breaches the terms of such licence or this Pledge; or
 - (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).

7. Transfers of Pledged Patents and/or Experimental Data

The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.

8. No Warranty

The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;

Signatory	means any party who has agreed to be bound by the terms of this Pledge; and
Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

University Court of the University of Glasgow **(Grant Recipient)**

University Avenue, Glasgow,

G12 8QQ

18 June 2025

Attention: Colin McInnes

Dear Colin,

FPCW-PR01-P022 - An assessment of a space-based solar radiation management technology demonstrator – Standard Grant Funding Letter

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to Exploring Climate Cooling and ARIA is pleased to offer you a Grant for the performance of the Project Activities up to the Maximum Sum, subject to your agreement to, and compliance with, the terms and conditions set out in this Grant Funding Letter and its Schedules.

1. Overview of the Grant

Any reference in this letter to "you" or "your" means the Grant Recipient and any capitalised terms have the meanings given in the ARIA Grant Conditions (Conditions).

The key elements of the Grant are described in the table below:

Project Activities	An assessment of a space-based solar radiation management technology demonstrator. A more detailed description of the Project Activities is set out in Schedule 2 (Project Activities).
Maximum Sum of the Grant (inclusive of taxes)	£342,216 inclusive of all taxes where applicable)
Commencement Date	The commencement date is 1 October 2025
Completion Date	The completion is 30 September 2026
Grant Review Intervals	ARIA will review the Grant at quarterly intervals using the process referred to in clause 6 of the Conditions

Adequate Insurance	Employers' liability - At least £5 million (as required by the Employers' Liability (Compulsory Insurance Act 1969)) Public liability: £5 million (per year in aggregate)	
Monitoring and Reporting	The performance reports referred to in clause 7 of the Conditions shall be provided at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Project Representative	Professor Colin McInnes, James Watt Chair, Professor of Engineering Science, [REDACTED]	
Grant Manager	Mark Symes, Programme Director [REDACTED]	
Escalation Contacts	ARIA	Grant Recipient
	Chief Product Officer [REDACTED]	[REDACTED] Head of Research Contracts, [REDACTED]
Notices	ARIA Contracts [REDACTED]	[REDACTED], Project Coordinator, [REDACTED] [REDACTED]

Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Grant and return it to finance@aria.org.uk

3. The Grant Agreement

- 3.1. Once you sign a copy of this Grant Funding Letter in accordance with paragraph 6 (Acceptance) below, it will form a binding "**Grant Agreement**" between you and ARIA that includes and incorporates the following documents:

3.1.1. the **Grant Conditions** in Schedule 1;

3.1.2. the **Project Activities, Milestones** and **Grant Application** in Schedule 2;

3.1.3. the **Royalty percentages** (including annexes) in Schedule 3; and

3.1.4. the terms relating to Data Protection in Schedule 4.

3.2. The parties confirm that it is their intention to be legally bound by the Grant Agreement.

3.3. Not used.

4. Warranties

4.1. By signing this Grant Funding Letter, you warrant and represent that:

4.1.1. your obligations under the Grant Agreement are legal, valid, binding and enforceable;

4.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Grant Agreement have been obtained;

4.1.3. the person signing the Grant Agreement is duly authorised to sign on your behalf; and

4.1.4. your Project Representative referenced in the table above is authorised to make decisions and provide information on your behalf.

5. Amendments to the Grant Conditions

5.1. Not used.

6. Acceptance

6.1. To accept this Grant Funding Letter, please arrange for an authorised signatory to sign and date the duplicate copy of this Grant Funding Letter as indicated below, and return to ARIA as a complete signed original of the Grant Agreement including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Grant Agreement and to bind the Grant Recipient.

6.2. The offer of this Grant Funding Letter will expire on 20 June 2025.

Yours sincerely

for and on behalf of ARIA

Name of ARIA signatory:

Position Held:

Date:

I confirm the agreement of University Court of the University of Glasgow to the terms and conditions in this Grant Funding Letter and its Schedules.

Signature:

Name:

Position:

Date:

SCHEDULE 1 - GRANT CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up the Grant Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Grant Funding Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to the Grant Agreement with the exception of Schedule 2 Part 2 (the Grant Application);
 - (d) Schedule 2 Part 2 (the Grant Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, the Grant Agreement.

2. DURATION AND PURPOSE OF THE GRANT

- 2.1 The Grant Agreement will subsist for the duration of the Funding Period unless extended by written agreement signed by a duly authorised representative of the parties or terminated earlier in accordance with its terms. Any provision of the Grant Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Grant Agreement shall remain in full force and effect, including clauses 1, 2, 4, 7.4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.3, 22.7, 22.8, 22.11, 22.12, 23, 24, 26, 27, 28, and 30.
- 2.2 You may only use the Grant for carrying out the Project Activities. You may not make any changes to the Project Activities without ARIA's prior written agreement.
- 2.3 You may not unreasonably withhold, condition or delay your agreement to any changes requested by ARIA to the Project Activities or the amount of the Grant. Any agreed change will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

3. ENVIRONMENTAL AND SAFETY REQUIREMENTS

- 3.1 In performing the Project Activities, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. PAYMENT OF GRANT

- 4.1 Subject to the remainder of this clause 4, ARIA will pay the Grant to you:
- (a) up to the Maximum Sum;
 - (b) in pounds sterling (GBP) by wire transfer into your bank account, details of which you provided in the Confirmation of Bank Details form attached to the Grant Funding Letter; and
 - (c) if a tax is chargeable in respect of the Grant, all payments will be deemed to be inclusive of all such taxes and ARIA will not be obliged to pay any additional amount.
- 4.2 The bank account of which you provided details in your Confirmation of Bank Details form (and any alternative bank details nominated subsequently by you) must be an ordinary business bank account

with appropriate segregation of duties and control. During the Funding Period, you must notify ARIA of any change of bank account details as soon as reasonably practicable on the same form and signed by an approved signatory. You must notify ARIA of any change of signatory for approval, as soon as known.

- 4.3 You will be the sole recipient of the Grant and you will be responsible for managing the Grant as between you and any Third Parties involved in performing the Project Activities. This includes securing the repayment of the Grant if requested by ARIA in accordance with the Grant Conditions, including where the Grant has already been distributed to Third Parties.
- 4.4 You must promptly notify ARIA if any money is incorrectly paid to you for any reason, and must repay it as soon as reasonably practicable. Any amount not immediately repaid will be recoverable as a civil debt.
- 4.5 ARIA reserves the right not to pay any Grant Claims that are not submitted within the period set out in the Grant Funding Letter or that are incomplete, incorrect or not accompanied by full supporting documentation (including any documentation that ARIA reasonably requests).
- 4.6 You may not apply for or obtain Duplicate Funding for any Project Activities.
- 4.7 You may not retain any Unspent Monies and must repay them to ARIA within 30 days after ARIA's request for repayment.
- 4.8 You acknowledge the critical importance of cash flow for Sub-Contractors (including startups and small businesses) and commit to paying all valid and undisputed invoices relating to the Project within a maximum of 30 days from the date of receipt.
- 4.9 Where required, you will work with Sub-Contractors to arrange more frequent payment schedules (e.g., same day, weekly or milestone-based payments) to better support their cash flow needs.

5. ELIGIBLE AND INELIGIBLE EXPENDITURE

- 5.1 ARIA will only pay the Grant for Eligible Expenditure incurred by you in carrying out the Project Activities. You must provide ARIA with any evidence reasonably requested by ARIA (including receipts, invoices and other documentary evidence) that all Grant Claims relate to costs that are Eligible Expenditure.
- 5.2 You may not in any circumstance claim as Eligible Expenditure paid-for lobbying, which means using the Grant to fund lobbying (via an external firm or in-house staff) in order to undertake activities intended to influence or attempt to influence Parliament, government or political activity; or attempting to influence legislative or regulatory action.

6. GRANT REVIEW

- 6.1 ARIA will review the Grant at the intervals specified in the Grant Funding Letter. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.3.

- 6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:
- (a) consent to the Project Activities and the Grant Agreement continuing in line with existing plans;
 - (b) increase or decrease the Grant for the remainder of the Funding Period, as applicable;
 - (c) redefine the Milestones;
 - (d) require you to carry out remedial activity with the aim of improving delivery of the Project Activities; and/or
 - (e) terminate the Grant Agreement in accordance with clause 22.
- 6.3 Any change to these Grant Terms, the Project Activities, or the Grant pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Grant Agreement in accordance with clause 26.
- 6.4 Not used.

7. MONITORING AND REPORTING

- 7.1 You must closely monitor the carrying out of the Project Activities throughout the Funding Period and must notify ARIA as soon as reasonably practicable of any actual or potential failure to comply with any of your obligations under the Grant Agreement.
- 7.2 ARIA does not limit its engagement with you to purely administrative activities and will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project Activities. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.
- 7.3 You must provide ARIA with:
- (a) the Milestones and a report on your performance against the Milestones at the intervals and for the periods of time specified in the Grant Funding Letter. ARIA may copy and adapt the contents of any of the Milestones and those reports for ARIA's internal use to review, develop and shape ARIA's funded research programmes, but ARIA will treat those contents as your Confidential Information under clause 11;
 - (b) any assistance and information reasonably requested by ARIA to establish whether you have used the Grant in accordance with the Grant Agreement; and
 - (c) a quarterly report on the use of the Maximum Sum, details broken down in accordance with ARIA's prescribed form.
- 7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its funding activities and compliance with the terms of the Grant Agreement. ARIA will therefore have the right to make

reasonable requests for information from you from time to time after the end of the Funding Period about the impact metrics, commercial exploitation or other dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Grant Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Grant Agreement.

8. AUDITING AND ASSURANCE

- 8.1 For Grants between £100k and £500k: At the end of the Funding Period you must provide ARIA with independent assurance that the Grant has been used for carrying out the Project Activities. To satisfy this requirement you must provide a statement showing that the use of the Grant has been certified by an independent and appropriately qualified auditor or accountant.
- 8.2 Subject to clause 11, ARIA and/or its authorised representative may, at any time during the Funding Period and for up to 7 years after the end of the Funding Period, conduct audits in relation to your use of the Grant and your compliance with the Grant Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.
- 8.3 You must:
- (a) maintain an appropriate system of financial management and controls, maintain detailed records in relation to those controls, and provide copies of those records to ARIA on request; and
 - (b) retain, and procure that your Sub-Contractors retain and will provide to you on request, all relevant documentation relating to the Eligible Expenditure (including invoices, receipts and accounting records) during the Funding Period and for a period of 7 years thereafter.

9. FINANCIAL MANAGEMENT

- 9.1 You must:
- (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Grant; and
 - (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project Activities as soon as they are identified, and keep ARIA informed of your remedial actions.
- 9.2 In the event of any actual or suspected fraud, theft or other financial irregularity (which includes use of the Grant for any purpose other than that envisaged by the Grant Agreement), ARIA may, at its absolute discretion:
- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
 - (b) suspend the Project Activities and future payment of the Grant to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

- 10.1 You must inform ARIA promptly of any actual, perceived or potential conflicts between your and your Representatives' obligations under the Grant Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Funding Period.
- 10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that these conflicts are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you or your Representative to cease the conflicting activity and if that is not acceptable to you or your Representative, either party may terminate the Grant Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

- 11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the provision of the Project Activities, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.
- 11.2 ARIA may publish a summary of the Grant Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Grant Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.
- 11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:
- (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;
 - (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information necessary for the purpose concerned and obtains appropriate confidentiality undertakings in relation to such information;
 - (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and where no exception to disclosure under them is applicable; or

- (d) where that party (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.

11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under the Grant Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

12.1 Each party must comply with its obligations under the Law, including where applicable the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.

12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.

12.3 You acknowledge that ARIA, acting in accordance with the Information Acts (other than the FOIA), may disclose information concerning you and the Grant Agreement without consulting you. ARIA must take reasonable steps to notify you of any request for information to the extent permissible and reasonably practical and will give you adequate opportunity to make representations before ARIA discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.

12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or the Grant Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.

12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.

12.6 You must take account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.

- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with the Grant Agreement. If either party anticipates that the other will process any Personal Data on its behalf under the Grant Agreement it must notify the other party and the parties must agree a variation to the Grant Agreement under clause 26 to incorporate appropriate provisions (such as those set out in Schedule 4) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. SUBSIDY CONTROL AND STATE AID

- 14.1 ARIA intends that the Grant complies with the Subsidy Control Act 2022 on the basis that the Project Activities are not economic activities and do not give a specific advantage to one or more enterprises. You must take all reasonable steps to maintain this position and to assist ARIA to comply with the requirements of the Act and must cooperate with any investigations under the Act.
- 14.2 Where the EU state aid laws apply to the Grant (where the Project Activities will affect trade between Northern Ireland and the EU), you acknowledge that the Project Activities are designed and performed so they are compatible with state aid laws. You will take all reasonable steps to assist ARIA to comply with state aid law requirements and cooperate with any investigations by the European Commission into the Project Activities.
- 14.3 ARIA will immediately stop future payments of the Grant and may require repayment of some or all of the Grant if subsidy control or state aid laws so require for the funding to be compliant.

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and not seek to avoid their application by artificial means.

Background IP

- 15.2 The Grant Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Funding Period if any additional Background IP is required either to carry out the Project Activities or to exploit commercially any of the Results.

Foreground IP ownership

- 15.3 You will own all Foreground IP unless your policy is for individual researchers to own the Foreground IP they create, or you agree your Sub-Contractor (or another third party) will own all, or parts of, the Foreground IP. Where your Sub-Contractor or individual researchers (or any other third party involved in the performance of the Project Activities) will own any of the Foreground IP you must impose on them the obligations relating to Foreground IP and Results contained in clauses 15 and 16. Where you assign any Foreground IP to a Third Party (including your technology transfer company) you must impose on that Third Party the obligations relating to Foreground IP and Results contained in clauses 15 and 16.
- 15.4 You must submit all (i) all patents within or covering the Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the Future Proofing our Climate and

Weather Intellectual Property Pledge promptly following creation or filing (as applicable) of such patents and/or data (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge. You hereby agree to comply and uphold the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.5 You must ensure that whenever any Results are used with or communicated to Third Parties or are exploited commercially, ARIA's funding of the Project Activities is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and publication

- 15.6 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.7 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.8 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to fund future prosecution and maintenance and/or request the assignment of the patents to ARIA or its nominee.

Inventor first preference

- 15.9 Subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge if any inventor or active participant in the Project Activities expresses interest in the exploitation of the Foreground IP they have developed, you must give them an opportunity to negotiate an assignment or commercial licence of the Foreground IP, on reasonable terms, prior to negotiating with any entity in which an inventor or active participant in the Project Activities is not involved as a shareholder or other key stakeholder.

16. COMMERCIALISATION OF RESULTS

- 16.1 Save for Results that are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge, where they are capable of commercial exploitation you should seek to exploit the Results commercially. This should be done, where applicable, in accordance with the Commercialisation Hypothesis.
- 16.2 Save for Results that are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge, if for any reason you choose not to exploit any such Results commercially within a reasonable timeframe (or, where applicable, the timeframe set out in the Commercialisation

Hypothesis) you are encouraged to discuss the position with ARIA, and you may request that ARIA exploit them or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Non-UK Commercialisation

- 16.3 Save as set out in the Future Proofing our Climate and Weather Intellectual Property Pledge, to avoid any restriction on commercialisation, no consent is required from ARIA for any Non-UK commercialisation or any sale of Foreground IP to a Non-UK Entity. However, ARIA is set up to create value for the UK and therefore you must secure a fee payable to ARIA (**ARIA Non-UK Fee**) in each of the following circumstances:
- (a) where you are a Non-UK Entity;
 - (b) where you become a Non-UK Entity;
 - (c) where you assign or Commercially License any Foreground IP to a Non-UK Entity; or
 - (d) where you have assigned or Commercially Licensed any Foreground IP to a UK Entity that subsequently becomes a Non-UK Entity.
- 16.4 In order to avoid any unnecessary complexity, the ARIA Non-UK Fee will be based on the terms that you agree with any person to which you assign or Commercially License the relevant Foreground IP. This ARIA Non-UK Fee will amount to an additional twenty-five per cent (25%) of the value of the consideration (including upfronts, licence fees, milestone payments, royalties, shares or other securities, buyouts, exit fees and other consideration) that you receive from the exploitation of the relevant Foreground IP during any period that the above circumstances exist.
- 16.5 For example, if you would receive £100 (via royalty or royalty buyout), you must ensure your contractual mechanism enables you to collect an additional £25 and pay that additional amount to ARIA.
- 16.6 The ARIA Non-UK Fee is payable within 90 days after the end of each relevant Financial Year for receipts related to that calendar year. You are encouraged to use the clauses in Annex 1 in your Commercialisation Licences of Foreground IP.

Crown Body customers

- 16.7 You must ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities, and in suitable quantities for the Crown Body's requirements.

Spin-outs

- 16.8 ARIA seeks to maximise future investment of entrepreneurial talent and capital in start-up companies commercialising the Results of its funded activities. To that end, having funded the full economic cost of the research, ARIA places restrictions on the level of equity stakes and royalties that you may negotiate in exchange for the assignment or Commercialisation Licence of any Foreground IP.

- 16.9 If you or your technology transfer company assign or licence any Foreground IP to any third party or to a start-up established for the purpose of commercially exploiting the Results (a NewCo) you together with any connected person (including any investment fund to which you may transfer any part of your stake) shall be entitled to:

EITHER

- (a) hold or have the right to hold no more than 10% in fully-dilutable shares or equity (pre investment) in the third party or NewCo (with no other preferential subscription rights), not including any shares or equity subscribed for cash on arm's length terms alongside other investors;

OR

- (b) charge a royalty, with no upfront payments, annual fees, milestone payments or minimum royalties, payable by the third party or NewCo under any licence or assignment of the Foreground IP at no more than the relevant rate, and on the other terms, set out in Schedule 3.

- 16.10 The provisions of clauses 16.9(a) and 16.9(b) shall not apply to any equity taken or royalty charged in consideration of:

- (a) IP other than Foreground IP licensed or assigned to the third party or NewCo; or
(b) facilities, equipment, personnel or other material support or services provided to the third party or NewCo independent of the Project Activities,
with such equity or royalty limited to the proportion that reflects the contribution made by IP that is not Foreground IP.

- 16.11 You must notify ARIA in writing before any transaction completes of the overall equity stake or royalty percentages agreed under clause 16.8 (and any impact of clause 16.9, if relevant).

17. ASSETS

- 17.1 You must keep a register during the Funding Period and for up to 7 years after the end of the Funding Period of all Assets, with all relevant details about each Asset. You must use any Assets purchased with Grant monies for the Project Activities.
- 17.2 At the end of the Funding Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

- 18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Grant Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUBCONTRACTING

- 19.1 You may not transfer, assign, novate or otherwise dispose of the whole or any part of the Grant Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.
- 19.2 You shall not subcontract any of the Project Activities to a Third Party except to the extent permitted, and to the person or persons identified, in Schedule 2 Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractor as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Grant Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Grant Agreement.

20. BORROWING, LOSSES, GIFTS, SPECIAL PAYMENTS

- 20.1 You must obtain ARIA's prior written consent before:
- (a) borrowing or lending money from any source in connection with the Grant Agreement;
 - (b) giving any guarantee, indemnity, security over any Asset or letter of comfort in relation to the Grant Agreement;
 - (c) making any gift or writing off any debt or liability in connection with the Grant, and must keep a record of all gifts given and received in connection with the Grant.

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Grant and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Grant or publicise details of the Grant Agreement without the other's consent, except as required by Law.
- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

- 22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events occur:
- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13, 15.5 or 25, or commit a material breach of any other term of the Grant Agreement in the reasonable opinion of ARIA;
 - (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
 - (c) you fail to improve the performance of the Project Activities, notwithstanding your having undertaken the remedial activity agreed with ARIA in the remedial plan under clause 6.2(d);

- (d) you or the researchers involved in the Project Activities obtain any funding from a Third Party that, in the opinion of ARIA, undertakes activities that are likely to bring the reputation of the Project Activities or ARIA into disrepute;
- (e) you provide ARIA with any materially misleading or inaccurate information in your grant application or in subsequent related correspondence;
- (f) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Third Party, immediately upon becoming aware of it;
- (g) you are subject to an Insolvency Event;
- (h) the Grant or any part of it is held by a court or competent authority to be a prohibited subsidy under the Subsidy Control Act 2022 or an illegal state aid;
- (i) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project Activities;
 - (ii) result in your being unable to receive the Grant; and/or
 - (iii) raises national security concerns.

Rights reserved for ARIA in relation to an Event of Default

22.2 If an Event of Default has or may have occurred, ARIA may by written notice to you take any one or more of the following actions:

- (a) suspend the Project Activities and payment of the whole or any part of the Grant for such period as ARIA may determine, acting reasonably;
- (b) reduce the Maximum Sum, in which case the payment of Grant will thereafter be made in accordance with the reduction and notified to you; and/or
- (c) subject to clause 22.4, terminate the Grant Agreement with immediate effect as from the date of service of the notice of that termination.

22.3 Where this Grant Agreement is terminated for an Event of Default described in clause 22.1(f) or 22.1(h), ARIA may require you to repay the entire amount of the Grant previously paid to you.

Opportunity for you to remedy an Event of Default

22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:

- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and
- (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

22.5 Without prejudice to any other provision of the Grant Agreement, you may terminate the Grant Agreement on written notice to ARIA if ARIA commits a material breach of the Grant Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

General Termination Rights

- 22.6 Notwithstanding ARIA's right to terminate the Grant Agreement under clause 22.2(c), either party may terminate the Grant Agreement (in whole or in part) at any time by giving at least 60 days' prior written notice to the other party.
- 22.7 You must promptly notify ARIA in writing if at any time the principal investigator or any key researcher(s) named in Schedule 2 working on the Project Activities is unable or unwilling to continue to be involved in the Project Activities or is moving to a new organisation without the desire to continue the research. Within 60 days after the date of that notice, you must either:
- (a) nominate one or more successors, subject to ARIA's approval; or
 - (b) agree that the Grant is transferred to another organisation subject to your and the new organisation's agreement in writing and ARIA's approval of the transfer

If ARIA is unwilling to accept the nominated successor(s) or does not approve a request for transfer, it may terminate the Grant Agreement by at least 30 days' written notice to you.

Consequences of Termination

- 22.8 If the Grant Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.
- 22.9 Where ARIA terminates the Grant Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:
- (a) you taking all reasonable steps to mitigate such loss; and
 - (b) the Unavoidable Costs being:
 - (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Grant Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA;
 - (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you;
 - (v) costs that would not have been incurred had this Grant Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period).
- 22.10 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Services, over £250,000 will terminate automatically and immediately upon termination of this Agreement.

- 22.11 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Grant Agreement in the event that the Grant Agreement was terminated (calculated on the basis described in clause 22.8).
- 22.12 ARIA's total liability under clause 22.9 shall be limited to the Maximum Sum under the Grant Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.13 If the Grant Agreement is terminated or expires ARIA will not be liable to pay any of your costs or those of any of your contractors or suppliers related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Grant Funding Letter and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Grant Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Grant Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the Grant Manager and the Project Representative.
- 23.3 If the dispute cannot be resolved between the Grant Manager and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to a formal meeting between the parties' Escalation Contacts.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:
- (a) fraudulent misrepresentation or any other fraudulent act or omission;
 - (b) payment of sums properly due and owing to the other in the normal course of performance of this Grant Agreement;
 - (c) a breach of clause 13;
 - (d) liability arising under any indemnity in this Grant Agreement; or
 - (e) liability which may not lawfully be excluded or limited.
- 24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Grant Agreement or for ARIA's breach of this Grant Agreement), whether arising directly or indirectly, that may arise in connection with:
- (a) your carrying out the Project Activities;
 - (b) the use of the Grant by any person;
 - (c) any reduction, suspension, withdrawal or request for repayment of the Grant in accordance with this Grant Agreement; or

(d) termination of the Grant Agreement in accordance with this Grant Agreement.

24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:

- (a) loss of profit, sales or turnover;
- (b) loss of contracts or business opportunities;
- (c) loss of anticipated savings;
- (d) loss of goodwill or damage to reputation; or
- (e) any indirect, special or consequential loss or damage;

in each case arising out of or relating to the Grant Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.

24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to the Grant Agreement or its subject matter or anything which it has done or not done in connection with the Grant Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the amount of the Maximum Sum.

24.5 You shall under no circumstances in connection with this Grant Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.

24.6 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Grant Agreement.

25. RESEARCH ETHICS AND CODE OF CONDUCT

25.1 As a recipient of a Government grant you must operate in accordance with the Concordat.

25.2 All research data:

- (a) must be generated using sound scientific techniques and processes;
- (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and
- (c) must be analysed appropriately, without bias and in accordance with good scientific practices.

25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.

25.4 You must comply with the Code of Conduct and ensure that your Representatives undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

- 26.1 Any variation to the Grant Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

27. GENERAL

- 27.1 Notices: All notices and other communications in relation to this Grant Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such communications will be deemed to have been given and received on the third Working Day following such mailing.
- 27.2 Change of control: You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(i) is likely to apply.

28. GOVERNING LAW

- 28.1 This Grant Agreement (including any non-contractual disputes or claims arising in connection with this Grant Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. NOT USED

30. DEFINITIONS AND INTERPRETATION

- 30.1 Where they appear in these Conditions or the Grant Agreement:
- Adequate Insurance** means the insurance requirements and amounts set out in the Grant Funding Letter.
- Asset** means any asset that is purchased, improved or developed using the Grant including equipment and fixed assets;
- Background IP** means IP that is:
- (a) owned by or licensed to a party prior to the Commencement Date; or
 - (b) developed by or on behalf of a party during the Funding Period but not in connection with the Project Activities,
- and is in either case used in connection with the Project Activities;
- Bribery Act** means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;
- Change of Control** means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Recipients of Government General Grants published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754555/2018-11-06_Code_of_Conduct_for_Grant_Recipients.pdf

including any subsequent updates from time to time;

Commencement Date means the date set out in the Grant Funding Letter;

Commercialisation Licence means a licence of IP other than a research or evaluation licence and/or subcontract manufacture (and **Commercially License** means to license under a Commercialisation Licence);

Commercialisation Hypothesis means the exploitation plan approved by ARIA and set out at Schedule 2 Part 2, as may be amended by agreement between the parties during and after the Funding Period;

Completion Date means the date set out in the Grant Funding Letter;

Concordat means the Concordat to Support Research Integrity which can be found at <https://ukrio.org/about-us/the-concordat-to-support-research-integrity/>

Conditions means these ARIA Grant Conditions;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Grant Agreement, that ought reasonably to be considered to be confidential (whether or not it is so marked), (a) including: (i) information relating to the business, affairs, customers, clients, suppliers or plans of the disclosing party; (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party; (iii) any information developed by the parties in the course of carrying out the Project Activities; (iv) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Grant Agreement; and (v) and any information derived from any of the above,

(b) but not including information which: (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11); (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party; (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or (iv) is independently developed without access to the Confidential Information; and (v) the content of this specific version of the Grant Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

Duplicate Funding means funding provided to you by a Third Party which is to fund the same activities as the Project Activities;

EA means the Equality Act 2000 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Eligible Expenditure means the payments made by you during the Funding Period for the purposes of carrying out the Project Activities which comply with clause 5 and ARIA's published eligibility rules (which provide for full economic cost reimbursement) and as agreed in the Grant Funding Letter;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Grant Funding Letter;

Event of Default means any of the events or circumstances set out in clause 22.1;

Financial Year means 1 April to 31 March;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means any IP in the Results;

Funding Period means the period commencing on the Commencement Date and ending on the Completion Date or such later date as may be agreed between the parties unless otherwise determined in accordance with the terms of the Grant Agreement;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification (operated by ARIA or by a third party), in the form set out at Annex A;

GDPR means Regulation (EU) 2016/679;

Grant means the sum or sums ARIA will pay to you up to the amount set out in the Grant Funding Letter, in accordance with clause 4 and subject to the provisions set out at clause 22.

Grant Agreement has the meaning given in the Grant Funding Letter;

Grant Claim means a request submitted by you to ARIA for payment of the Grant;

Grant Funding Letter means the letter from ARIA to you to which these Conditions are annexed;

Grant Manager means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Grant;

Grant Review means the process for reviewing the grant outlined in clause 6;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Ineligible Expenditure means expenditure incurred by you which is not Eligible Expenditure as set out in clause 5 and ARIA's published eligibility rules;

Information Acts means the Data Protection Legislation, FOIA and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property Rights or **IP** means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions, semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation;

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise;

Maximum Sum means the maximum amount of the Grant stated in the Grant Funding Letter;

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

NewCo has the meaning given in clause 16;

Non-UK Entity means a legal entity that is not a UK Entity;

Personal Data has the meaning given to it in the Data Protection Legislation as amended from time to time;

Prohibited Act means:

(a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Grant Agreement; and/or (ii) showing or not showing favour or disfavour to any person in relation to the Grant Agreement;

(b) committing any offence: (i) under the Bribery Act; (ii) under legislation creating offences in respect of fraudulent acts; and/or (iii) at common law in respect of fraudulent acts in relation to the Grant Agreement; and/or

(c) defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the activities to be carried out by you that are described in the Grant Funding Letter and in Schedule 2 Part 1;

Project Representative means the representative appointed by you, who at the Commencement Date will be the individual listed as such in the Grant Funding Letter;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means all information, data, techniques, inventions, discoveries, works, software and materials generated in the course of the Project Activities;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Project Activities or any part thereof or facilities or services necessary for the performance of the Project Activities or any part thereof or necessary for the management, direction or control of the Project Activities or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

UK Entity means a legal entity whose ultimate parent company has its headquarters and principal establishment in the United Kingdom;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Grant Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Funding Period because of termination or breach of the Grant Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination; and

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 In these Conditions and the Grant Agreement, unless the context otherwise requires:

- (a) references to "party" and "parties" are to the parties to the Grant Agreement;
- (b) the singular includes the plural and vice versa;
- (c) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (d) references to clauses and Schedules are to the clauses of these Conditions and to the Schedules to the Grant Agreement;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation"; and
- (g) the headings in the Grant Agreement are for ease of reference only and will not affect the interpretation or construction of the Grant Agreement.

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

Space-based solar radiation management using sunshades is seen as a means of reducing solar insolation to offset the radiative forcing due to increased CO₂ concentration. A range of concepts have been proposed, with most centring on the use of multiple sunshades located sunward of the Sun-Earth L₁ Lagrange point on the line connecting the Sun and the Earth. In order to take the first steps towards such a future an end-to-end in-space demonstration is required. For example, a small sunshade could be delivered from a low-cost CubeSat platform in Earth orbit on a day/night orbit passing in front of the solar disk. An array of ground-based telescopes under the orbit ground track could then be used to image the sunshade as it passes in front of the solar disk, while attempting to measure the reduction in solar flux at the observation points.

2. Aims and objectives of the Project Activities

The top-level objective of the project is to deliver a technical assessment, cost estimate and schedule for a space-based solar radiation management technology demonstrator. The project will:

1. Define strategies which can demonstrate a measurable reduction in solar insolation in a minimum viable experiment;
2. Propose a mission concept to make such measurements;
3. Work with our industrial partner to determine technical feasibility and cost;
4. Define a multi-year phased development of the mission.

3. Project Activities

3.1 Work package (WP) summary:

WP1: Science goals for artificial solar occultation

WP1 will define the science goals, assess what occultation measurements could feasibly be made and provide inputs for subsequent WPs. The specific tasks comprise:

Task 1.1 Modelling of shading on Earth

Task 1.2 Measurement strategies

Task 1.3 Data analysis strategies

WP2: In-orbit technology demonstrator mission

WP2 will design the sunshade mission and spacecraft, trading off the different options and providing inputs for subsequent WPs 3 and 4. The specific tasks comprise:

Task 2.1 Mission design

Task 2.2 ADCS (attitude determination and control system)

Task 2.3 Spacecraft design

WP3: Industry assessment

WP3 will integrate the outputs of WP1 and WP2 to conduct an industrial assessment of the mission. This will include evaluating and defining a spacecraft solution, and identifying the necessary engineering modifications to AAC Clyde Space's EPIC spacecraft. Additionally, WP3 will assess the delivery timeline and total costs. WP3 will also provide support to WP1 and WP2 to ensure integration of the project tasks to deliver a feasible mission concept.

Task 3.1 Spacecraft design

Task 3.2 Programmatic assessment

Task 3.3 Commercial assessment

WP4: Mission roadmap, risks and reporting

WP4 will define the future development of the technology demonstration mission with a realistic assessment of the technical challenges, schedule and budget. The final report for ARIA will be delivered at the end of WP4. The specific tasks to be undertaken comprise:

Task 4.1 Mission roadmap planning and cost estimation

Task 4.2 Key technical challenges, programmatic and regulatory risks

Task 4.3 Final reporting to ARIA

3.2 The following Milestones will be used to monitor your delivery of the Project. The costs associated with completing these Milestones are estimated in the cost breakdown sheet 

ID	Milestones	Measure	Date
1	Completion of shading model and initial mission design	Completion of Task 1.1 and Task 2.1. Functional code to predict reduction in solar insolation. Feasible initial mission concept developed.	Commencement Date + 3 months
2	Completion of measurement strategy analysis	Completion of Task 1.2. Feasible strategy for solar insolation reduction measurement, and/or alternative scenarios (planetary disk, stellar occultation).	Commencement Date + 6 months
3	Completion of mission and spacecraft design for input to WP 3	Completion of Work package 1 and Work package 2 ready for industrial assessment by AAC Clyde Space.	Commencement Date + 9 months

In addition to the above Milestones, the following project plan will be used to track progress throughout the project and may be updated from time to time: [REDACTED]

3.3 The intended long-term outcomes are summarised below:

Space-based solar radiation management has long been discussed as a speculative concept for the future. The key motivation for the project is to assess the feasibility of a near-term, low cost end-to-end technology demonstration mission. If the study demonstrates that an end-to-end technology demonstrator is feasible, and falls within ARIA cost envelopes, the long-term outcome would be the first in-orbit demonstration of scaled solar radiation management, which would pave the way for future development of the technology.

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement
Kick off	• Roles and responsibilities • External communications • Project details
Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Invoicing and cost reporting Optional: • Key Learning, discoveries and decisions • Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • technical evidence saved to drive e.g. report or presentation as requested by PD • review meeting slide deck saved to drive as requested by PD Review meeting with ARIA Programme Team
Annual	• ARIA impact metrics

	Attendance at annual ARIA event
Ad hoc	- As required, Programme Director/ Programme Team may request additional information and evidence - Workshops - potential to be invited to ARIA workshops
Project closure	Project closure report

5. Payment

5.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments quarterly in arrears.

5.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

5.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end of the relevant period.

5.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

6. Principal investigator/key researchers

6.1 For the purposes of clause 22.7, the following principle investigators or key researchers have been identified:

Name	Role	Organisation
Colin McInnes	Principal Investigator	University of Glasgow
Matteo Ceriotti	Co-investigator	University of Glasgow
Onur Çelik	Co-investigator	Delft University of Technology

7. Sub-Contractors

7.1 For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Location
Delft University of Technology	Lead for Work package 1: Science goals for artificial solar occultation Contributor to Work package 4: Mission	Netherlands

	roadmap, risks and reporting	
AAC Clyde Space	Lead for Work package 3: Industry Assessment Contributor to Work package 4: Mission roadmap, risks and reporting	Glasgow

PART 2 - GRANT APPLICATION

Application titled "An assessment of a space-based solar radiation management technology demonstrator" submitted 6 December 2024

SCHEDULE 3

Royalty Percentages

Royalties on the sale or supply of products or services that are covered by, use or incorporate the Foreground IP licensed to the NewCo will only become due on aggregate net sales derived from the Foreground IP exceeding £50 million.

The maximum headline percentage royalty rate (i.e. before any royalty stacking, step-down or other reduction and excluding any ARIA Non-UK Fee) for products or services that are covered by, use or incorporate the Foreground IP, and of sublicensing income, shall be one of the following:

Type of product	Applicable headline royalty percentage (up to)
Low margin	0.5% of net sales
Medium margin	1% of net sales
High margin	2% of net sales
Sublicensing royalty	10% of net receipts

ANNEX 1

Clause for inclusion in licences of Foreground IP

[] **ARIA NON-UK FEE**

[].1 In this clause:

“ARIA” means the Advanced Research and Invention Agency;

“Crown Body” means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

“UK Entity” means a legal entity that has or whose ultimate parent company has its headquarters and principal establishment in the United Kingdom.

[].2 The Foreground IP was developed with funding from ARIA. As a condition of its funding ARIA requires that a benefit is returned to the United Kingdom where the Foreground IP is licensed by the Licensor to any person that is not a UK Entity. Accordingly, in addition to any other sums payable by the Licensee to the Licensor under this Agreement, the Licensee shall pay to the Licensor within 90 days after the end of each calendar year during the Relevant Period (as defined below), and within 90 days after the end of the Relevant Period, a fee (**ARIA Non-UK Fee**) on all amounts (including upfronts, licence fees, milestone payments, royalties, shares or other securities, exit fees, buyout or other consideration) payable by the Licensee to the Licensor under this Agreement in relation to the exploitation of any Foreground IP (**Relevant Amount**) that accrues during, or relates to, any period of time that the Licensee is not a UK Entity (**Relevant Period**). The amount of the ARIA Non-UK Fee is 25% of the Relevant Amount, and is payable by the Licensee to the Licensor in addition to the amounts that would otherwise be payable under this Agreement. For example if the Relevant Amount is £100 the ARIA Non-UK Fee is an additional £25, which the Licensee shall pay to the Licensor and the Licensor shall remit to ARIA.

Crown Body customers

[].3 You must also ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities and in suitable quantities for the Crown Body's requirements.

[].4 ARIA shall have the right to enforce this clause [] under the Contracts (Rights of Third Parties) Act 1999. Neither party may amend this Agreement in a way that detracts from ARIA's right to enforce its rights under this clause without ARIA's prior written consent.

[1] When using this clause you may substitute the relevant defined terms used elsewhere in the agreement to capture the concept of "Foreground IP". Where the clause refers to the "Licensor" and "Licensee" please use the appropriate defined terms to include the licensor, licensee, assignor and assignee of the Foreground IP. This clause is not suitable for assignments of the Foreground IP in consideration of the payment of one or more lump sum payments. In those cases the Licensor needs to be informed, and potentially make an additional payment, if the Foreground IP is subsequently assigned to a non-UK Entity or if the Assignee ceases to be a UK Entity.

SCHEDULE 4: Data Protection

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Grant Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Grant Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Grant Agreement:
 - 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are

relying on Domestic Law as the basis for processing Personal Data, you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;

- 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);
- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Grant Agreement unless required by Domestic Law to store the Personal Data; and

- 3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.
- 3.4. [[ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):
- 3.4.1. cancel its plans to change the affected sub-Processor;
- 3.4.2. offer an alternative which is acceptable to ARIA; or
- 3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.
- 3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Grant Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.
- 3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]
- 3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Grant agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it, storing it, retrieving it, consulting it, disseminating it or destroying it, etc.

	Note the definition of processing in the UK GDPR: <i>“any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction”]</i>
Duration of Processing:	Duration of this Grant Agreement (and any post termination processing that is permitted / required).
Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called “special categories” of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: <i>“data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation”]</i>
Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors,

	clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. You shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.
- 4.2. Any limitation of liability set out in this Grant Agreement will not apply to this Schedule's indemnity or reimbursement obligations.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

1. Submission of Pledged Patents and Experimental Data
 - 1.1 The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
 - 1.2 The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.
2. Experimental Data Licence
 - 2.1 Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
 - 2.2 The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
 - 2.3 The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
 - 2.4 The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).
3. Research Licence
 - 3.1 Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
 - 3.2 The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
 - 3.3 Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.

3.5 The Research Licensee must:

- (a) at all times when using the Pledged Patents comply with all Laws; and
- (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).

4. Commercial Licence

4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.

4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.

4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.

5. Pledgor Know-How

At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.

6. Termination

6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:

- (a) materially breaches the terms of such licence or this Pledge; or
- (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).

7. Transfers of Pledged Patents and/or Experimental Data

The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.

8. No Warranty

The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and

Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

University of Reading **(Grant Recipient)**

Whiteknights House, Reading RG6 6UR

03 July 2025

Attention: Giles Harrison

Dear Giles,

FPCW-PR01-P004 BrightSpark: cloud brightening with electric charge– Standard Grant Funding Letter

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to Exploring Climate Cooling and ARIA is pleased to offer you a Grant for the performance of the Project Activities up to the Maximum Sum, subject to your agreement to, and compliance with, the terms and conditions set out in this Grant Funding Letter and its Schedules.

1. Overview of the Grant

Any reference in this letter to "you" or "your" means the Grant Recipient and any capitalised terms have the meanings given in the ARIA Grant Conditions (Conditions).

The key elements of the Grant are described in the table below:

Project Activities	BrightSpark: cloud brightening with electric charge. A more detailed description of the Project Activities is set out in Schedule 2 (Project Activities).
Maximum Sum of the Grant (inclusive of taxes)	£1,970,786 (inclusive of all taxes where applicable)
Commencement Date	The commencement date is 1 September 2025
Completion Date	The completion is 31 August 2028
Grant Review Intervals	ARIA will review the Grant at quarterly intervals using the process referred to in clause 6 of the Conditions

Adequate Insurance	Employers' liability - At least £5 million (as required by the Employers' Liability (Compulsory Insurance Act 1969)) Public liability: £5 million (per year in aggregate)	
Monitoring and Reporting	The performance reports referred to in clause 7 of the Conditions shall be provided at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Project Representative	Prof Giles Harrison, Department of Meteorology, University of Reading [REDACTED] [REDACTED]	
Grant Manager	Mark Symes, Programme Director, [REDACTED]	
Escalation Contacts	ARIA	Grant Recipient
	Chief Product Officer [REDACTED]	For contractual escalation: SMPCS Contracts Manager, The University of Reading, Research and Enterprise, [REDACTED] [REDACTED] [REDACTED] [REDACTED] [REDACTED] For technical escalation: Giles Harrison, Professor of Atmospheric Physics, Department of Meteorology, The University of Reading, [REDACTED] [REDACTED] [REDACTED] [REDACTED]

Notices	ARIA Contracts 	 For contractual notices: SMPCS Contracts Manager, The University of Reading, Research and Enterprise, For technical notices: Giles Harrison, Professor of Atmospheric Physics, Department of Meteorology, The University of Reading,

Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Grant and return it to finance@aria.org.uk

3. The Grant Agreement

- 3.1. Once you sign a copy of this Grant Funding Letter in accordance with paragraph 6 (Acceptance) below, it will form a binding "**Grant Agreement**" between you and ARIA that includes and incorporates the following documents:
- 3.1.1. the **Grant Conditions** in Schedule 1;
 - 3.1.2. the **Project Activities, Milestones** and **Grant Application** in Schedule 2;
 - 3.1.3. the **Royalty percentages** (including annexes) in Schedule 3; and
 - 3.1.4. the terms relating to Data Protection in Schedule 4.
- 3.2. The parties confirm that it is their intention to be legally bound by the Grant Agreement.

3.3. Not used

4. Warranties

4.1. By signing this Grant Funding Letter, you warrant and represent that:

- 4.1.1. your obligations under the Grant Agreement are legal, valid, binding and enforceable;
- 4.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Grant Agreement have been obtained;
- 4.1.3. the person signing the Grant Agreement is duly authorised to sign on your behalf; and
- 4.1.4. your Project Representative referenced in the table above is authorised to make decisions and provide information on your behalf.

5. Amendments to the Grant Conditions

Not Used

6. Acceptance

- 6.1. To accept this Grant Funding Letter, please arrange for an authorised signatory to sign and date the duplicate copy of this Grant Funding Letter as indicated below, and return to ARIA as a complete signed original of the Grant Agreement including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Grant Agreement and to bind the Grant Recipient.
- 6.2. The offer of this Grant Funding Letter will expire on 7 July 2025.

Yours sincerely

for and on behalf of ARIA

Name of ARIA signatory:

Position Held:

Date:

I confirm the agreement of University of Reading to the terms and conditions in this Grant Funding Letter and its Schedules.

Signature:

Name:

Position:

Date:

SCHEDULE 1 - GRANT CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up the Grant Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Grant Funding Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to the Grant Agreement with the exception of Schedule 2 Part 2 (the Grant Application);
 - (d) Schedule 2 Part 2 (the Grant Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, the Grant Agreement.

2. DURATION AND PURPOSE OF THE GRANT

- 2.1 The Grant Agreement will subsist for the duration of the Funding Period unless extended by written agreement signed by a duly authorised representative of the parties or terminated earlier in accordance with its terms. Any provision of the Grant Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Grant Agreement shall remain in full force and effect, including clauses 1, 2, 4, 7.4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.3, 22.7, 22.8, 22.11, 22.12, 23, 24, 26, 27, 28, and 30.
- 2.2 You may only use the Grant for carrying out the Project Activities. You may not make any changes to the Project Activities without ARIA's prior written agreement.
- 2.3 You may not unreasonably withhold, condition or delay your agreement to any changes requested by ARIA to the Project Activities or the amount of the Grant. Any agreed change will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

3. ENVIRONMENTAL AND SAFETY REQUIREMENTS

- 3.1 In performing the Project Activities, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. PAYMENT OF GRANT

- 4.1 Subject to the remainder of this clause 4, ARIA will pay the Grant to you:
- (a) up to the Maximum Sum;
 - (b) in pounds sterling (GBP) by wire transfer into your bank account, details of which you provided in the Confirmation of Bank Details form attached to the Grant Funding Letter; and
 - (c) if a tax is chargeable in respect of the Grant, all payments will be deemed to be inclusive of all such taxes and ARIA will not be obliged to pay any additional amount.
- 4.2 The bank account of which you provided details in your Confirmation of Bank Details form (and any alternative bank details nominated subsequently by you) must be an ordinary business bank account

with appropriate segregation of duties and control. During the Funding Period, you must notify ARIA of any change of bank account details as soon as reasonably practicable on the same form and signed by an approved signatory. You must notify ARIA of any change of signatory for approval, as soon as known.

- 4.3 You will be the sole recipient of the Grant and you will be responsible for managing the Grant as between you and any Third Parties involved in performing the Project Activities. This includes securing the repayment of the Grant if requested by ARIA in accordance with the Grant Conditions, including where the Grant has already been distributed to Third Parties.
- 4.4 You must promptly notify ARIA if any money is incorrectly paid to you for any reason, and must repay it as soon as reasonably practicable. Any amount not immediately repaid will be recoverable as a civil debt.
- 4.5 ARIA reserves the right not to pay any Grant Claims that are not submitted within the period set out in the Grant Funding Letter or that are incomplete, incorrect or not accompanied by full supporting documentation (including any documentation that ARIA reasonably requests).
- 4.6 You may not apply for or obtain Duplicate Funding for any Project Activities.
- 4.7 You may not retain any Unspent Monies and must repay them to ARIA within 30 days after ARIA's request for repayment.
- 4.8 You acknowledge the critical importance of cash flow for Sub-Contractors (including startups and small businesses) and commit to paying all valid and undisputed invoices relating to the Project within a maximum of 30 days from the date of receipt.
- 4.9 Where required, you will work with Sub-Contractors to arrange more frequent payment schedules (e.g., same day, weekly or milestone-based payments) to better support their cash flow needs.

5. ELIGIBLE AND INELIGIBLE EXPENDITURE

- 5.1 ARIA will only pay the Grant for Eligible Expenditure incurred by you in carrying out the Project Activities. You must provide ARIA with any evidence reasonably requested by ARIA (including receipts, invoices and other documentary evidence) that all Grant Claims relate to costs that are Eligible Expenditure.
- 5.2 You may not in any circumstance claim as Eligible Expenditure paid-for lobbying, which means using the Grant to fund lobbying (via an external firm or in-house staff) in order to undertake activities intended to influence or attempt to influence Parliament, government or political activity; or attempting to influence legislative or regulatory action.

6. GRANT REVIEW

- 6.1 ARIA will review the Grant at the intervals specified in the Grant Funding Letter. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.3.

- 6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:
- (a) consent to the Project Activities and the Grant Agreement continuing in line with existing plans;
 - (b) increase or decrease the Grant for the remainder of the Funding Period, as applicable;
 - (c) redefine the Milestones;
 - (d) require you to carry out remedial activity with the aim of improving delivery of the Project Activities; and/or
 - (e) terminate the Grant Agreement in accordance with clause 22.
- 6.3 Any change to these Grant Terms, the Project Activities, or the Grant pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Grant Agreement in accordance with clause 26.
- 6.4 For the avoidance of doubt any decision to terminate the Grant Agreement as a result of a Go/No Go Milestone will be made at ARIA's sole discretion and done so in accordance with clause 22.6.

7. MONITORING AND REPORTING

- 7.1 You must closely monitor the carrying out of the Project Activities throughout the Funding Period and must notify ARIA as soon as reasonably practicable of any actual or potential failure to comply with any of your obligations under the Grant Agreement.
- 7.2 ARIA does not limit its engagement with you to purely administrative activities and will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project Activities. ARIA will treat the Results and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.
- 7.3 You must provide ARIA with:
- (a) the Milestones and a report on your performance against the Milestones at the intervals and for the periods of time specified in the Grant Funding Letter. ARIA may copy and adapt the contents of any of the Milestones and those reports for ARIA's internal use to review, develop and shape ARIA's funded research programmes, but ARIA will treat those contents as your Confidential Information under clause 11;
 - (b) any assistance and information reasonably requested by ARIA to establish whether you have used the Grant in accordance with the Grant Agreement; and
 - (c) a quarterly report on the use of the Maximum Sum, details broken down in accordance with ARIA's prescribed form.

- 7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its funding activities and compliance with the terms of the Grant Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time after the end of the Funding Period about the impact metrics, commercial exploitation or other dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Grant Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Grant Agreement.

8. AUDITING AND ASSURANCE

- 8.1 Annually, and on each anniversary of the Commencement Date and at the end of the Funding Period you must provide ARIA with independent assurance that the Grant has been used for carrying out the Project Activities. To satisfy this requirement you must provide a statement showing that the use of the Grant has been certified by an independent and appropriately qualified auditor or accountant.]
- 8.2 Subject to clause 11, ARIA and/or its authorised representative may, at any time during the Funding Period and for up to 7 years after the end of the Funding Period, conduct audits in relation to your use of the Grant and your compliance with the Grant Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.
- 8.3 You must:
- (a) maintain an appropriate system of financial management and controls, maintain detailed records in relation to those controls, and provide copies of those records to ARIA on request; and
 - (b) retain, and procure that your Sub-Contractors retain and will provide to you on request, all relevant documentation relating to the Eligible Expenditure (including invoices, receipts and accounting records) during the Funding Period and for a period of 7 years thereafter.

9. FINANCIAL MANAGEMENT

- 9.1 You must:
- (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Grant; and
 - (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project Activities as soon as they are identified, and keep ARIA informed of your remedial actions.
- 9.2 In the event of any actual or suspected fraud, theft or other financial irregularity (which includes use of the Grant for any purpose other than that envisaged by the Grant Agreement), ARIA may, at its absolute discretion:

- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
- (b) suspend the Project Activities and future payment of the Grant to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation. You must, if required by ARIA, refer the matter to an external auditor or any other relevant Third Party.

10. CONFLICTS OF INTEREST

- 10.1 You must inform ARIA promptly of any actual, perceived or potential conflicts between your and your Representatives' obligations under the Grant Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or potential conflicts of interest, whether identified in the application process or notified to ARIA during the Funding Period.
- 10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that these conflicts are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you or your Representative to cease the conflicting activity and if that is not acceptable to you or your Representative, either party may terminate the Grant Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

- 11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by the other party, each party must treat all Confidential Information belonging to or disclosed by the other party as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the other party, except to any persons who are directly involved in the provision of the Project Activities, who need to know the information and who are subject to binding obligations of confidentiality to the disclosing party.
- 11.2 ARIA may publish a summary of the Grant Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Grant Agreement agreed from time to time. Additionally, ARIA may publish a copy of the Milestones (in whole or in part) in any medium (provided that, where such Milestones contain or constitute your Confidential Information, ARIA has given you a reasonable opportunity to make representations in respect of any redactions or amendments you wish to be applied). For the avoidance of doubt, ARIA's publication rights under this clause 11.2 are exercisable at ARIA's sole discretion.
- 11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of the other party:
 - (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;
 - (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information necessary for the purpose

concerned and obtains appropriate confidentiality undertakings in relation to such information;

- (c) where disclosure is required by Law, including under the Information Acts to the extent they apply to that party and where no exception to disclosure under them is applicable; or
- (d) where that party (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.

- 11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under the Grant Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

- 12.1 Each party must comply with its obligations under the Law, including where applicable the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.
- 12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.
- 12.3 You acknowledge that ARIA, acting in accordance with the Information Acts (other than the FOIA), may disclose information concerning you and the Grant Agreement without consulting you. ARIA must take reasonable steps to notify you of any request for information to the extent permissible and reasonably practical and will give you adequate opportunity to make representations before ARIA discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.
- 12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or the Grant Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.
- 12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.
- 12.6 You must take account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

- 13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.
- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with the Grant Agreement. If either party anticipates that the other will process any Personal Data on its behalf under the Grant Agreement it must notify the other party and the parties must agree a variation to the Grant Agreement under clause 26 to incorporate appropriate provisions in accordance with, or as otherwise required by, the Data Protection Legislation.

14. SUBSIDY CONTROL AND STATE AID

- 14.1 ARIA intends that the Grant complies with the Subsidy Control Act 2022 on the basis that the Project Activities are not economic activities and do not give a specific advantage to one or more enterprises. You must take all reasonable steps to maintain this position and to assist ARIA to comply with the requirements of the Act and must cooperate with any investigations under the Act.
- 14.2 Where the EU state aid laws apply to the Grant (where the Project Activities will affect trade between Northern Ireland and the EU), you acknowledge that the Project Activities are designed and performed so they are compatible with state aid laws. You will take all reasonable steps to assist ARIA to comply with state aid law requirements and cooperate with any investigations by the European Commission into the Project Activities.
- 14.3 ARIA will immediately stop future payments of the Grant and may require repayment of some or all of the Grant if subsidy control or state aid laws so require for the funding to be compliant.

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and not seek to avoid their application by artificial means.

Background IP

- 15.2 The Grant Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Funding Period if any additional Background IP is required either to carry out the Project Activities or to exploit commercially any of the Results.

Foreground IP ownership

- 15.3 You will own all Foreground IP unless your policy is for individual researchers to own the Foreground IP they create, or you agree your Sub-Contractor (or another third party) will own all, or parts of, the Foreground IP. Where your Sub-Contractor or individual researchers (or any other third party involved in the performance of the Project Activities) will own any of the Foreground IP you must impose on them the obligations relating to Foreground IP and Results contained in clauses 15 and 16. Where you

assign any Foreground IP to a Third Party (including your technology transfer company) you must impose on that Third Party the obligations relating to Foreground IP and Results contained in clauses 15 and 16.

- 15.4 You must submit all (i) all patents within or covering the Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the Future Proofing our Climate and Weather Intellectual Property Pledge promptly following creation or filing (as applicable) of such patents and/or data (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge. You hereby agree to comply and uphold the terms of the Future Proofing our Climate and Weather Intellectual Property Pledge.

Attribution to ARIA

- 15.5 You must ensure that whenever any Results are used with or communicated to Third Parties or are exploited commercially, ARIA's funding of the Project Activities is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and publication

- 15.6 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.7 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.8 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to fund future prosecution and maintenance and/or request the assignment of the patents to ARIA or its nominee.

Inventor first preference

- 15.9 Subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge] if any inventor or active participant in the Project Activities expresses interest in the exploitation of the Foreground IP they have developed, you must give them an opportunity to negotiate an assignment or commercial licence of the Foreground IP, on reasonable terms, prior to negotiating with any entity in which an inventor or active participant in the Project Activities is not involved as a shareholder or other key stakeholder.

16. COMMERCIALISATION OF RESULTS

- 16.1 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge], where they are capable of commercial exploitation you should seek to exploit the Results commercially. This should be done, where applicable, in accordance with the Commercialisation Hypothesis.
- 16.2 Save for Results that are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge], if for any reason you choose not to exploit any such Results commercially within a reasonable timeframe (or, where applicable, the timeframe set out in the Commercialisation Hypothesis) you are encouraged to discuss the position with ARIA, and you may request that ARIA exploit them or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Non-UK Commercialisation

- 16.3 Save as set out in the [Future Proofing our Climate and Weather Intellectual Property Pledge], to avoid any restriction on commercialisation, no consent is required from ARIA for any Non-UK commercialisation or any sale of Foreground IP to a Non-UK Entity. However, ARIA is set up to create value for the UK and therefore you must secure a fee payable to ARIA (**ARIA Non-UK Fee**) in each of the following circumstances:
- (a) where you are a Non-UK Entity;
 - (b) where you become a Non-UK Entity;
 - (c) where you assign or Commercially License any Foreground IP to a Non-UK Entity; or
 - (d) where you have assigned or Commercially Licensed any Foreground IP to a UK Entity that subsequently becomes a Non-UK Entity.
- 16.4 In order to avoid any unnecessary complexity, the ARIA Non-UK Fee will be based on the terms that you agree with any person to which you assign or Commercially License the relevant Foreground IP. This ARIA Non-UK Fee will amount to an additional twenty-five per cent (25%) of the value of the consideration (including upfronts, licence fees, milestone payments, royalties, shares or other securities, buyouts, exit fees and other consideration) that you receive from the exploitation of the relevant Foreground IP during any period that the above circumstances exist.
- 16.5 For example, if you would receive £100 (via royalty or royalty buyout), you must ensure your contractual mechanism enables you to collect an additional £25 and pay that additional amount to ARIA.
- 16.6 The ARIA Non-UK Fee is payable within 90 days after the end of each relevant Financial Year for receipts related to that calendar year. You are encouraged to use the clauses in Annex 1 in your Commercialisation Licences of Foreground IP.

Crown Body customers

- 16.7 You must ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities, and in suitable quantities for the Crown Body's requirements.

Spin-outs

- 16.8 ARIA seeks to maximise future investment of entrepreneurial talent and capital in start-up companies commercialising the Results of its funded activities. To that end, having funded the full economic cost of the research, ARIA places restrictions on the level of equity stakes and royalties that you may negotiate in exchange for the assignment or Commercialisation Licence of any Foreground IP.
- 16.9 If you or your technology transfer company assign or licence any Foreground IP to any third party or to a start-up established for the purpose of commercially exploiting the Results (a NewCo) you together with any connected person (including any investment fund to which you may transfer any part of your stake) shall be entitled to:

EITHER

- (a) hold or have the right to hold no more than 10% in fully-dilutable shares or equity (pre investment) in the third party or NewCo (with no other preferential subscription rights), not including any shares or equity subscribed for cash on arm's length terms alongside other investors;

OR

- (b) charge a royalty, with no upfront payments, annual fees, milestone payments or minimum royalties, payable by the third party or NewCo under any licence or assignment of the Foreground IP at no more than the relevant rate, and on the other terms, set out in Schedule 3.

- 16.10 The provisions of clauses 16.9(a) and 16.9(b) shall not apply to any equity taken or royalty charged in consideration of:
- (a) IP other than Foreground IP licensed or assigned to the third party or NewCo; or
- (b) facilities, equipment, personnel or other material support or services provided to the third party or NewCo independent of the Project Activities,
- with such equity or royalty limited to the proportion that reflects the contribution made by IP that is not Foreground IP.
- 16.11 You must notify ARIA in writing before any transaction completes of the overall equity stake or royalty percentages agreed under clause 16.8 (and any impact of clause 16.9, if relevant).

17. ASSETS

- 17.1 You must keep a register during the Funding Period and for up to 7 years after the end of the Funding Period of all Assets, with all relevant details about each Asset. You must use any Assets purchased with Grant monies for the Project Activities.
- 17.2 At the end of the Funding Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

- 18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Grant Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUBCONTRACTING

- 19.1 You may not transfer, assign, novate or otherwise dispose of the whole or any part of the Grant Agreement or any rights under it, to another organisation or individual, without ARIA's prior written consent.
- 19.2 You shall not subcontract any of the Project Activities to a Third Party except to the extent permitted, and to the person or persons identified, in Schedule 2 Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractor as though they were your own, and (ii) enter into a written agreement with each Sub-Contractor on terms that are at least as protective of ARIA's rights and interests as the terms of this Grant Agreement and which contains all other provisions as are necessary to ensure that the Sub-Contractor complies with your obligations under this Grant Agreement.

20. BORROWING, LOSSES, GIFTS, SPECIAL PAYMENTS

- 20.1 You must obtain ARIA's prior written consent before:
- (a) borrowing or lending money from any source in connection with the Grant Agreement;
 - (b) giving any guarantee, indemnity, security over any Asset or letter of comfort in relation to the Grant Agreement;
 - (c) making any gift or writing off any debt or liability in connection with the Grant, and must keep a record of all gifts given and received in connection with the Grant.

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Grant and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Grant or publicise details of the Grant Agreement without the other's consent, except as required by Law.
- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

- 22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events occur:

- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13, 15.5 or 25, or commit a material breach of any other term of the Grant Agreement in the reasonable opinion of ARIA;
- (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
- (c) you fail to improve the performance of the Project Activities, notwithstanding your having undertaken the remedial activity agreed with ARIA in the remedial plan under clause 6.2(d);
- (d) you or the researchers involved in the Project Activities obtain any funding from a Third Party that, in the opinion of ARIA, undertakes activities that are likely to bring the reputation of the Project Activities or ARIA into disrepute;
- (e) you provide ARIA with any materially misleading or inaccurate information in your grant application or in subsequent related correspondence;
- (f) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Third Party, immediately upon becoming aware of it;
- (g) you are subject to an Insolvency Event;
- (h) the Grant or any part of it is held by a court or competent authority to be a prohibited subsidy under the Subsidy Control Act 2022 or an illegal state aid;
- (i) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project Activities;
 - (ii) result in your being unable to receive the Grant; and/or
 - (iii) raises national security concerns.

Rights reserved for ARIA in relation to an Event of Default

- 22.2 If an Event of Default has or may have occurred, ARIA may by written notice to you take any one or more of the following actions:
- (a) suspend the Project Activities and payment of the whole or any part of the Grant for such period as ARIA may determine, acting reasonably;
 - (b) reduce the Maximum Sum, in which case the payment of Grant will thereafter be made in accordance with the reduction and notified to you; and/or
 - (c) subject to clause 22.4, terminate the Grant Agreement with immediate effect as from the date of service of the notice of that termination.
- 22.3 Where this Grant Agreement is terminated for an Event of Default described in clause 22.1(f) or 22.1(h), ARIA may require you to repay the entire amount of the Grant previously paid to you.

Opportunity for you to remedy an Event of Default

- 22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:
- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and

- (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

22.5 Without prejudice to any other provision of the Grant Agreement, you may terminate the Grant Agreement on written notice to ARIA if ARIA commits a material breach of the Grant Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

General Termination Rights

22.6 Notwithstanding ARIA's right to terminate the Grant Agreement under clause 22.2(c), either party may terminate the Grant Agreement (in whole or in part) at any time by giving at least 60 days' prior written notice to the other party.

22.7 You must promptly notify ARIA in writing if at any time the principal investigator or any key researcher(s) named in Schedule 2 working on the Project Activities is unable or unwilling to continue to be involved in the Project Activities or is moving to a new organisation without the desire to continue the research. Within 60 days after the date of that notice, you must either:

- (a) nominate one or more successors, subject to ARIA's approval; or
- (b) agree that the Grant is transferred to another organisation subject to your and the new organisation's agreement in writing and ARIA's approval of the transfer

If ARIA is unwilling to accept the nominated successor(s) or does not approve a request for transfer, it may terminate the Grant Agreement by at least 30 days' written notice to you.

Consequences of Termination

22.8 If the Grant Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.

22.9 Where ARIA terminates the Grant Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:

- (a) you taking all reasonable steps to mitigate such loss; and
- (b) the Unavoidable Costs being:
 - (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Grant Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA;

- (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you;
- (v) costs that would not have been incurred had this Grant Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period).

- 22.10 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Services, over £250,000 will terminate automatically and immediately upon termination of this Agreement.
- 22.11 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Grant Agreement in the event that the Grant Agreement was terminated (calculated on the basis described in clause 22.8).
- 22.12 ARIA's total liability under clause 22.9 shall be limited to the Maximum Sum under the Grant Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.
- 22.13 If the Grant Agreement is terminated or expires ARIA will not be liable to pay any of your costs or those of any of your contractors or suppliers related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Grant Funding Letter and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Grant Agreement.

23. DISPUTE RESOLUTION

- 23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Grant Agreement.
- 23.2 All disputes and complaints must be referred in the first instance to the Grant Manager and the Project Representative.
- 23.3 If the dispute cannot be resolved between the Grant Manager and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to a formal meeting between the parties' Escalation Contacts.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:
- (a) fraudulent misrepresentation or any other fraudulent act or omission;
 - (b) payment of sums properly due and owing to the other in the normal course of performance of this Grant Agreement;
 - (c) a breach of clause 13;

- (d) liability arising under any indemnity in this Grant Agreement; or
- (e) liability which may not lawfully be excluded or limited.

24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses (except, for clarity, as set out in this Grant Agreement or for ARIA's breach of this Grant Agreement), whether arising directly or indirectly, that may arise in connection with:

- (a) your carrying out the Project Activities;
- (b) the use of the Grant by any person;
- (c) any reduction, suspension, withdrawal or request for repayment of the Grant in accordance with this Grant Agreement; or
- (d) termination of the Grant Agreement in accordance with this Grant Agreement.

24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:

- (a) loss of profit, sales or turnover;
- (b) loss of contracts or business opportunities;
- (c) loss of anticipated savings;
- (d) loss of goodwill or damage to reputation; or
- (e) any indirect, special or consequential loss or damage;

in each case arising out of or relating to the Grant Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.

24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to the Grant Agreement or its subject matter or anything which it has done or not done in connection with the Grant Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the amount of the Maximum Sum.

24.5 You shall under no circumstances in connection with this Grant Agreement be entitled to recover damages, or obtain payment, reimbursement or restitution more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.

24.6 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Grant Agreement.

25. RESEARCH ETHICS AND CODE OF CONDUCT

25.1 As a recipient of a Government grant you must operate in accordance with the Concordat.

25.2 All research data:

- (a) must be generated using sound scientific techniques and processes;
- (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and

(c) must be analysed appropriately, without bias and in accordance with good scientific practices.

25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.

25.4 You must comply with the Code of Conduct and ensure that your Representatives undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

26.1 Any variation to the Grant Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

27. GENERAL

27.1 Notices: All notices and other communications in relation to this Grant Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such communications will be deemed to have been given and received on the third Working Day following such mailing.

27.2 Change of control: You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(i) is likely to apply.

28. GOVERNING LAW

28.1 This Grant Agreement (including any non-contractual disputes or claims arising in connection with this Grant Agreement) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. Not used

30. DEFINITIONS AND INTERPRETATION

30.1 Where they appear in these Conditions or the Grant Agreement:

Adequate Insurance means the insurance requirements and amounts set out in the Grant Funding Letter.

Asset means any asset that is purchased, improved or developed using the Grant including equipment and fixed assets;

Background IP means IP that is:

(a) owned by or licensed to a party prior to the Commencement Date; or
(b) developed by or on behalf of a party during the Funding Period but not in connection with the Project Activities,

and is in either case used in connection with the Project Activities;

Bribery Act means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;

Change of Control means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Recipients of Government General Grants published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754555/2018-11-06_Code_of_Conduct_for_Grant_Recipients.pdf

including any subsequent updates from time to time;

Commencement Date means the date set out in the Grant Funding Letter;

Commercialisation Licence means a licence of IP other than a research or evaluation licence and/or subcontract manufacture (and **Commercially License** means to license under a Commercialisation Licence);

Commercialisation Hypothesis means the exploitation plan approved by ARIA and set out at Schedule 2 Part 2, as may be amended by agreement between the parties during and after the Funding Period;

Completion Date means the date set out in the Grant Funding Letter;

Concordat means the Concordat to Support Research Integrity which can be found at <https://ukrio.org/about-us/the-concordat-to-support-research-integrity/>

Conditions means these ARIA Grant Conditions;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by or on behalf of a party to the other party, whether before or after the date of the Grant Agreement, that ought reasonably to be considered to be confidential (whether or not it is so marked), (a) including: (i) information relating to the business, affairs, customers, clients, suppliers or plans of the disclosing party; (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party; (iii) any information developed by the parties in the course of carrying out the Project Activities; (iv) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Grant Agreement; and (v) and any information derived from any of the above,

(b) but not including information which: (i) was public knowledge at the time of disclosure (otherwise than by breach of clause 11); (ii) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party; (iii) is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure; or (iv) is independently developed without access to the Confidential Information; and (v) the content of this specific version of the Grant Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party;

Crown Body means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Data Protection Legislation means all applicable laws from time to time in force in England and Wales on data protection, including but not limited to, the Data Protection Act 2018, the retained EU law version of the GDPR and the Privacy and Electronic Communications (EC Directive) Regulations 2003, SI 2003/2426, and any national laws or regulations implementing Directive 2002/58/EC (as updated by Directive 2009/136/EC) and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

Duplicate Funding means funding provided to you by a Third Party which is to fund the same activities as the Project Activities;

EA means the Equality Act 2000 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Eligible Expenditure means the payments made by you during the Funding Period for the purposes of carrying out the Project Activities which comply with clause 5 and ARIA's published eligibility rules (which provide for full economic cost reimbursement) and as agreed in the Grant Funding Letter;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Grant Funding Letter;

Event of Default means any of the events or circumstances set out in clause 22.1;

Financial Year means 1 April to 31 March;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means any IP in the Results;

Funding Period means the period commencing on the Commencement Date and ending on the Completion Date or such later date as may be agreed between the parties unless otherwise determined in accordance with the terms of the Grant Agreement;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification (operated by ARIA or by a third party), in the form set out at Annex A;

GDPR means Regulation (EU) 2016/679;

Go/No-Go Milestone means a decision point for ARIA to determine whether it wishes to proceed with or terminate the Project Activities (any decision regarding a Go/No-Go Milestone will be made at ARIA's sole discretion, following a Grant Review as outlined in Clause 6);

Grant means the sum or sums ARIA will pay to you up to the amount set out in the Grant Funding Letter, in accordance with clause 4 and subject to the provisions set out at clause 22.

Grant Agreement has the meaning given in the Grant Funding Letter;

Grant Claim means a request submitted by you to ARIA for payment of the Grant;

Grant Funding Letter means the letter from ARIA to you to which these Conditions are annexed;

Grant Manager means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Grant;

Grant Review means the process for reviewing the grant outlined in clause 6;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Ineligible Expenditure means expenditure incurred by you which is not Eligible Expenditure as set out in clause 5 and ARIA's published eligibility rules;

Information Acts means the Data Protection Legislation, FOIA and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property Rights or **IP** means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions, semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation;

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise;

Maximum Sum means the maximum amount of the Grant stated in the Grant Funding Letter;

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

NewCo has the meaning given in clause 16;

Non-UK Entity means a legal entity that is not a UK Entity;

Personal Data has the meaning given to it in the Data Protection Legislation as amended from time to time;

Prohibited Act means:

(a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Grant Agreement; and/or (ii) showing or not showing favour or disfavour to any person in relation to the Grant Agreement;

(b) committing any offence: (i) under the Bribery Act; (ii) under legislation creating offences in respect of fraudulent acts; and/or (iii) at common law in respect of fraudulent acts in relation to the Grant Agreement; and/or

(c) defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the activities to be carried out by you that are described in the Grant Funding Letter and in Schedule 2 Part 1;

Project Representative means the representative appointed by you, who at the Commencement Date will be the individual listed as such in the Grant Funding Letter;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means all information, data, techniques, inventions, discoveries, works, software and materials generated in the course of the Project Activities;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Sub-Contract means any contract or agreement or proposed contract or agreement between you and any Third Party whereby that Third Party agrees to provide to you the Project Activities or any part thereof or facilities or services necessary for the performance of the Project Activities or any part thereof or necessary for the management, direction or control of the Project Activities or any part thereof, and **Sub-Contractor** shall be construed accordingly;

Third Party means any person or organisation other than you or ARIA;

UK Entity means a legal entity whose ultimate parent company has its headquarters and principal establishment in the United Kingdom;

Unavoidable Costs means the amounts paid or payable by you to your Sub-Contractors or other third parties in respect of the termination of Sub-Contracts as a direct result of the early termination of this Grant Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Funding Period because of termination or breach of the Grant Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination; and

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 In these Conditions and the Grant Agreement, unless the context otherwise requires:

- (a) references to "party" and "parties" are to the parties to the Grant Agreement;
- (b) the singular includes the plural and vice versa;
- (c) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (d) references to clauses and Schedules are to the clauses of these Conditions and to the Schedules to the Grant Agreement;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation"; and
- (g) the headings in the Grant Agreement are for ease of reference only and will not affect the interpretation or construction of the Grant Agreement.

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

This project – BrightSpark - will investigate electric charge emission as a method for modifying droplet size distributions to increase their reflectivity, to evaluate this as a potential method to achieve marine cloud brightening.

2. Aims and objectives of the Project Activities

The aims of the project are:

- Equipping microdrones with lightweight charge emission technology
- Develop control systems and strategies for coordinating microdrone operation in fogs
- Identify a measuring site and install monitoring equipment and microdrones
- Scope and implement experimental infrastructure for fog experiments
- Model the effects of a charge release experiment in the quantities which can be recorded
- Undertake the charge release experiments in fog
- Use modelling to explore how the technology can be scaled up for marine cloud
- Report results

3. Project Activities

3.1 Workstream descriptions

Workstream	Scope	Purpose
WS1	Charge delivery systems	Optimising size and efficiency of ion emitters for microdrones
WS2	UAV instrumentation integration	Integration and testing of cloud and reflectivity sensors with monitoring drones
WS3	Site identification and engagement	Assessment and prioritising of experimental sites, and engagement with stakeholders
WS4	Swarm technology	Develop control and operation systems for the microdrones. Submissions for field experiment and other permissions
WS5	Charge microphysics modelling	Representing relevant charge microphysics in high resolution models and Met Office NERC Cloud Model (MONC). Model runs with upper bound scenarios on albedo: derive optimal intervention strategies and bounding adverse effects

WS6	Site instrumentation	Constructing surface measurement and monitoring systems
WS7	Field experiments	Range of experiments to test the microdrone swarm in clear and foggy air
WS8	Field experiment modelling	Ensembles of high-resolution model runs to assess natural variability in reflectivity. Evaluate if interventions lie outside the control ensemble
WS9	Marine stratus scoping	Evaluating marine platforms for a microdrone system
WS10	Reporting and data archiving	Ongoing throughout the project, through international conferences and peer-reviewed publications. Data archiving activities also.

3.2 The following Milestones will be used to monitor your delivery of the Project. The costs associated with completing these Milestones are estimated in the cost breakdown sheet :



ID	Milestones	Measure	Date
1	Preparations for outdoor experiments underway	Suitable field sites identified and initial technical feasibility study conducted. Outline engagement plan complete and presented to internal ARIA team and Oversight Committee. Reports on both of the above submitted to the programme team and oversight committee for review.	Commencement date + 3 months
2	Functioning charge delivery systems for microdrones demonstrated This is a Go/No Go Milestone	Drones can stay airborne whilst carrying charge delivery system. Threshold voltage to achieve charge emission met.	Commencement date + 12 months

3	Engagement for outdoor experiments underway	Initial mapping of stakeholders complete. Appropriate first community engagement/codesign/education event held.	Commencement Date + 9 months
4	Atmospheric monitoring capability on UAV1 and UAV2 demonstrated	Measurement of solar radiation, temperature, humidity, droplet properties at suitable resolution and accuracy demonstrated (although all of these sensors need not be carried by a single drone)	Commencement date + 15 months
5	Independent risk/impact assessment	Risk and impact assessment by independent environmental consultant complete Risk assessment shared with stakeholders for further codesign as appropriate	Commencement Date + 15 months
6	Demonstrate charge microphysics modelling capability for layer cloud properties	Maximum physics based upper bound effect that could be expected from charge-induced cloud brightening is quantified	Commencement date + 21 months
7	Final submission for funding for outdoor perturbative experiment This is a Go/No Go Milestone	Full experimental and engagement details submitted to ARIA, with evidence that the field trials can be conducted in a safe manner, compliant with regulation, with effective control measures and that key stakeholders, the local population and the wider public have been effectively consulted in keeping with the size and scale of the experiments Outdoor experiments (if approved) are then expected run M27 to M30 (wintertime)	Commencement Date + 21 months

8	Model options to scale up technology to marine stratus defined	Expansion of models to regional/global scale complete, allowing answers to questions such as "What scale of effect could be produced?"	Commencement date + 27 months
9	Outdoor experiment completed	Effects on scale of around 100 metres are identified over timescales of ~minutes, as and when fog is available Duration of effects on a local scale after charge emission has ceased will be quantified. Does the effect dissipate, or are effects longer lasting?	Commencement date + 30 months
10	Project complete	Simulate scientific results from field experiments, complete data archiving and make this data available on open-access ARIA repository	Commencement date + 36 months

In addition to the above Milestones, the following project plan will be used to track progress throughout the project and may be updated from time to time: [REDACTED].

3.3 The intended long-term outcomes are summarised below:

- If successful, a new method of cloud perturbation using electric charge will be demonstrated
- Effective use of a swarm to provide charge modification
- Development of models to include charge interactions
- Modelling and technology development will allow the scalability of the technique to be tested subsequently

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement
Planning	• Roles and responsibilities • External communications • Vision • Project details • Code and data management • Project plan + project management
Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Key Learning, discoveries and decisions • Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • Invoicing and cost reporting Optional: • technical evidence saved to drive e.g. report or presentation as requested by PD • review meeting slide deck saved to drive as requested by PD
Annual	• ARIA impact metrics • Attendance at annual ARIA event
Ad hoc	• As required, Programme Director/ Programme Team may request additional information and evidence • Workshops - potential to be invited to ARIA workshops
Project closure	• Project closure report

5. Payment

5.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments quarterly in arrears.

For quarterly payments, the cadence of payments will align with ARIAs financial year beginning 1st April e.g Quarter 1 Grant Claims will be for the period of 1st April to 30 June, Quarter 2 Grant Claims will be for the period of 1st July to 30 Sept and so on.

5.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for Grant relates).

5.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end of the relevant period.

5.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

6. Principal investigator/key researchers

6.1 For the purposes of clause 22.7, the following principal investigators or key researchers have been identified:

Name	Role	Organisation
Prof Giles Harrison	PI	University of Reading
Dr Keri Nicoll	Co-I (experiments)	University of Reading
Prof Maarten Ambaum	Co-I (modelling)	University of Reading

7. Sub-Contractors

7.1 For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Headquarters Location
Menapia	Provision of scientific services with UAVs, including atmospheric profiling	Leeds, UK
Celestial	Coordinated operation of multiple microdrones for field experiments	Norton St Philip, UK
TBC	Provision of environmental law expertise and ethical expertise	TBC

PART 2 - GRANT APPLICATION

Application titled "BrightSpark: cloud brightening with electric charge" submitted 9 December 2024

SCHEDULE 3

Royalty Percentages

Royalties on the sale or supply of products or services that are covered by, use or incorporate the Foreground IP licensed to the NewCo will only become due on aggregate net sales derived from the Foreground IP exceeding £50 million.

The maximum headline percentage royalty rate (i.e. before any royalty stacking, step-down or other reduction and excluding any ARIA Non-UK Fee) for products or services that are covered by, use or incorporate the Foreground IP, and of sublicensing income, shall be one of the following:

Type of product	Applicable headline royalty percentage (up to)
Low margin	0.5% of net sales
Medium margin	1% of net sales
High margin	2% of net sales
Sublicensing royalty	10% of net receipts

ANNEX 1

Clause for inclusion in licences of Foreground IP

[] **ARIA NON-UK FEE**

[].1 In this clause:

“ARIA” means the Advanced Research and Invention Agency;

“Crown Body” means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

“UK Entity” means a legal entity that has or whose ultimate parent company has its headquarters and principal establishment in the United Kingdom.

[].2 The Foreground IP was developed with funding from ARIA. As a condition of its funding ARIA requires that a benefit is returned to the United Kingdom where the Foreground IP is licensed by the Licensor to any person that is not a UK Entity. Accordingly, in addition to any other sums payable by the Licensee to the Licensor under this Agreement, the Licensee shall pay to the Licensor within 90 days after the end of each calendar year during the Relevant Period (as defined below), and within 90 days after the end of the Relevant Period, a fee (**ARIA Non-UK Fee**) on all amounts (including upfronts, licence fees, milestone payments, royalties, shares or other securities, exit fees, buyout or other consideration) payable by the Licensee to the Licensor under this Agreement in relation to the exploitation of any Foreground IP (**Relevant Amount**) that accrues during, or relates to, any period of time that the Licensee is not a UK Entity (**Relevant Period**). The amount of the ARIA Non-UK Fee is 25% of the Relevant Amount, and is payable by the Licensee to the Licensor in addition to the amounts that would otherwise be payable under this Agreement. For example if the Relevant Amount is £100 the ARIA Non-UK Fee is an additional £25, which the Licensee shall pay to the Licensor and the Licensor shall remit to ARIA.

Crown Body customers

[].3 You must also ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities and in suitable quantities for the Crown Body's requirements.

[].4 ARIA shall have the right to enforce this clause [] under the Contracts (Rights of Third Parties) Act 1999. Neither party may amend this Agreement in a way that detracts from ARIA's right to enforce its rights under this clause without ARIA's prior written consent.

[1] When using this clause you may substitute the relevant defined terms used elsewhere in the agreement to capture the concept of "Foreground IP". Where the clause refers to the "Licensor" and "Licensee" please use the appropriate defined terms to include the licensor, licensee, assignor and assignee of the Foreground IP. This clause is not suitable for assignments of the Foreground IP in consideration of the payment of one or more lump sum payments. In those cases the Licensor needs to be informed, and potentially make an additional payment, if the Foreground IP is subsequently assigned to a non-UK Entity or if the Assignee ceases to be a UK Entity.

SCHEDULE 4: Data Protection NOT USED

1. DEFINITIONS

The following definitions apply in this Schedule.

Controller, Processor, Data Subject, Personal Data, Personal Data Breach and Processing: have the meanings given to them in the Data Protection Legislation.

Data Protection Legislation all applicable data protection and privacy legislation in force from time to time in the UK including the UK GDPR; the Data Protection Act 2018 (DPA 2018) (and regulations made thereunder) and the Privacy and Electronic Communications Regulations 2003 (SI 2003/2426) as amended and all other legislation and regulatory requirements in force from time to time which apply to a party relating to the use of Personal Data (including, without limitation, the privacy of electronic communications); and the guidance and codes of practice issued by the Information Commissioner or other relevant regulatory authority and applicable to a party.

Domestic Law: the law of the United Kingdom or a part of the United Kingdom.

UK GDPR: has the meaning given to it in section 3(10) (as supplemented by section 205(4)) of the Data Protection Act 2018.

2. GENERAL OBLIGATION

- 2.1. Both parties will comply with all applicable requirements of the Data Protection Legislation. This paragraph 2.1 is in addition to, and does not relieve, remove or replace, a party's obligations or rights under the Data Protection Legislation.

3. DATA PROCESSING

- 3.1. The parties acknowledge that for the purposes of the Data Protection Legislation, ARIA is the Controller and you are the Processor when performing its obligations under this Grant Agreement (the scope, nature and purpose of processing by the Provider, the duration of the processing and the types of Personal Data and categories of Data Subject are set out in paragraph 3.7, as updated from time to time).
- 3.2. Without prejudice to the generality of paragraph 2.1, ARIA will ensure that it has all necessary appropriate consents and notices in place to enable lawful transfer of the Personal Data to you [and/or lawful collection of the Personal Data by [the Provider] on behalf of ARIA] for the duration and purposes of Grant Agreement.
- 3.3. Without prejudice to the generality of paragraph 2.1, you shall, in relation to any Personal Data processed in connection with the performance by the Provider of its obligations under Grant Agreement:
 - 3.3.1. process that Personal Data only on the documented written instructions of ARIA unless you are required by Domestic Law to otherwise process that Personal Data. Where you are

relying on Domestic Law as the basis for processing Personal Data, you shall promptly notify ARIA of this before performing the processing required by the Domestic Law unless the Domestic Law prohibits you from so notifying ARIA;

- 3.3.2. ensure that it has in place appropriate technical and organisational measures, reviewed and approved by ARIA, to protect against unauthorised or unlawful processing of Personal Data and against accidental loss or destruction of, or damage to, Personal Data, appropriate to the harm that might result from the unauthorised or unlawful processing or accidental loss, destruction or damage and the nature of the data to be protected, having regard to the state of technological development and the cost of implementing any measures (those measures may include, where appropriate, pseudonymising and encrypting Personal Data, ensuring confidentiality, integrity, availability and resilience of its systems and services, ensuring that availability of and access to Personal Data can be restored in a timely manner after an incident, and regularly assessing and evaluating the effectiveness of the technical and organisational measures adopted by it);
- 3.3.3. ensure that all personnel who have access to and/or process Personal Data are obliged to keep the Personal Data confidential; and
- 3.3.4. not transfer any Personal Data outside of the UK unless the prior written consent of ARIA has been obtained and the following conditions are fulfilled:
 - 3.3.4.1. ARIA or you have provided appropriate safeguards in relation to the transfer;
 - 3.3.4.2. the Data Subject has enforceable rights and effective legal remedies;
 - 3.3.4.3. you comply with your obligations under the Data Protection Legislation by providing an adequate level of protection to any Personal Data that is transferred; and
 - 3.3.4.4. you comply with reasonable instructions notified to you in advance by ARIA with respect to the processing of the Personal Data;
- 3.3.5. assist ARIA, at ARIA's cost, in responding to any request from a Data Subject and in ensuring compliance with its obligations under the Data Protection Legislation with respect to security, breach notifications, impact assessments and consultations with supervisory authorities or regulators;
- 3.3.6. notify ARIA without undue delay on, and in event within 24 hours of, becoming aware of a Personal Data Breach;
- 3.3.7. at the written direction of ARIA, delete or return Personal Data and copies thereof to ARIA on termination of Grant Agreement unless required by Domestic Law to store the Personal Data; and

- 3.3.8. maintain complete and accurate records and information to demonstrate its compliance with this Schedule and allow for audits by ARIA or ARIA's designated auditor and immediately inform ARIA if, in the opinion you, an instruction infringes the Data Protection Legislation.
- 3.4. [[ARIA does not consent to you appointing any sub-Processor of Personal Data under this Schedule.] OR [ARIA consents to your use of sub-Processors engaged in the processing of Personal Data by way of general authorisation in respect of all sub-Processors as at the date of this Schedule. You shall make a list available to ARIA upon request. You shall give ARIA not less than 15 days' prior written notice of a change in the list of sub-Processors to give ARIA an opportunity to object to such change. ARIA must notify you in the event that it does not agree to a proposed change within 15 days of receiving a notification from you , specifying its grounds for such objection (acting reasonably). If you receive such an objection, then you may (at its option):
- 3.4.1. cancel its plans to change the affected sub-Processor;
- 3.4.2. offer an alternative which is acceptable to ARIA; or
- 3.4.3. take corrective steps to remove the objection identified by ARIA to ARIA's reasonable satisfaction, after which you may proceed with the appointment of the relevant sub-Processor.
- 3.5. If none of the above options resolve the objection, then without liability for either party, either party may terminate Grant Agreement by providing written notice of termination with immediate effect where such notice of termination is served within 30] days of you informing ARIA of the proposed change.
- 3.6. You confirm that it has entered or (as the case may be) will enter with its sub-Processors into written agreements incorporating terms which are substantially similar to those set out in this Schedule and which you confirm reflects and will continue to reflect the requirements of the Data Protection Legislation. As between you and ARIA, you shall remain fully liable for all acts or omissions of any sub-Processor appointed by it pursuant to this paragraph 3.4 to 3.6.]
- 3.7. Scope, Nature, Purpose of Processing, Types of Personal Data and Categories of Data Subjects.

Scope and purpose of Processing:	Provision of the Project Activities by you under this Grant agreement.
Nature of Processing:	[Here you should describe what the Processor will be doing with the Personal Data, for example collecting it, storing it, retrieving it, consulting it, disseminating it or destroying it, etc.

	Note the definition of processing in the UK GDPR: <i>“any operation or set of operations which is performed on personal data or on sets of personal data, whether or not by automated means, such as collection, recording, organisation, structuring, storage, adaptation or alteration, retrieval, consultation, use, disclosure by transmission, dissemination or otherwise making available, alignment or combination, restriction, erasure or destruction”]</i>
Duration of Processing:	Duration of this Grant Agreement (and any post termination processing that is permitted / required).
Types of Personal Data:	[Describe here the types of data relating to the individuals concerned, e.g. names, addresses, email addresses, financial details, date of birth, place of birth, photographs, nationality, gender, signature, health records, work appraisal records, disciplinary processes, references, job applications, CVs, notes of interviews, etc. If so-called “special categories” of personal data (currently known as sensitive data) are being processed describe them here. Note the definition of special categories of personal data in the UK GDPR: <i>“data revealing racial or ethnic origin, political opinions, religious or philosophical beliefs, or trade union membership, and the processing of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health or data concerning a natural person’s sex life or sexual orientation”]</i>
Categories of Data Subjects:	[Describe here the individuals whose data will be processed, by reference to their relationship with the company and its business, e.g. employees, directors,

	clients, prospects, suppliers, sub-contractors, consultants, job applicants, advisors, key opinion leaders, etc.]

4. INDEMNIFICATION

- 4.1. You shall indemnify and keep ARIA indemnified against all losses, claims, damages, liabilities, fines, interest, penalties, costs, charges, sanctions, expenses, compensation paid to Data Subjects (including compensation to protect goodwill and ex gratia payments), demands and legal and other professional costs (calculated on a full indemnity basis and in each case whether or not arising from any investigation by, or imposed by, a supervisory authority) arising out of or in connection with any failure by you or your employees, subcontractors or agents to comply with any of its obligations under this Schedule or the Data Protection Legislation.
- 4.2. Any limitation of liability set out in this Grant Agreement will not apply to this Schedule's indemnity or reimbursement obligations.

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

1. Submission of Pledged Patents and Experimental Data
 - 1.1 The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
 - 1.2 The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.
2. Experimental Data Licence
 - 2.1 Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
 - 2.2 The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
 - 2.3 The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
 - 2.4 The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).
3. Research Licence
 - 3.1 Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
 - 3.2 The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
 - 3.3 Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

- 3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.
- 3.5 The Research Licensee must:
- (a) at all times when using the Pledged Patents comply with all Laws; and
 - (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).
4. Commercial Licence
- 4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.
- 4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.
- 4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.
5. Pledgor Know-How
- At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.
6. Termination
- 6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:
- (a) materially breaches the terms of such licence or this Pledge; or
 - (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).
7. Transfers of Pledged Patents and/or Experimental Data
- The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.
8. No Warranty
- The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and
Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.

Cornell University (Grant Recipient)

373 Pine Tree Road, Cornell University, Ithaca, New York 14850-2820 USA

25/06/2025

Attention: Douglas MacMartin

Dear Douglas ,

FPCW-PR01-P020 - Defining the minimum scale of an SAI test: a fundamental first step towards an outdoor large scale experiment— Standard Grant Funding Letter

Congratulations, we can't wait to see what you will achieve and very much look forward to working with you and your team.

You recently submitted an application in response to Exploring Climate Cooling and ARIA is pleased to offer you a Grant for the performance of the Project Activities up to the Maximum Sum, subject to your agreement to, and compliance with, the terms and conditions set out in this Grant Funding Letter and its Schedules.

1. Overview of the Grant

Any reference in this letter to "you" or "your" means the Grant Recipient and any capitalised terms have the meanings given in the ARIA Grant Conditions (Conditions).

The key elements of the Grant are described in the table below:

Project Activities	Defining the minimum scale of an SAI test: a fundamental first step towards an outdoor large scale experiment. A more detailed description of the Project Activities is set out in Schedule 2 (Project Activities).
Maximum Sum of the Grant (inclusive of taxes)	£444,970 (inclusive of all taxes where applicable)
Commencement Date	The commencement date is 15 July 2025
Completion Date	The completion is 14 July 2027
Grant Review Intervals	ARIA will review the Grant at quarterly intervals using the process referred to in clause 6 of the Conditions

Adequate Insurance	Commercial General Liability- \$1,000,000 million per occurrence Automobile Liability- Combined Single Limit Each Accident \$1,000,000 Million Umbrella Liability- \$1,000,000 per occurrence Educators Liability- \$1,000,000 per claim Workers Compensation- Self-Insured Retention \$1,500,000 per claim.	
Monitoring and Reporting	The performance reports referred to in clause 7 of the Conditions shall be provided at the frequency identified in Schedule 2 to the ARIA point of contact as set out in the project kick-off documentation.	
Project Representative	Douglas MacMartin, Associate Professor Sibley School of Mechanical and Aerospace Engineering [REDACTED]	
Grant Manager	Mark Symes, Programme Director [REDACTED]	
Escalation Contacts	ARIA	Grant Recipient
	Chief Product Officer [REDACTED]	[REDACTED] Sr. Grant & Contract Officer [REDACTED]
Notices	ARIA Contracts [REDACTED]	[REDACTED] Sr. Grant & Contract Officer [REDACTED]

2. Confirmation of Bank Details

- 2.1. You must complete and sign the Confirmation of Bank Details form available [here](#) as part of your acceptance of the Grant and return it to finance@aria.org.uk

3. The Grant Agreement

- 3.1. Once you sign a copy of this Grant Funding Letter in accordance with paragraph 6 (Acceptance) below, it will form a binding "**Grant Agreement**" between you and ARIA that includes and

incorporates the following documents:

- 3.1.1. the **Grant Conditions** in Schedule 1;
 - 3.1.2. the **Project Activities, Milestones** and **Grant Application** in Schedule 2;
 - 3.1.3. the **Royalty percentages** (including annexes) in Schedule 3; and
 - 3.1.4. the terms relating to Data Protection in Schedule 4.
- 3.2. The parties confirm that it is their intention to be legally bound by the Grant Agreement.

4. Warranties

- 4.1. By signing this Grant Funding Letter, you warrant and represent that:
- 4.1.1. your obligations under the Grant Agreement are legal, valid, binding and enforceable;
 - 4.1.2. all authorisations and consents necessary to enable you to enter into and perform the obligations in the Grant Agreement have been obtained;
 - 4.1.3. the person signing the Grant Agreement is duly authorised to sign on your behalf; and
 - 4.1.4. your Project Representative referenced in the table above is authorised to make decisions and provide information on your behalf.

5. Amendments to the Grant Conditions

- 5.1. Not Used

6. Acceptance

- 6.1. To accept this Grant Funding Letter, please arrange for an authorised signatory to sign and date the duplicate copy of this Grant Funding Letter as indicated below, and return to ARIA as a complete signed original of the Grant Agreement including its Schedules, accompanied by evidence of the authorised signatory's authority to enter into the Grant Agreement and to bind the Grant Recipient.
- 6.2. The offer of this Grant Funding Letter will expire on 4 July 2025.

Yours sincerely

for and on behalf of ARIA

Name of ARIA signatory:

Position Held:

Date:

I confirm the agreement of Cornell University to the terms and conditions in this Grant Funding Letter and its Schedules.

Signature:

Name:

Position:

Date:

SCHEDULE 1 - GRANT CONDITIONS

1. PRECEDENCE

- 1.1 Where there is any conflict between the documents that make up the Grant Agreement the conflict will be resolved in accordance with the following order of precedence:
- (a) the Grant Funding Letter;
 - (b) these Conditions;
 - (c) the remaining Schedules to the Grant Agreement with the exception of Schedule 2 Part 2 (the Grant Application);
 - (d) Schedule 2 Part 2 (the Grant Application); and
 - (e) any other documents incorporated by reference in, or developed in accordance with, the Grant Agreement.

2. DURATION AND PURPOSE OF THE GRANT

- 2.1 The Grant Agreement will subsist for the duration of the Funding Period unless extended by written agreement signed by a duly authorised representative of the parties or terminated earlier in accordance with its terms. Any provision of the Grant Agreement that expressly or by implication is intended to come into or continue in force on or after termination or expiry of the Grant Agreement shall remain in full force and effect, including clauses 1, 2, 4, 7.4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22.3, 22.7, 22.8, 22.11, 22.12, 23, 24, 26, 27, 28, and 30.
- 2.2 You may only use the Grant for carrying out the Project Activities. You may not make any changes to the Project Activities without ARIA's prior written agreement.
- 2.3 You may not unreasonably withhold, condition or delay your agreement to any changes requested by ARIA to the Project Activities or the amount of the Grant. Any agreed change will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

3. ENVIRONMENTAL AND SAFETY REQUIREMENTS

- 3.1 In performing the Project Activities, you shall meet the requirements of all applicable Laws regarding the environment and safety, including laboratory safety requirements, in all material respects.

4. PAYMENT OF GRANT

- 4.1 Subject to the remainder of this clause 4, ARIA will pay the Grant to you:
- (a) up to the Maximum Sum;
 - (b) in pounds sterling (GBP) by wire transfer into your bank account, details of which you provided in the Confirmation of Bank Details form attached to the Grant Funding Letter; and
 - (c) if a tax is chargeable in respect of the Grant, all payments will be deemed to be inclusive of all such taxes and ARIA will not be obliged to pay any additional amount.
- 4.2 The bank account of which you provided details in your Confirmation of Bank Details form (and any alternative bank details nominated subsequently by you) must be an ordinary business bank account

with appropriate segregation of duties and control. During the Funding Period, you must notify ARIA of any change of bank account details as soon as reasonably practicable on the same form and signed by an approved signatory. You must notify ARIA of any change of signatory for approval, as soon as known.

- 4.3 You will be the sole recipient of the Grant and you will be responsible for managing the Grant as between you and any Third Parties involved in performing the Project Activities.
- 4.4 You must promptly notify ARIA if any money is incorrectly paid to you for any reason, and must repay it as soon as reasonably practicable. Any amount not repaid will be recoverable as a civil debt.
- 4.5 ARIA reserves the right not to pay any Grant Claims that are not submitted within the period set out in the Grant Funding Letter or that are incomplete, incorrect or not accompanied by full supporting documentation (including any documentation that ARIA reasonably requests).
- 4.6 You may not apply for or obtain Duplicate Funding for any Project Activities.
- 4.7 You may not retain any Unspent Monies and must repay them to ARIA within 30 days after ARIA's request for repayment.

5. ELIGIBLE AND INELIGIBLE EXPENDITURE

- 5.1 ARIA will only pay the Grant for Eligible Expenditure incurred by you in carrying out the Project Activities. You must provide ARIA with any evidence reasonably requested by ARIA (including receipts, invoices and other documentary evidence) that all Grant Claims relate to costs that are Eligible Expenditure.
- 5.2 You may not in any circumstance claim as Eligible Expenditure paid-for lobbying, which means using the Grant to fund lobbying (via an external firm or in-house staff) in order to undertake activities intended to influence or attempt to influence Parliament, government or political activity; or attempting to influence legislative or regulatory action.

6. GRANT REVIEW

- 6.1 ARIA will review the Grant at the intervals specified in the Grant Funding Letter. The review will take into account your carrying out of the Project Activities against the Milestones. As part of the ARIA review process, ARIA will review the reports produced by you in accordance with clause 7.3.. The Grant Recipient will use reasonable, good faith, diligent efforts in performance of the Project Activities. However, ARIA and you acknowledge that research, developments, and outcomes may be somewhat uncertain, unanticipated, or unpredictable, and the Project Activities will be pursued without guarantee regarding the achievement of any specific results.
- 6.2 Following the review carried out under clause 6.1, ARIA may choose to do any of the following, taking into account any representations made by you in the course of the review:
 - (a) consent to the Project Activities and the Grant Agreement continuing in line with existing plans;

- (b) increase or decrease the Grant for the remainder of the Funding Period, as applicable;
- (c) redefine the Milestones;
- (d) require you to carry out remedial activity with the aim of improving delivery of the Project Activities; and/or
- (e) terminate the Grant Agreement in accordance with clause 22.

6.3 Any change to these Grant Terms, the Project Activities, or the Grant pursuant to clause 6.2(a), 6.2(c) or 6.2(d) will be recorded in a written variation to the Grant Agreement in accordance with clause 26.

7. MONITORING AND REPORTING

7.1 You must closely monitor the carrying out of the Project Activities throughout the Funding Period and must notify ARIA as soon as reasonably practicable of any actual or potential failure to comply with any of your obligations under the Grant Agreement.

7.2 ARIA does not limit its engagement with you to purely administrative activities and will require details of all Results and all material Foreground IP, so you must allow ARIA personnel to visit your premises at a reasonable frequency and at dates and times agreed with you to liaise with your applicable researchers for the purpose of identifying Foreground IP, evaluating Milestones and assessing progress with the Project Activities. ARIA will treat the and Foreground IP, and other information it learns from such visits, as your Confidential Information under clause 11.

7.3 You must provide ARIA with:

- (a) the Milestones and a report on your performance against the Milestones at the intervals and for the periods of time specified in the Grant Funding Letter. ARIA may copy and adapt the contents of any of the Milestones and those reports for ARIA's internal use to review, develop and shape ARIA's funded research programmes.
- (b) any assistance and information reasonably requested by ARIA to establish whether you have used the Grant in accordance with the Grant Agreement; and
- (c) a quarterly report on the use of the Maximum Sum, details broken down in accordance with ARIA's prescribed form.

7.4 ARIA is built for long-term impact and needs to be kept informed of the impact of its funding activities and compliance with the terms of the Grant Agreement. ARIA will therefore have the right to make reasonable requests for information from you from time to time after the end of the Funding Period about the impact metrics, commercial exploitation or other dissemination of the Results and how this has benefited the United Kingdom. You must respond and provide the information requested within one month (unless ARIA specifies otherwise). If requested, ARIA will treat the information provided as your Confidential Information under clause 11. Nothing in this Grant Agreement will be deemed to limit ARIA's ability to use, share or publish such information as part of aggregated and anonymised reporting. This clause 7.4 shall survive termination or expiry of this Grant Agreement.

8. AUDITING AND ASSURANCE

- 8.1 Within six months after the end of each Financial Year and after the end of the Funding Period you must provide ARIA with independent assurance that the Grant has been used for carrying out the Project Activities. To satisfy this requirement you must provide a statement showing that the use of the Grant which is signed by a senior finance individual.
- 8.2 Subject to clause 11, ARIA and/or its authorised representative may, at any time upon thirty (30) days written notice during the Funding Period and for up to 7 years after the end of the Funding Period, conduct audits in relation to your use of the Grant and your compliance with the Grant Agreement. You must act reasonably in cooperating with any such audit, including by granting access to relevant documentation, premises and personnel.
- 8.3 You must:
- (a) maintain an appropriate system of financial management and controls, maintain detailed records in relation to those controls, and provide copies of those records to ARIA on request; and
 - (b) retain, all relevant documentation relating to the Eligible Expenditure (including invoices, receipts and accounting records) during the Funding Period and for a period of 7 years thereafter.

9. FINANCIAL MANAGEMENT

- 9.1 You must:
- (a) maintain a sound administration and audit process, including internal financial controls, to safeguard against fraud and theft, money laundering, terrorist financing or any other impropriety, or mismanagement in connection with the administration of the Grant; and
 - (b) notify ARIA of any actual or suspected cases of fraud, theft or financial irregularity relating to the Project Activities as soon as they are identified, and keep ARIA informed of your remedial actions.
- 9.2 In the event of any actual or suspected fraud, theft or other financial irregularity (which includes use of the Grant for any purpose other than that envisaged by the Grant Agreement), ARIA may, at its absolute discretion:
- (a) require you to take any remedial steps that ARIA may reasonably specify; and/or
 - (b) suspend the Project Activities and future payment of the Grant to you,

and in all cases you must explain to ARIA what steps are being taken to investigate the fraud, theft or irregularity (as applicable) and must keep ARIA informed about the progress of any such investigation.

10. CONFLICTS OF INTEREST

- 10.1 You must inform ARIA promptly of any actual, perceived or potential conflicts between your and your Representatives' obligations under the Grant Agreement and your and their personal, business or professional interests. You must have adequate procedures to manage and monitor any actual or

potential conflicts of interest, whether identified in the application process or notified to ARIA during the Funding Period.

- 10.2 If ARIA is not satisfied that you are adequately managing any actual or potential conflicts of interest, or that these conflicts are not capable of such management, the parties will discuss the issues raised and try to agree a resolution. If this is not possible, ARIA may request you or your Representative to cease the conflicting activity and if that is not acceptable to you or your Representative, either party may terminate the Grant Agreement on at least 30 days' notice in writing.

11. CONFIDENTIALITY

- 11.1 Except to the extent set out in this clause 11 or where disclosure is expressly permitted by ARIA, You must treat all Confidential Information belonging to or disclosed by ARIA as confidential and will not disclose any such Confidential Information to any other person without the prior written consent of the ARIA, except to any persons who are directly involved in the provision of the Project Activities, who need to know the information and who are subject to binding obligations of confidentiality similar to those herein.

- 11.2 Both parties may publish a summary of the Grant Agreement in any medium (having redacted both parties' Confidential Information), including a summary of any changes to the Grant Agreement agreed from time to time. Additionally, Both parties may publish a copy of the Milestones (in whole or in part) in any medium.

- 11.3 Nothing in this clause 11 will prevent either party disclosing any Confidential Information of ARIA:
- (a) for the purpose of the examination and certification of its accounts and/or pursuant to section 6(1) of the National Audit Act 1983;
 - (b) to any government department, consultant, contractor or other person engaged by that party, provided that such party only discloses information necessary for the purpose concerned and obtains appropriate confidentiality undertakings in relation to such information;
 - (c) where disclosure is required by any applicable Law, including under the Information Acts to the extent they apply to that party and where no exception to disclosure under them is applicable; or
 - (d) where that party (acting reasonably) considers disclosure necessary or appropriate for the carrying out of its public functions.

- 11.3.2 Confidential Information shall not include the following:

- (a) Information that was previously known to you free of an obligation to keep it confidential (otherwise than by breach of clause 13);
- (b) was in the possession of the receiving party, without restriction as to its disclosure, before receiving it from the disclosing party; is received from a Third Party (who lawfully acquired it) without restriction as to its disclosure;
- (c) is already in the possession of or is independently developed by you;

- (d) is released with ARIA's written consent; or
- (e) the content of this specific version of the Grant Agreement, save in respect of any information which is exempt from disclosure under the Information Acts as they apply to the relevant party

11.4 Nothing in this clause 11 will prevent either party from using any techniques, ideas or know-how gained during the performance of its obligations under the Grant Agreement in the course of its normal business or activities, to the extent that this does not result in a disclosure of the other party's Confidential Information or an infringement of the other party's Intellectual Property Rights.

12. STATUTORY DUTIES

- 12.1 Each party must comply with its obligations under the Law, including where applicable the Information Acts, the EA and the HRA and you shall notify ARIA immediately of any investigation of or proceedings against you under the EA.
- 12.2 You acknowledge that ARIA is subject to requirements under the Information Acts (other than the FOIA) and you will provide reasonable assistance and cooperation to ARIA to assist ARIA's compliance with its information disclosure obligations.
- 12.3 You acknowledge that ARIA, acting in accordance with the Information Acts (other than the FOIA), may disclose information concerning you and the Grant Agreement without consulting you. ARIA must take reasonable steps to notify you of any request for information to the extent permissible and reasonably practical and will give you adequate opportunity to make representations before ARIA discloses any information relating to such matters. ARIA will be responsible for determining in its absolute discretion whether any information is exempt from disclosure in accordance with the Information Acts.
- 12.4 Where you are subject to the Information Acts and receive a request for disclosure that relates to ARIA or the Grant Agreement you will notify ARIA and give ARIA adequate opportunity to make representations to you before you disclose any information relating to such matters.
- 12.5 You must take account of the requirements of the National Security and Investment Act 2021 before assigning or licensing Results or Foreground IP. You are encouraged to give a voluntary notice to the Secretary of State under the Act in advance of any such assignment or licence if the assignment or licence is likely to meet the requirements of section 18 of the Act and inform ARIA if any mandatory or voluntary notification is made.
- 12.6 You must take account of the Secure Innovation and Trusted Research Guidance. You must also consider any risks to the physical safety and security of the public and implement any appropriate mitigations and measures where the Project Activities you carry out have the potential to interact with the public.

13. DATA PROTECTION

- 13.1 Each party must comply at all times with its obligations under the Data Protection Legislation. At ARIA's request you must provide ARIA with all relevant documents and information relating to your data protection policies and procedures that ARIA may reasonably request.
- 13.2 The parties do not envisage that either party will process any Personal Data for or on behalf of the other party under or in connection with the Grant Agreement. If either party anticipates that the other will process any Personal Data on its behalf under the Grant Agreement it must notify the other party and the parties must agree a variation to the Grant Agreement under clause 26 to incorporate appropriate provisions (such as those set out in Schedule 4) in accordance with, or as otherwise required by, the Data Protection Legislation.

14. SUBSIDY CONTROL AND STATE AID

- 14.1 ARIA intends that the Grant complies with the Subsidy Control Act 2022 on the basis that the Project Activities are not economic activities and do not give a specific advantage to one or more enterprises. You must take all reasonable steps to maintain this position and to assist ARIA to comply with the requirements of the Act and must cooperate with any investigations under the Act.
- 14.2 Not Used.
- 14.3 ARIA will immediately stop future payments of the Grant and may require repayment of some or all of the Grant if subsidy control or state aid laws so require for the funding to be compliant.

15. INTELLECTUAL PROPERTY RIGHTS

- 15.1 You must act in good faith and comply with the spirit of clauses 15 and 16 and not seek to avoid their application by artificial means.

Background IP

- 15.2 The Grant Agreement does not affect the ownership of your Background IP. You must notify ARIA during the Funding Period if any additional Background IP is required either to carry out the Project Activities or to exploit commercially any of the Results.

Foreground IP ownership

- 15.3 You will own all Foreground IP unless your policy is for individual researchers to own the Foreground IP they create. Where your individual researchers will own any of the Foreground IP you must impose on them the obligations relating to Foreground IP and Results contained in clauses 15 and 16.
- 15.4 You must submit all (i) Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the [Future Proofing our Climate and Weather Intellectual Property Pledge] promptly following creation or filing (as applicable) of such Foreground IP (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the [Future Proofing our Climate

and Weather Intellectual Property Pledge]. You hereby agree to comply and uphold the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge].

- 15.5 You must submit all (i) all patents within or covering the Foreground IP and (ii) data generated from any activities or experiments identified in the Project Activities to the [Future Proofing our Climate and Weather Intellectual Property Pledge] promptly following creation or filing (as applicable) of such patents and/or data (unless otherwise agreed in writing with, or instructed by, ARIA). For clarity, your rights to use and commercialise Foreground IP set out in clauses 15 and 16 are subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge]. You hereby agree to comply and uphold the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge].

Attribution to ARIA

- 15.6 You must ensure that whenever any Results are used with or communicated to Third Parties or are exploited commercially, ARIA's funding of the Project Activities is suitably accredited in accordance with ARIA's accreditation guidelines in force at the time. When using ARIA's name and logo you will comply with ARIA's branding guidelines in force at the time.

Patenting and publication

- 15.7 You must ensure that all Foreground IP is protected and managed in a professional manner, which may include patenting of any Results that are patentable.
- 15.8 You must notify ARIA where practicable at least 30 days (and in any event at least 48 hours) before publication of any Results by any person. This is intended to give ARIA the opportunity to discuss with you the possibility of filing a patent application before publication, and if appropriate assisting you with that process.
- 15.9 You must give ARIA as much notice as possible, but no less than 30 days' notice, of any decision to abandon or withdraw patent protection for any of the Results for the lifetime of the relevant patents or such shorter period as is agreed with ARIA so that ARIA can consider whether it wishes to fund future prosecution and maintenance and/or request the assignment of the patents to ARIA or its nominee.

Inventor first preference

- 15.10 Subject to the terms of the [Future Proofing our Climate and Weather Intellectual Property Pledge] if any inventor or active participant in the Project Activities expresses interest in the exploitation of the Foreground IP they have developed, you must give them an opportunity to negotiate an assignment or commercial licence of the Foreground IP, on reasonable terms, prior to negotiating with any entity in which an inventor or active participant in the Project Activities is not involved as a shareholder or other key stakeholder.

16. COMMERCIALISATION OF RESULTS

- 16.1 Where they are capable of commercial exploitation you should seek to exploit the Results commercially.
- 16.2 If for any reason you choose not to exploit any such Results commercially within a reasonable timeframe you are encouraged to discuss the position with ARIA, and you may request that ARIA exploit them or assist you with their exploitation. In this case ARIA may request that you assign the relevant Foreground IP to it or its nominee. Any assignment would include a licence back to the relevant Foreground IP for research purposes.

Non-UK Commercialisation

- 16.3 Save as set out in the [Future Proofing our Climate and Weather Intellectual Property Pledge], to avoid any restriction on commercialisation, no consent is required from ARIA for any Non-UK commercialisation or any sale of Foreground IP to a Non-UK Entity. However, ARIA is set up to create value for the UK and therefore you must secure a fee payable to ARIA (**ARIA Non-UK Fee**) in each of the following circumstances:
- (a) where you are a Non-UK Entity;
 - (b) where you become a Non-UK Entity;
 - (c) where you assign or Commercially License any Foreground IP to a Non-UK Entity; or
 - (d) where you have assigned or Commercially Licensed any Foreground IP to a UK Entity that subsequently becomes a Non-UK Entity.
- 16.4 In order to avoid any unnecessary complexity, the ARIA Non-UK Fee will be based on the terms that you agree with any person to which you assign or Commercially License the relevant Foreground IP. This ARIA Non-UK Fee will amount to an additional twenty-five per cent (25%) of the value of the consideration (including upfronts, licence fees, milestone payments, royalties, shares or other securities, buyouts, exit fees and other consideration) that you receive from the exploitation of the relevant Foreground IP during any period that the above circumstances exist.
- 16.5 For example, if you would receive £100 (via royalty or royalty buyout), you must ensure your contractual mechanism enables you to collect an additional £25 and pay that additional amount to ARIA.
- 16.6 The ARIA Non-UK Fee is payable within 90 days after the end of each relevant Financial Year for receipts related to that calendar year. You are encouraged to use the clauses in Annex 1 in your Commercialisation Licences of Foreground IP.

Crown Body customers

- 16.7 You must ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities, and in suitable quantities for the Crown Body's requirements.

Spin-outs

- 16.8 ARIA seeks to maximise future investment of entrepreneurial talent and capital in start-up companies commercialising the Results of its funded activities. To that end, having funded the full economic cost

of the research, ARIA places restrictions on the level of equity stakes and royalties that you may negotiate in exchange for the assignment or Commercialisation Licence of any Foreground IP.

16.9 If you or your technology transfer company assign or licence any Foreground IP to any third party or to a start-up established for the purpose of commercially exploiting the Results (a NewCo) you together with any connected person (including any investment fund to which you may transfer any part of your stake) shall be entitled to negotiate for consideration consistent with your institution's practices.

16.10 Not Used.

16.11 Not Used.

17. ASSETS

17.1 You must keep a register during the Funding Period and for up to 7 years after the end of the Funding Period of all Assets, with all relevant details about each Asset. You must use any Assets purchased with Grant monies for the Project Activities.

17.2 At the end of the Funding Period all equipment purchased for use on the Project with funds provided by ARIA shall remain your property.

18. INSURANCE

18.1 You must maintain Adequate Insurance (including public liability insurance) either as a self-insurance arrangement or with an insurer of good repute to cover all insurable claims and liabilities under or in connection with the Grant Agreement. You must provide evidence of that insurance to ARIA on request.

19. ASSIGNMENT AND SUBCONTRACTING

19.1 Neither party may transfer, assign, novate or otherwise dispose of the whole or any part of the Grant Agreement or any rights under it, to another organisation or individual, without ARIA's the non-assigning party's prior written consent.

19.2 You shall not subcontract any of the Project Activities to a Third Party except to the extent permitted, and to the person or persons identified, in Schedule 2 Part 1. You must seek ARIA's prior consent to appoint any new Sub-Contractors not identified in Schedule 2 Part 1. You shall (i) be responsible for the acts and omissions of any Sub-Contractor as though they were your own.

20. BORROWING, LOSSES, GIFTS, SPECIAL PAYMENTS

20.1 You must obtain ARIA's prior written consent before:

- (a) borrowing or lending money from any source in connection with the Grant Agreement;
- (b) giving any guarantee, indemnity, security over any Asset or letter of comfort in relation to the Grant Agreement;
- (c) making any gift or writing off any debt or liability in connection with the Grant, and must keep a record of all gifts given and received in connection with the Grant.

21. PUBLICITY

- 21.1 The parties will agree the text of a press release or other announcement to publicise the award of the Grant and all such publicity must comply with ARIA's accreditation and branding guidelines. Neither party may make any other press release or announcement about the Grant or publicise details of the Grant Agreement without the other's consent, except as required by Law.
- 21.2 You must comply with all reasonable requests from ARIA to facilitate visits and provide reports, statistics, photographs (with consent of your personnel if required) and case studies that will assist ARIA in its promotional and impact assessment activities relating to the Project Activities.

22. EVENTS OF DEFAULT AND TERMINATION

Events of Default

- 22.1 ARIA may exercise its rights set out in clause 22.2 if any of the following events occur:
- (a) you fail to comply with any of your obligations under clauses 2.2, 7.2, 9.1, 11, 12, 13, 15.5 or 25, or commit a material breach of any other term of the Grant Agreement in the reasonable opinion of ARIA;
 - (b) you do not commence the Project Activities within 30 days after the Commencement Date unless an extension is agreed with ARIA;
 - (c) you fail to improve the performance of the Project Activities, notwithstanding your having undertaken the remedial activity agreed with ARIA in the remedial plan under clause 6.2(d);
 - (d) not used.
 - (e) you provide ARIA with any materially misleading or inaccurate information in your grant application or in subsequent related correspondence;
 - (f) you commit a Prohibited Act or fail to report a Prohibited Act to ARIA, whether committed by you or a Third Party, immediately upon becoming aware of it;
 - (g) you are subject to an Insolvency Event;
 - (h) the Grant or any part of it is held by a court or competent authority to be a prohibited subsidy under the Subsidy Control Act 2022 or an illegal state aid;
 - (i) you undergo a Change of Control which will, in the reasonable opinion of ARIA:
 - (i) be materially detrimental to, or result in fundamental changes to, the Project Activities;
 - (ii) result in your being unable to receive the Grant; and/or
 - (iii) raises national security concerns.

Rights reserved for ARIA in relation to an Event of Default

- 22.2 If an Event of Default has or may have occurred, ARIA may by written notice to you take any one or more of the following actions:
- (a) suspend the Project Activities and payment of the whole or any part of the Grant for such period as ARIA may determine, acting reasonably;

- (b) reduce the Maximum Sum, in which case the payment of Grant will thereafter be made in accordance with the reduction and notified to you; and/or
- (c) subject to clause 22.4, terminate the Grant Agreement with immediate effect as from the date of service of the notice of that termination.

22.3 Where this Grant Agreement is terminated for an Event of Default described in clause 22.1(f) or 22.1(h), ARIA may require you to repay the entire amount of the Grant previously paid to you.

Opportunity for you to remedy an Event of Default

22.4 If ARIA wishes to exercise any right under clause 22.2 in connection with an Event of Default which is capable of remedy:

- (a) ARIA will provide reasonable notice to you specifying particulars of the Event of Default, how it must be remedied and the timescales for its remedy; and
- (b) following receipt of a notification under clause 22.4(a), you will be given a reasonable opportunity to remedy the Event of Default before ARIA exercises the relevant right under clause 22.2.

22.5 Without prejudice to any other provision of the Grant Agreement, you may terminate the Grant Agreement on written notice to ARIA if ARIA commits a material breach of the Grant Agreement which is either not capable of being remedied or, if the breach is capable of being remedied, ARIA fails to remedy such breach within 30 (thirty) days of receiving written notice requiring it to do so.

General Termination Rights

22.6 Notwithstanding ARIA's right to terminate the Grant Agreement under clause 22.2(c), either party may terminate the Grant Agreement (in whole or in part) at any time by giving at least 60 days' prior written notice to the other party.

22.7 You must promptly notify ARIA in writing if at any time the principal investigator or any key researcher(s) named in Schedule 2 working on the Project Activities is unable or unwilling to continue to be involved in the Project Activities or is moving to a new organisation without the desire to continue the research. Within 60 days after the date of that notice, you must either:

- (a) nominate one or more successors, subject to ARIA's approval; or
- (b) agree that the Grant is transferred to another organisation subject to your and the new organisation's agreement in writing and ARIA's approval of the transfer

If ARIA is unwilling to accept the nominated successor(s) or does not approve a request for transfer, it may terminate the Grant Agreement by at least 30 days' written notice to you.

Consequences of Termination

22.8 If the Grant Agreement is terminated you must return any Unspent Monies to ARIA within 30 days after the date of the termination notice, save where ARIA gives written consent to their retention.

22.9 Where ARIA terminates the Grant Agreement in accordance with clause 22.6, ARIA will be liable to pay any Unavoidable Costs subject to:

- (a) you taking all reasonable steps to mitigate such loss; and
- (b) the Unavoidable Costs being:
 - (i) proven, reasonable, and not capable of avoidance or recovery;
 - (ii) incurred under arrangements or agreements that are directly associated with this Grant Agreement;
 - (iii) supported by full particulars, including a fully itemised and costed list of such costs, with supporting evidence and copies of any relevant Sub-Contracts, and such information has been provided to the reasonable satisfaction of ARIA;
 - (iv) costs not relating to Sub-Contracts with an entity which directly or indirectly controls you, is controlled by you, or is under direct or indirect common control with you;
 - (v) costs that would not have been incurred had this Grant Agreement continued until the end of the Funding Period as set out in the Grant Funding Letter (or, if it has been extended, the expiry of such additional period).

22.10 You shall ensure that any Sub-Contract, or the part of the Sub-Contract which relates to the Services, over £250,000 will terminate automatically and immediately upon termination of this Agreement.

22.11 If requested by ARIA from time-to-time, you must (acting in good faith) provide ARIA with a reasonable estimate of the Unavoidable Costs which would be payable under this Grant Agreement in the event that the Grant Agreement was terminated (calculated on the basis described in clause 22.8).

22.12 ARIA's total liability under clause 22.9 shall be limited to the Maximum Sum under the Grant Agreement (or relevant part), including any sums paid, due or becoming due to you at the date of termination.

22.13 If the Grant Agreement is terminated or expires ARIA will not be liable to pay any of your costs or those of any of your contractors or suppliers related to any transfer or termination of employment of any employees engaged in the provision of the Project Activities, unless they have been hired for the purpose of the Project Activities, are specified personnel in the Grant Funding Letter and are normal statutory or contractual requirements. You must at ARIA's request promptly prepare a written exit plan to provide for the cessation or seamless transfer to a Third Party of the Project Activities following expiry or termination of the Grant Agreement.

23. DISPUTE RESOLUTION

23.1 The parties must use all reasonable endeavours to resolve in good faith any dispute that arises during the term of the Grant Agreement.

23.2 All disputes and complaints must be referred in the first instance to the Grant Manager and the Project Representative.

- 23.3 If the dispute cannot be resolved between the Grant Manager and the Project Representative within a maximum of 15 Working Days, then the matter will be escalated to a formal meeting between the parties' Escalation Contacts.

24. LIMITATION OF LIABILITY

- 24.1 Neither party's liability for any of the following shall be subject to the limitations or exclusions of liability otherwise provided for in this clause:

- (a) fraudulent misrepresentation or any other fraudulent act or omission;
- (b) payment of sums properly due and owing to the other in the normal course of performance of this Grant Agreement;
- (c) liability which may not lawfully be excluded or limited.

- 24.2 Subject to clause 24.1, ARIA accepts no liability for any consequences or Losses, whether arising directly or indirectly, that may arise in connection with:

- (a) your carrying out the Project Activities;
- (b) the use of the Grant by any person;
- (c) any reduction, suspension, withdrawal or request for repayment of the Grant in accordance with this Grant Agreement; or
- (d) termination of the Grant Agreement in accordance with this Grant Agreement.

- 24.3 Subject to clause 24.1, neither party will be liable to the other party, whether for breach of contract, tort (including negligence) or otherwise, for:

- (a) loss of profit, sales or turnover;
- (b) loss of contracts or business opportunities;
- (c) loss of anticipated savings;
- (d) loss of goodwill or damage to reputation; or
- (e) any indirect, special or consequential loss or damage;

in each case arising out of or relating to the Grant Agreement, whether or not such loss or damage was foreseeable or the other party was advised of its possibility.

- 24.4 Subject to clause 24.1, each party's total aggregate liability arising out of or relating to the Grant Agreement or its subject matter or anything which it has done or not done in connection with the Grant Agreement or its subject matter (whether for breach of contract, tort, including negligence, or otherwise), will not exceed the amount of the Maximum Sum.

- 24.5 You shall under no circumstances in connection with this Grant Agreement be entitled to recover damages, or obtain payment, reimbursement, restitution or indemnity more than once in respect of the same loss, shortfall, damage, deficiency, breach or other event or circumstance.

- 24.6 ARIA shall be entitled to set off any of your outstanding liabilities against any amounts that are payable by it pursuant to this Grant Agreement.

25. RESEARCH ETHICS AND CODE OF CONDUCT

- 25.1 As a recipient of a Government grant you must operate in accordance with the Concordat.
- 25.2 All research data:
- (a) must be generated using sound scientific techniques and processes;
 - (b) must be accurately recorded in accordance with good scientific practices by the people conducting the research; and
 - (c) must be analysed appropriately, without bias and in accordance with good scientific practices.
- 25.3 The Results must be stored securely and be easily retrievable with document trails that allow reconstruction of key decisions and conclusions of the Project.
- 25.4 You must comply with the Code of Conduct and ensure that your Representatives undertake their duties in a manner consistent with the principles set out in the Code of Conduct. You must immediately notify ARIA if you become aware of any actual or suspected breaches of the principles contained in the Code of Conduct.

26. VARIATIONS

- 26.1 Any variation to the Grant Agreement will only be valid if it is agreed in writing and signed by an authorised representative of each party.

27. GENERAL

- 27.1 Notices: All notices and other communications in relation to this Grant Agreement must be in writing and will be deemed to have been duly given if personally delivered, e-mailed, or mailed (first class postage prepaid) to the address of the relevant party as stated in clause 2.1 of the Offer Letter. If personally delivered or if e-mailed all such communications will be deemed to have been given when received (except that if received on a non-working day or after 5.00 pm on any Working Day they will be deemed received on the next Working Day) and if mailed all such communications will be deemed to have been given and received on the third Working Day following such mailing.
- 27.2 Change of control: You must notify ARIA as soon as practicable in writing of any arrangements that are in progress or in contemplation that if completed will result in a Change of Control, and must provide to ARIA sufficient details about the circumstances surrounding the proposed Change of Control and the identity of the proposed acquiror to allow ARIA to assess whether clause 22.1(i) is likely to apply.

28. GOVERNING LAW

- 28.1 This Grant Agreement will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

29. NOT USED

30. DEFINITIONS AND INTERPRETATION

30.1 Where they appear in these Conditions or the Grant Agreement:

Adequate Insurance means the insurance requirements and amounts set out in the Grant Funding Letter.

Asset means any asset that is purchased, improved or developed using the Grant including equipment and fixed assets;

Background IP means IP that is:

(a) owned by or licensed to a party prior to the Commencement Date; or

(b) developed by or on behalf of a party during the Funding Period but not in connection with the Project Activities.

Bribery Act means the Bribery Act 2010 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning this legislation;

Change of Control means the sale of all or substantially all your assets; any merger, consolidation or acquisition of you with, by or into another person, or any change in the ownership of more than fifty percent (50%) of your voting capital in one or more related transactions;

Code of Conduct means the Code of Conduct for Recipients of Government General Grants published by the Cabinet Office in November 2018 which is available (at the Commencement Date) at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/754555/2018-11-06_Code_of_Conduct_for_Grant_Recipients.pdf

including any subsequent updates from time to time;

Commencement Date means the date set out in the Grant Funding Letter;

Commercialisation Licence means a licence of IP other than a research or evaluation licence and/or subcontract manufacture (and **Commercially License** means to license under a Commercialisation Licence);

Commercialisation Hypothesis means the exploitation plan approved by ARIA and set out at Schedule 2 Part 2, as may be amended by agreement between the parties during and after the Funding Period;

Completion Date means the date set out in the Grant Funding Letter;

Concordat means the Concordat to Support Research Integrity which can be found at <https://ukrio.org/about-us/the-concordat-to-support-research-integrity/>

Conditions means these ARIA Grant Conditions;

Confidential Information means any information (however conveyed, recorded or preserved) disclosed by ARIA to the other party whether after the date of the Grant Agreement, which may include any information that ought reasonably to be considered to be confidential (whether or not it is so marked) relating to: (i) the business, affairs, customers, clients, suppliers or plans of the disclosing party; or (ii) the operations, processes, product information, know-how, designs, trade secrets or software of the disclosing party; (iii) any information developed by the parties in the course of carrying out the Project Activities which has not been published or otherwise publicly disclosed; (iv) Personal Data supplied by either party to the other for the purposes of, or in connection with, the Grant Agreement; notwithstanding the foregoing, neither party anticipates or plans disclosure to the other of any Personal Data in connection with this Grant Agreement and the activities conducted

hereunder; **Crown Body** means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

Data Protection Legislation means all applicable laws from time to time in force which apply to the party relating to the use of Personal Data, and any judicial or administrative interpretation of any of the above, and any guidance, guidelines, codes of practice, approved codes of conduct and approved certification mechanisms issued by any relevant supervisory authority as applicable;

Duplicate Funding means funding provided to you by a Third Party which is to fund the same activities as the Project Activities;

EA means the Equality Act 2000 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

EIR means the Environmental Information Regulations 2004 or Environmental Information (Scotland) Regulations 2004;

Eligible Expenditure means the payments made by you during the Funding Period for the purposes of carrying out the Project Activities which comply with clause 5 and ARIA's published eligibility rules (which provide for full economic cost reimbursement) and as agreed in the Grant Funding Letter;

Escalation Contact means the escalation contact appointed by ARIA or by you (as the case may be), which at the Commencement Date will be the individuals listed as such in the Grant Funding Letter;

Event of Default means any of the events or circumstances set out in clause 22.1;

Financial Year means 1 April to 31 March;

FOIA means the Freedom of Information Act 2000 and the Freedom of Information (Scotland) Act 2002, any subordinate legislation made under those Acts from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Foreground IP means any IP in the Results;

Funding Period means the period commencing on the Commencement Date and ending on the Completion Date or such later date as may be agreed between the parties unless otherwise determined in accordance with the terms of the Grant Agreement;

Future Proofing our Climate and Weather Intellectual Property Pledge means the pledging system for patents relating to approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification (operated by ARIA or by a third party), in the form set out at Annex A;

Grant means the sum or sums ARIA will pay to you up to the amount set out in the Grant Funding Letter, in accordance with clause 4 and subject to the provisions set out at clause 22.

Grant Agreement has the meaning given in the Grant Funding Letter;

Grant Claim means a request submitted by you to ARIA for payment of the Grant;

Grant Funding Letter means the letter from ARIA to you to which these Conditions are annexed;

Grant Manager means the individual who has been nominated by ARIA to be your day-to-day point of contact in relation to the Grant;

Grant Review means the process for reviewing the grant outlined in clause 6;

HRA means the Human Rights Act 1998 and any subordinate legislation made under that Act from time to time together with any guidance or codes of practice issued by the relevant government department concerning the legislation;

Ineligible Expenditure means expenditure incurred by you which is not Eligible Expenditure as set out in clause 5 and ARIA's published eligibility rules;

Information Acts means the Data Protection Legislation, FOIA and the EIR, as amended from time to time;

Insolvency Event means:

(i) where you pass a resolution, or the court makes an order that you be wound up (otherwise than for the purpose of a bona fide and solvent reconstruction or amalgamation); or (ii) a receiver, manager or administrator on behalf of a creditor is appointed in respect of all or part of your business or assets; or (iii) circumstances arise which entitle a court or creditor to appoint a receiver, manager or administrator or which entitle the court (otherwise than for the purpose of a solvent and bona fide reconstruction or amalgamation) to make a winding up order; or (iv) you cease to trade or are unable to pay your debts within the meaning of the Insolvency Act 1986 or any similar event occurs under the law of any other jurisdiction;

Intellectual Property Rights or **IP** means copyright, rights related to or affording protection similar to copyright, rights in databases, patents and rights in inventions, semi-conductor topography rights, trade marks, rights in internet domain names and website addresses and other rights in trade names, designs, know-how, trade secrets and any modifications, amendments, updates and new releases of the same and all similar or equivalent rights or forms of protection which subsist or will subsist now or in the future in any part of the world;

Law means any law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code, judgement of a relevant court of law, or directives or requirements of any regulatory body, delegated or subordinate legislation;

Losses means all losses, liabilities, damages, costs, expenses (including legal fees), disbursements, costs of investigation, litigation, settlement, judgement, interest and penalties whether arising in contract, tort (including negligence), breach of statutory duty, misrepresentation or otherwise;

Maximum Sum means the maximum amount of the Grant stated in the Grant Funding Letter;

Milestones means the outputs of the Project Activities described in paragraph 3.2 of Schedule 2;

NewCo has the meaning given in clause 16;

Non-UK Entity means a legal entity that is not a UK Entity;

Personal Data has the meaning given to it in the Data Protection Legislation as amended from time to time;

Prohibited Act means:

(a) directly or indirectly offering, giving or agreeing to give to any servant of ARIA or the Crown any gift or consideration of any kind as an inducement or reward for (i) doing or not doing (or for having done or not having done) any act in relation to the obtaining or performance of the Grant Agreement; and/or (ii) showing or not showing favour or disfavour to any person in relation to the Grant Agreement;

(b) committing any offence: (i) under the Bribery Act; (ii) under legislation creating offences in respect of fraudulent acts; and/or (iii) at common law in respect of fraudulent acts in relation to the Grant Agreement; and/or

(c) defrauding or attempting to defraud or conspiring to defraud ARIA or the Crown;

Project means the Project Activities together with the Results;

Project Activities means the activities to be carried out by you that are described in the Grant Funding Letter and in Schedule 2 Part 1;

Project Representative means the representative appointed by you, who at the Commencement Date will be the individual listed as such in the Grant Funding Letter;

Representative means any of the parties' duly authorised directors, employees, officers, agents, professional advisors and consultants;

Results means all information, data, and materials generated in the course of the Project Activities;

Secure Innovation and Trusted Research Guidance means the best practice for the implementation of basic protective security measures guidance provided by NCSC and NPSA which can be found on ARIA's website;

Third Party means any person or organisation other than you or ARIA;

UK Entity means a legal entity whose ultimate parent company has its headquarters and principal establishment in the United Kingdom;

Unavoidable Costs means the amounts paid to you in respect of the termination as a direct result of the early termination of this Grant Agreement and which are not capable of recovery;

Unspent Monies means any monies paid to you which remain unspent at the end of the Funding Period because of termination or breach of the Grant Agreement. Unspent Monies do not include non-cancellable costs incurred prior to termination; and

Working Day means any day other than a Saturday, Sunday or public holiday in England and Wales.

30.2 In these Conditions and the Grant Agreement, unless the context otherwise requires:

- (a) references to "party" and "parties" are to the parties to the Grant Agreement;
- (b) the singular includes the plural and vice versa;
- (c) references to a person include an individual, company, body corporate, corporation, unincorporated association, firm, partnership or other legal entity or Crown Body;
- (d) references to clauses and Schedules are to the clauses of these Conditions and to the Schedules to the Grant Agreement;
- (e) a reference to any Law includes a reference to that Law as amended, extended, consolidated or re-enacted from time to time;
- (f) the words "including", "other", "in particular", "for example" and similar words will not limit the generality of the preceding words and will be construed as if they were immediately followed by the words "without limitation"; and
- (g) the headings in the Grant Agreement are for ease of reference only and will not affect the interpretation or construction of the Grant Agreement.

SCHEDULE 2

PART 1 - PROJECT ACTIVITIES

1. Background

Stratospheric aerosol injection (SAI) could be used to reflect a small amount of sunlight back to space, cooling the planet. We know with certainty that this would cool, and if it were started at high latitudes where the tropopause is lower, it could potentially be conducted using existing (but modified) aircraft, making this the most near-term option for radically reducing the risks of climate change. Nonetheless, there are still critical uncertainties that would need to be narrowed before informed decisions about using SAI could be considered robust.

You will start from the assumption that the nearest-term use of SAI is highly likely to be with sulfate aerosols, with gaseous dispersal of a precursor (SO₂ being the obvious candidate), and released from aircraft. The expectation that sulfate is the nearest-term option is due to the close similarity with natural analogues, and due to your knowledge of the environmental impacts of sulfate compared to novel materials; releasing as a gaseous precursor is expected to be more straightforward, and is again consistent with natural analogues. (And analyses consistently show that aircraft are likely the cheapest means of lofting material). This makes reducing the remaining uncertainties associated with SO₂ release a high priority for near-term research.

With SO₂, the biggest source of testable uncertainty that could be reduced at a scale relevant for an outdoor experiment is associated with aerosol microphysics, leading to uncertainty in the aerosol size distribution, and hence both lifetime and radiative efficacy; this ultimately affects the overall amount one needs to inject to achieve a given amount of cooling. This uncertainty comes from the potential competition between nucleation (new particle formation) and condensation/coagulation (particle growth) of H₂SO₄ vapors and already nucleated sulfate aerosols, which in turn is strongly dependent on spatial inhomogeneity, as well as on initial conditions (such as ion-induced nucleation within the plume of an aircraft). In a climate model, these small-scale processes are represented by simplified parametrizations, based on a small amount of existing observations after volcanic eruptions, pyrocumulus etc. However, these representations have already been demonstrated to be highly model dependent (roughly a factor of two range across models), including even dependent on the physical timescale of the calculations, due to competition between different simultaneous processes (nucleation versus coagulation) that need to be resolved at a high temporal scale. Even more critically, the existing observations that lead to current parameterizations are from analogues that are not fully representative of the conditions that would happen during SAI, and there is little basis to guess how large an effect this might have on predictions without direct experimentation.

An outdoor experiment could be designed specifically aimed at reducing this uncertainty, but it is unclear what scale this experiment would need to be. This is the primary question you will address here - not the detailed experiment design, but rather a robust scientific definition of the scale that such an experiment would need to be conducted at in order for it to meaningfully constrain some of the key microphysical uncertainties. This would not just be a critical first step in the design of the experiment, but would provide critical information for supporting evidence-based conversations on research governance.

There are two key observations that guide your thinking in the potential design of such an experiment:

It would be essential to conduct the putative experiment in as close a way as possible to the way SO₂ would be released in practice, in order to ensure that the conclusions were applicable to a realistic scenario. This would require release from an aircraft, and at release rates (kg/s or kg/km of travel) similar to rates expected in an actual SAI event. This would ensure both that the initial plume concentrations were relevant, and also that the test did not over- or under-represent effects from exhaust ions or aircraft wake turbulence for example.

It would be essential to be able to track the resulting plume until oxidation and aerosol formation were mostly complete, so 2-4 weeks. This would require a sufficiently large initial injection of material to ensure that after several weeks of mixing, the aerosol concentrations remained locally high enough that the plume could be found.

The initial plume of SO₂ from the aircraft would gradually spread, advecting with the local winds, and diffusing, but even after a few weeks would lead to a broad plume or tube of higher aerosol concentrations that would not necessarily be close to uniformly mixed throughout the scale of a climate model grid cell.

2. Aims and objectives of the Project Activities

Your goal is to determine the minimum size of an experiment that would allow for a substantial reduction in this uncertainty.

The two main questions that need to be answered to address this goal are (i) understand the range of plausible plume spreading rates, and (ii) assess the ability to forecast future plume location (to reduce the search space). In addition it is important to understand instrument detection thresholds, and to assess potential transboundary implications of such a test.

3. Project Activities

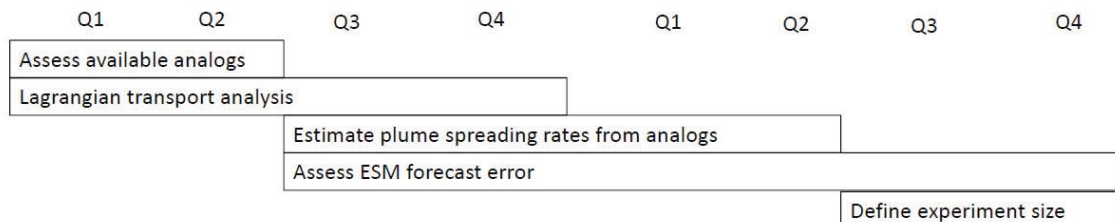
- 3.1 The first task is to quantify the range of plausible rates of plume diffusion over the first month following a hypothetical experimental release of material. To help constrain this, you will use satellite observations from TROPOMI after volcanic eruptions, which have been demonstrated to be capable of tracking plumes of SO₂ at a scale relevant to a large-scale SAI experiment. While this can only be used to determine spreading rates for spatial scales larger than the spatial resolution of TROPOMI (about 25 km horizontally), that can be extrapolated to bound spreading rates at smaller spatial scales as well. Analysis after different volcanic eruptions will provide information about how variable these rates might be under different stratospheric conditions. In addition, you will also explore the use of other potential analogs as well (e.g., pyrocumulus plumes), as described in your first milestone. This effort will allow you to determine, as a function of the initial SO₂ mass release rate, estimates for how broad the resulting plume would be as a function of time and the estimated peak aerosol concentration within the plume.
- 3.2 A related second task is to clarify the potential sensitivity of observational capability for remotely detecting SO₂ and detecting sulfate aerosols. The aerosols can be detected through upwards-facing LIDAR on aircraft; these instruments are already in use (on the NOAA SABRE

missions, for example), but you will engage in conversations about the potential for modifications for this particular mission.

- 3.3 The third task aims to provide statistical information about the movement of air plumes at different geographical locations and altitudes based on reanalyses and trajectory models. This provides a starting point for the final task below to understand the range of possible future plume locations if there is no forecast capability, and can clarify whether there are altitudes or locations that an experiment could be conducted at that would lead to more or less predictability. Furthermore, understanding the ultimate tropospheric deposition distribution will help inform future discussions around potential transboundary issues with outdoor SAI experiments. This will allow you to clarify under which conditions and injection amounts there might be foreseeable chances of some of the plume material falling into the troposphere within a country's airspace and hence the potential for deposition. This will provide information for the modality of "safe" outdoor experiments that do not significantly infringe on other countries' airspaces. This will allow you to address the potential relevance of the experiment in light of current, established protocols around environmental pollutants, such as the Convention on Long-Range Transboundary Air Pollution, by communicating at which scales, and from which locations, detectable transboundary effects could be relevant.
- 3.4 Finally, task 4 addresses the ability to forecast the future location of the center of the plume if the current location is known. Here you will use the Whole Atmosphere Community Climate Model (WACCM) in forecast mode, where it is initialized with stratospheric winds (based on re-analysis). By comparing short-term WACCM forecasts of volcanic aerosols against observations, initialized at different times in the evolution of the volcanic plume, this tool will allow you to quantify the likely predictive accuracy with lead time, better constraining the search region that would need to be explored to find the aerosol plume (assuming that it is not always continuously tracked). You will also explore the use of other potential analogs (e.g., pyrocumulus plumes) for which data may be available.
- 3.5 Collectively, these tasks will be integrated to determine what spatial scale of experiment would be needed to allow reliably finding the plume if it is not continuously observed. Once the plume location is known, existing observational assets could be used for in-situ sampling to determine aerosol concentrations, size distribution, etc. Knowing the required mass release is an essential precursor to designing details of aircraft release systems as well.
- 3.6 The tasks above are separated out in terms of the goals, whereas the milestones below are defined temporally. The first milestone ensures that you are evaluating all of the observational data available primarily for task 1, but potentially task 4 as well. The second milestone addresses task 3, and is a starting point for task 4. The third and fourth milestones complete tasks 1 and 4. (You do not include a milestone for the smaller task 2.)
- 3.7 The following Milestones will be used to monitor your delivery of the Project. The costs associated with completing these Milestones are estimated in the cost breakdown sheet [REDACTED]

ID	Milestones	Measure	Date
1	Identify key eruptions and other relevant analogs that can help constrain plume forecast and spreading, and download observational datasets	Compile a list of available analogs to study, provide an initial internal report providing an overview of which analogs are more useful and usable for future analyses	Commencement date + 6 months
2	Conduct Lagrangian analysis (based on reanalysis) to simulate transport and assess both variance of stratospheric transport and ultimate tropospheric deposition	Analyse simulations results in order to assess model's skills, highlighting differences with observations	Commencement date + 12 months
3	Estimate plume spreading rates (or equivalently mixing or diffusivity) from eruption and other analogs	Determine aerosol peak concentration over time relative to initial concentration and determine initial concentration needed for detectability with LIDAR	Commencement date + 18 months
4	Assess forecast error as a function of lead-time and location for initialized climate model simulations	Draft paper written that integrates information across project to define minimum size limit for a hypothetical experiment	Commencement date + 24 months

In addition to the above Milestones, the following project plan will be used to track progress throughout the project and may be updated from time to time:



3.8 The intended long-term outcomes are summarised below:

- Provide the basis for more detailed experimental design once size requirements are better understood.
- Much clearer understanding of the roadmap towards supporting informed decisions in this space, supporting research investment decisions to enable necessary experimentation
- Your findings can be used during future community engagements and attempts to co-design outdoor experiments, by providing a best estimate of impacts and scales at play, potentially facilitating the role of other ARIA R&D Creators.
- The first, scientifically backed, grounded estimate of minimal size for the detection of an experiment across different scales will have allowed for more informed conversations, helping policymakers understand at what scale of an experiment do concerns about transboundary effects and potential interactions with international treaties merit strengthened governance regimes, as well as guiding potential actors aiming to design such experiments towards safe, responsible and useful experimental protocols. This will also inform countries' strategies towards better integrated observational systems to detect and attribute changes due to potential SAI scenarios, for instance by improving precision and accuracy of future orbital observational systems, strengthen on-the-ground observations and improve modeling practices towards more relevant identification strategies.

4. Project Reporting requirements

You will complete, submit and attend the following reporting/meeting requirements at the frequency set out below:

Frequency	Requirement
Kick off	• Roles and responsibilities • External communications • Project details
Quarterly	Reporting: • Technical status - Red/Amber/Green • Delivery status - Red/Amber/Green • The latest progress against milestone(s) from last quarter • Invoicing and cost reporting Optional: • Key Learning, discoveries and decisions • Stories to highlight • Priorities for the next quarter • Challenges • Changes to team and new collaborations • technical evidence saved to drive e.g. report or presentation as requested by PD • review meeting slide deck saved to drive as requested by PD Review meeting with ARIA Programme Team
Annual	• ARIA impact metrics • Attendance at annual ARIA event
Ad hoc	• As required, Programme Director/ Programme Team may request additional information and evidence • Workshops - potential to be invited to ARIA workshops
Project closure	• Project closure report

5. Payment

5.1 Subject to your compliance with the terms of this Grant Agreement, ARIA will make Grant payments monthly in arrears based on actual costs incurred.

Monthly payments will align with the calendar month.

5.2 Before paying any Grant Claim, ARIA must be satisfied that the Project Activities have been carried out during the Funding Period (or that part of the Funding Period to which the claim for

Grant relates).

5.3 Grant Claims must be submitted to ARIA by the 15th Working Day of the month following the end of the relevant period.

5.4 Payment of the Grant Claim will be made within 30 days after ARIA approves your Grant Claim.

6. Principal investigator/key researchers

6.1 For the purposes of clause 22.7, the following principle investigators or key researchers have been identified:

Name	Role	Organisation
Douglas MacMartin	PI	Cornell University
Daniele Visioni	Co-PI	Cornell University

7. Sub-Contractors

7.1 For the purposes of clause 19, the following Sub-Contractors have been agreed:

Name	Description of activity	Location

PART 2 - GRANT APPLICATION

Application titled: Defining the minimum scale of an SAI test: A fundamental first step towards an outdoor large scale experiment dated 07 December 2024

SCHEDULE 3

Not Used

ANNEX 1

Clause for inclusion in licences of Foreground IP

[] **ARIA NON-UK FEE**

[].1 In this clause:

“ARIA” means the Advanced Research and Invention Agency;

“Crown Body” means the government of the United Kingdom (including the Northern Ireland Assembly and Executive Committee, the Scottish Executive and the National Assembly for Wales), including, but not limited to, government ministers and government departments and particular bodies, persons, commissions or agencies from time to time carrying out functions on its behalf;

“UK Entity” means a legal entity that has or whose ultimate parent company has its headquarters and principal establishment in the United Kingdom.

[].2 The Foreground IP was developed with funding from ARIA. As a condition of its funding ARIA requires that a benefit is returned to the United Kingdom where the Foreground IP is licensed by the Licensor to any person that is not a UK Entity. Accordingly, in addition to any other sums payable by the Licensee to the Licensor under this Agreement, the Licensee shall pay to the Licensor within 90 days after the end of each calendar year during the Relevant Period (as defined below), and within 90 days after the end of the Relevant Period, a fee (**ARIA Non-UK Fee**) on all amounts (including upfronts, licence fees, milestone payments, royalties, shares or other securities, exit fees, buyout or other consideration) payable by the Licensee to the Licensor under this Agreement in relation to the exploitation of any Foreground IP (**Relevant Amount**) that accrues during, or relates to, any period of time that the Licensee is not a UK Entity (**Relevant Period**). The amount of the ARIA Non-UK Fee is 25% of the Relevant Amount, and is payable by the Licensee to the Licensor in addition to the amounts that would otherwise be payable under this Agreement. For example if the Relevant Amount is £100 the ARIA Non-UK Fee is an additional £25, which the Licensee shall pay to the Licensor and the Licensor shall remit to ARIA.

Crown Body customers

[].3 You must also ensure that any Crown Body is able to procure any products and services that are covered by, use or incorporate the relevant Foreground IP within a reasonable time period at prices that are no higher than those offered to or agreed with any other customer for equivalent quantities and in suitable quantities for the Crown Body's requirements.

[].4 ARIA shall have the right to enforce this clause [] under the Contracts (Rights of Third Parties) Act 1999. Neither party may amend this Agreement in a way that detracts from ARIA's right to enforce its rights under this clause without ARIA's prior written consent.

[1] When using this clause you may substitute the relevant defined terms used elsewhere in the agreement to capture the concept of "Foreground IP". Where the clause refers to the "Licensor" and "Licensee" please use the appropriate defined terms to include the licensor, licensee, assignor and assignee of the Foreground IP. This clause is not suitable for assignments of the Foreground IP in consideration of the payment of one or more lump sum payments. In those cases the Licensor needs to be informed, and potentially make an additional payment, if the Foreground IP is subsequently assigned to a non-UK Entity or if the Assignee ceases to be a UK Entity.

SCHEDULE 4

NOT USED

Annex A - Future Proofing our Climate and Weather Intellectual Property Pledge

1. Submission of Pledged Patents and Experimental Data

- 1.1 The Pledgor undertakes to submit relevant details of all Pledged Patents to the operator of the Pledge Repository in accordance with the Submission Guidelines.
- 1.2 The Pledgor undertakes to:
 - (a) submit (or provide a link to a publicly available digital copy of) all Experimental Data to the operator of the Pledge Repository in accordance with the Submission Guidelines; and
 - (b) publish such Experimental Data in accordance with the Submission Guidelines.

2. Experimental Data Licence

- 2.1 Subject to Clause 6.1, the Pledgor hereby grants a royalty-free, non-exclusive licence under the Experimental Data to any party that wishes to accept it ("Experimental Data Licensee") solely for the purpose of carrying out research in the Field.
- 2.2 The licence granted under Clause 2.1:
 - (a) is non-transferable and non-sublicensable;
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Experimental Data.
- 2.3 The Experimental Data Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Experimental Data Licensee must ensure that such third party agrees to comply with the terms of Clause 2.4 as if such third party were the Experimental Data Licensee.
- 2.4 The Experimental Data Licensee must:
 - (a) at all times when using the Experimental Data comply with all Laws; and
 - (b) to the extent that any data relating to the Field is generated by or on behalf of the Experimental Data Licensee in the course of carrying out research activities based on or using the Experimental Data or the Pledged Patents, make such data available on the terms of this Pledge (and such data shall be deemed to be Experimental Data pursuant to this Pledge).

3. Research Licence

- 3.1 Subject to Clause 6.1, the Pledgor grants a royalty-free, non-exclusive licence under the Pledged Patents to any party that wishes to accept it ("Research Licensee") solely for the purpose of carrying out research in the Field.
- 3.2 The licence granted under Clause 3.1:
 - (a) is non-transferable and non-sublicensable; and
 - (b) permits research activities but does not permit development, manufacture, sale or other exploitation of products or services under the Pledged Patents.
- 3.3 Subject to Clause 6.1, the licence granted in accordance with Clause 3.1 shall subsist until the expiry of the final Pledged Patent.

- 3.4 The Research Licensee may conduct relevant research activities itself or in collaboration with a third party, provided that the Research Licensee must ensure that such third party agrees to comply with the terms of Clause 3.5 as if such third party were the Research Licensee.
- 3.5 The Research Licensee must:
- (a) at all times when using the Pledged Patents comply with all Laws; and
 - (b) to the extent that any patents relating to the Field are filed by or on behalf of the Research Licensee covering data generated in the course of carrying out research activities based on or using the Pledged Patents or Experimental Data, make such patents available on the terms of this Pledge (and such patents shall be deemed to be Pledged Patents pursuant to this Pledge).

4. Commercial Licence

- 4.1 The Pledgor undertakes to grant a non-exclusive licence on reasonable terms under the Pledged Patents and/or Experimental Data to any Signatory that requests it ("Commercial Licensee") for the purpose of carrying out commercial activities (including development, manufacture, sale or other exploitation of products or services) in the Field.
- 4.2 The Pledgor must grant the licence set out Clause 4.1 in good faith and in a timely fashion following such a licence being requested by the Commercial Licensee.
- 4.3 The Commercial Licensee must at all times when using the Pledged Patents and/or Experimental Data comply with all Laws.

5. Pledgor Know-How

At the request of a Licensee, the Pledgor undertakes to negotiate in good faith with any Licensee regarding a non-exclusive licence in the Field under any Know-how owned by such Pledgor that is necessary for a Licensee to use the technology covered by the Pledgor's Pledged Patents. Such licence may be for research or commercial purposes as agreed between the Pledgor and Licensee.

6. Termination

- 6.1 The Pledgor may terminate any licence it grants to an Experimental Data Licensee and/or Research Licensee under this Pledge in the event that such Licensee:
- (a) materially breaches the terms of such licence or this Pledge; or
 - (b) breaches any Laws in its use of the Experimental Data or Pledged Patents (as applicable).

7. Transfers of Pledged Patents and/or Experimental Data

The Pledgor undertakes to make any future assignment of the Pledged Patents and/or Experimental Data to any other party (the "Recipient") conditional on the Recipient (and any successor in title) agreeing to be bound by the terms of this Pledge.

8. No Warranty

The Pledgor provides the Pledged Patents and the Experimental Data on an "as is" basis. The Pledgor makes no express or implied warranty or representation concerning the Pledged Patents or Experimental Data including but not limited to non-infringement or to the accuracy or completeness of the Pledged Patents or Experimental Data.

9. Compliance with Laws

For the avoidance of doubt, nothing in this Pledge operates to require a Pledgor, Licensee or Signatory to do any acts or grant any rights that do not comply with Laws.

10. Further Publication or Licensing

For the avoidance of doubt, nothing in this Pledge operates to restrain a Pledgor from publishing or licensing any Experimental Data or Pledged Patents more widely or on more permissive terms than those described herein.

11. Governing law and jurisdiction

This Pledge (including any non-contractual disputes or claims arising in connection with this Pledge) will be governed by and construed in accordance with the laws of England and Wales and the parties irrevocably submit to the exclusive jurisdiction of the courts of England and Wales.

Part 1 of Annex A: Definitions

1. In this Pledge, unless the context otherwise requires, the following definitions shall apply:

Experimental Data	means data generated by or on behalf of the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.2;
Field	means approaches for intentionally altering the Earth system through solar radiation modification, modification of ocean circulations, modification of cloud properties, surface engineering works, or weather modification;
Know-how	means the information, methods, formulae, processes and/or applications which may or may not be documented and which enable the use of the technology covered by the Pledged Patents;
Law(s)	means any applicable law, statute, bye-law, regulation, order, regulatory policy, guidance or industry code having the force of law, rule of court, delegated or subordinate legislation in force from time to time;
Licensee	means any Commercial Licensee, Research Licensee or Experimental Data Licensee;
Pledge	means the commitments in relation to patents, know-how and data set out in this pledge document;
Pledge Repository	[TBC]
Pledged Patents	means patents or patent applications owned by the Pledgor relating to the Field and identified by the Pledgor for inclusion in the Pledge pursuant to Clause 1.1;
Signatory	means any party who has agreed to be bound by the terms of this Pledge; and

Submission Guidelines	means the guidelines governing the submission of Experimental Data and details of the Pledged Patents to the Pledge Repository, as amended from time to time.