Advanced Research + Invention Agency ARIA

# Forecasting Tipping Points: Uniting climate measurements and models to create an early warning system

## Call for proposals

**Date: 04.09.2024**

V1

 

Advanced Research + Invention Agency ARIA

## SECTION 1: Programme Thesis and Overview

This solicitation is derived from the Programme Thesis Forecasting Tipping Points: Uniting climate measurements and models to create an early warning system, in turn derived from the ARIA Opportunity Space Scoping our Planet. We strongly recommend reading both of these documents before reading this one.

Climate tipping points exist where changes in a part of the climate system become self-perpetuating. Crossing climate tipping points will lead to substantial and widespread impacts on the Earth and its inhabitants, from sea level rise unprecedented on human timescales, to inhospitable weather extremes. Already, at today's 1.2°C global warming relative to pre-industrial levels, the threat of crossing climate tipping points in this century is real and urgent, yet we are unprepared for the potentially devastating consequences.

This programme will: innovate and deploy calibrated observation technologies, validate critical processes in models, and unite these to create an early warning system for climate tipping points. We will demonstrate a compelling proof-of-concept that such an early warning system can be *affordable*, *sustainable* and *justified*. The programme will achieve this demonstration through the targeted deployment of low-cost sensing systems in harsh environments, making new observations that have well-characterised uncertainties, in tandem with accelerated development of physics- and AI-driven models that can identify the subtle early warning signs of tipping.

We currently have no early warning system for climate tipping points. Without early warning, we have no way of preparing, adapting, mitigating, or intervening in the timescales required to avert disaster. This programme will demonstrate that an affordable, sustainable and justified early warning system is possible. If successful, this programme will **increase confidence and precision** in *when* tipping points are likely to be crossed, what the *consequences* would be and *over what timescales* they would unfold, establishing early warning signals that are trustworthy and actionable, empowering decision makers to accelerate proactive climate mitigation and adaptation.

## SECTION 2: Programme Objectives

### The breakthroughs we hope to accomplish

We plan to fund a five-year coordinated programme uniting a group of R&D Creators, recipients of ARIA research funding, that bring a diverse range of expert knowledge and are passionate about tackling the challenges outlined in our programme thesis. The programme will fund international multidisciplinary teams across a broad range of organisations with an emphasis on breaking systemic research silos. If successful, this programme will:

- **Build an early warning system through united innovation in observation and modelling.** It is not yet clear that an early warning system is even possible given the need to detect subtle trends on substantial background variation; we aim to find out if it is possible through this coordinated effort.
- **Reduce uncertainty in predictions of *when* tipping will occur in the exemplar systems of the Greenland Ice Sheet (GrIS) and Subpolar Gyre (SPG), what the *consequences* of crossing these tipping points will be, and *over what timescales* impacts will be felt.** Reducing uncertainty (1) in both the timescales and expected impacts of tipping will empower decision making around adaptation or intervention for tipping points, while adding urgency to mitigation activities towards net zero.
- **Unlock the value of low size/weight/power/cost (SWaP-C) instruments and artificial intelligence (AI) in climate science.**
    - Dense, distributed measurements in harsh environments can be unlocked through a low SWaP-C approach. SWaP-C innovation in consumer electronics and photonics provides dramatic upscaling of sensing systems, which enables a vast increase in our monitoring capability for a fixed observation budget.
    - AI is already having a huge impact on weather forecasting (2), however, the potential of AI has barely been explored in climate forecasting, let alone climate tipping points.
- **Open the global conversation on early warning for climate tipping points with the broadest range of stakeholders possible to deliver social and economic impacts from the knowledge created in the programme.**

## Technical areas of focus

The early warning system demonstration will focus on the tipping systems of the Greenland Ice Sheet (GrIS) and the adjacent Subpolar Gyre (SPG) circulation. These are prioritised as 'at risk' systems with different tipping dynamics, but are intimately connected with important interactions. The programme will be organised into three deeply connected technical areas:

+ **Technical area 1 (TA1): new sensing systems** will accelerate innovation and development of low-cost sensing systems that address unmet observational needs in harsh environments.
+ **Technical area 2 (TA2): deployment** will deploy existing and newly developed sensing systems in a coordinated multi-year field campaign targeted to the Greenland Ice Sheet and Subpolar Gyre to create an observational network to monitor these tipping systems.
+ **Technical area 3 (TA3): models for early warning** will unlock the mathematical, physical and computational methods necessary to create and test an early warning system for tipping points.

We expect to invest at least £10m in TA1, £16m in TA2 and £20m in TA3 at the first (current) solicitation point (year 0), with further funding being unlocked at the second solicitation point (year 2) across a 5 year programme. We are open to considering a diverse range of projects, from those that focus on solely on innovation in sensing systems in TA1 or dynamical models in TA3 (e.g. £1m over 3 years), through initial field testing of new technologies in TA2 (e.g. £50k over 4 months), to projects that span across all three TAs with a comprehensive integration of measurement and modelling (e.g. £15m over 5 years). We are also open to proposals that target expansion or extension of capabilities within existing observing networks that unlock their potential to contribute to an early warning system. Due to the high ambition and aggressive timelines, applicants are encouraged to consider plans that will reach success (or failure) on fast timelines.

Our vision for unifying teams across TA1, 2 and 3 is illustrated in a cycle (**Figure 1**), whereby new observations can feed into modelling experiments and model outputs can be used to target future observations. Close coordination of these different programme elements is vital. By enabling teaming (see **Section 4**), we aim to encourage those who have not previously worked in climate science to pivot their research activities into the programme.

**Projects that span TA1, TA2 and TA3 are strongly encouraged.**

Embedded across the entire programme are two **cross-cutting themes** (CCTs) that are detailed in the updated Programme Thesis. In short:

+ **Cross cutting theme 1 (CCT1)** underpins the integration of measurement and modelling through calibration and validation.
+ **Cross cutting theme 2 (CCT2)** exists to break systemic barriers in climate science.

**Creators can cost for activities that link to CCT1 and CCT2 within their proposals and will be asked how they plan to engage with these thematic activities either within their projects or as part of the broader programme.**

CCT1 will harmonise technology benchmarking and information flow between TAs. We anticipate a significant degree of in-person co-design among teams at the outset of the programme to agree meaningful data, calibration and validation standards within CCT1. CCT2 will aid productive dialogue between researchers, decision-makers and the public, which will build throughout the programme duration.

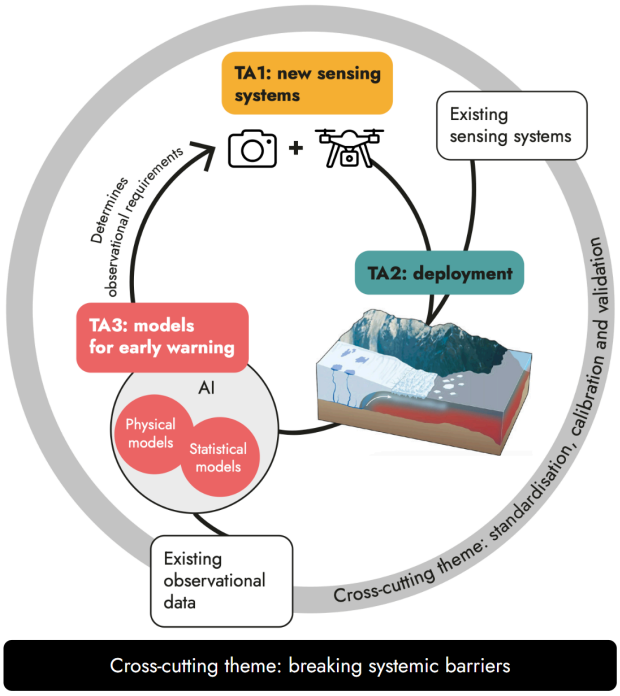


***Figure 1: Illustration of how we expect the TAs and the cross-cutting themes to interact.*** *Circular structure indicates the iterative nature of the research and demonstrates opportunities for external engagement. TA2 figure from (3).*

## TA1

Multidisciplinary teams of sensor and platform specialists will work in TA1 to co-design an *affordable* and *sustainable* harmonised 'internet of things' network of remote and *in situ* observations. In what follows, 'sensing systems' refers to the combination of a measurement sensor (e.g. camera) and the delivery platform that takes it to the location of measurement (e.g. drone); innovation may be required in one or both parts of the sensing system. We strongly encourage co-design of sensing systems by multidisciplinary teams that bring expertise in sensors and platforms together with experts in climate tipping point measurement and modelling.

Delivery platforms considered for funding by the programme could include, but are not limited to:

+ Small / cube / nano satellites,
+ Drones / airborne systems / high altitude platforms (HAPs),
+ Drifters / floats / buoys,
+ Submersibles / gliders / sea drones.

We particularly welcome innovations that fill unmet needs in the observing ecosystem, for example:

+ At-sea, under-sea and under-ice real-time communications and navigation, enabling fleet operation of autonomous vehicles.
+ Full-depth ocean robotic platforms capable of routine sustained observations to abyssal depths.
+ Lower-cost and lower-carbon footprint ice-capable vessels, both uncrewed and autonomous, enabling year-round sustained observations.
+ Satellite constellations or high altitude platforms suitable for polar observing, with ultra-high bandwidth communications for full real-time data retrieval and rapid command transmission.

Initially, teams will target observations of processes within the GrIS and SPG that are crucial for understanding instabilities in these systems but not well served by existing measurements, particularly in remote sensing. Some of these processes can be linked to essential climate variables (ECVs) drawn from the Global Climate Observing System, which already have target performance requirements (4), defined by the WIGOS 2040 report (5).

 

Integrating feedback on our programme thesis, we have formed an initial target set of variables (see **Table 1**).

***Table 1: Priority processes under consideration for targeting of initial measurements.*** *The list is not exhaustive and Creators may target variables beyond this list, provided they explain why the target variable is important for understanding tipping-related processes in GrIS and the SPG. Note that some target measurements are important for more than one process so appear more than once. Even for a process that can already be measured, further innovation may be needed to achieve it through a SWaP-C instrument or to achieve higher performance.*

| **Earth system domain** | **Process** | **Example target(s) for measurement** | **Can it currently be measured?** |
|---|---|---|---|
| Cryosphere | Marine ice sheet instability (MISI) | Grounding line location (m) and front location (m) | No |
| | | Grounding line ice thickness (m) | Yes |
| | | Sea surface salinity (g $kg^{-1}$) | Yes |
| | | Depth-resolved interior salinity (g $kg^{-1}$) | No |
| | | Surface / subsurface melt rates at the ice-ocean interface ($ms^{-1}$) | No |
| | Marine ice cliff instability (MICI) | Ice sheet velocity ($ms^{-1}$) | Yes |
| | | Ice cliff geometry (m) | Yes |
| | | Ice sheet surface melting ($ms^{-1}$) | Yes |
| | Surface elevation melt instability (SEMI) | Ice sheet velocity ($ms^{-1}$) | Yes |
| | | Ice sheet surface melting ($ms^{-1}$) | Yes |
| | Sea ice | Sea ice thickness (m) | No |
| | | Sea ice temperature (K) | Yes |
| Ocean / Cryosphere | Ocean warming | Sea surface temperature (K) | Yes |
| | | Depth-resolved interior temperature (K) | No |

| | | | |
|---|---|---|---|
| | Fjord circulation (see also ocean / atmosphere variables) | Surface albedo (dimensionless)<br>Subglacial / river discharge rate ($m^3s^{-1}$)<br>Supraglacial runoff rate ($m^3s^{-1}$)<br>Glacier front melt / calving rate (m $yr^{-1}$)<br>Glacier velocity (m $yr^{-1}$) | Yes<br>Yes<br>Yes<br>Yes<br>Yes |
| Ocean | Ocean biogeochemistry | Total alkalinity (µmol $kg^{-1}$)<br>Dissolved oxygen concentration (µmol $kg^{-1}$)<br>Nutrients (e.g. phosphate, nitrate, silicate, µmol $kg^{-1}$)<br>Phytoplankton diversity (#/unit vol)<br>Phytoplankton biomass (mg $m^{-3}$)<br>Phytoplankton productivity (µmol $m^{-2}$ $s^{-1}$)<br>Chlorophyll-a concentration (µg $L^{-1}$) | Yes<br>Yes<br>Yes<br>No<br>Yes<br>No<br>Yes |
| Ocean / Atmosphere | Ocean circulation | Sea surface salinity (g $kg^{-1}$)<br>Depth-resolved interior salinity (g $kg^{-1}$)<br>Total surface currents ($ms^{-1}$)<br>Ekman currents ($ms^{-1}$)<br>Geostrophic current ($ms^{-1}$)<br>Vertical mixing ($ms^{-1}$)<br>Significant wave height (m)<br>Ocean surface vector wind speed ($ms^{-1}$)<br>Ocean surface stress ($Nm^{-2}$) | Yes<br>No<br>No<br>Yes<br>Yes<br>No<br>No<br>Yes<br>No |
| | Ocean surface heat flux | Radiative heat flux (Wm-2)<br>Sensible heat flux (Wm-2)<br>Latent heat flux (Wm-2) | Yes<br>Yes<br>Yes |
| Atmosphere | Precipitation | Accumulated precipitation (mm) | Yes |
| | Atmospheric warming and circulation near surface | Air temperature (K)<br>Wind speed ($ms^{-1}$)<br>Wind direction (degree true)<br>Wind vector ($ms^{-1}$)<br>Atmospheric pressure (hPa) | Yes<br>Yes<br>Yes<br>Yes<br>Yes |

## TA2

Funding in TA2 will support teams to rapidly deploy sensing systems in a comprehensive, multi-year, massively coordinated field campaign in the GrIS and SPG, to demonstrate new technologies and sow the seeds of a long-term monitoring capability. Teams deploying sensing systems in TA2 may come directly from TA1 of the programme, maturing technology innovations from the lab to the field, or may come from new teams who wish to enter innovative sensing systems developed through other funding mechanisms into our field campaign. Teams in TA2 will benefit from a base level of field campaign infrastructure provided centrally by the programme, including an operational coordination office operated together with key partners potentially including the NERC Arctic Office, National Physical Laboratory (NPL) and the Met Office.

**Use of Natural Environment Research Council (NERC) Facilities**
We're working with the NERC to establish how their facilities may support the programme.

**If your proposed research requires the support and use of a NERC facility, you should do the following at each stage of the application process:**

### Stage 1 - Concept Papers

You should contact the NERC facility, service and/or High Performance Computing (HPC) consortia lead to notify them of a potential dependency before submitting your concept paper. If applicable you should also notify Marine Planning via marineplanning@nerc.ukri.org directly if your proposal requires use of NERC's marine facilities. For facilities relating to arctic services please contact arctic@bas.ac.uk

In submitting your concept paper, you must note potential use of the facility by detailing the relevant facility(ies) in the concept paper application portal. Details and facility costs do not have to be included at concept paper stage. You can find guidance on what to include in a concept paper here.

### Stage 2 - Full proposals

If encouraged to submit a full application, you should contact the NERC facility, service or HPC consortia lead as soon as possible to discuss your research proposal, and where

applicable to complete any necessary HPC or facility form/application process as requested by the facility/marine planning, following the facility's normal access request procedures. As part of this process, NERC will provide a costed quotation for the services. The costing methods for this activity are currently being established with NERC and may not be finalised in time for the deadline for submission of proposals, as such in submitting your full proposal you should:

- Note the potential use of the NERC facilities in your proposal by completing the specific question included in the full proposal application portal. You can find guidance on what to include in a full proposal here.
- For proposals that are assessed as compliant and in scope (in accordance with our project review process) you will be asked to submit a quotation from the HPC Consortia lead or facility, and prior agreement from the facility that your request is feasible and deliverable in the timeline indicated in your proposal, this should be submitted to ARIA no later than 19th November 2024. You will be notified by email that this information is required to be submitted via the application portal.

In any case you must ensure that you have discussed your proposal with the facility in good time prior to full application submission.

Further discussion may be needed with any successful projects requiring marine or polar facilities, or use of the Facility for Airborne Atmospheric Measurements (FAAM), in order to determine the most effective usage for delivery of the fieldwork aspects of the programme.

Creators may also cost for their own field campaign activities beyond those available from NERC and other partners (e.g. satellite launches), but will nonetheless be required to coordinate their deployments with our central operational office. Programme funding may be requested to support or expand existing satellite or *in situ* measurements in GrIS and/or SPG if needed to provide a baseline for performance comparison of new sensing systems.

As the programme evolves, all teams will be involved in a process of defining additional variables and requirements, along with target measurement locations, as informed by the modelling outcomes of TA3. We plan to open at least one future solicitation at year 2 to fund further innovation in sensing systems and/or deployments to target new priority variables and/or measurement locations.

 

### TA3

Teams will be funded to develop, test and cross-validate competing modelling approaches to characterise the tipping dynamics, the subsequent impacts and the economic consequences of crossing tipping points in GrIS and SPG.

Research activities in TA3 could include:

+ Creation or application of methods to maximise the information available from existing observations and models, such as reanalysis or digital twins, to address spatial or temporal discontinuities in datasets, or integrate alternative data sources, such as extension of historical records through digitisation, integration of indigenous measurements (6), or paleo-climate research.
+ The development and validation of mathematical approaches for detecting generic and/or system-specific early warning signals from physical model projections and/or assimilated observational data, such as statistical analyses or space-for-time substitution.
+ Innovation in physical models to improve the representation of GrIS and SPG, their interaction, their tipping dynamics, and cascades to other tipping systems.
+ Innovation in the use of data-driven approaches, such as exploiting AI to: detect characteristics of tipping phenomena in raw data, combine observations from disparate sources into unified datasets, or accelerate observing system simulation experiments (OSSEs) that help identify variables or locations to enhance monitoring and target efforts in TA2.
+ Hybrid approaches combining physical models with AI-based models, for example, training AI-based climate models using data compilations from physical model runs.
+ Economic assessment of both the techno-economic impacts of technologies arising from the programme, costs of deploying an early warning system (7), and the economic impacts of crossing a particular tipping point considering the anticipated exposures (8).
+ Other research activities needed to ensure the EWS is actionable (linked to CCT2) such as science and technology studies or other topics in the social sciences, including research into ethical issues, exploring moral, legal, and social implications.

## SECTION 3: Technical Metrics

We expect Creator teams contributing to TA1 and TA2 to outline ambitious design specifications for their sensing system(s) to resolve the target variable(s) of interest and

perform an environmental assessment to consider the climate impact of the system. As target specifications will be judged compared to the state-of-the-art based on their improvements in performance or lower SWaP-C, we define an improvement ratio, $I_R$:

$$I_R = \frac{performance}{size \times weight \times power \times cost}$$

where *performance* should be defined by the Creators and could include (but not be limited to) any combination of the following:

+ Precision
+ Accuracy
+ Spatial resolution
+ Temporal resolution
+ Sensitivity
+ Longevity
+ Coverage.

***Success in TA1*** will require demonstration that a given team can measure a target variable at a >100x increase in $I_R$ (with at least 10x of that improvement from potential cost savings) with a robust sensing system. Sensing system performance will be evaluated using standardised processes developed through CCT1 and using local field trials before progressing through to TA2 deployment.

***Success in TA2*** will be measured against aggressive deployment times, which we will begin in year 2; initial field testing is expected before this date and further deployment windows beyond this date, expected across years 3-5. Rapid timeframes will force innovation in the process of testing and certification of technologies, particularly for satellite launches, allowing for such learning and iteration of device design. A key achievement from TA2 will be assimilation of common data from multi-platform deployment through CCT1. At the end of the programme, our ambition is to deliver a permanent network of low-cost sensing systems for sustained observation of vital variables for early warning.

***Success in TA3*** will be measured in a range of ways, for example by: successfully directing TA1 + TA2 observations for validation, reducing current projection uncertainties, improving understanding of tipping point exposures, and increasing confidence in economic impacts of these scenarios. At the end of the programme, we expect to have demonstrated iterative model validation against field and/or historical data, moving towards a real-time operational

platform for detecting early warning signals automatically from the observational data. Both measurements and model runs undertaken will form a substantial body of open data. Successful research funded through the programme should contribute to international risk assessment processes that inform decision making in this area, forging the path towards a tipping point early warning system within a stable climate monitoring ecosystem.

The following tables summarise the overall programme goals. **Table 2** gives a summary of the programme goals within the five-year timeframe. **Table 3** outlines longer term ambitions that teams should be able to demonstrate a pathway towards. We do not expect all teams to be able to demonstrate all capabilities; the programme requires a portfolio of projects that when united can deliver these goals.

***Table 2: Goals that are expected to be demonstrated by teams within one or more TAs in the timeframe of the programme.*** *See TA1 for definition of $I_R$.*

| **Metric: must be demonstrated within the programme** | **Why this was chosen** | **TA** |
|---|---|---|
| Sensing systems with >100x increase in $I_R$ (with at least 10x of that improvement from potential cost savings). | $I_R$ metric designed to capture improved performance and/or reduced SWaP-C without constraining Creators as targets will be technology-dependent. 100x target to increase ambition of teams. 10x cost target because of the importance of minimising cost to enable sustained measurement beyond the programme. | 1+CCT1 |
| Sensing systems robust to harsh environments. | Must be able to be deployed and sustained in SPG or GrIS. | 1+2 |
| Coordinated sensing systems deployed rapidly. | Timeframes of state-of-the-art are too slow, need to be able to deploy, measure and iterate quickly. | 1+2 |
| Cross-calibration of multiple systems to maximise data quality. | SWaP-C approach in isolation will lead to worse performance, holistic approach required to prevent this. | CCT1 |

| | | |
|---|---|---|
| Integration with existing observing networks and missions. | Need to be differentiated and maximise efforts from the existing ecosystem. | 1+2+ CCT1 |
| Enabling of new observations of poorly understood processes. | Need better understanding of physical systems in order to validate an early warning system. | 1 |
| Data suitable (e.g. coverage/resolution) for model validation. | Targeting measurements for the models that use them will improve efficiency on both sides and increase chances of success. | all |
| Appropriate representation of physical processes in models. | Current physical models do not capture many important processes involved in GrIS and SPG (e.g. ice sheets not coupled to ocean). | 3 |
| Validation of physical models. | Measurements in these harsh environments are currently limited so cannot validate physical models. | 3+CCT1 |
| Increased speed and capability of tipping point modelling. | Number of runs to observe tipping behaviour is very high so currently it is very computationally expensive. | 3 |
| Deployment of model-driven tipping system observations. | Need to identify tipping system observation and then develop a sustained system for measurement. | all |
| Testing of early warning system indicators. | Need to develop a method to test the early warning system to build confidence and credibility. | 3 |
| Convergence of model predictions with observational records. | Required for confidence in models and therefore early warning systems. Currently there are concerning gaps between observations and models, especially in these under-observed environments. | 2+3 |
| 10x decrease in uncertainty on timescales of tipping in the GrIS and SPG. | In order for an early warning system to be actionable, we need to reduce the uncertainty on timeframes over which tipping thresholds might be crossed and changes might unfold. | 3 |

 

| | | |
|---|---|---|
| Improved understanding of societal / economic impacts of tipping. | Public engagement and communication of the socioeconomic impacts will be required for any action to be taken. | 3 |
| Report on the state of climate tipping points knowledge in 2029. | Success of the programme will be determined by the general consensus of improved confidence in tipping likelihood. | all |

***Table 3: Ambitions beyond the programme that teams must show a clear pathway to fulfilling.*** **confidence as determined by the IPCC process (1). See TA1 for definition of $I_R$.*

| **Metric: must have a pathway to delivery beyond the programme** | **Why this was chosen** | **TA** |
|---|---|---|
| Sensing systems with >1000x increase in $I_R$. | To enable sustained high-quality measurements at an affordable price point. | 1 |
| Automated observation and EWS detection. | Human deployment is not sustainable, an autonomous system (for both measurement and models) must be achieved in the long term. | all |
| Scalable and sustainable deployment. | Deployment must not damage the environment we are monitoring. | 1+2 |
| Sustained observations through a permanent sensing network. | Climate projections require long time-series data that is reliable to detect subtle changes over natural background variability; any gaps will jeopardise the success of an early warning system. | 2 |
| Affordable sensing systems and models. | The techno-economics of deployment vs. economic impact of crossing a tipping point without warning must be elucidated. | all |
| An early warning system with decadal precision. | In order for an early warning system to be actionable, we need to reduce the timeframes over which we can predict tipping might unfold to precision of (at least) decades. | all |

| | | |
|---|---|---|
| 100x reduction in uncertainty for the global risks of tipping. | For an early warning system to be actionable, uncertainty must be low and state of knowledge improved across all potential tipping systems - false positives and false negatives are not acceptable. | 3 |
| Methods translatable to other tipping systems. | The GrIS and SPG are just 2 of many tipping systems across the globe. We have chosen 2 different systems spanning Earth system domains to demonstrate the early warning approach with the ambition of enabling methods to translate. | all |

## SECTION 4: What are we looking for/what are we not looking for

### What we expect to fund (but not strict conditions):

**Science**

- We are interested in approaches that leverage insights from other disciplines to tackle the challenges of measurement and modelling that we outline in our Programme Thesis.
- We expect to see proposals that are clearly differentiated from existing work and investment, which could catalyse innovation and impacts that would not be possible otherwise.
- We expect proposals with speculative or ambitious stretch goals, but that appear tractable i.e. you are confident that there are ways to make progress on the problem.
- We encourage proposals that present an integrated approach that includes all three technical areas.
- We will consider proposals to expand existing field campaigns in the region, but these must make a compelling case for the added scientific value and why ARIA is the only funder that can support the additional activity.
- We will seriously consider proposals that differ substantially from the guidance set out in this document and our programme thesis, but make a compelling case for their differing approach to solve a similar scope of problems.

**People**

- Participation in the programme will require a significant time commitment from all those involved, so we encourage proposals that include a majority of the time for as many members of the team as possible.
- We are keen to explore structures not typical in academic research, such as supporting early career researchers as project leads or funding large (>80%) proportions of senior academics' time so that they can focus fully on their ARIA project.
- We particularly wish to encourage applications from (or including):
    - Researchers who have not previously worked in climate science, for example, technologists, engineers, computer scientists, mathematicians, economists, etc.
    - Underrepresented groups in science, technology, engineering and mathematics.
    - Those returning to science after a career break.
    - Residents of Greenland. Note that if you are planning to establish a partnership with researchers in Greenland, please ensure that you give as much notice as possible and establish a mutually respectful partnership.
    - Creators aligned with CCT2, such as those producing materials for climate: communication, training, risk communication, and/or public engagement.

### Efforts that are likely out of scope:

- Incremental advances of existing technologies.
- Approaches that lack a clear pathway to long-term low-cost deployment.
- Proposals that tackle other climate tipping systems, unless the Creators are undertaking activity with other funders and would benefit from the interface with our programme (see update to Programme Thesis).

## SECTION 5: Programme Duration and Project Management

The maximum term of the programme is 5 years, though applicants are encouraged to consider plans that will reach success (or failure) on faster timelines. The three TAs will run in parallel over a five-year period, with the present solicitation (year 0) and at least one subsequent solicitation in year 2 (**Figure 2**). Partner organisations supporting field deployments in TA2 and the cross-cutting themes will be engaged before the start of the programme. For teams proposing sensing systems that will be deployed in our field

campaign, we expect systems should be ready for evaluation in benchmarking studies and local field testing within year 3.

Teams selected at the full proposal stage will enter into a contracting phase with ARIA where the specific scope of work will be finalised. This phase will require updated and more accurate cost assessments. Individual teams can launch as soon as everything is in place; they do not need to wait for other teams except where there could be dependencies. More information on how we select projects and the application stages can be found in **Section 6**.

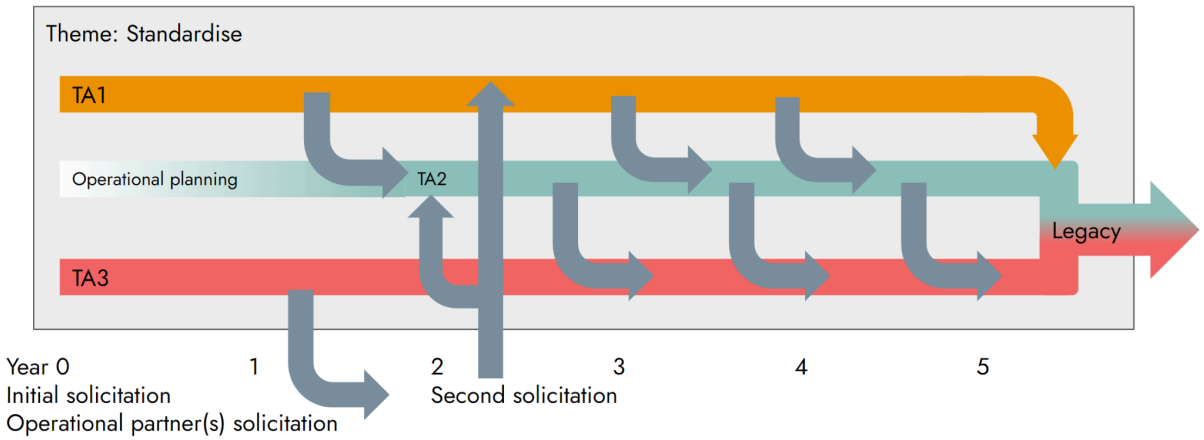


***Figure 2: Schematic of expected timelines for interaction of the TAs and timepoints for solicitations.***

As noted above, teams can apply to be part of at least one of the three TAs or may develop a project that spans all three TAs. Of course, some Creators might not have an existing network ready to apply with. For those seeking specific expertise to support their proposal, we have created a teaming request form to facilitate finding potential team members who have registered their interest in this programme. By following the link to the sign up form here you will be able to register, submit your details, and gain access to a list of other individuals seeking to find/share their expertise. All requests are screened via ARIA's internal team prior to access, after which connections will be made by individual users based on aligned expertise.

### Approach to collaboration, data, and intellectual property

We strongly believe that open science will deliver the most substantial impact and legacy for our programme. Creators will be expected to enter into the fully collaborative spirit of the

programme. We expect that all Creators will need to share some level of technology specification or modelling methodology with other programme participants.

Creators are also expected to comply with our programme intellectual property (IP) and data policies.

Creators in this programme will own any new IP generated as a result of the grant/contract. We encourage collaborative sharing of IP between Creator teams throughout the programme (whether pre-existing or created during the course of programme activities). To facilitate collaboration between creators, we would encourage creators to enter into any agreements or arrangements necessary to protect confidential information, respect existing IP rights, or manage the co-creation of new IP.

We will pursue a highly open approach to data sharing according to the recommendations of the Creative Commons Recommendations for Better Sharing of Climate Data, which cover data licences, metadata considerations and principles of effective climate data management. Through co-creation at a dedicated workshop organised with NPL (CCT1) in year 1 and open to all Creators, we will agree on a common data format, metadata content, and sharing mechanism, to ensure data is shared efficiently and according to FAIR principles.

It is a priority for this programme that any IP generated during the course of its activities is put to use. As such where Creators are capable of exploitation they should use all reasonable endeavours to exploit the Foreground IP. This should be done in accordance with the Commercialisation Hypothesis (required as part of the full proposal submission). If for any reason you choose not to exploit any of the Foreground IP within a reasonable timeframe or where applicable the timeframe set out in the Commercialisation Hypothesis, Creators are encouraged to discuss the position with ARIA, and Creators may request that ARIA exploit the Foreground IP or assist you with their exploitation.

**Project Milestones**

Each project's progress will be monitored using clearly defined milestones. Milestones will be defined by the applicant prior to the start of a project, be agreed upon by ARIA during the negotiation phase, and should be designed to easily convey progress to a third party. Due to the field campaign in TA2, some milestones may have fixed deadlines to align with deployment windows. In order to do this, milestones should:

- Be specific, measurable, and signify a meaningful step towards reaching the overall programme goals as defined in **Section 3**.
- Include details on methods used to achieve each milestone.
- Be defined on a quarterly cadence for all phases of the Programme.
- Include major "Go / No-Go" decision points.

**Programme & Project Management**

Alongside our standard project management requirements (light touch quarterly reporting on progress towards milestones and cost information more information can be found here), the ARIA programme team expects to meet our Creators regularly to review progress, discuss whether the initial project goals and milestones remain realistic, and decide whether it is necessary to change course or pivot. Creators will receive both written and verbal feedback. On an ongoing basis, the Programme Directors will continue to shape and manage the project with you with the aim of achieving outputs most beneficial to the overall programme. Success/pivot/closure criteria for each project will be determined by the applicant's ability to meet their agreed-upon milestones and the Programme Directors will work with Creators throughout their project to refine and pivot as required.

**Community events**

We are aware of the complex and challenging nature of such interdisciplinary work and we need to break silos across multiple axes (e.g. climate / tech, Earth system domains, measurement / models) in order to succeed. Our coordinated programmatic approach should tackle this, but we additionally plan to encourage collisions across the TAs through regular Creator fora, for example: sandpit workshops to enable co-design of sensing systems, and design sprints / hackathons associated with performance prizes. Aligned with these aspirations, we also expect Creators to dedicate a substantial proportion of their working time to the programme. We will also provide the resources necessary to enable trainees funded through the programme to form a unified interdisciplinary cohort, to achieve deeper collaboration between modelling and measurement in the next-generation, involving training workshops and early career events. Creators should therefore ensure they include a budget for travel and subsistence for each team member.

 

## SECTION 6: Eligibility & Application process

### Eligibility

We welcome applications from across the R&D ecosystem, including individuals, universities, research institutions, small, medium and large companies, charities and public sector research organisations.

Our primary focus is on funding those who are based in the UK. For the vast majority of applicants, we therefore require the majority of the project work to be conducted in the UK (i.e. >50% of project costs and personnel time).

However, we can award funding to applicants whose projects will primarily take place outside of the UK, if we believe it can boost the net impact of a programme.

In these instances, you must outline any proposed plans or commitments in the UK that will contribute to the programme within the project's duration (note the maximum project duration is 5 years). If you are selected for an award subject to negotiation, these plans will form part of those negotiations and any resultant contract/grant.

Engaging researchers, local communities and government in Greenland will be vital to the success of the programme. The programme will benefit substantially from the scientific knowledge and lived experience of researchers in Greenland. Their involvement is also crucial from the outset in co-design and co-delivery of any fieldwork, to ensure field campaigns are conducted in a manner respectful of, and in compliance with, local frameworks and legislation. As such applicants from Greenland are strongly encouraged to apply.

**More information on the evaluation criteria we will use to assess benefit to the UK can be found later in the document here.**

### Application Process

The application process for Technical Areas 1, 2 and 3 consists of two stages:

### Stage 1 - Concept paper

Concept Papers are designed to make the solicitation process as efficient as possible for applicants. By soliciting short concept papers (no more than three pages) ARIA reviewers

are able to gauge the feasibility and relevance of the proposed project and give an initial indication of whether we think a full proposal would be competitive. Based on this feedback you can then decide whether you want to submit a full proposal. **If you miss the deadline for submission of concept papers you can still submit a full proposal.** You can find out more about ARIAs review process here.

**If you miss the deadline for submission of concept papers you can still submit a full proposal. However, we strongly encourage you to submit a concept paper. On average, only 8% of applicants that do not submit a concept paper are selected for award.**

To ensure the process is quick and open we do not require your organisation's consent prior to submission of a concept paper.

You can find guidance on what to include in a concept paper here.

Following review of concept papers applicants will either be encouraged or discouraged from submitting a full proposal. For more details on the evaluation criteria we'll use, click here.

**Stage 2 - Full proposals**

This step requires you to submit a detailed proposal including:

- **Project & Technical information** to help us gain a detailed understanding of your proposal
- **Information about the team** to help us learn more about who will be doing the research, their expertise, and why you/the team are motivated to solve the problem
- **Administrative questions** to help ensure we are responsibly funding R&D. Questions relate to budgets, IP, potential COIs etc

You can find more detailed guidance on what to include in a full proposal here. **You can submit a full proposal even if you did not submit a concept paper.**

For more details on the evaluation criteria we'll use, click here.

## SECTION 7: Timelines

This call for project funding will be open for applications as follows (we may update timelines based on the volume of responses we receive):

| | |
|---|---|
| **Applications open** | **4 September** |
| **Concept paper submission deadline** | **23 September (12:00 midday BST)** |
| **Concept paper review & notification of encouraged/not encouraged to submit full proposal sent** | **23 September - 4 October** |

At this stage and based on your concept paper, you will either be encouraged/ discouraged to submit a full proposal. If you receive feedback indicating that you are not encouraged to submit a full proposal you can still choose to submit a full proposal. You should note that this preliminary assessment/encouragement provides no guarantee of any full proposal being selected for award of funding.

| | |
|---|---|
| **Full proposal submission deadline** | **11 November (12:00 midday GMT)** |
| **Full proposal review** | **11 November - 20 December** |

As part of our review we may invite applicants to meet with the Programme Director to discuss any critical questions/concerns prior to final selection — this discussion can happen virtually or we may seek clarification on certain aspects of your proposal via email.

| | |
|---|---|
| **Successful/Unsuccessful applicants notified** | **19 December** |

At this stage you will be notified if you have or have not been selected for an award subject to due diligence and negotiation. If you have been selected for an award (subject to negotiations) we expect a 1 hour initial call to take place between ARIAs PD and your lead researcher within 21 working days of being notified.

We expect contract/grant signature to be no later than 10 weeks from successful/ unsuccessful notifications. During this period the following activity will take place:

- Due diligence will be carried out
- The PD and the applicant will discuss, negotiate and agree the project activities, milestones and budget details
- Agreement to the set Terms and Conditions of the Grant/Contract. You can find a copy of our funding agreements here

## SECTION 8: Evaluation Criteria

### Concept Paper and Proposal Evaluation Principles

To build a programme at ARIA, each Programme Director directs the review, selection, and funding of a portfolio of projects, whose collective aim is to unlock breakthroughs that impact society. As such, we empower Programme Directors to make robust selection decisions in service of their programme's objectives ensuring they justify their selection recommendations internally for consistency of process and fairness prior to final selection.

We take a criteria-led approach to evaluation, as such all proposals are evaluated against the criteria outlined below. We expect proposals to spike against our criteria and have different strengths and weaknesses. Expert technical reviewers (both internal and external to ARIA) evaluate proposals to provide independent views, stimulate discussion and inform decision-making. Final selection will be based on an assessment of the programme portfolio as a whole, its alignment with the overall programme goals and objectives and the diversity of applicants across the programme.

Further information on ARIAs proposal review process can be found here.

### Proposal evaluation process and criteria

Proposals will pass through an initial screening and compliance review to ensure proposals conform to the format guidance and they are within the scope of the solicitation. At this stage we will also carry out some checks to verify your identity, review any national security risks and check for any conflicts of interest. Prior to review of applications Programme Directors and all other reviewers are required to recuse themselves from decision making related to any party that represents a real or perceived conflict.

Where it is clear that a proposal is not compliant and/or outside the scope, these proposals will be rejected prior to a full review on the basis they are not compliant or non-eligible.

Proposals that pass through the initial screening and compliance review will then proceed to full review by the Programme Director and expert technical reviewers.

In conducting a full review of the proposal we'll consider the following criteria:

1) **Worth Shooting For** – The proposed project uniquely contributes to the overall portfolio of approaches needed to advance the programme goals and objectives. It has the potential to be transformative and/or address critical challenges within and/or meaningfully contribute to the programme thesis, metrics or measures.

2) **Differentiated** – The proposed approach is innovative and differentiated from commercial or emerging technologies being funded or developed elsewhere.

3) **Well defined** – The proposed project clearly identifies what R&D will be done to advance the programme thesis, metrics or measures, is feasible and supported by data and/or strong scientific rationale. The composition and planned coordination and management of the team is clearly defined and reasonable. Task descriptions and associated technical elements provided are complete and in a logical sequence with all proposed stage-gates and deliverables clearly defined.The costs and timelines proposed are reasonable/realistic.

4) **Responsible** – The proposal identifies major ethical, legal or regulatory risks and that planned mitigation efforts are clearly defined and feasible.

5) **Intrinsic motivation** – The individual or team proposed demonstrates deep problem knowledge, have advanced skills in the proposed area and shows intrinsic motivation to work on the project. The proposal brings together disciplines from diverse backgrounds.

6) **Benefit to the UK**

There is a clear case for how the project will benefit the UK. Strong cases for benefit to the UK include proposals that:

1. Are led by an applicant within the UK who will perform the majority (>50% of project costs spent in the UK) of the project within the UK
2. Are led by an applicant outside the UK who seeks to establish operations inside the UK, perform a majority (>50% of project costs

spent in the UK) of the project inside the UK and present a credible plan for achieving this within the programme duration.

For all other applicants we will evaluate the proposal based on its potential to boost the net impact of the programme in the UK. This could include:

3. A commitment to providing a direct benefit to the UK economy, scientific innovation, invention, or quality of life, commensurate with the value of the award;
4. The project's inclusion in the programme significantly boosts the probability of success and/or increases the net benefit of specific UK-based programme elements, for example, by engaging directly with the Greenland community or the project represents a small but essential component of the programme for which there is no reasonable, comparably capable UK alternative.

When considering the benefit to the UK, the proposal will be considered on a portfolio basis and with regard to the next best alternative proposal from a UK organisation/individual.

## SECTION 9: How to apply

Before submitting an application we strongly encourage you to read this call in full, as well as the general ARIA funding FAQs. If you have any questions relating to the call, please submit your question to clarifications@aria.org.uk.

Clarification questions should be submitted no later than 4 days prior to the relevant deadline date. Clarification questions received after this date will not be reviewed. Any questions or responses containing information relevant to all applicants will be provided to everyone that has started a submission within the application portal. We'll also periodically publish questions and answers on our website, to keep up to date click here.

Please read the portal instructions below and create your account before the application deadline. In case of any technical issues with the portal please contact clarifications@aria.org.uk.

Application Portal instructions

APPLY HERE

## SECTION 10: References


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