Advanced Research + Invention Agency ARIA

Programme Discussion Report

Sarah Bohndiek & Gemma Bale | Scoping Our Planet | March 2024

Workshop Report

One of the key underlying principles of ARIA's solicitation is fair, open and transparent competition, as such we are publishing a summary of the outputs of programme discussions.

Advanced Research + Invention Agency ARIA

SECTION 1: Workshop Overview

Opportunity space / PD	Scoping Our Planet/ Sarah Bohndiek & Gemma Bale
Date	13/03/2024 - 14/03/2024
Location	Møller Institute, Cambridge
Goal	The goal of the workshop was to bring together the climate science community with the optics and photonics community, nucleating a new climate optics community. The desired outcome was to test emerging programme thesis ideas and identify impactful unanswered questions in climate science.
Goals met?	Yes

Background

The programme discussion was designed to bring together people working in climate science with people developing technologies that could be used to monitor the planet, and to find the opportunities to create maximum innovation by identifying the overlap between the two.

The first day was designed to introduce attendees to the key challenges in monitoring the climate and breakdown respective disciplinary silos. The goal was to identify the current state-of-the-art in their respective fields, how this was expected to evolve in the next decades, and help to identify the most important gaps in terms of climate observation / monitoring in order to focus the programme thesis.

The second day was designed to further break down silos and encourage interaction between individuals working in different fields to identify common needs, and areas in which they would be able to work together.

Key Discussion Points

The key discussion points that were targeted in the meeting can be grouped by pre-work, Breakout 1, Breakout 2, and Breakout 3.

Pre-work

Attendees were asked to provide responses to a pre-work assignment in advance of the workshop. Attendees were asked to answer a series of questions around the simulations: "Imagine you have a magic wand and with it you can create any technology capability to transform your current research" and "Imagine you have a magic wand and with it you can address the most significant unanswered question in your research today".

Before the start of the workshop, Gemma & Sarah reviewed the entries and captured common themes. These are outlined below and were discussed with the workshop attendees prior to the start of the Breakout 1 session.

<u>What capabilities are important, but missing in the current landscape?</u>

- Frequent, high sensitivity, low-power, lightweight spectrometers suitable for constellation (satellite, UAV, terrestrial) deployment for measurement of gaseous species, including those of greenhouse concern (CO2, CH4) and health concern (NO2, SO2): concentration, fluxes, spatially resolved.
- *In situ* characterisation of aerosols, including size distribution, composition and species (bio-aerosols).
- Effective measurement of the full carbon cycle, including (stored / fluxes of carbon in) biomass, soil, ocean and beyond.
- Massively improved (*especially real-time, high resolution, high sensitivity*) measurements of: properties of nuclei in ice / mixed-phase cloud, precipitation, wind, relative humidity, ozone, phytoplankton, deforestation, vegetation, radiative forcing (of contrails, aerosols)…
- Effective calibration / validation embedded from the outset of any observation or record; driving sensor design from the data needs.

What emerging technology solutions could meet these needs?

- Autonomous sensing platforms e.g. networks of drones, high altitude platforms, smaller satellites flying in constellations to deliver multimodal data streams for coverage / cross-validation.
- Multi-sensor packages on board e.g. "satellite buses" that have accelerated launch timeframes (1 year).
- Sensors
- Scalable methods for production of low-cost devices e.g. a 3D printer for structured optics, enabling holographic / hyperspectral imaging with smartphone sensors.
- Fully integrated silicon photonics with III-V materials (for mid-IR lasers / detectors).
- The perfect imaging spectrometer: many hundreds of bands covering the full 300 - 12,000 nm range, high sensitivity and spatial resolution, low noise, AND compact, robust (weather proof), low cost, scalable.

The big questions that are top of mind:

- How will the Earth system respond to a warming climate on a local or global scale?
    - Which of these changes could lead to irreversible / catastrophic consequences?
- How do we engage governments / policymakers / the public to care enough to take action on climate change?
- What would it take to effectively police the climate?
    - Can we adequately detect abnormal events linked to geoengineering or attribute emissions to hold governments accountable?
- What would a planetary scale digital twin look like and could it transform real-time forecasting capabilities?
- How do we build demand to enable large-scale low-cost manufacturing? e.g. semiconductor fabs embracing new materials, or on-chip photonics outside telecoms wavelengths

Breakout 1

Technology-focussed attendees were asked to respond to the following questions:

- What are the next big technology innovations on the horizon?

- What would the specifications of a product launched in 2050 look like?
- How could we realise this capability?

Climate science-focussed attendees were asked to respond to the following questions:

- What climate science breakthroughs are vital to fundamentally change our thinking?
- How can we disrupt the current conversation?
- What are the technology requirements to deliver these?

Breakout 2

The second breakout discussion was run in an unconference style. The topics brought up via the suggestion box and in the room on the day were:

- What one (top 5) measurement(s) would be most impactful in unlocking proportionate funding for climate science and make a difference to policymakers? And how do you make it? (e.g. extreme weather events, what minimum parameter set is needed to predict risk?)
- How do we deliver miniaturisation / SWaPC for wider deployment of existing instrumentation?
- Specific requirements / specifications/ metrics on a measurement need to be shared with technologists (Outside current capability. E.g. wavelength band; connection of measurement to interpretation)
- If you were in our shoes, how would you put together the programme? Can the different Earth system domains (atmosphere, land, ocean, cryosphere) be united? How do we facilitate talent retention in the field?
- What infrastructure should we fund? (E.g. cal/val / long-term monitoring / digital infrastructure: digital twins, data (better use of), computing / storage reqs)
- Should we / how could we run an impactful field campaign to demonstrate the value of observations?
- Agriculture
- What do the high resolution models of the future need?
- Specifying uncertainty from process to measurement to models, targeted / top down impact traceability

Breakout 3

Building on learnings from Breakouts 1 and 2, Gemma + Sarah refined the questions to be discussed in the final breakout session.

- What climate and/or tech challenge could we focus a programme on if we wanted to span all Earth system domains (land/atmosphere/ocean/cryosphere)? e.g. specs for a particle size distribution and composition sensor in atmos / ocean?
- How could we better parameterise agricultural greenhouse gas impacts?
- How do we predict / better respond to "extreme events"?
- How do we better understand the physics of ocean currents and heat distribution?
- How do we see inside clouds?
- How do we make use of opportunistic platforms or data for atmospheric measurements?
- How could we measure ocean subsurface biology and chemistry with in situ sensors?

Outcomes

The workshop was valuable for the development of this programme and refined our thinking in the following areas:

- A focus on early warning systems for climate tipping points.
- Identification of domains most in need of observations (ocean, poles) and key individuals with drive to make a change in those domains.
- Agreement that Earth system domains should not be treated in isolation and any programme should be inclusive, considering boundaries / interfaces between the domains in particular.
- The most significant technology driver right now is making existing measurements in smaller, lighter, lower power and cost instruments.
- The need to include a technical area on modelling to inform the observations.
- Ecosystem mapping, spotlighting untapped networks.
- The value of funding within the programme to:

- Support career development and training,
- Enable meaningful field campaigns across platforms,
- Support calibration / validation activities.

Advanced Research + Invention Agency ARIA

SECTION 2: Agenda

Day 1 Agenda | 13/03/2024

Time	Session Name
09:45	Arrivals and Registration
10:30	Welcome and Housekeeping
10:35	Intro to ARIA and our Opportunity Space
11:00	The climate measurement challenge
11:20	Panel with climate experts doing deeper into measurement challenge
11:45	Flash talks round 1 (Climate)
12:30	Lunch
14:00	Flash talks round 2 (Tech)
14:45	Intro to breakout session 1, feedback from pre-work
15:15	Breakout session 1
16:30	Coffee break
16:45	Plenary feedback from breakout session 1
17:30	Debate
18:15	Day 1 reflections and close
18:30	Networking and light buffet dinner

Day 2 Agenda | 14/03/2024

Time	Session Name
09:00	Light breakfast
09:30	Intro to breakout session 2
10:00	Breakout session 2

11:15	Feedback from breakout session 2
12:00	Lunch
13:00	Intro to breakout session 3
13:15	Breakout session 3
15:00	Feedback from breakout session 3
15:45	Closing reactions and remarks
16:00	Close
16:00	Optional session for direct reactions or ideas