# Beyond Net Zero

How can greenhouse gas removal from the atmosphere contribute to the delivery of net zero and beyond?

*Kelly Wanser*
*Executive Director*
*SilverLining*

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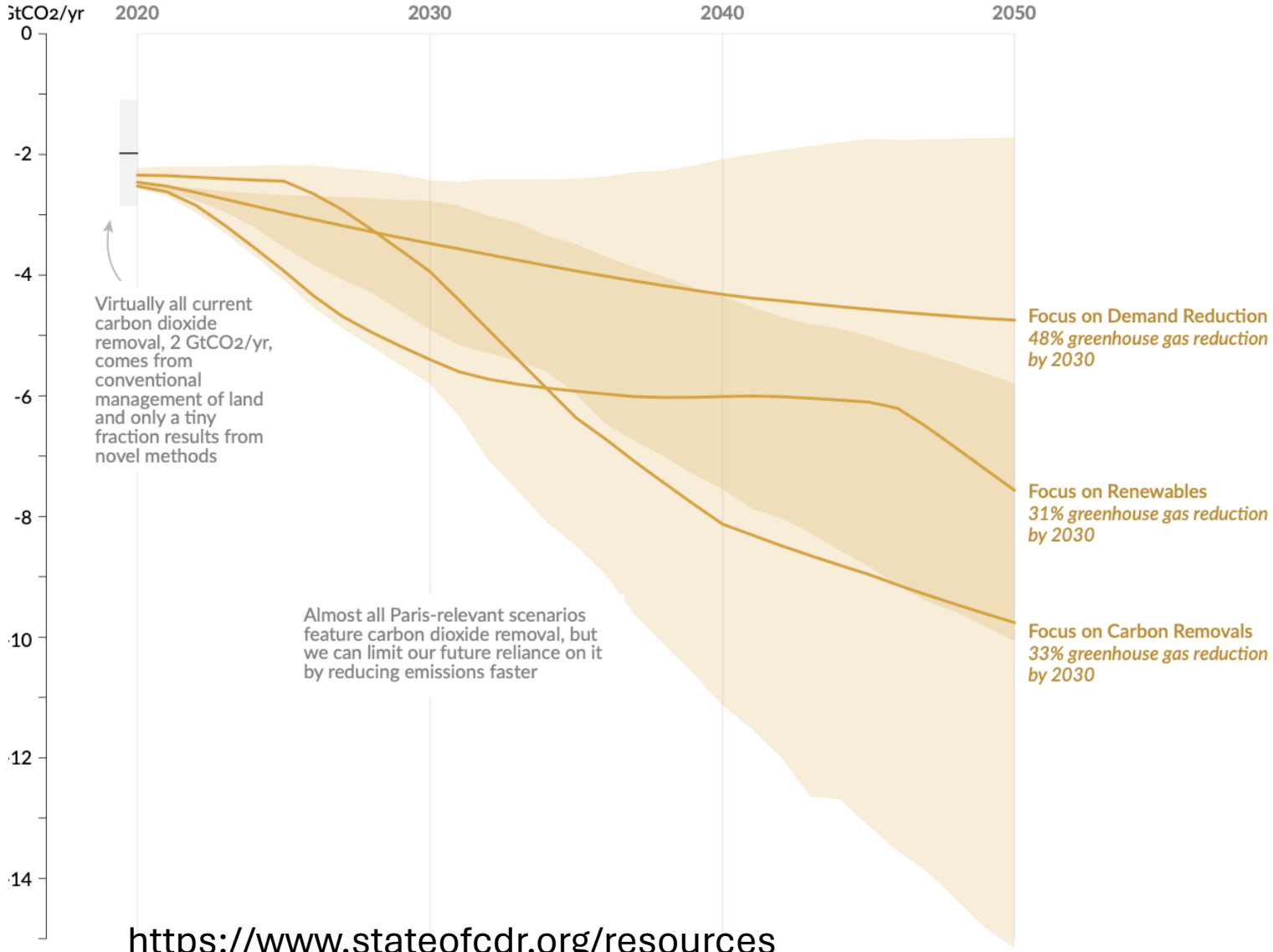
# Carbon Dioxide Removal

A global, independent scientific assessment of Carbon Dioxide Removal

**1st EDITION**

## Carbon dioxide removal is a feature of all scenarios that meet the Paris temperature goal, in addition to reducing emissions

Carbon dioxide removal ($GtCO_2/yr$), in 2020 and in three Paris-consistent scenarios




https://www.stateofcdr.org/resources

# THE STATE OF Carbon Dioxide Removal

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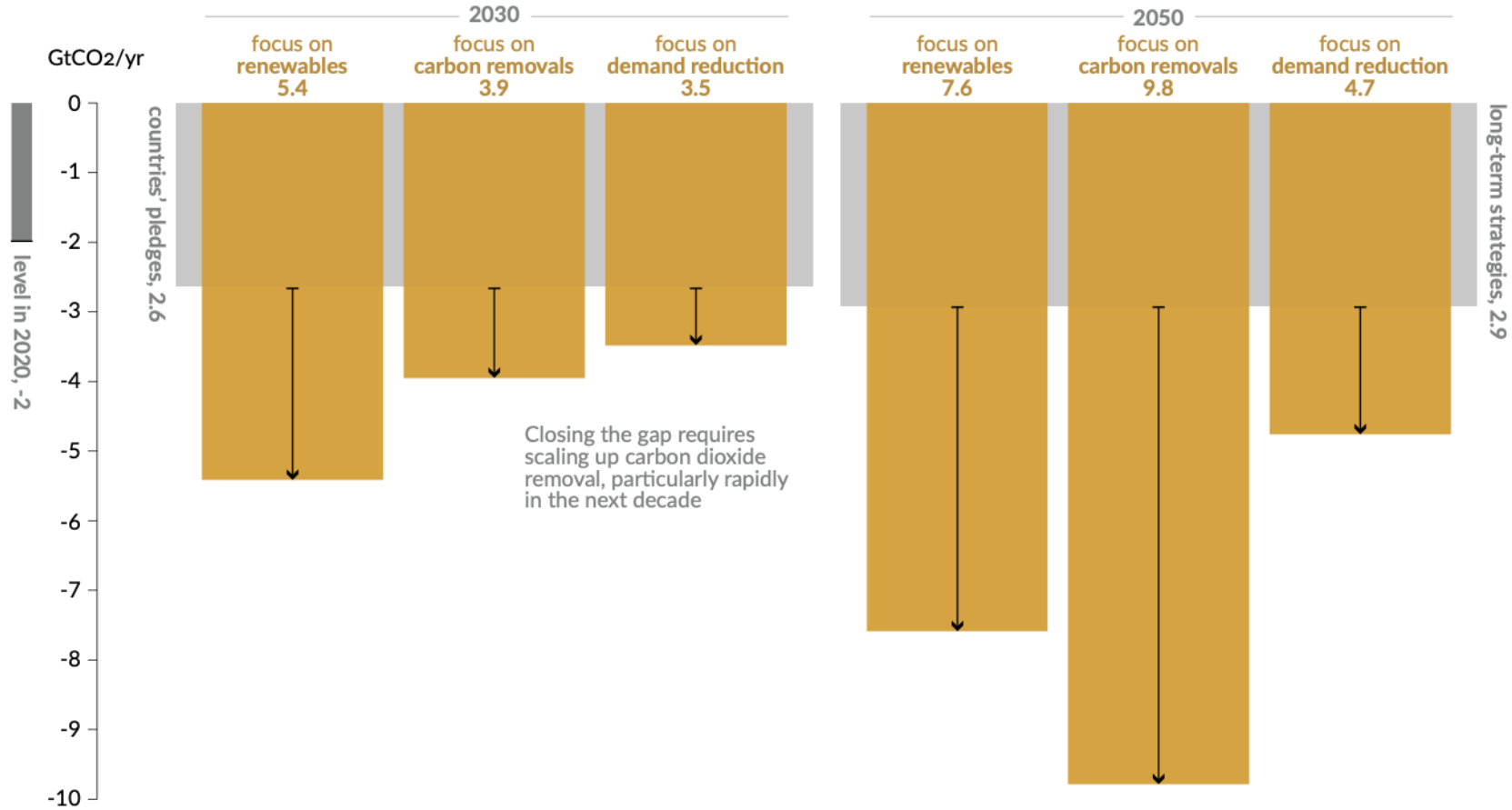
**There is a ↧ gap between proposed levels of carbon dioxide removal and what is needed to meet the Paris temperature goal**

Carbon dioxide removal ($GtCO_2/yr$), proposed levels compared to three Paris-relevant scenarios in 2030 and 2050



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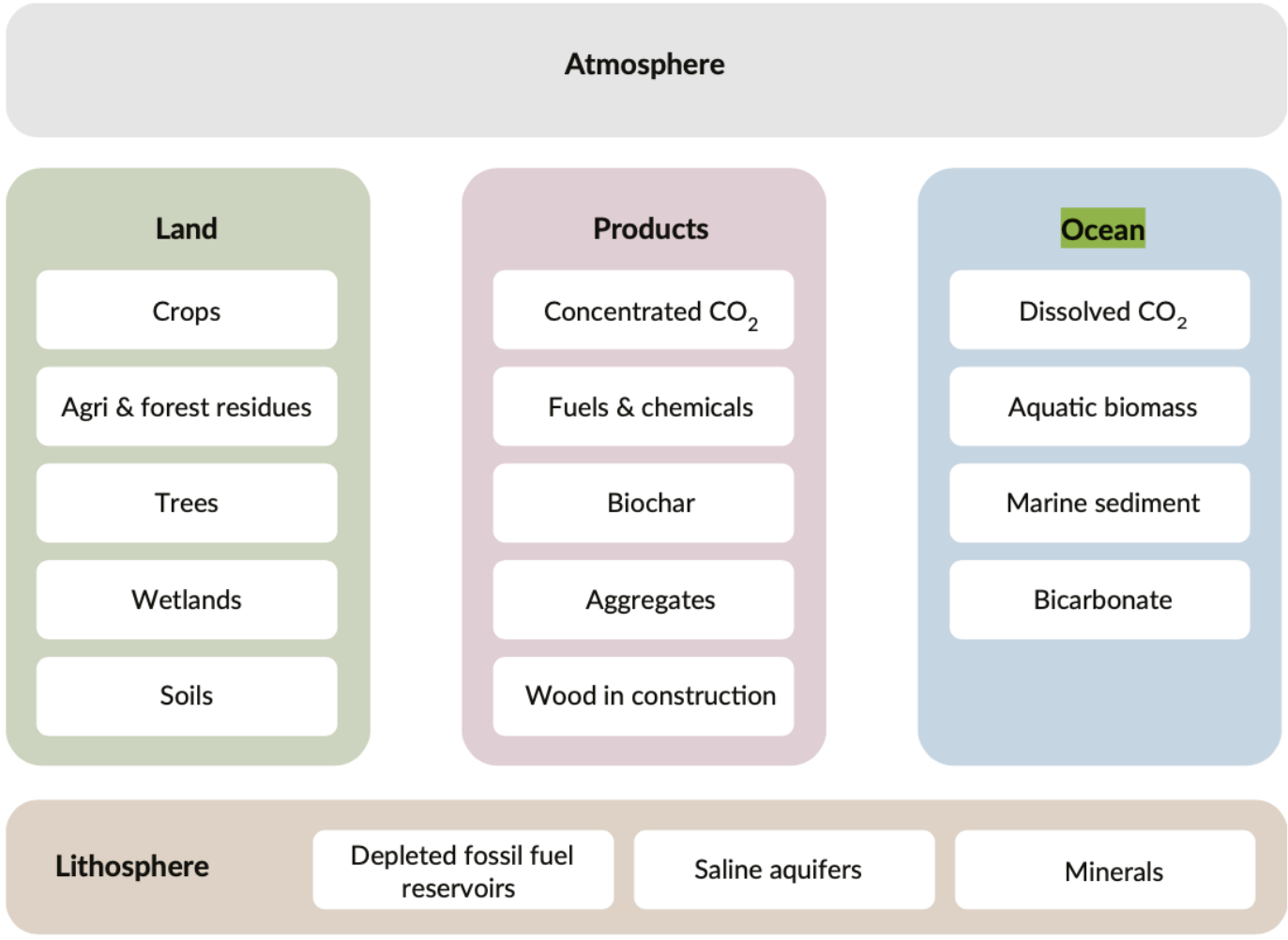


Figure 1.2. *The global carbon cycle consists of five main carbon reservoirs: the atmosphere, land, products, ocean and lithosphere (geological formations). Within each reservoir there are various carbon pools (indicated in each reservoir) whose characteristics vary in terms of storage capacity and durability. Carbon Dioxide Removal methods transfer $CO_2$ from the atmosphere into other durable pools within the global carbon cycle.*

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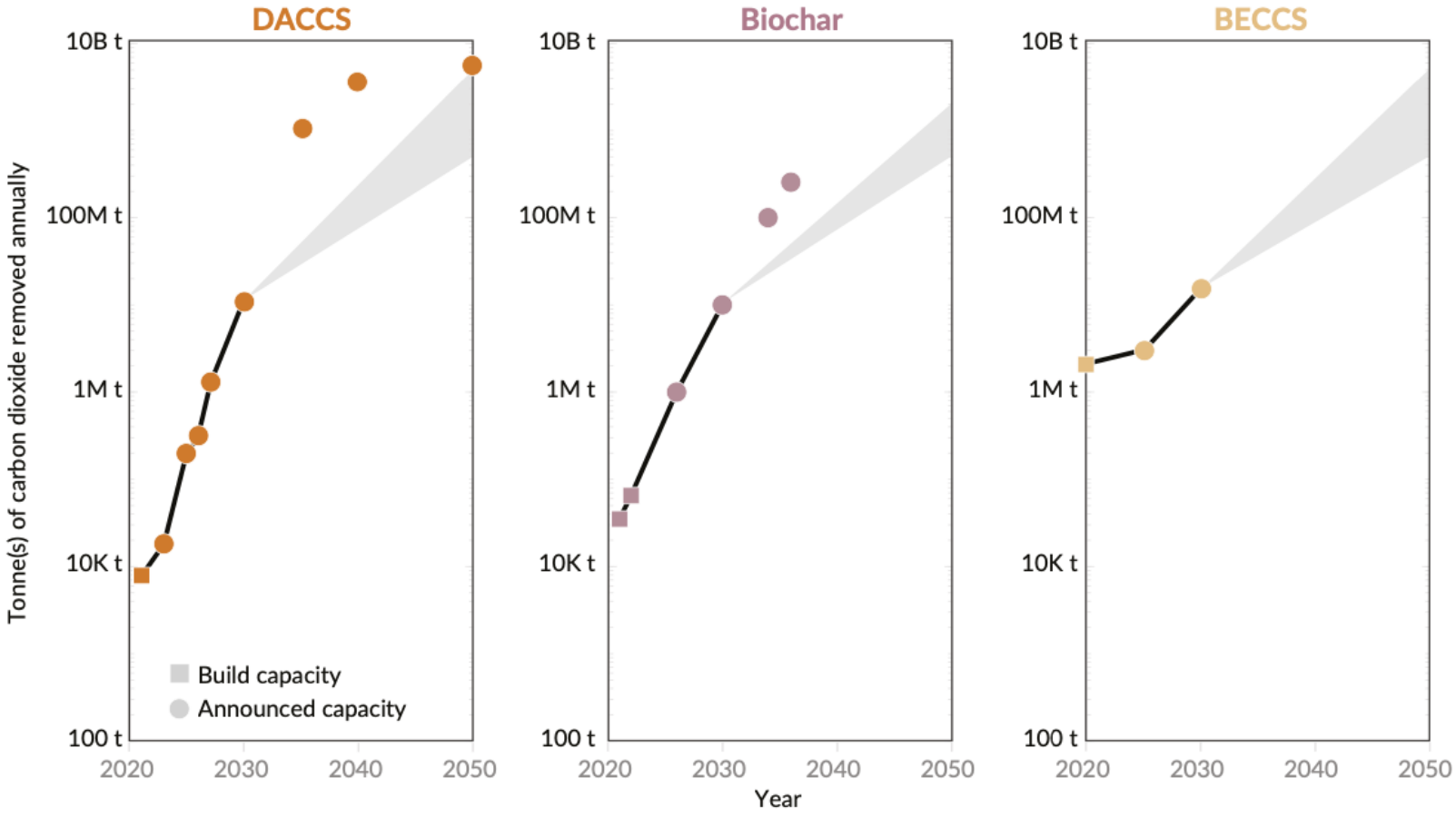
Growth trajectories of three terrestrial CDR methods, incorporating both announced and built capacities from industry and businesses




“Since the early 1990s, research on CDR has grown exponentially – faster than for climate change as a whole.”

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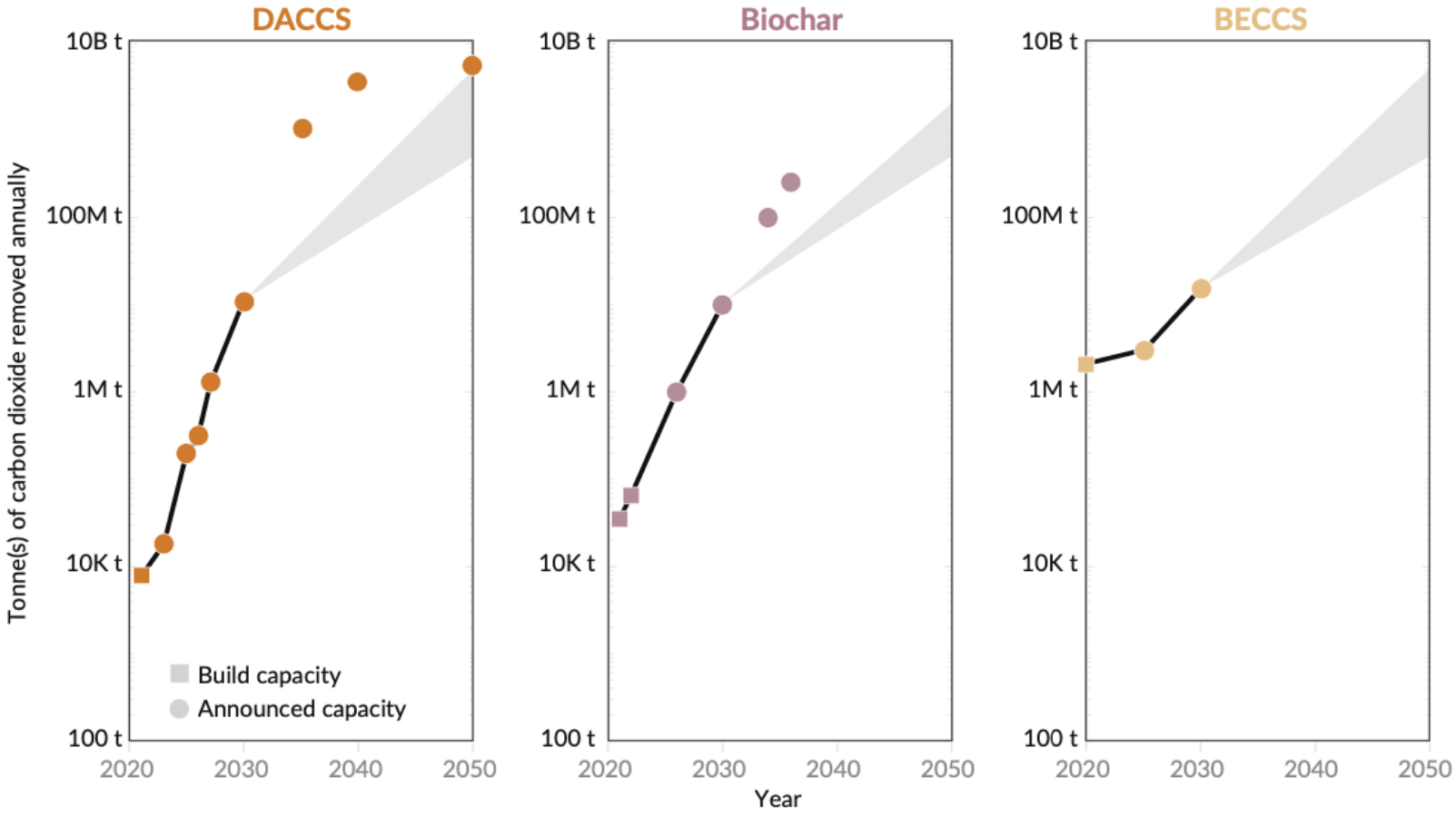

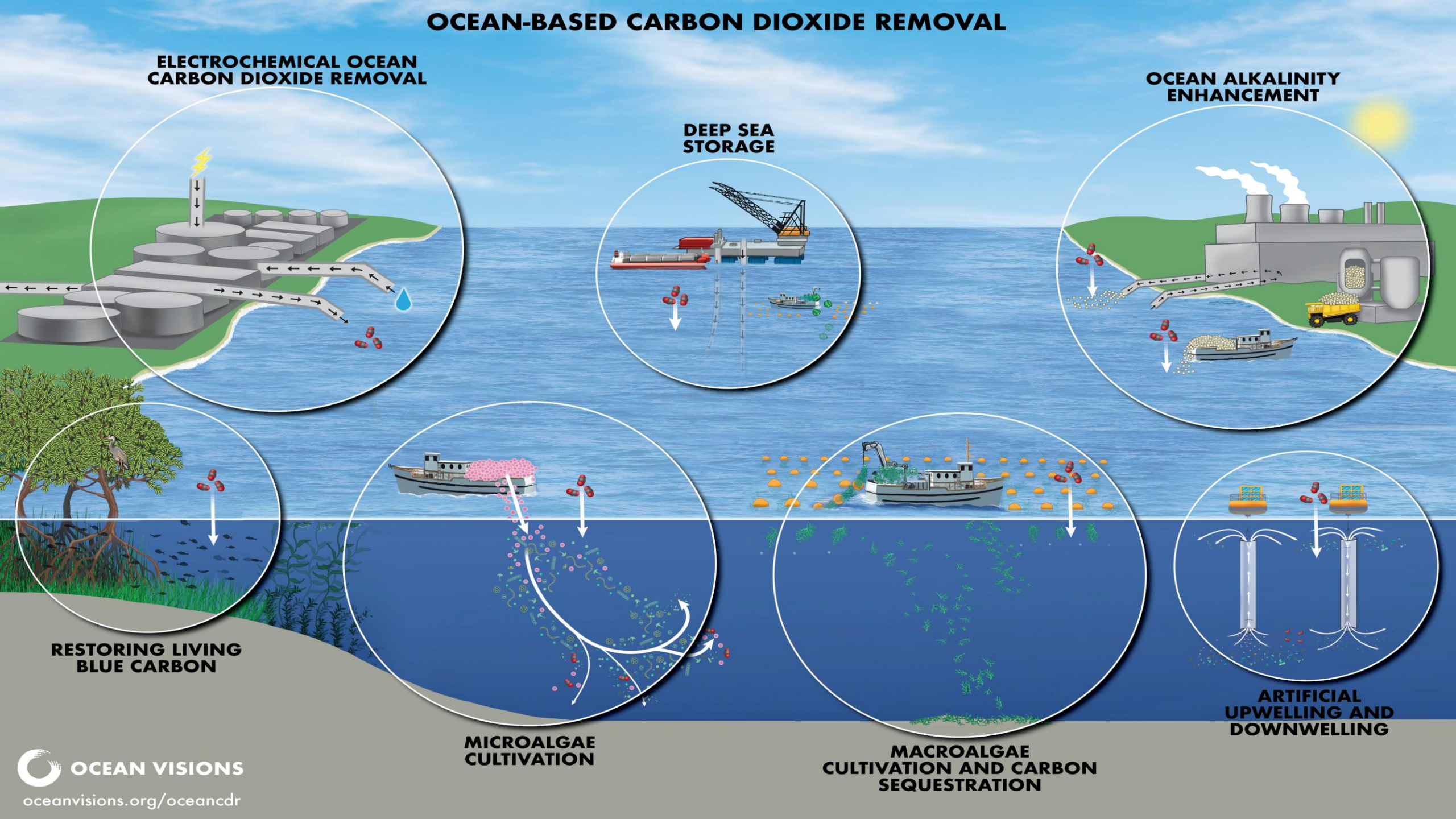
OCEAN-BASED CARBON DIOXIDE REMOVAL
ELECTROCHEMICAL OCEAN CARBON DIOXIDE REMOVAL
DEEP SEA STORAGE
OCEAN ALKALINITY ENHANCEMENT
RESTORING LIVING BLUE CARBON
MICROALGAE CULTIVATION
MACROALGAE CULTIVATION AND CARBON SEQUESTRATION
ARTIFICIAL UPWELLING AND DOWNWELLING
OCEAN VISIONS
oceanvisions.org/oceancdr

# Climate interventions that take us to net zero and beyond require earth-scale information systems

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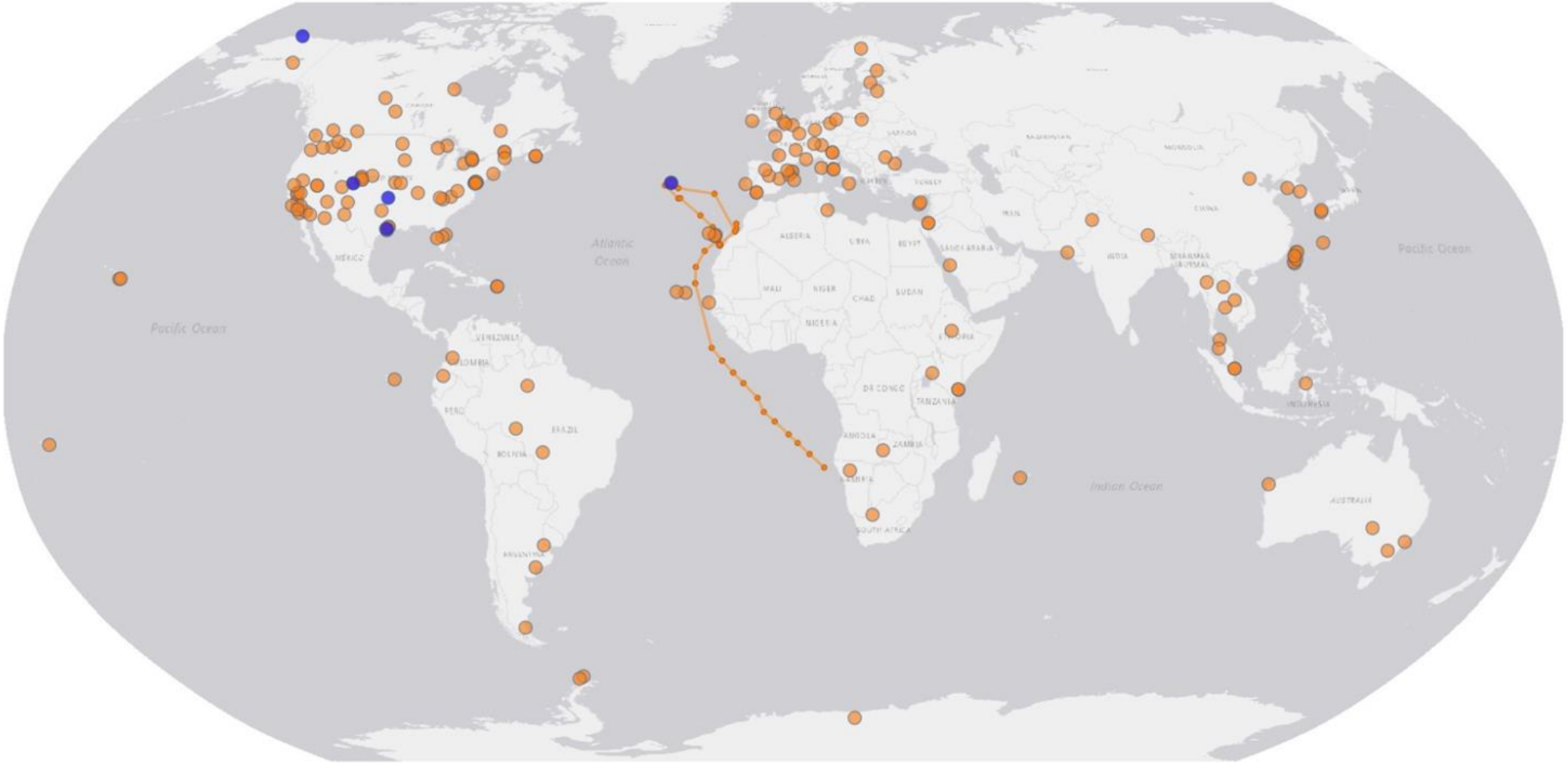
# There are large gaps to close in global atmospheric monitoring, especially over the oceans.




Atmospheric observation sites and ship cruises active on 01/01/23: AERONET, MPLNET, MAN, ARM

# There is also a gap in instruments available to take advanced measurements in efficient ways.

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$<50K

**1 Basic Measurements**

Low-cost physical observations to inform size and spatial distribution

*National Aeronautics and Space Administration AERONET Photometer*

**2 ?**

Mid-range, scalable package that provides attainable sophistication

No middle ground

$20m

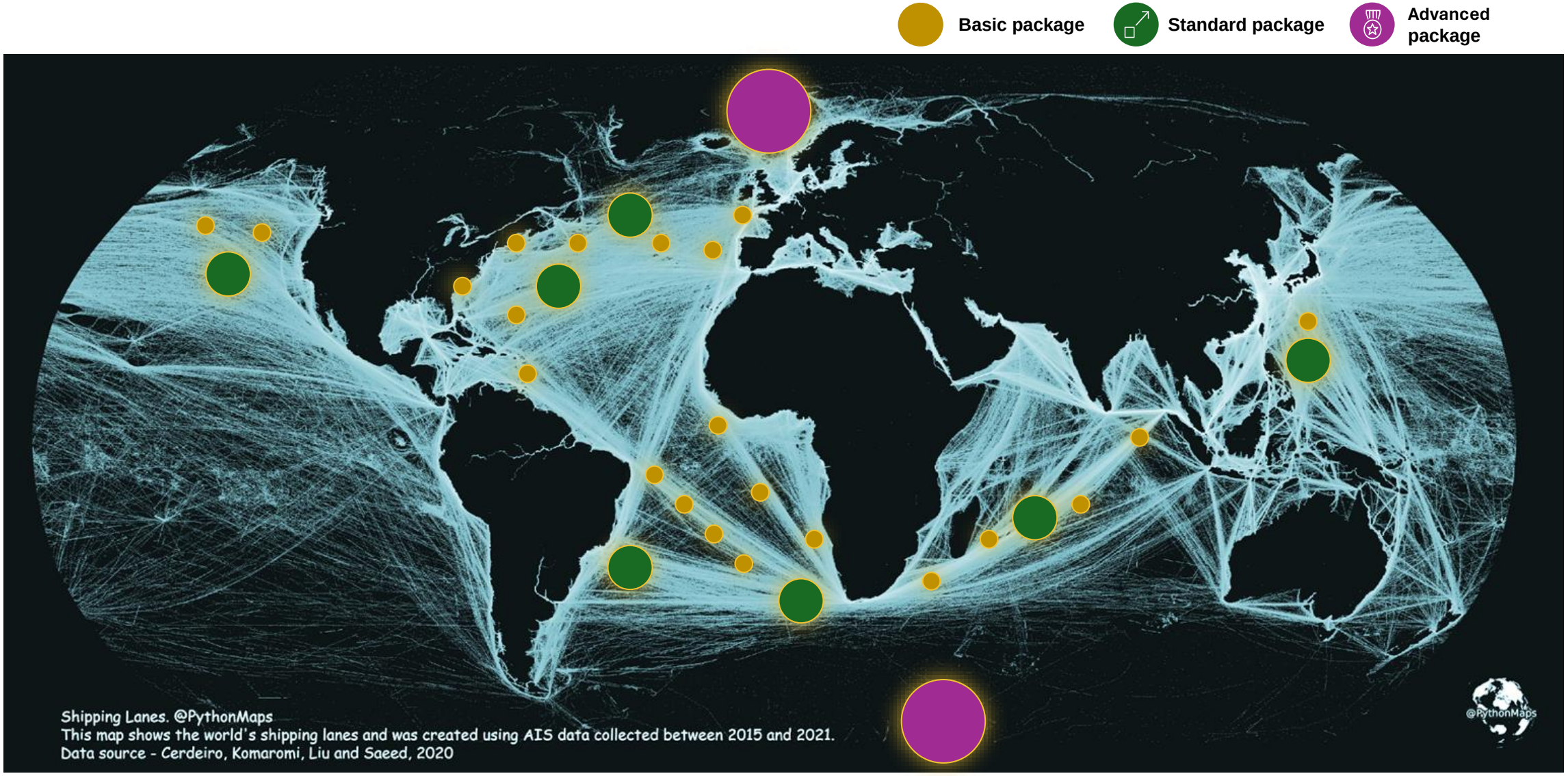
**3 Advanced Measurements**

Comprehensive, sophisticated package that includes chemical composition

*US Department of Energy Atmospheric Radiation Measurement (ARM) Facility*

***Low*** ***Sophistication / Cost*** ***High***

# A portfolio of optimized instrument packages can leverage shipping routes to create a global marine atmosphere observing network.



# Ships of Opportunity for Atmospheric Research (SOAR)

## A Global Observing Network for the Marine Atmosphere

March 2024

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# Ships of Opportunity for Atmospheric Research (SOAR) will create a global observing system of marine atmospheric constituents by leveraging existing shipping routes and vessels with a new generation of operationalized instruments.

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## SCIENTIFIC DEFINITION & DESIGN

Engage key scientific stakeholders to align on the definition and design. This is vital to ensure that SOAR's foundation is grounded in science and iteratively developed to deliver high value scientific products.

## INSTRUMENT PACKAGE DEVELOPMENT

Evaluate specific instruments based on their measurement capabilities, pricing, and compatibility for ship implementation. These instruments are later piloted to assess their readiness for scale.

## INSTALLATION & OPERATIONAL NETWORK

Collaboration to automate, streamline and implement best practices for installing and maintaining instrument packages with market development and support for instrument manufacturers and platform partners.

## DATA GATHERING, PROCESSING & DISTRIBUTION

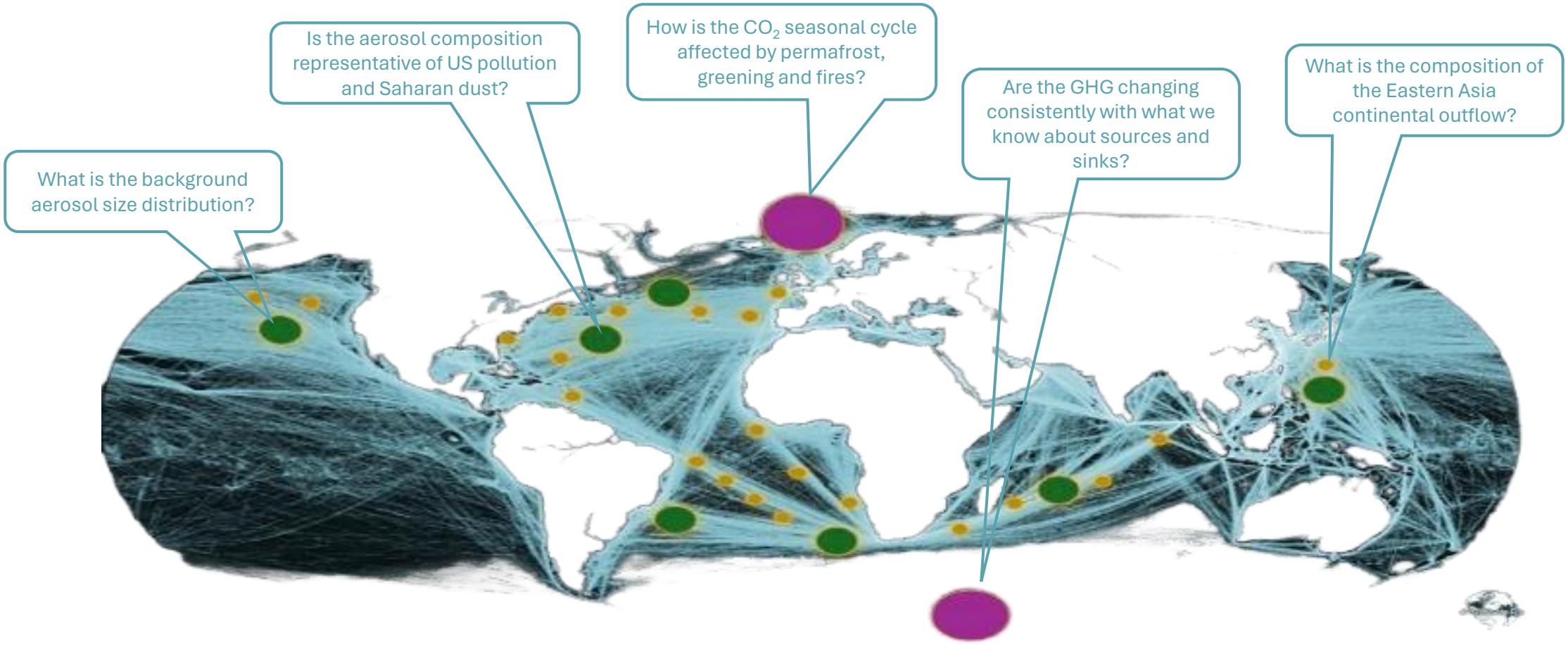
Ensure data collected through the instrument packages is regularly gathered, reviewed, cleaned, and validated for a consistent format and reliability. The data is integrated into existing global datasets where possible and hosted in a cloud environment for global access.

**Scientific collaboration is key to enable Ships of Opportunity for Atmospheric Research across all parts of the solution**

**Executive management, administration and funding operate across all parts of the solution**

# The global marine atmosphere observing network will generate open data to support an international community of researchers in an array of scientific efforts and enable major advances in systemic capabilities.

**ATMOSPHERIC BASELINES** ◆ **CLIMATE AND WEATHER MODEL IMPROVEMENTS** ◆ **MONITORING, REPORTING AND VALIDATION** ◆ **SATELLITE GROUND-TRUTHING**



# SOAR’s range of atmospheric measurements gathered over the oceans makes it uniquely valuable to people and planet.

## THE VALUE PROPOSITION

SOAR captures vital atmospheric aerosol, cloud and carbon flux data over oceans to confront the ongoing climate risk presented by limited understanding of these influences. Scientific instrument packages are strategically placed on commercial shipping vessels to leverage existing infrastructure. The resulting publicly accessible data will propel progress within the scientific community, safeguarding a safer future for both people and the planet.

## BENEFICIARIES

### Scientific Community

By harnessing new atmospheric aerosol and cloud data over oceans, climate and atmospheric researchers and analysis users gain a powerful data resource to inform analyses and improve models to address critical uncertainties.

### Public Sector

The public sector & policymakers gain access to powerful new information about the state of the atmosphere to provide insights into the implications of various policy choices to promote human and natural system wellbeing snd inform strategies to address climate risks.

### Private Sector

By participating in the SOAR program shipping companies and other commercial partners gain environmental data and add a valuable capability for to their CSR portfolio.  Philanthropic funders realize powerful impact from their support.

# Learnings from other Ships of Opportunity programs can be leveraged for the successful implementation of SOAR.

## RELATED EFFORTS

| Program name | | Program Focus | Key learnings |
|---|---|---|---|
| | NOAA Greenhouse Gas Marine Boundary Layer Reference | GHGs | **Data must be easily accessible** and interoperable with existing data |
| | AERONET / MAN | Aerosol optical depth | **Southern Hemisphere** and **open ocean are under-observed** but especially important for understanding climate radiative balance |
| | JCOMM VOS | Maritime weather observations | 8000 ships in largest existing "ships of opportunity" program; this represents approximately the maximum market penetration |
| | ARM/DOE | Highly-advanced atmospheric observations (3 land-based,1 marine) | Instrument package "**tiers**" should be **allocated on the basis of science value** and **operational considerations** |

# SOAR leverages partners with complementary capabilities and expertise.

## PARTNER ECOSYSTEM


## TYPE OF CAPABILITIES

**Science**
Collaboratively drives the definition and development of the data, instruments, network design and products

**Instrument development**
Refine the instruments to capture required data

**Operationalization**
Logistics, supply-chain, compliance

**Shipping**
Carry instrument package for data collection while traversing ocean

**Open data platform(S)**
Make data accessible for download

**Funding**
Private and public sector funders of open science and climate research

Private Commercial Sector
Scientific User Community
Public Sector & Policymakers

Secured partners
NOAA
UNIVERSITY of WASHINGTON
OCEANS X

# Collaborators define and deliver against a roadmap of science, innovation and operations to launch, operationalize and scale solutions.

## HIGH LEVEL ROADMAP

### Develop SOAR organization structure and roadmap

Developing organization structure and program plan that enables the program to succeed as well as key partnerships and investments to reach scale

### Pilot instruments to form actual knowhow for operations

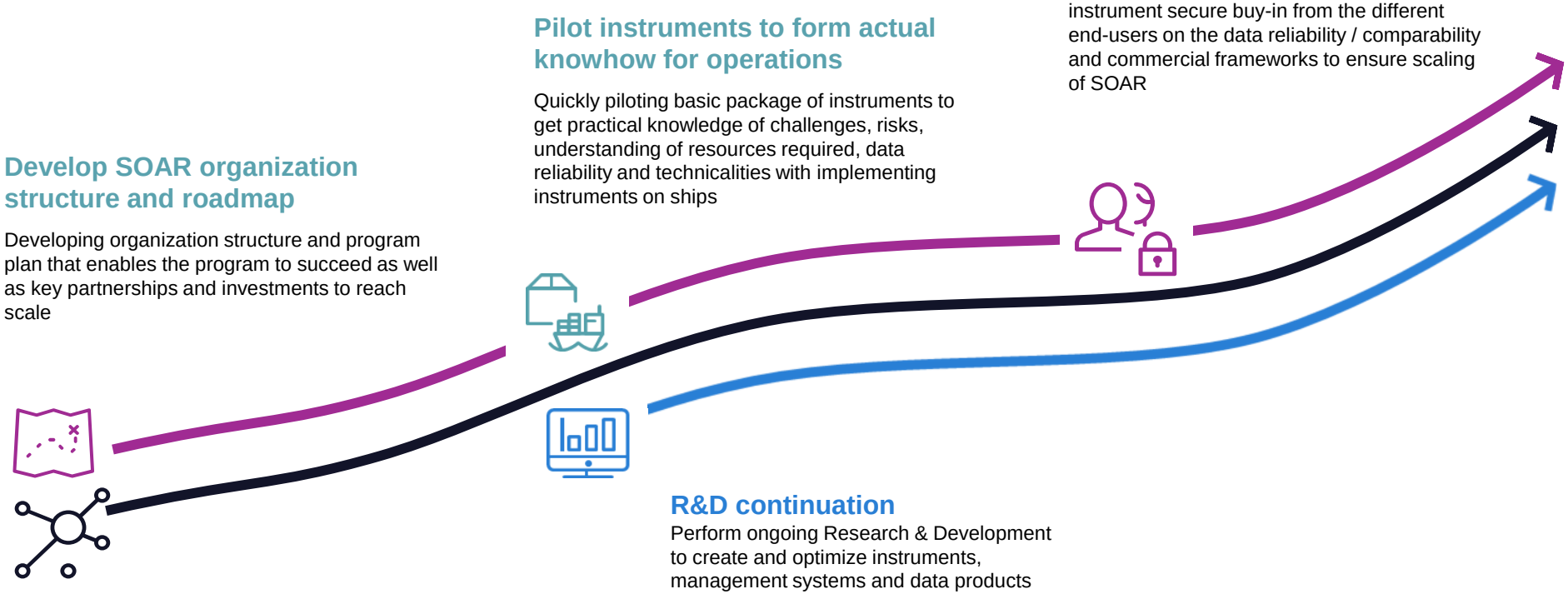
Quickly piloting basic package of instruments to get practical knowledge of challenges, risks, understanding of resources required, data reliability and technicalities with implementing instruments on ships

### Secure buy-in from end users

Through the data captured in piloting the instrument secure buy-in from the different end-users on the data reliability / comparability and commercial frameworks to ensure scaling of SOAR

### Scale SOAR

Implementing SOAR at scale to secure marine atmospheric constituents including aerosols and greenhouse gases over oceans



### Network Design & Development

Identify key stakeholders to be involved in network that secured the program success through providing input on everything from type of instruments required to installation and maintenance as well as requirements for data usability

### R&D continuation

Perform ongoing Research & Development to create and optimize instruments, management systems and data products

# A growing network of institutions and collaborators are advancing SOAR.

## TEAM AND COLLABORATORS

### SOAR Team

Alex Wong, *Research Director*
Jean-François Lamarque, *Chief Scientist*
Sean Garner, Director, SOAR
Kelly Wanser, Executive Director

Berend van de Kraats, *Chair*
Hans Bouchier, *Treasurer*

### Science

*GLOBAL MONITORING LAB*
Colm Sweeney, *Associate Director of Science*
John Miller, *Senior Research Scientist*
Don Neff, *Shipboard Atmosphere Instrumentation*
Xin Lan, *Research Scientist*

*AERONET*
Alexander Smirnov, *Maritime Aerosol Network Project Scientist*
Pawan Gupta, *Co-Lead*
Elena Lind, *Co-Lead*

*SCIENTIFIC COLLABORATORS*
Rob Wood, University of Washington
Joel Thornton, University of Washington
Ernie Lewis, Brookhaven National Laboratory

### Operations

Vikrant Raar, Master Rubicon

Jóhan av Reyni, *COO*
Súni J. Simonsen, *Mykines Captain*

Kyrin Pollock
Alanna Schenk
Sriram Varadarajan

# Early pilots provide operational insight & valuable scientific data.

## GREENHOUSE GAS MEASUREMENTS


Maersk Rubicon deployment – September 2023 Baselining Tropical Pacific


NOAA GHG Flask Sampler

# Early pilots provide operational insight & valuable scientific data.

## AEROSOL MEASUREMENTS

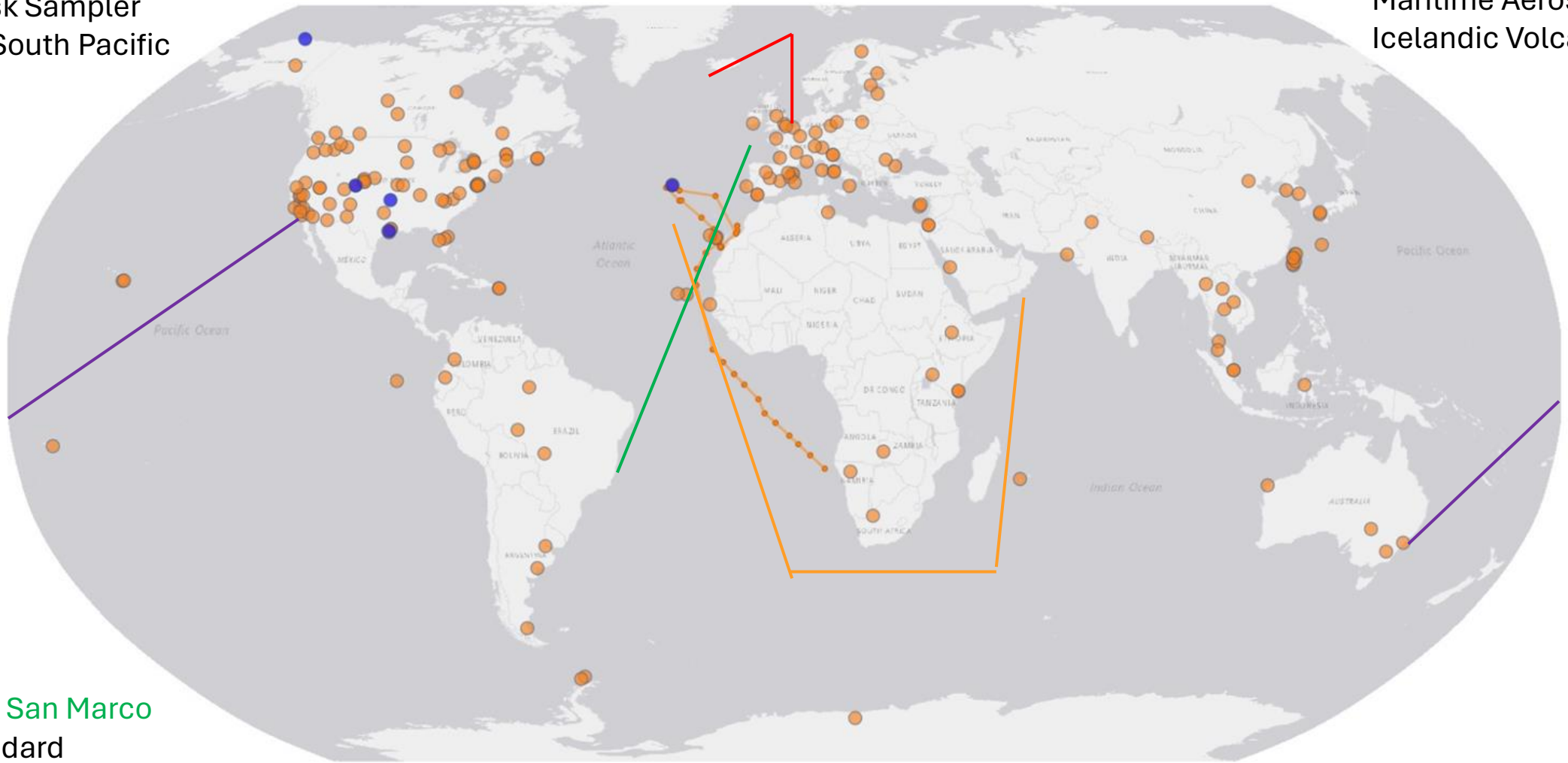

**Smyril Mykines Deployment - February 2024**
**Observing Icelandic volcano plume**

**NASA Maritime Aerosol Photometer**

# Current SOAR Pilot Routes

#1 Maersk Rubicon
NOAA GML
GHG Flask Sampler
Tropical/South Pacific baseline

#2 Smyril Mykines
NASA Goddard
Maritime Aerosol Network
Icelandic Volcano Plume




#3 Maersk San Marco
NASA Goddard
Maritime Aerosol Network
Saharan Dust & Biomass

NEXT: Maersk Kentucky
NOAA/NCAR
African Continental Fluxes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