# Research Priorities in mCDR

Dr. Julie Pullen
Partner & Chief Scientist, Propeller Ventures
Adjunct Research Scientist, Columbia

PROPELLER

COLUMBIA CLIMATE SCHOOL


**Propeller backs ocean ventures using science and technology to propel climate solutions forward.**

# Themes

## Ocean Carbon

Science-backed climate solutions with delivery and measurement

- **Kelp, seagrass, wetlands and mangrove restoration/protection (blue carbon & biodiversity)**
- **Monitoring, Reporting and Verification (MRV)**
- **Ocean CDR**

## Ocean Organics

Full ocean depth cultivation for decarbonization and food

- **Alternative proteins and sustenance**
- **Sustainable ocean fisheries & farming/aquaculture**
- **Ingredients for packaging, pharma & cosmetics, etc.**
- **Novel phytoplankton, microbe, algae and marine fungi applications**

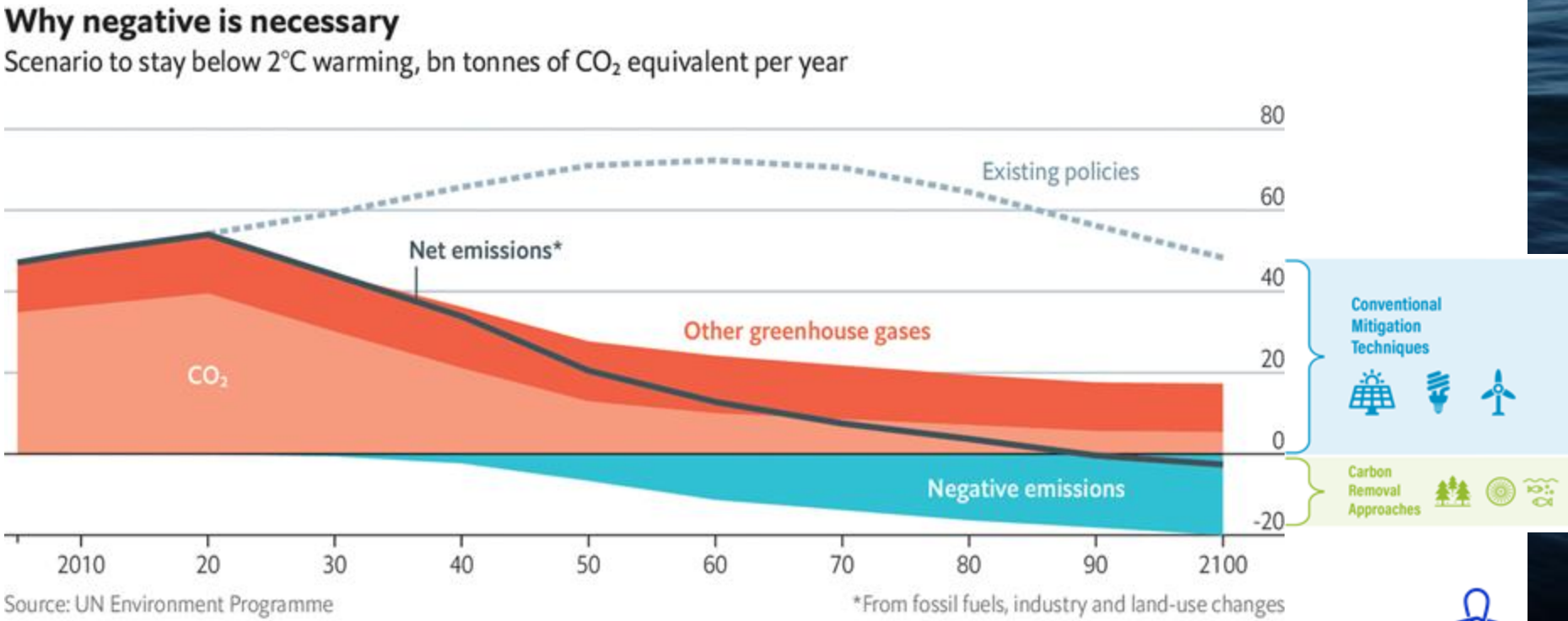
## Ocean Industrials

Big gains in agile, multi-functional, modular deployments and retrofitting

- **Offshore renewable energy**
- **Ocean-based transportation decarbonization**
- **Wastewater remediation and recycling**
- **Retiring and refitting oil & gas infrastructure**
- **Desalination**

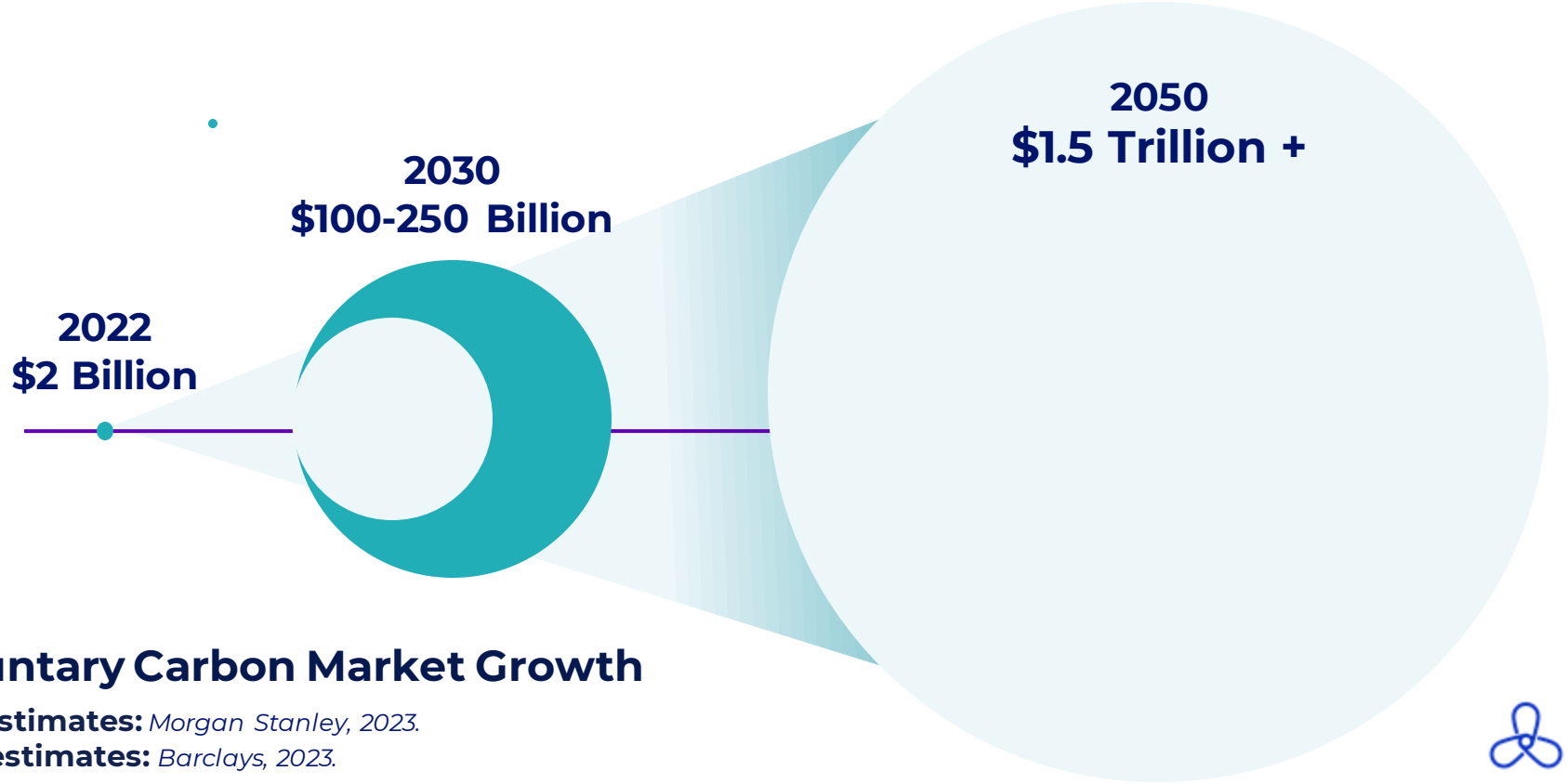
# Net-Zero

**The latest IPCC report specifies annual removal of gigatons of $CO_2$ /yr starting as soon as 2030**




*The Economist, 2021.*

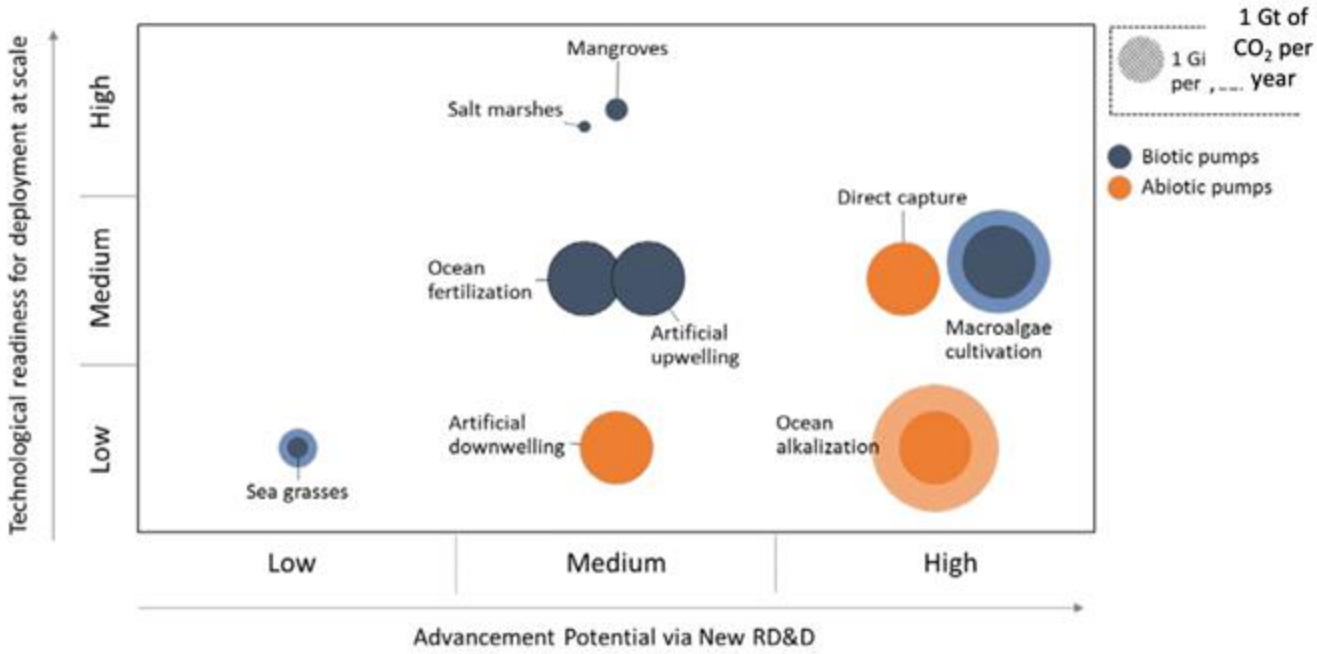
# Waste Management on a Massive Scale




## Voluntary Carbon Market Growth

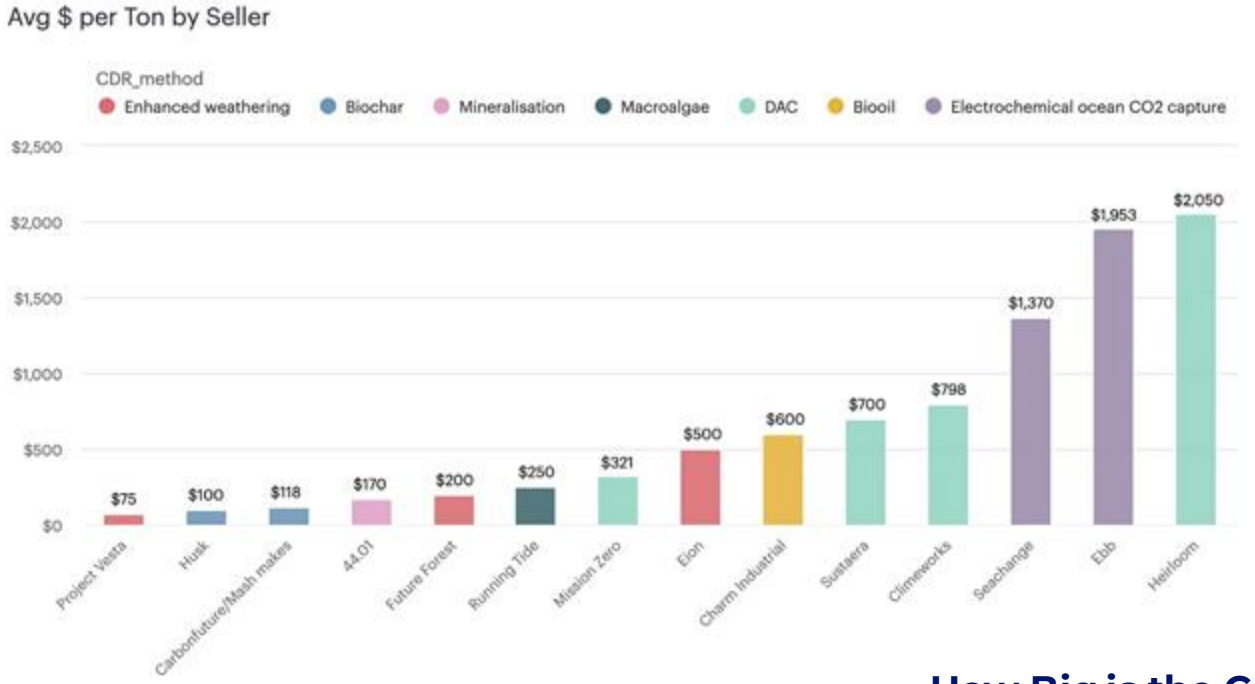
**Low estimates:** *Morgan Stanley, 2023.*
**High estimates:** *Barclays, 2023.*

# Promising Ocean-based Approaches to CDR




*Ocean CDR Primer, ClimateWorks & NAS Ocean CDR report.*

# Current Cost of Carbon Dioxide Removal (CDR)




Advance Market Commitments: **Frontier Fund** (~$1B+) with mCDR a growing part of portfolio

**How Big is the Carbon Removal Market, CDR.fyi, 2023.**

# Research Needs in mCDR

## Technology for mCDR:

- Efficiency gains in carbon removal (e.g., low-power, scalable)
- Innovation (e.g., hybrid CDR approaches that enhance natural processes)

## Science for MRV:

- Changes/stability of ocean carbon sinks (AMOC)
- Ecosystem impacts
- Research to inform/advance regulatory frameworks

## Expanded Capabilities:

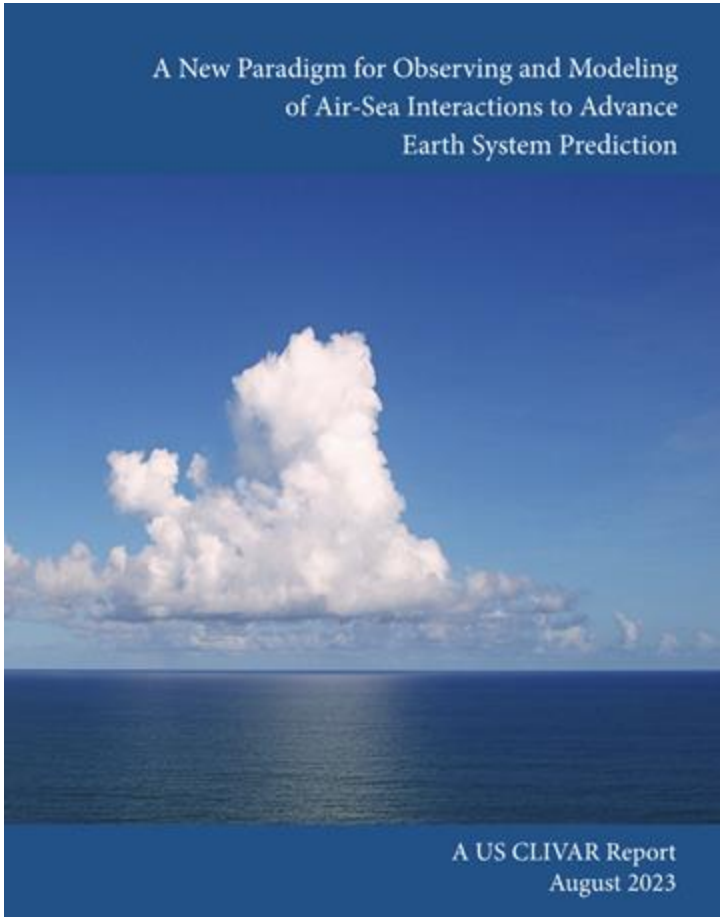
- Climate-scale Observatory
  - Novel, adaptive multi-use platforms with low-cost sensors
  - BCG Argo & CO2 direct fluxes (like OOI)
- Improved near-term high-res decadal modeling (genAI)

# CLIVAR Air Sea Transition Study Group

This report culminates with a set of recommendations and roadmaps for their implementation in Chapter 4. The Study Group identified four strategies that answer our charge of producing a "well-defined strategy to advance observing and modeling capabilities and understanding of air-sea interaction at all required scales for ESP." The four strategies are:

- **Develop observational and modeling technology for coupled ocean-atmosphere prediction.** *Advances in instrumentation, platforms, and parameterizations, as well as the collection, distribution, assimilation, and management of data, are all components of this strategy. These advances will permeate through each of the following strategies.*
- **Observe the ASTZ in strategic regions.** *Measurements of the atmospheric, oceanic, and interfacial components of the ASTZ that are coincident in time and colocated within a given sampling space will address the needs for improved understanding of ocean-atmosphere scale interactions, parameterization development, model physics for ESP, and statistical information needed for CDA.*
- **Expand observations of extremes and other challenging regimes.** *This strategy will require new ways of collecting ASTZ variables using technologies that can be quickly deployed in rapidly developing situations and the development of assets that can be positioned in climatologically important regimes that are challenging to sample at all or challenging to do so for a long time. This strategy will meet the need for societally relevant ESP on scales ranging from landfalling atmospheric rivers (ARs) or tropical cyclones to centuries-long global climate changes.*
- **Develop a global observing network to monitor key air-sea coupling variables.** *This strategy focuses on ASTZ variables associated with air-sea surface fluxes and emphasizes the importance of collecting these measurements across the global oceans, while still adhering to the "same time, same place" guidelines outlined above. This strategy can be achieved with both in situ and remote measurements and will address the needs of constraining global surface flux estimates and improving the initialization of coupled forecast models.*

**Strategic uses cases driven by climate extremes & impacts**



# Connectivity

- Workforce Preparation
  - Data science
  - Climate tech & science
  - Diversity
- Orchestration / Coordination
  - Collective Impact Organization
  - Centers & Initiatives
  - Industry/Startup Contributions

## NSF-NOAA partner to promote the creation of centers for modeling catastrophic impacts and risk assessment of climate change

May 16, 2023

Whether you own a home, a business or other assets, insurance is an important part of any budgetary calculation involving protection of property. While the insurance and reinsurance sector are at the forefront of translating weather and climate information into financial and societal risks, the industry's focus has been on use of catastrophe models rather than incorporating climate change data and projections that can help characterize future conditions.

A new agreement between the U.S. National Science Foundation and the National Oceanic and Atmospheric Administration will support the creation of an Industry-University Cooperative Research Center (IUCRC) focused on modeling catastrophic impacts and risk assessment of climate change to help better support the needs of the insurance sector.

IUCRCs are consortia developed by NSF where university faculty and students work with members of an industry to accelerate the impact of research focused on the collective needs of a sector of the U.S. economy. IUCRCs connect corporate partners, government agencies and academia through mutual interest, creating spaces that build partnerships and usher in science and technology breakthroughs in their respective fields. Consortia will have the opportunity to compete for the opportunity to lead this program and a selection will be made later in the year. The new research center will benefit from interactions with and the experiences of the current NSF and NOAA climate science centers, including NOAA labs and cooperative Institutes.

# Sustained / Hybrid Funding

NSF 23-151

## Dear Colleague Letter: $CO_2$ Removal and Solar Radiation Modification Strategies: Science, Governance and Consequences

September 12, 2023

Dear Colleagues:

The National Science Foundation's (NSF) Directorates for Geosciences (GEO), Social, Behavioral and Economic Sciences (SBE), and Office of International Science and Engineering (OISE) jointly support research to address the twenty-first century global challenge of climate change by seeking to increase understanding of Carbon Dioxide ($CO_2$) Removal (CDR) and Solar Radiation Modification (SRM) science, governance, and consequences. While the rapid reduction of $CO_2$ and other greenhouse gas (GHG) emissions remains a top priority, the scientific community has urged federal agencies to support research on additional potential solutions and their consequences, including strategies that may ameliorate anthropogenic climate change [1-2]. In addition, recent U.S. Government reports [4-5] seek to mobilize the Federal Government and civil society toward enhancing current understanding of potentially effective and innovative climate mitigation strategies. This Dear Colleague Letter (DCL) seeks to encourage submission of proposals on the fundamental understanding and assessment of environmental processes, and/or social, cultural, and ethical impacts of CDR and SRM.

CDR and SRM encompass a broad and growing range of strategies, each with specific potential environmental, and societal impacts and unintended consequences [1-3]. Effective strategies need to be co-developed in an environmentally and socially responsible manner that includes community-engaged research promoting and adhering to open scientific research aligned with FAIR [6] and CARE [7] principles of data sharing and data use. This DCL welcomes proposals in relevant areas of research that align with participating divisions, with particular interest on projects that integrate research programs from both GEO and SBE. Examples include projects that have integrative engagement with ethical frameworks, governance structures, and/or environmental justice issues that help guide research and potential scaling and deployment of CDR and SRM measures. Requests to form and foster interdisciplinary national and international research teams are particularly encouraged through submission of types of proposals described in Chapter II.F of the NSF Proposal & Award Policies & Procedures Guide (PAPPG), including planning, workshop [8], Grant Opportunities for Academic Liaison with Industry (GOALI), and Research Advanced by Interdisciplinary Science and Engineering (RAISE), and to existing program solicitations including Research Coordination Network (RCN), AccelNet, and Global Centers.

This DCL does not constitute a new competition or program. Rather, interested proposers should prepare and submit proposals in accordance with the guidance contained in the PAPPG and any solicitation or program specific instructions for the relevant programs.

All relevant programs within participating Divisions/Offices:
GEO/Division of Atmospheric and Geospace Sciences
GEO/Division of Earth Sciences
GEO/Division of Ocean Sciences
GEO/Office of Polar Programs
SBE/Division of Behavioral and Cognitive Sciences
SBE/Division of Social and Economic Sciences
OISE

**TIP Directorate potential programs:**

- CDR/SRM science for deployment
- Climate-scale modeling & observing for tipping points