NATIONAL ACADEMIES Sciences Engineering Medicine

Climate Intervention in an Earth Systems Science Framework: A Workshop

Climate intervention techniques are increasingly technically feasible, but remain highly controversial due to their transboundary nature, their risks of unintended harmful impacts, and the presence of fundamental ethical concerns. Advancing understanding of the potential efficacy, cascading environmental and social impacts, and societal acceptability of climate intervention requires broad public engagement and ongoing collaboration across a diverse spectrum of expertise.

This virtual workshop draws on the recent National Academies report *Next Generation Earth Systems Science at the National Science Foundation* to present climate intervention as an integrative but expansive framework, encompassing both natural and social processes. This convening will create a dialogue covering the human, physical, and technical dimensions of climate interventions, and will situate these considerations within the context of convergent research and the capacities of the National Science Foundation.

TUESDAY, JUNE 20, 2023

*All time is in Eastern Daylight Time (EDT)

11:00–11:15 **Welcome and Purpose of the Workshop**

Jim Hurrell, Chair of Workshop Organizing Committee

11:15–1:25 **Session 1: Cross Cutting Issues, Needs and Opportunities**

This session will frame the discussion of climate intervention from both a human dimensions perspective, and a physical sciences perspective. Participants will discuss research design, how to assess risk (relative to the risks of climate change), navigating societal & physical systems implications, unintended consequences, natural-social system interactions, as well as the essential need for governance research. Additionally, earth systems predictive capacity, current observation and monitoring infrastructure, as well as scalability and readiness of different techniques will be considered. This session will present key concepts and frameworks to inform how the following sessions consider specific techniques and applications.

Welcome, Framing Remarks
Manjana Milkoreit, Session Chair

Human Dimensions Keynote
Holly Buck, University of Buffalo

Human Dimensions Panel
Jane Flegal, Stripe
Philip Macnaghten, Wageningen University
Juan Moreno-Cruz, University of Waterloo
Simon Nicholson, American University
Christopher Trisos, University of Cape Town
With Q&A

Physical Dimensions Keynote
Ken Caldeira, Stanford University

Physical Dimensions Panel
Michael Diamond, Florida State University
Forrest Hoffmann, Oak Ridge National Laboratory
Ben Kravitz, Indiana University
Katherine Romanak, The University of Texas at Austin
Pete Smith, The University of Aberdeen
With Q&A

1:25–1:45 **Break**

1:45–3:15 **Session 2: Solar Climate Intervention**

Solar climate intervention encompasses techniques including stratospheric aerosol injection, marine cloud brightening, and cirrus cloud thinning. This session's panel will present the state of knowledge and readiness for these interventions, and engage in a robust discussion of the research, societal acceptance, and governance considerations surrounding this topic.

Welcome, Framing Remarks
Simone Tilmes, Session Chair

Keynote
Jim Haywood, University of Exeter

Panel
Ines Camilloni, University of Buenos Aires
Haruki Hirasawa, The University of Victoria
Karen Rosenlof, National Oceanic and Atmospheric Administration
Wake Smith, Harvard University
Daniele Visioni, Cornell University
With Q&A

3:15–3:30 **Break**

3:30–5:00 **Session 3: Land-based CDR and Reliable Sequestration**

Carbon dioxide removal (CDR) and sequestration are a set of negative emissions approaches falling under the umbrella of climate interventions. Land-based CDR and sequestration strategies including reforestation, forest management, soil carbon management, as well as bioenergy with carbon capture and storage and direct air capture, will be discussed in this session. This panel will discuss technological scalability and cost-effectiveness in this area, as well as societal considerations including siting and land-use.

Welcome, Framing Remarks
Phoebe Zarnetske, Session Chair

Keynote
Peter Lawrence, National Center for Atmospheric Research

Panel
Bruno Basso, Michigan State University
Sabine Fuss, Humboldt- Universität zu Berlin
Stephanie Roe, World Wildlife Fund
Gyami Shrestha, Lynker Corporation
With Q&A

5:00–5:15 **Day 1 Summary and Preview of Day 2**

Chris Field, Planning Committee member

5:15 **ADJOURN**

THURSDAY, JUNE 22, 2023

*All time is in Eastern Daylight Time (EDT)

11:00–11:05 **Welcome back & Recap of Day 1**

Jim Hurrell, Chair of Workshop Organizing Committee

11:05–12:35 **Session 4: Ocean-based CDR and Reliable Sequestration**

Ocean-based approaches for carbon dioxide removal and sequestration are a suite of climate interventions whose governance considerations, as well as approaches to technological development, are critical to consider. This session will address nutrient fertilization, artificial upwelling and downwelling, ocean alkalinity enhancement, in addition to electrochemical approaches, seaweed cultivation, and recovery strategies for ocean and coastal ecosystems.

Welcome, Framing Remarks
Joellen Russell, Session Chair

Keynote
Margaret Leinen, University of California San Diego

Panel
Phillip Boyd, University of Tasmania
Sarah Cooley, Ocean Conservancy
John Dunne, National Oceanic and Atmospheric Administration
Matthew Long, National Center for Atmospheric Research
Romany Webb, Columbia University
With Q&A

12:35–1:00 **Break**

1:00–2:30 **Session 5: The Role of the National Science Foundation**

This closing session will synthesize key insights and needs identified from the prior discussions, with an eye toward actionable steps for the National Science Foundation (NSF). This session will include a conversation on the best elements for convergent research proposals on climate intervention and what may be required as part of the review process to evaluate convergence in climate intervention research. Discussion pertaining to the design of NSF funding programs, including the roles for existing and new directorates, how NSF can coordinate with U.S. agencies and international efforts, as well as stay abreast of international debates and implications for US foreign relations, will also be held.

Welcome, Framing Remarks
Sonali McDermid, Session Chair

Keynote Speakers
Lynn Badia, Colorado State University
John Volckens, Colorado State University

Panel
James Arnott, Aspen Global Change Institute
Bill Easterling, Pennsylvania State University
Robert Kopp, Rutgers University
Michael Oppenheimer, Princeton University
Benjamin Sovacool, Boston University
With Q&A

2:30–2:45 **Synthesis Remarks**
Lili Xia, Planning Committee Member

2:45–3:00 **Next Steps and Future Work**
Brent Heard and Margo Corum, National Academies Staff

3:00 **MEETING ADJOURNS**