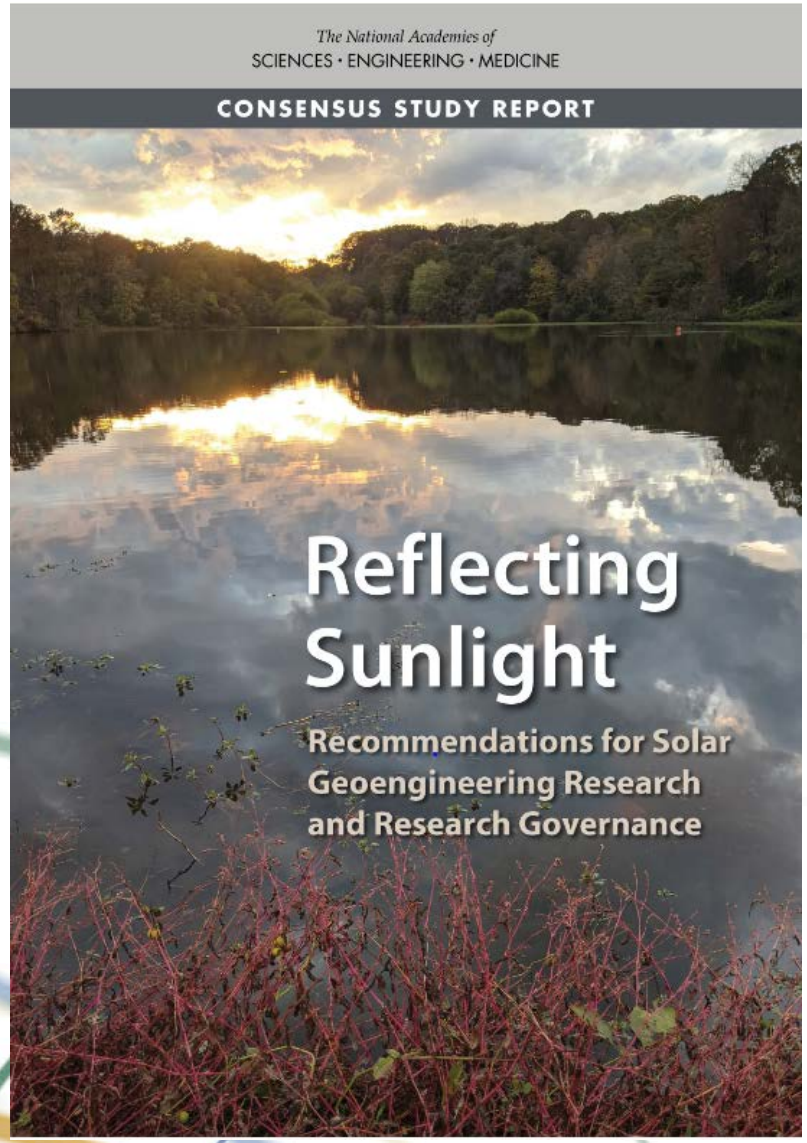
The National Academies of
SCIENCES · ENGINEERING · MEDICINE

Reflecting Sunlight: Recommendations for Solar Geoengineering Research and Research Governance



Climate change impacts are increasing

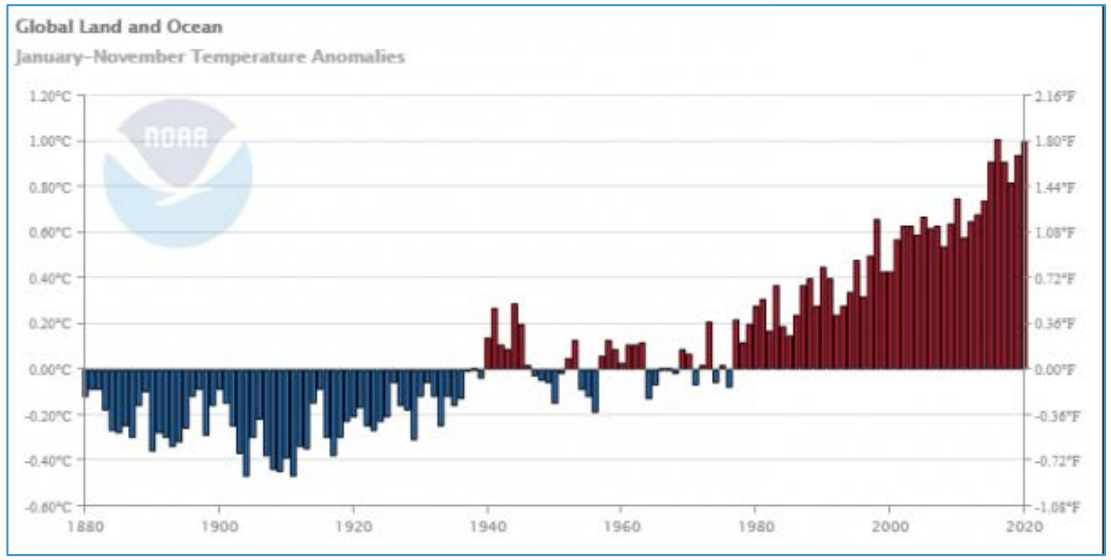
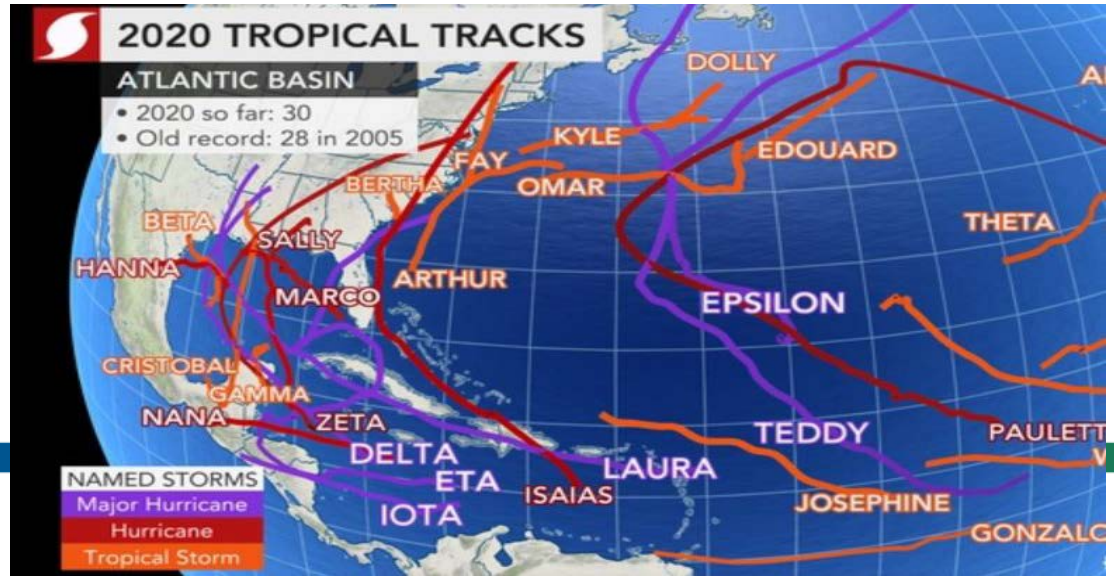


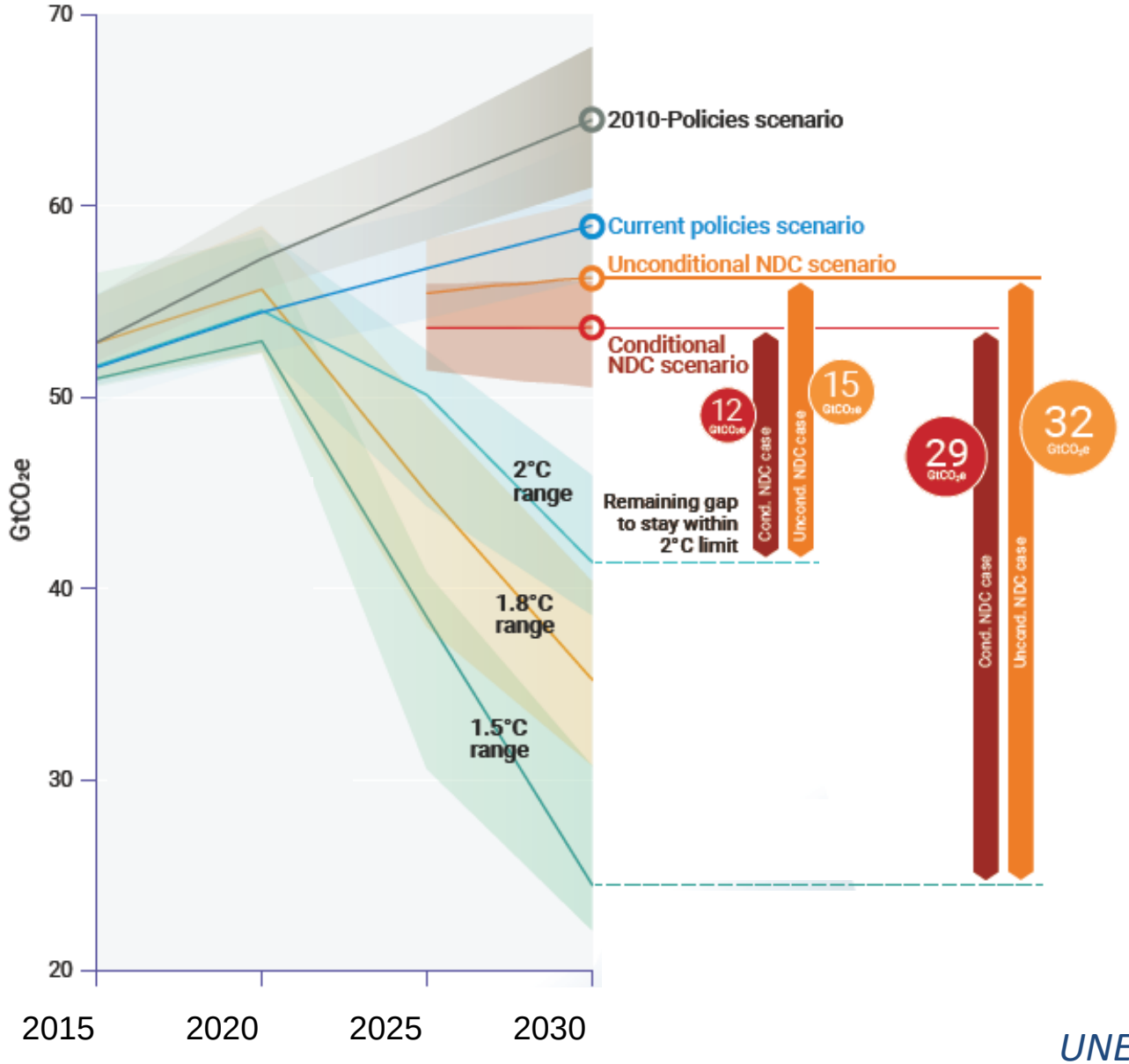
Photo from The Canadian Press

Photo By Noah Berger/AP



Credit: AccuWeather

Progress in responding to climate change is slow



UNEP Emissions Gap Report 2020

Attention & debate over geoengineering research is growing

The New York Times

October 28, 2020

As Climate Disasters Pile Up, a Radical Proposal Gains Traction

The idea of modifying Earth's atmosphere to cool the planet, once seen as too risky to seriously consider, is attracting new money and attention.

Image from https://www.youtube.com/watch?v=cgJyw2cTrW4

Search The Guardian US edition

February 8, 2021

Balloon test flight plan under fire over solar geoengineering fears

Swedish environmental groups warn test flight could be first step towards the adoption of a potentially "dangerous, unpredictable, and unmanageable" technology

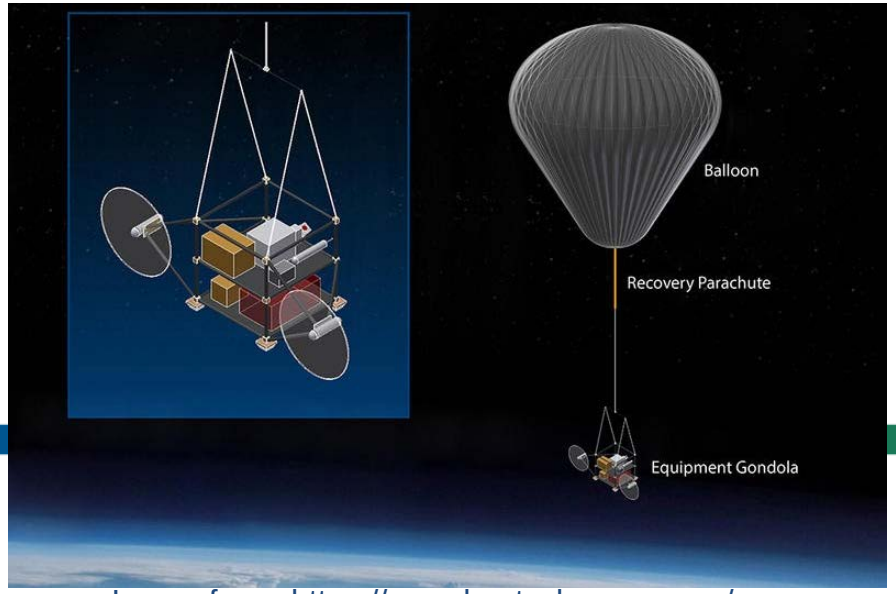
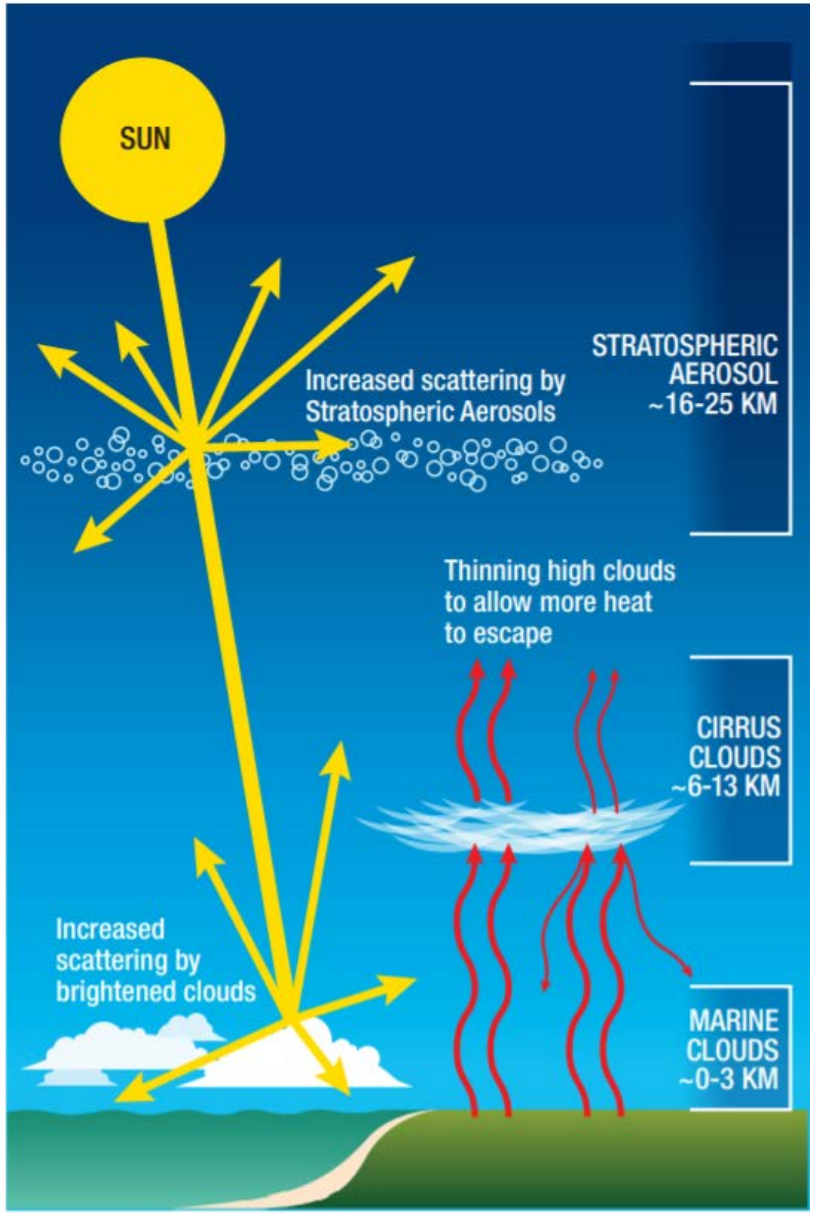


Image from: https://www.keutschgroup.com/scopex

Solar Geoengineering: proposals to moderate warming by increasing the amount of sunlight that the atmosphere reflects back to space or by reducing the trapping of outgoing thermal radiation



Stratospheric Aerosol Injection (SAI)

Cirrus Cloud Thinning (CCT)

Marine Cloud Brightening (MCB)

Charge to Study Committee

- Develop a **trans-disciplinary research agenda** for solar geoengineering
- Consider the **potential impacts**, both positive and negative, of solar geoengineering on the atmosphere, climate system, natural and managed ecosystems, and human systems; and the technological feasibility of these interventions.
- Explore and recommend appropriate **governance mechanisms** for solar geoengineering research.
- Address solar geoengineering **research needs and relevant research governance in tandem**, such that the understanding and thinking on each can inform the other.

Study Sponsors

John D. and Catherine T. MacArthur Foundation

BAND Foundation

Christopher Reynolds Foundation

V. Kann Rasmussen Foundation

National Aeronautics and Space Administration

Department of Energy

National Oceanic and Atmospheric Administration

National Academy of Sciences' Arthur L. Day Fund

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Hank Greely, Stanford Law School

Marion Hourdequin, Colorado College

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Albert Lin, Univ. California, Davis School of Law

Douglas MacMartin, Cornell University

Robert McHenry, Bright Silicon Technologies

Juan Moreno-Cruz, University of Waterloo

Katharine Ricke, University of California, San Diego

Lynn Russell, Scripps Institution of Oceanography

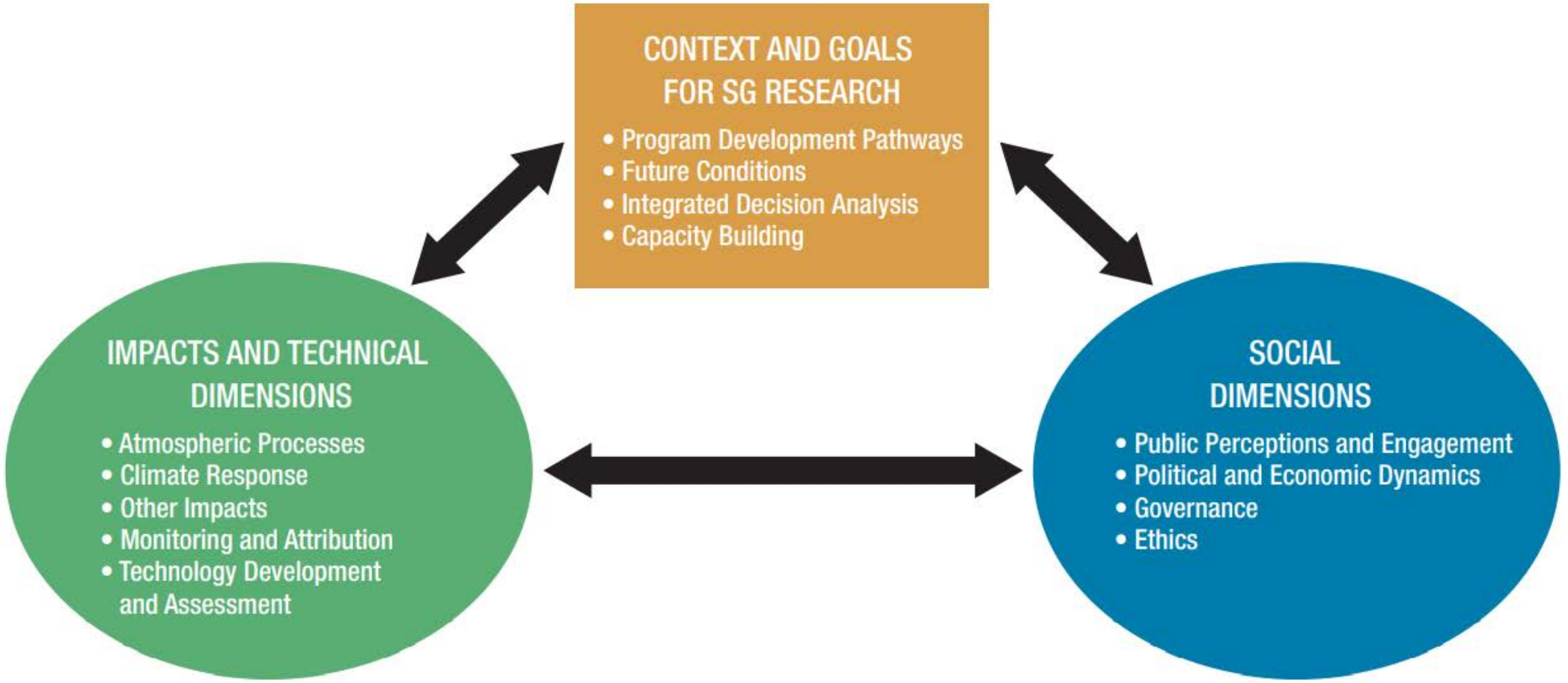
Ambuj Sagar, Indian Institute of Technology, Delhi

Paul Wennberg, CA Institute of Technology

Some Key Messages

- Solar geoengineering is not a substitute for reducing GHG emissions.
- Given the urgent, growing risks of climate change, it is important to understand the risks, feasibility and potential of solar geoengineering as a possible addition to the portfolio of climate response strategies
- The current state of understanding of solar geoengineering is not sufficient for supporting informed decisions.
- The U.S. should establish—in coordination with other countries—a transdisciplinary solar geoengineering research program. The USGCRP should coordinate and oversee this program. The program should focus on developing policy-relevant knowledge, rather than advancing a path for deployment.
- Solar geoengineering research should operate under robust research governance.

Recommendations: Integrated Research Agenda



Recommendation: USGCRP Coordination

The U.S. Global Change Research Program should be tasked to provide coordination and transparent oversight of the research program, by, for example:

- Coordinating across federal agencies
- Fostering transdisciplinary knowledge
- Ensuring rigorous peer-review
- Prioritize international coordination and co-development of research w/other nations
- Limiting research on technology with direct applicability to deployment to early-state, fundamental research
- Advancing public engagement within and beyond the U.S. and pathways for this engagement to help inform and shape the research program
- Key stakeholders include climate-vulnerable communities and underrepresented groups, including from indigenous populations and the Global South

Recommendations: Research Governance

A U.S. national research program should operate under robust research governance and support the eventual development or designation of international governance mechanisms.

- Code of Conduct
- Registry
- Data Sharing
- Assessments and Reviews
- Permitting
- Intellectual Property
- Participation and Stakeholder Engagement
- International Cooperation and Co-development on Research Teams
- International Cooperation Among National Scientific Agencies
- International Information Sharing and Cooperation
- International Anticipatory Governance Expert Committee

Recommendation: Code of Conduct

Funders of solar geoengineering research should mandate that researchers adhere to a code of conduct that includes the following elements:

- Protect the scientific quality of proposed research
- Assess, monitor, and minimize potential adverse effects from research
- Avoid atmospheric experiments with detectable climate or other environmental effects
- Accept research funding only from funding entities that recognize the importance of an overall balance of resources that prioritize mitigation and adaptation
- Make public research activities, funding sources, and results
- Identify and limit conflicts of interest
- Provide for suitable levels of public and stakeholder participation and engagement
- Actively support and advance the goals of racial, gender, geographic, and economic equity in the conduct of SG research

Recommendation: Promotion of International Cooperation & Co-development on Research Teams

Funders of solar geoengineering research should promote international cooperation—including with participants from the Global South—within research teams by:

- giving **priority to research efforts that include substantial international membership or institutional cooperation** or,
- in some cases, **requiring such cooperation and co-development as a condition for support.**

Researchers in the field at the 5th International Conference on Community Based Adaptation to Climate Change (CBA 5). Photo credit: N.A. Omolo

Recommendations: Outdoor Experimentation

Experiments that involve releasing substances into the atmosphere should be considered only when they can provide critical observations not already available or likely to become available through laboratory studies, modeling, and experiments of opportunity (e.g., observing volcanic eruptions, rocket plumes, ship tracks).

All outdoor experiments involving the release of substances into the atmosphere **should be subject to governance**, including a permitting system, impact assessment, and public engagement.

Any outdoor substance releases should be **limited to a quantity of material at least two orders of magnitude smaller than that which could cause detectable changes** in global mean temperature or adverse environmental effects.

Research program budget guidelines

- Solar geoengineering funding should **not shift the focus from other important global climate change research, nor exacerbate concerns about a slippery slope towards deployment**: the near-term budget should be small relative to total global change research budget, on the order of $100-200 million over the first 5 years.
- The program should **support equitably all research clusters from the outset**.
- Research funding should be accompanied by **support for implementing research governance and public engagement**.

Concluding Thoughts

- Solar geoengineering research makes sense only in the context of a priority commitment to mitigation and adaptation.
- These are recommendations for an initial exploratory phase of a research program.
- This research program could indicate that solar geoengineering should not be considered further or that it warrants additional effort.
- This program aims to assess both the *technical and social feasibility* of solar geoengineering.
- Research and research governance recommendations are intended as an integrated whole.