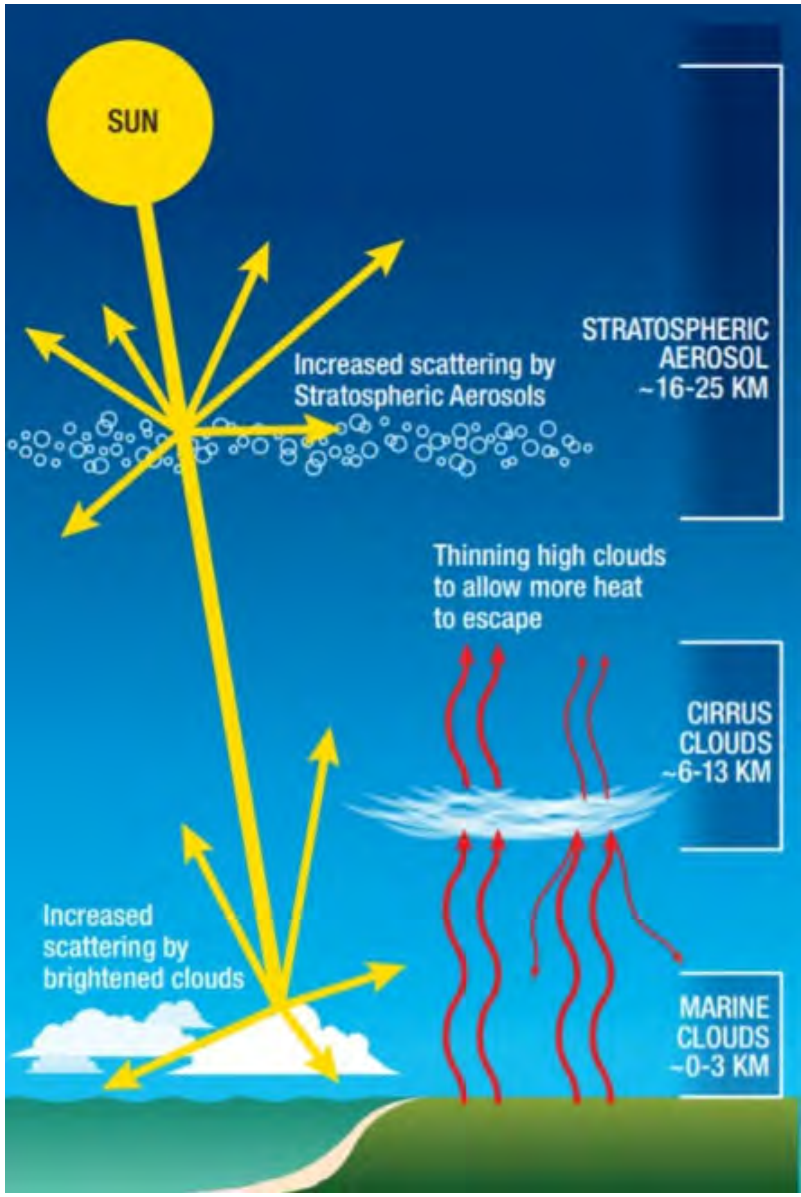
Solar Geoengineering Research: Time to Accelerate Progress?



Chris Field
Stanford | Doerr
School of Sustainability

Earth. Climate. Society.

Three recent reports all say yes, but…

- NASEM
- UNEP
- Climate Overshoot Commission

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- NASEM (2021)
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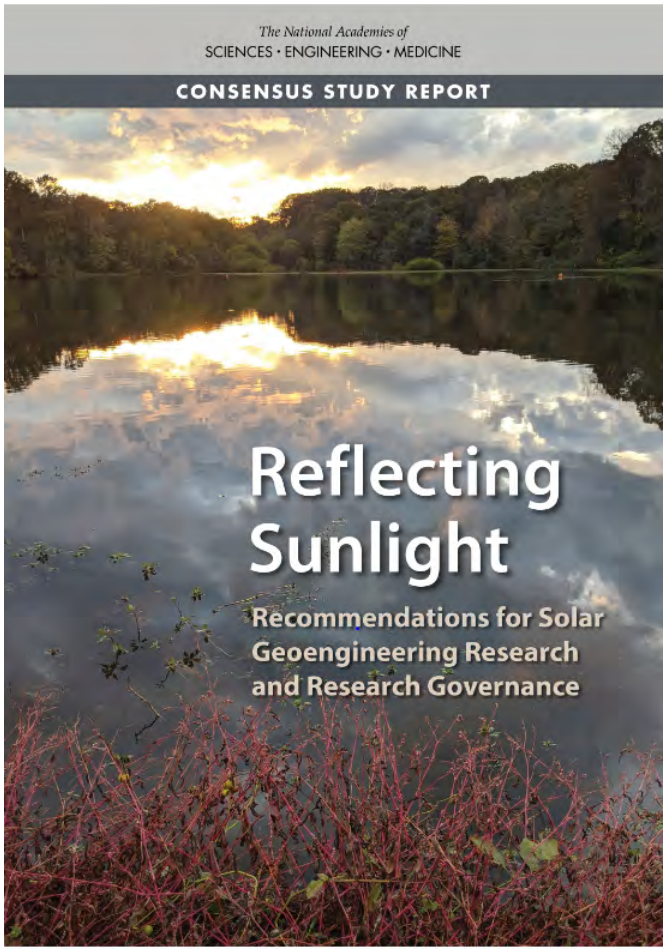

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Three recent reports all say yes, but…

- NASEM
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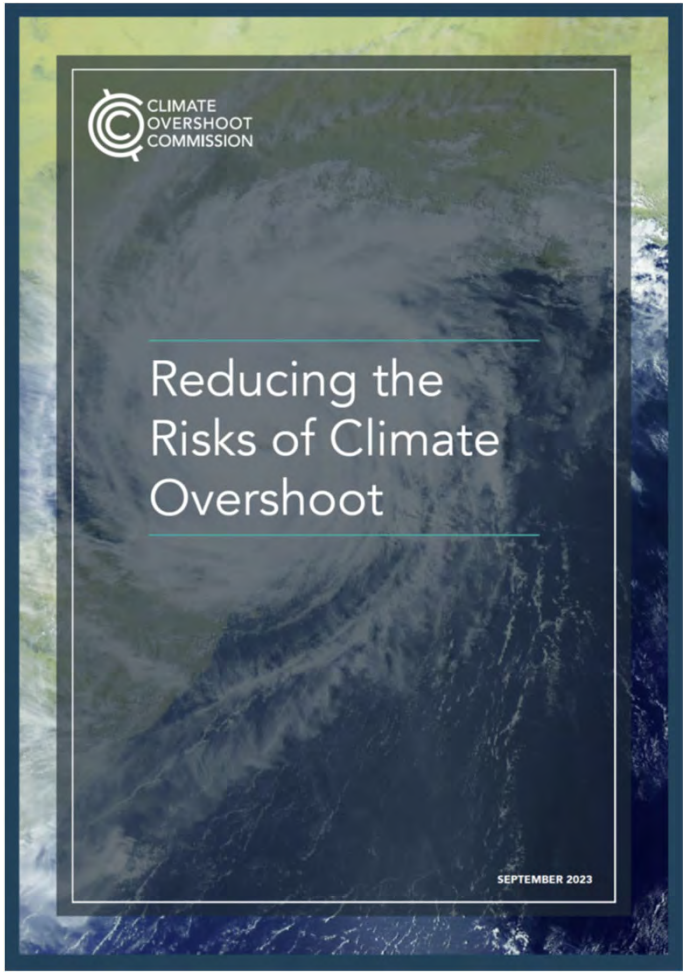
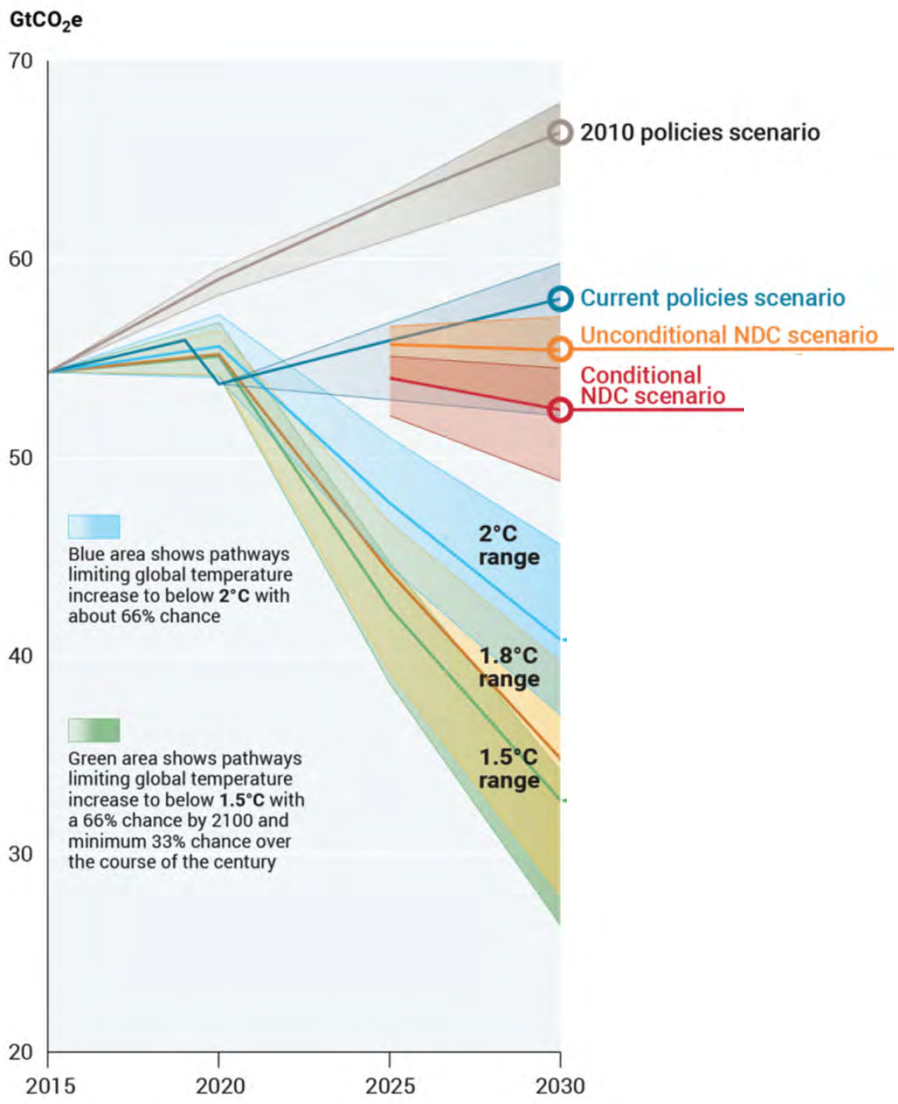


Context

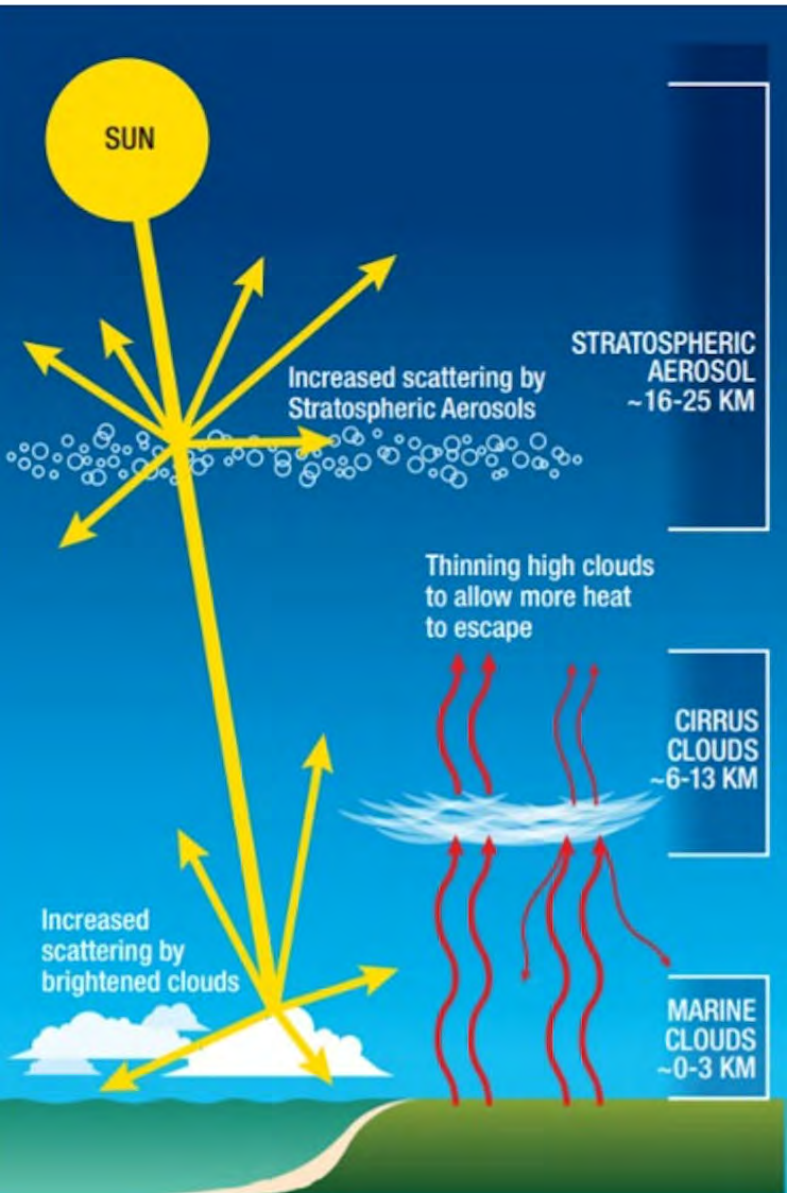
The ultimate objective of this Convention …
is to achieve … stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

Un Framework Convention on Climate Change, 1992



UNEP Gap Report, 2022


L'ÉCOLE APPELLE ÇA UNE ABSENCE INJUSTIFIÉE, NOUS SOMMES MOTIVÉES À SAUVER NOTRE PLANÈTE
RIP OLAF
D BE IN CHOOL IF THE WAS COOL
1.5 TO STAY ALIVE

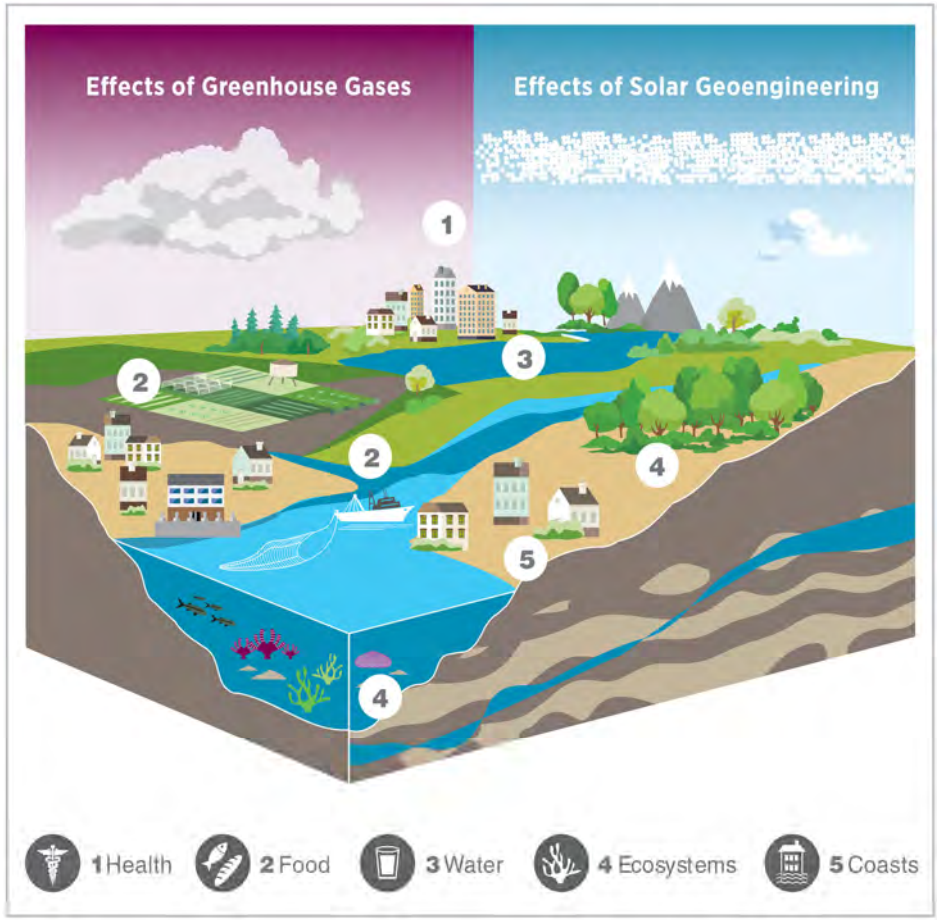


Solar Geoengineering Research

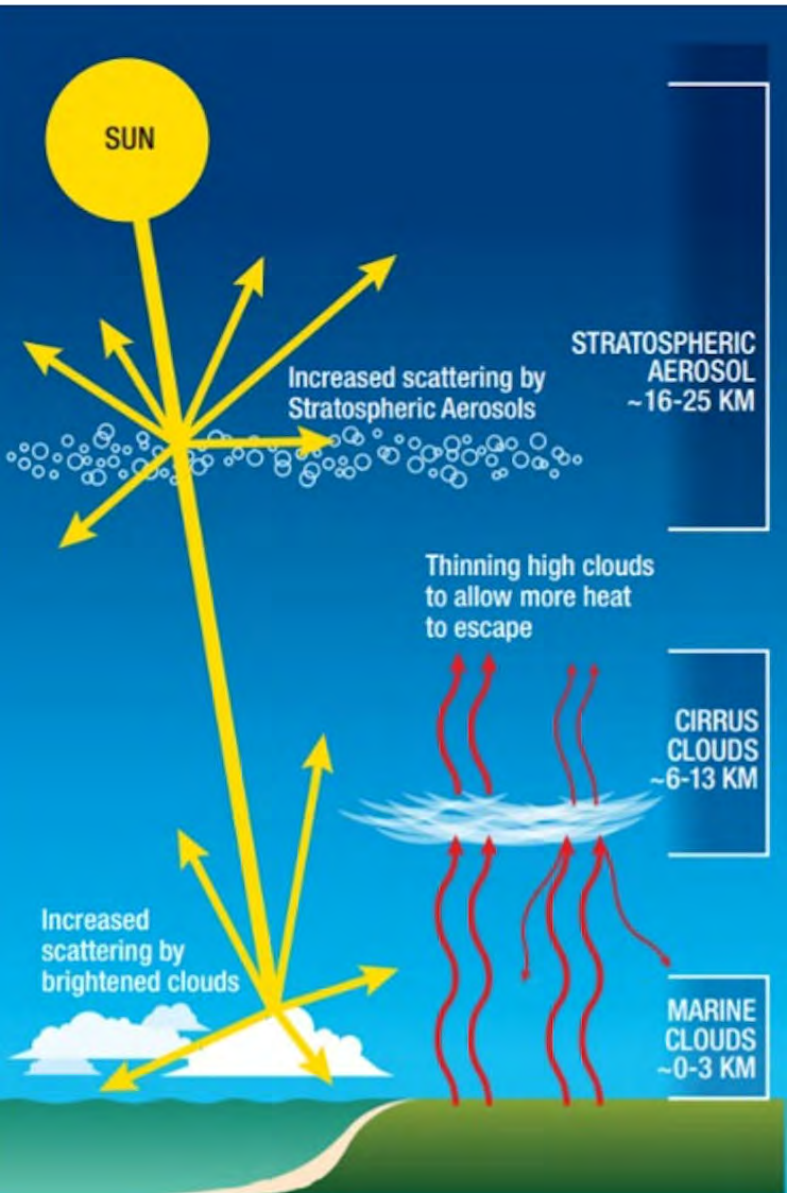
- > 2000 papers
- Effective at lowering mean temp
- Does not restore earlier climate

Consequences

Towards a comprehensive climate impacts assessment of solar geoengineering



Irvine, P. J., B. Kravitz, M. G. Lawrence, D. Gerten, C. Caminade, S. N. Gosling, E. J. Hendy, B. T. Kassie, W. D. Kissling, H. Muri, A. Oschlies, and S. J. Smith. 2017. Towards a comprehensive climate impacts assessment of solar geoengineering. Earth's Future **5:93-106.**

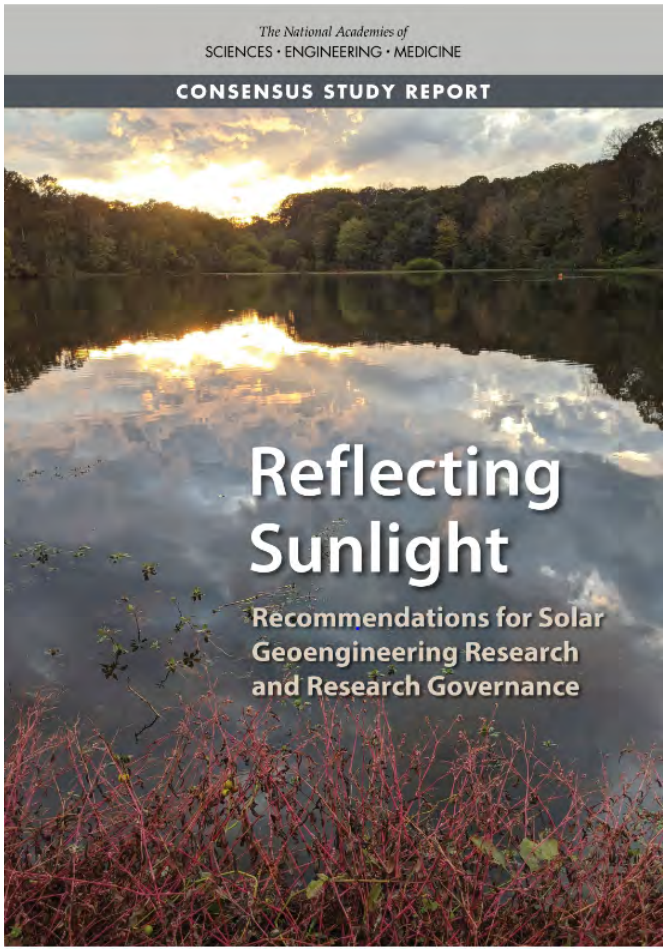


Solar Geoengineering Research

- Mitigation Deterrence (Moral Hazard)
- Slippery Slope
- Unintended Consequences
- Governance

National Academies: Reflecting Sunlight

- Assess the **technological feasibility** of solar geoengineering interventions.
- Consider **potential impacts**, both positive and negative, on the atmosphere, climate system, ecosystems, and society.
- Develop a **transdisciplinary research agenda.**
- Recommend **governance mechanisms** for solar geoengineering research.



Committee Members

Chris Field, Stanford University [Chair]

William Cheung, University of British Columbia

Lisa Dilling, University of Colorado

Peter Frumhoff, Union of Concerned Scientists

Hank Greely, Stanford Law School

Marion Hourdequin, Colorado College

Jim Hurrell, Colorado State University

Andrew Light, George Mason University

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

Key Conclusions

Given the urgent, growing risks of climate change, it is important to understand the feasibility, risks, benefits of all possible response options.

Solar geoengineering is a potential additional strategy for responding to climate change, but is not a substitute for reducing greenhouse gas emissions.

Recommendation: Implement a Research Program

Given the urgency of climate change concerns and the need for a full understanding of possible response options, **the U.S. should establish—in coordination with other countries—a transdisciplinary, SG research program.**

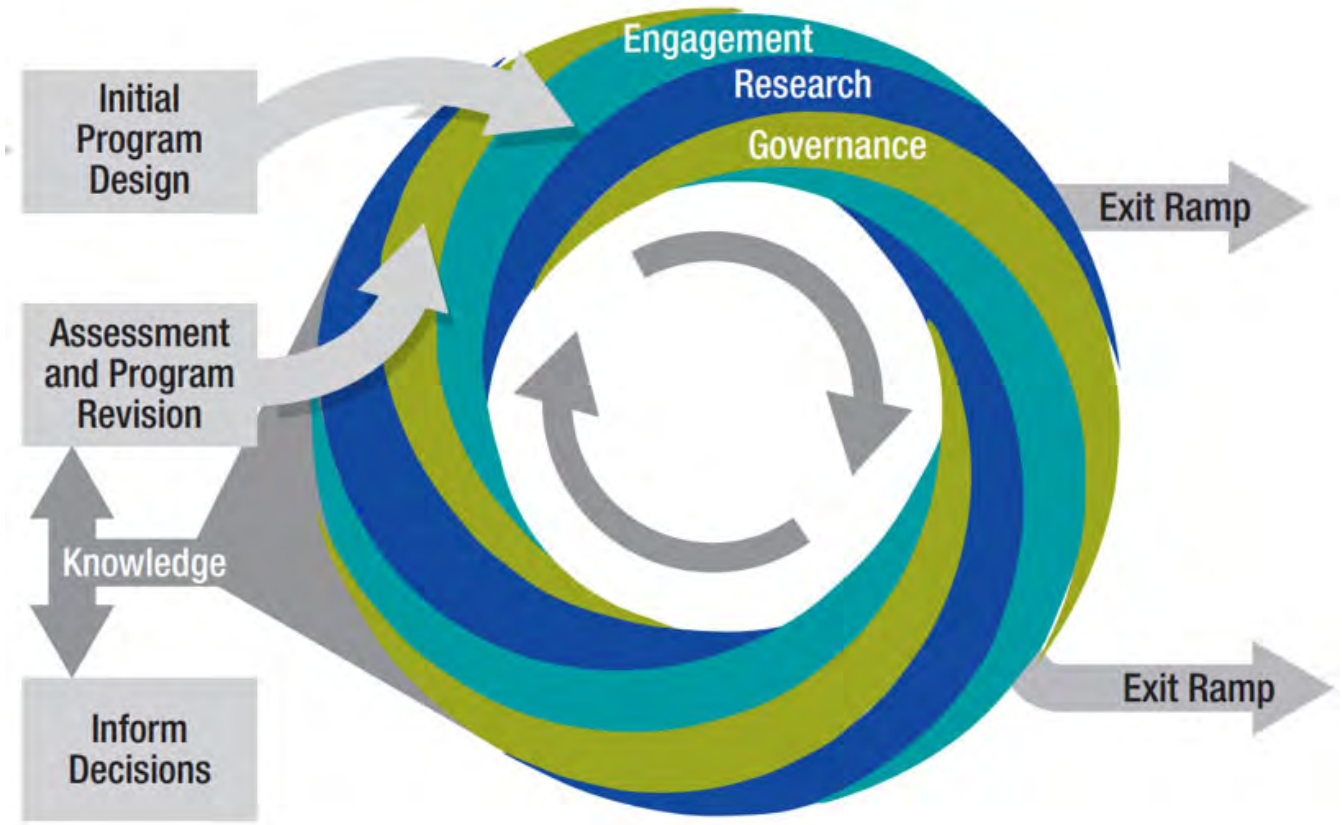
This program should be a minor part of the overall U.S. research program related to responding to climate change, and **it should focus on developing policy-relevant knowledge, rather than advancing a path for deployment.**

The U.S. Global Change Research Program should be tasked to provide coordination and transparent oversight of this effort.

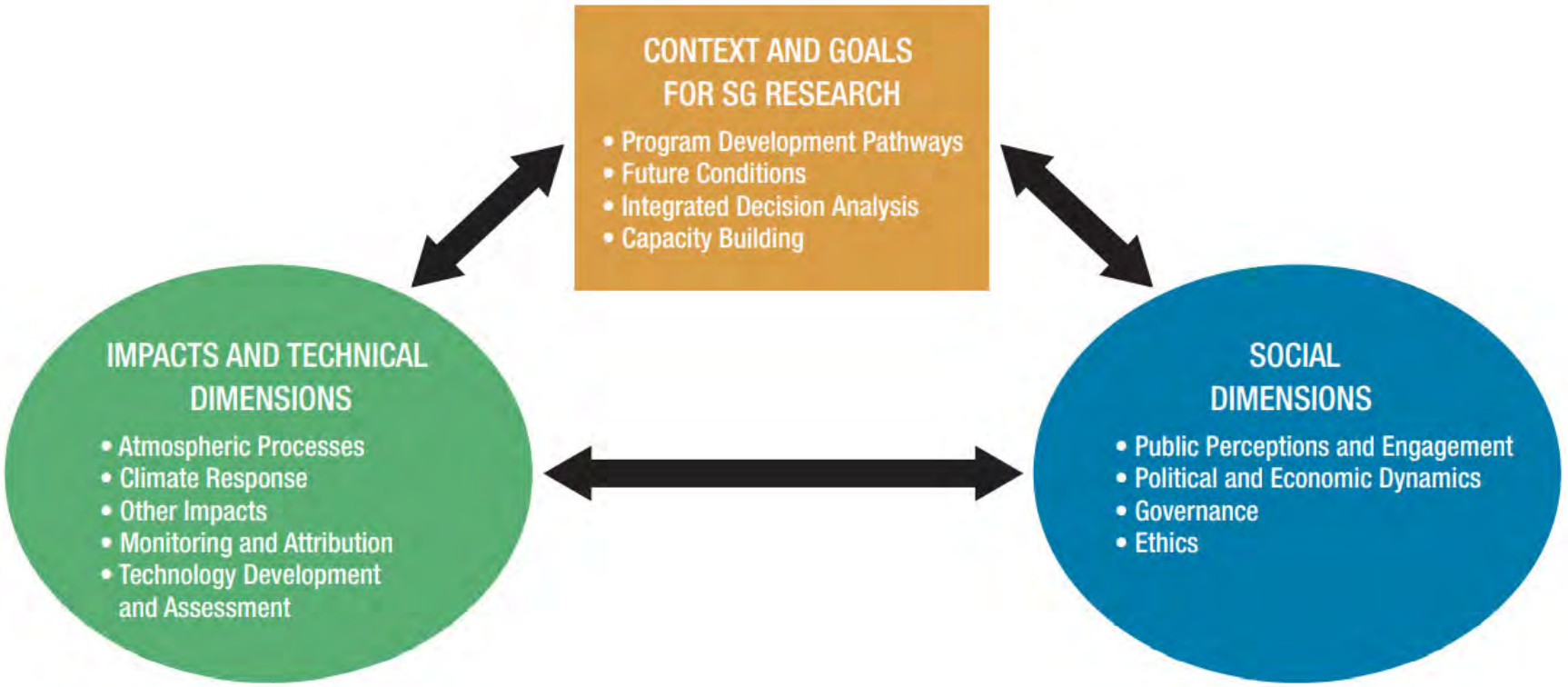
Recommendations: Research Governance

A U.S. national research program should operate under robust governance and support the development 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


Initial Program Design
Assessment and Program Revision
Knowledge
Inform Decisions
Engagement
Research
Governance
Exit Ramp
Exit Ramp

Recommendation: Integrated Research Agenda



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).

Outdoor experiments that release of substances into the atmosphere **should be subject to governance**, including a permitting system, impact assessment, 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.

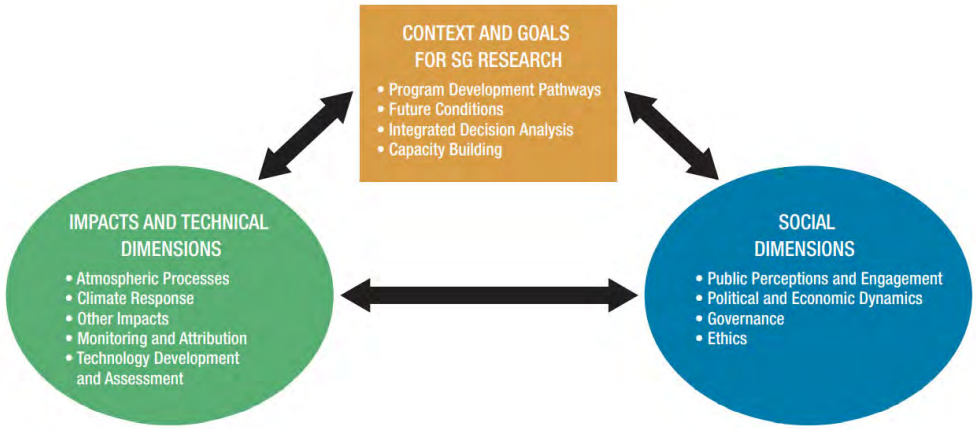
Research program budget guidelines

- 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 of the research clusters from the outset**.
- The budget should be able to **accommodate major field campaigns**.
- A substantial fraction of the research program should be **dynamically allocated** to allow the program to adapt as learning proceeds.
- Research funding should be accompanied by **support for implementing research governance and public engagement**.

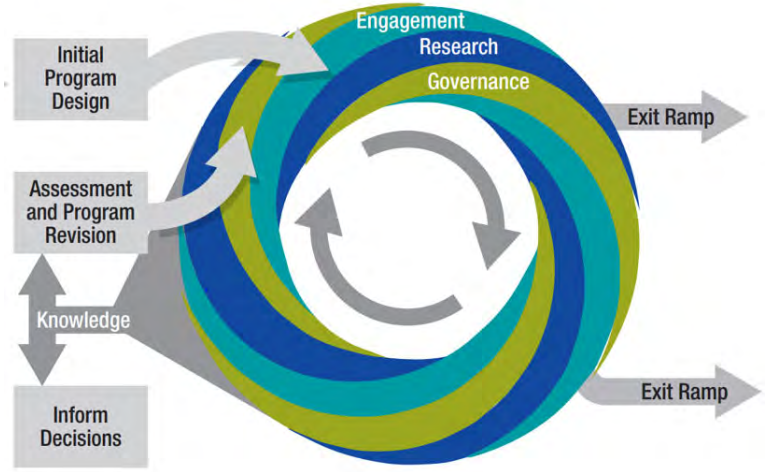
Some Concluding Thoughts

This research program must assess not only the *technical feasibility* but also the *social feasibility* of solar geoengineering.

The research agenda should be pursued as an integrated whole. Pursuing individual elements in isolation will undermine program goals and outcomes.



The recommended research governance and engagement efforts will enable the program to proceed in a societally responsive and acceptable manner.



UNEP: One Atmosphere

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Ines Camilloni, Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires
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Christopher Trisos, African Climate and Development Initiative (ACDI), University of Cape Town

Key Findings from One Atmosphere, 2023

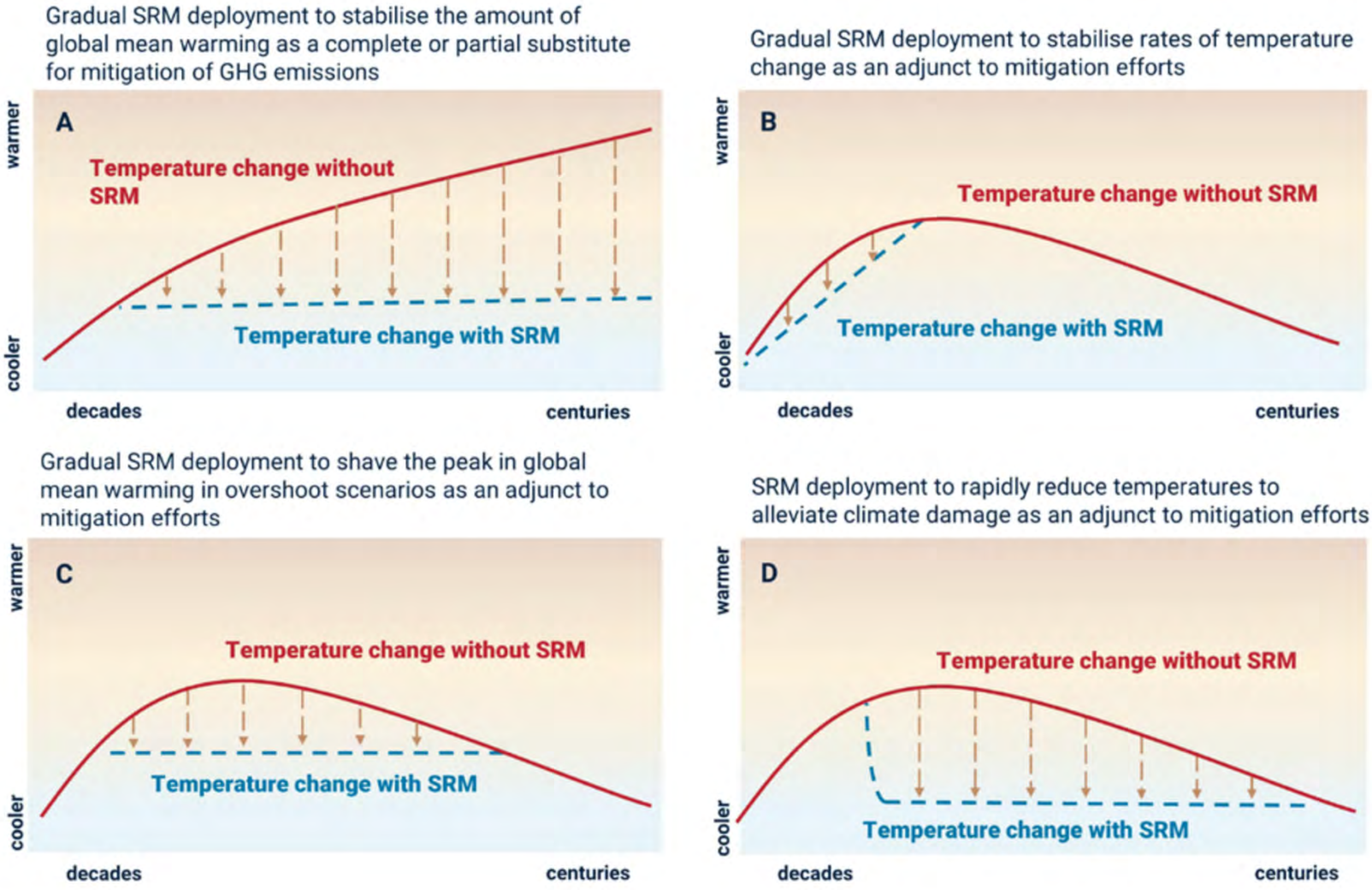
1. While international efforts must focus on rapid emissions mitigation and adapting to anthropogenically induced climate change, Solar Radiation Modification (SRM) is being discussed as an additional approach to offset some impacts and avoid global temperature exceeding the limits set in the Paris Agreement, while the global energy system is being transformed.

2. An operational SRM deployment would introduce new risks to people and ecosystems.

3. With many unknowns and risks, there is a strong need to establish an international scientific review process to identify scenarios, consequences, uncertainties and knowledge gaps.

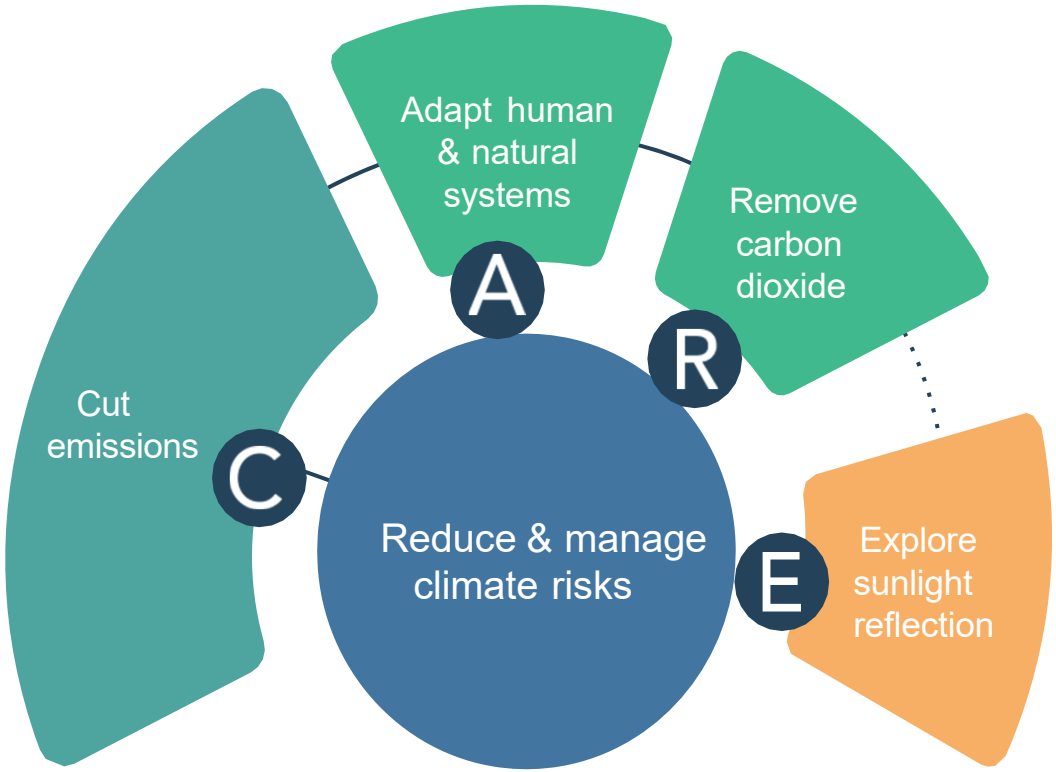
4. A governance process would be valuable to guide decisions around research activities, including indoor research, small-scale outdoor experiments and SRM deployments.

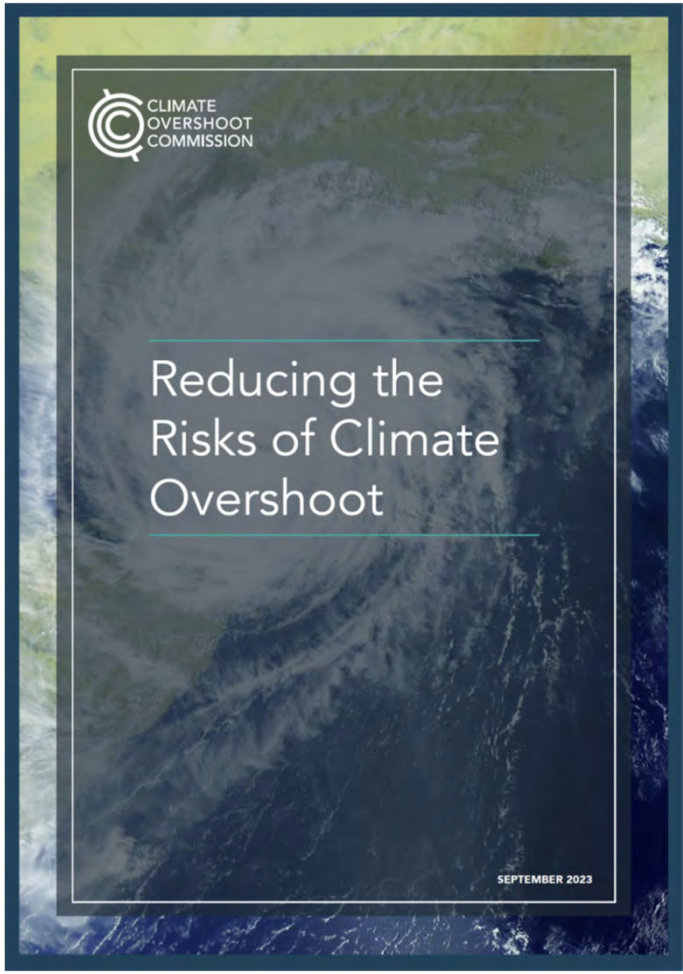
5. SRM research and deployment decisions require an equitable, transparent, diverse and inclusive discussion of the underpinning science, impacts, risks, uncertainties and governance.


Gradual SRM deployment to stabilise the amount of global mean warming as a complete or partial substitute for mitigation of GHG emissions
A
warmer
cooler
Temperature change without SRM
Temperature change with SRM
decades
centuries
Gradual SRM deployment to stabilise rates of temperature change as an adjunct to mitigation efforts
B
warmer
cooler
Temperature change without SRM
Temperature change with SRM
decades
centuries
Gradual SRM deployment to shave the peak in global mean warming in overshoot scenarios as an adjunct to mitigation efforts
C
warmer
cooler
Temperature change without SRM
Temperature change with SRM
decades
centuries
SRM deployment to rapidly reduce temperatures to alleviate climate damage as an adjunct to mitigation efforts
D
warmer
cooler
Temperature change without SRM
Temperature change with SRM
decades
centuries

UNEP 2023

Climate Overshoot Commission: Prioritizing Options





The Commissioners

Dr. Muhamad Chatib Basri
Former Minister of Finance of Indonesia

Ms. Frances Beinecke
President Emerita, Natural Resources Defense Council; board member, World Resources Institute, USA

The Right Honourable Kim Campbell
Canada's 19th Prime Minister, Founding Member of Club de Madrid

Mr. Jamshyd Godrej
Chairman of the board of Godrej & Boyce Mfg. Co. Ltd. and of the Council on Energy, Environment and Water, India

Ms. Arancha Gonzalez Laya
Dean, Paris School of International Affairs at Sciences Po, former Foreign Minister of Spain

His Excellency Mahamadou Issoufou
Former President of Niger Republic, President of Issoufou Mahamadou Foundation

Dr. Agnes Kalibata
UN Secretary-General's Special Envoy to the Food Systems Summit; President, Alliance for a Green Revolution in Africa, Rwanda

Ms. Hina Rabbani Khar
Former Minister of Foreign Affairs of Pakistan

Pascal Lamy, CHAIR
Vice-President of the Paris Peace Forum; former Director-General of the World Trade Organization, France

His Excellency Anote Tong
Former President of the Republic of Kiribati

Prof. Laurence Tubiana
CEO of the European Climate Foundation; former Climate Change Ambassador and Special Representative for COP21 of France

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Cheung Kong Distinguished Chair Professor and Dean of Schwarzman College, Tsinghua University, China

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Shirmai Chung
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Energy & Poverty

Louise Mabulo
Farming & Food Systems

Yuv Sungkur
Small Island Developing Statesi

Chandelle O'Neil
Human Rights

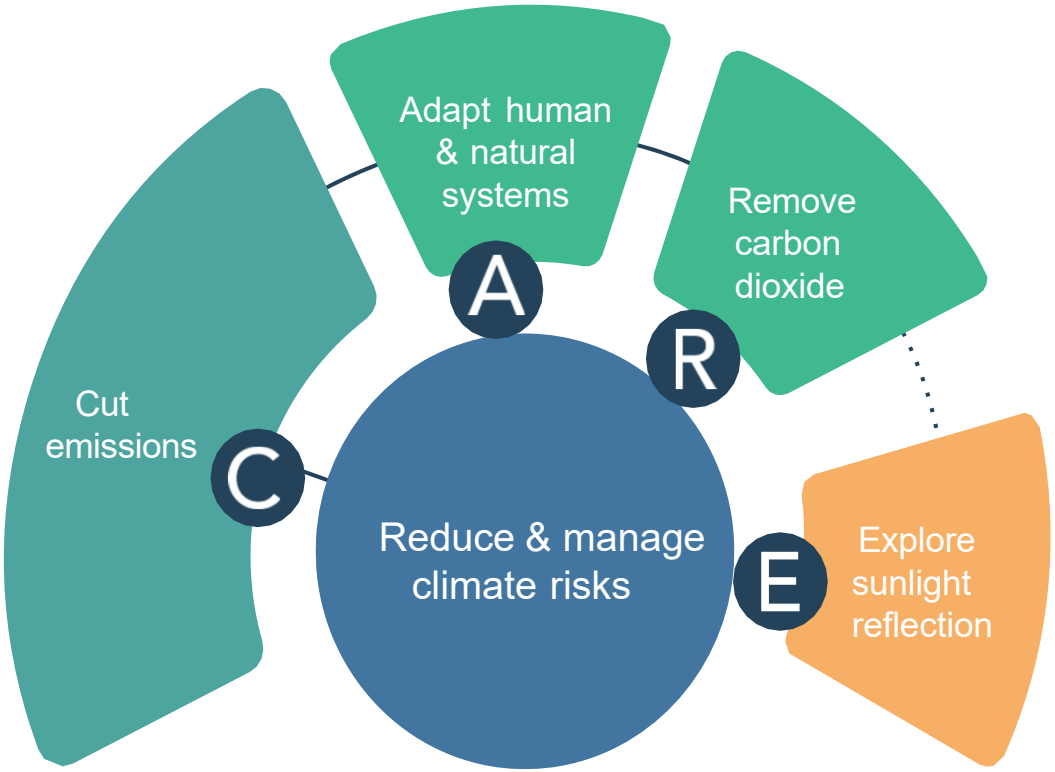
Alex Clark
Climate Economics

CLIMATE OVERSHOOT COMMISSION

E

Explore

Adopt a moratorium on large-scale solar radiation management and expand research and governance dialogue.



- Paris Agreement Goal:

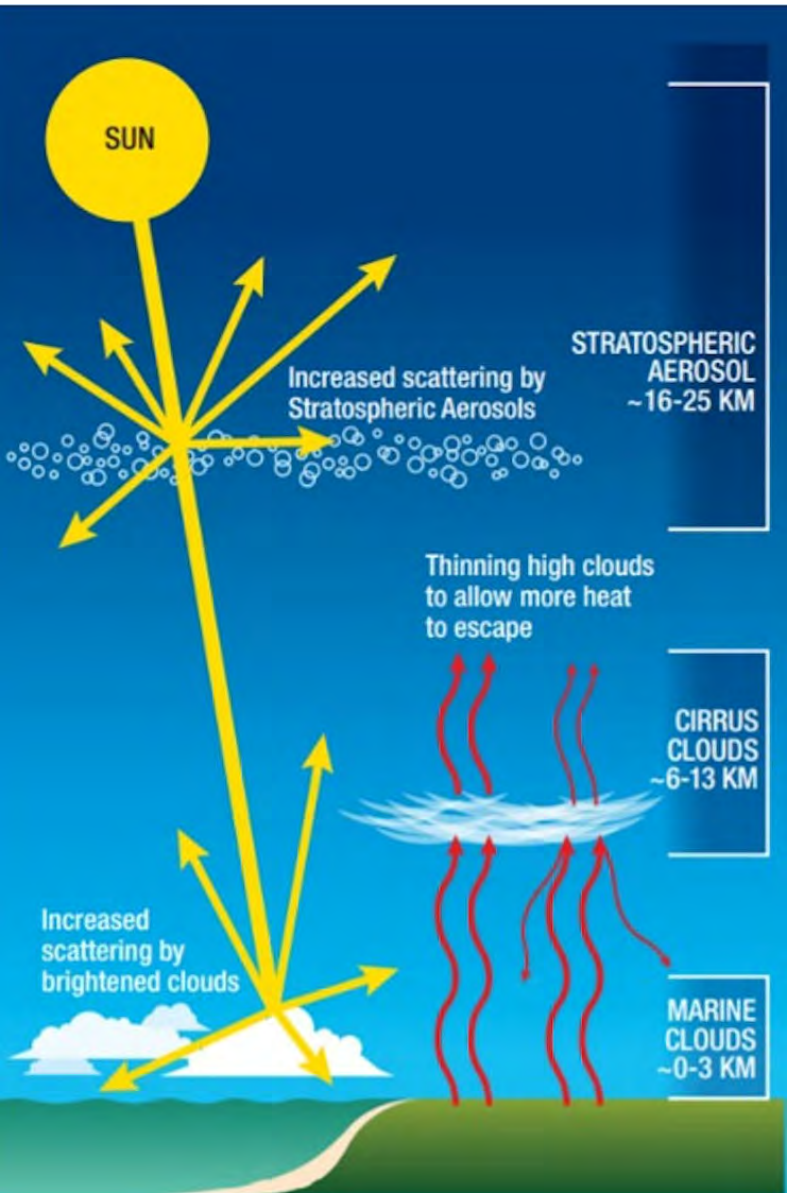
  Technically Feasible

- Adapt: Essential

- Remove CO_2: Smart

- Explore Sunlight Reflection:

  Understand Options



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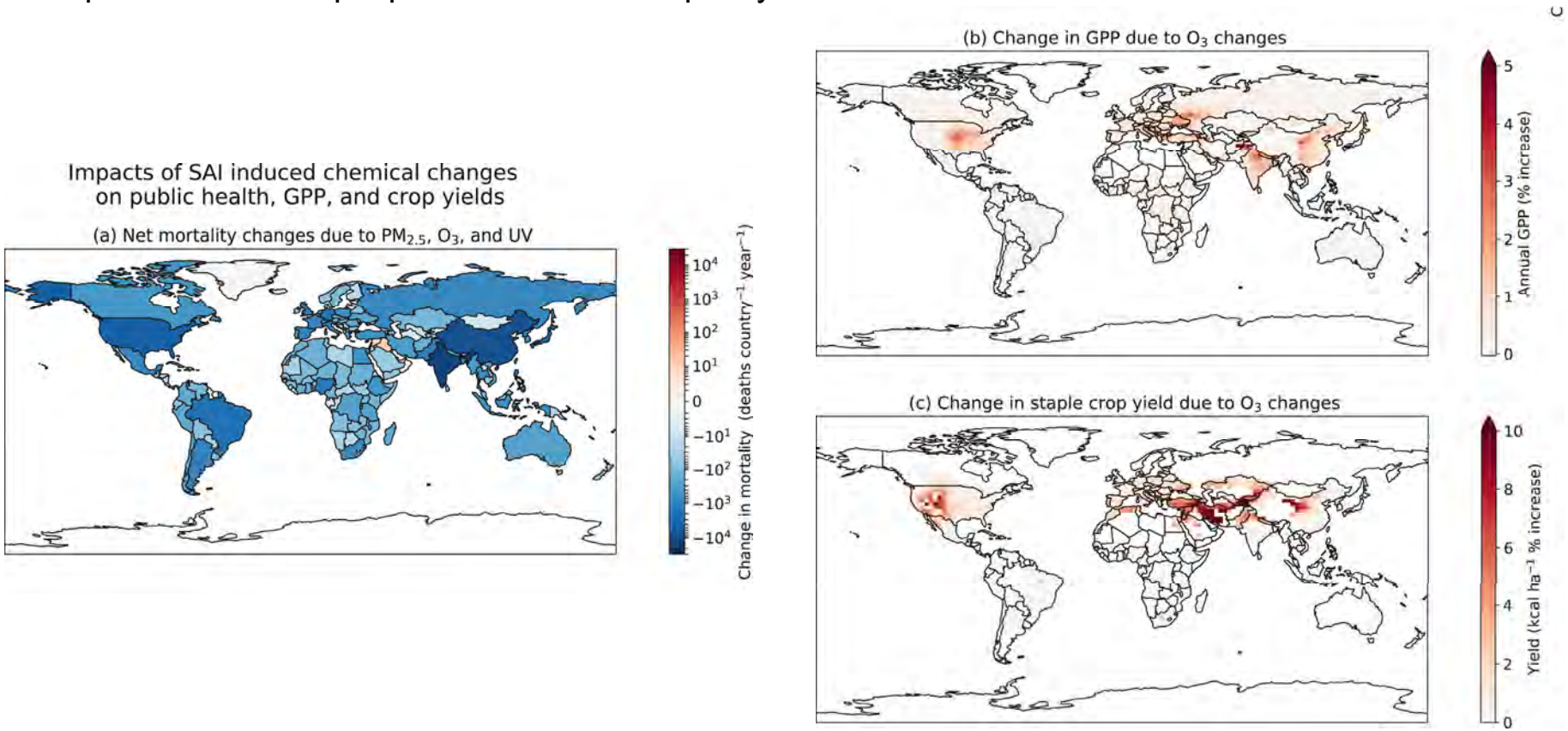
Consequences

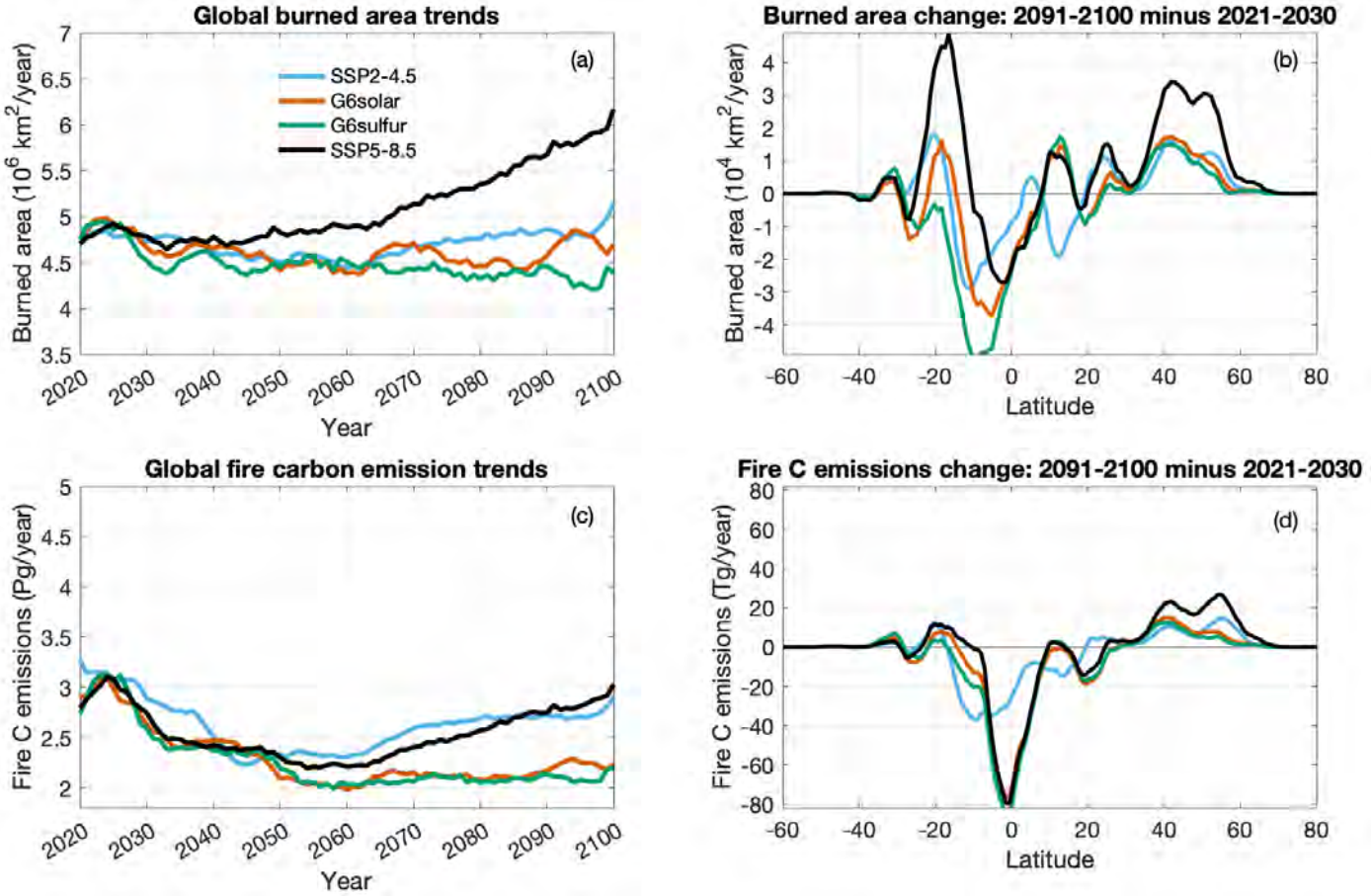
Overlooked Long-Term Atmospheric Chemical Feedbacks Alter the Impact of Solar Geoengineering: Implications for Tropospheric Oxidative Capacity



Moch, J. M., L. J. Mickley, S. D. Eastham, E. W. Lundgren, V. Shah, J. J. Buonocore, J. Y. S. Pang, M. Sadiq, and A. P. K. Tai. 2023. Overlooked Long-Term Atmospheric Chemical Feedbacks Alter the Impact of Solar Geoengineering: Implications for Tropospheric Oxidative Capacity. AGU Advances **4:e2023AV000911.**

Consequences

Wildfires: Global Burned Area Trends



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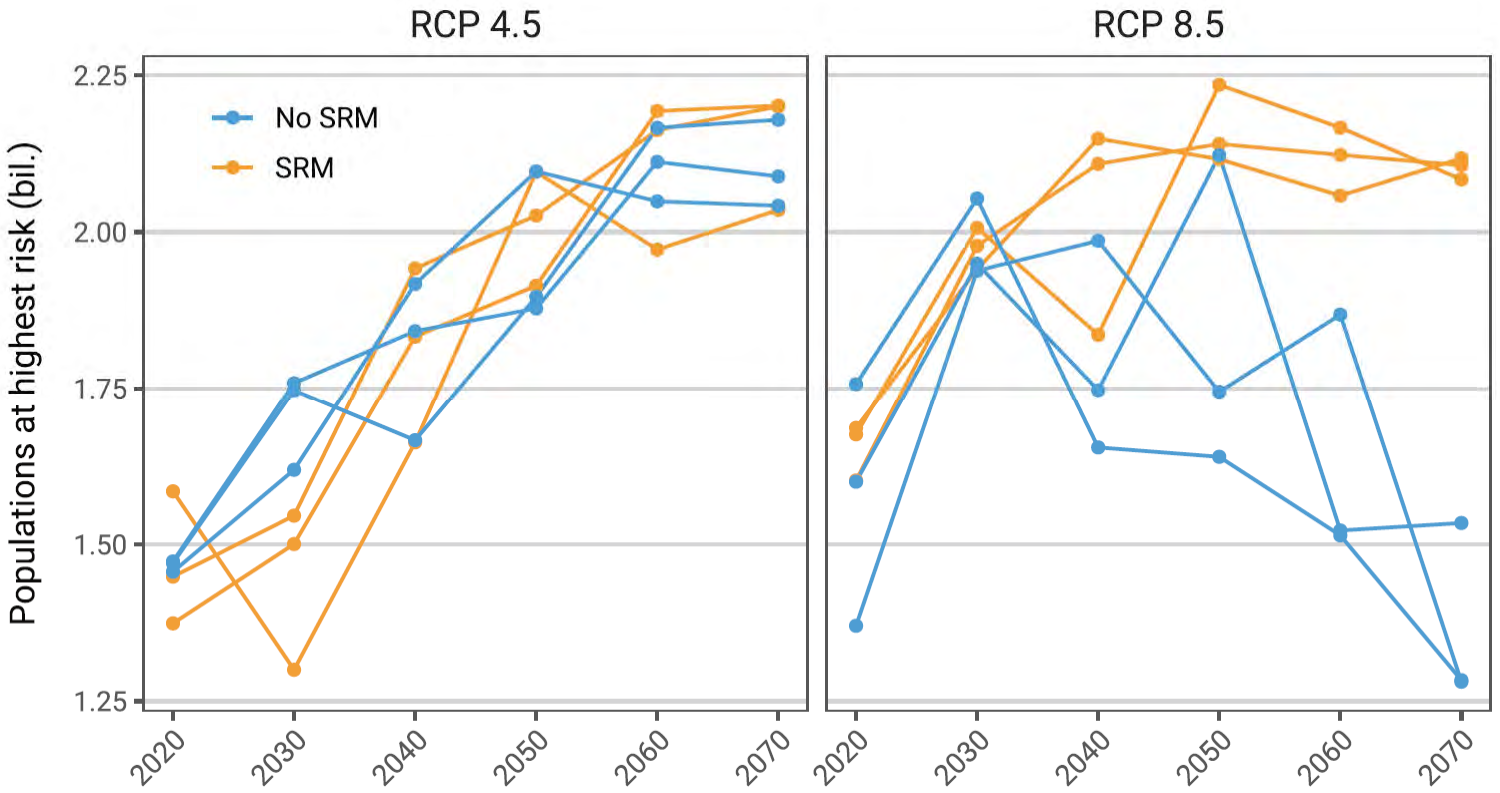
Consequences

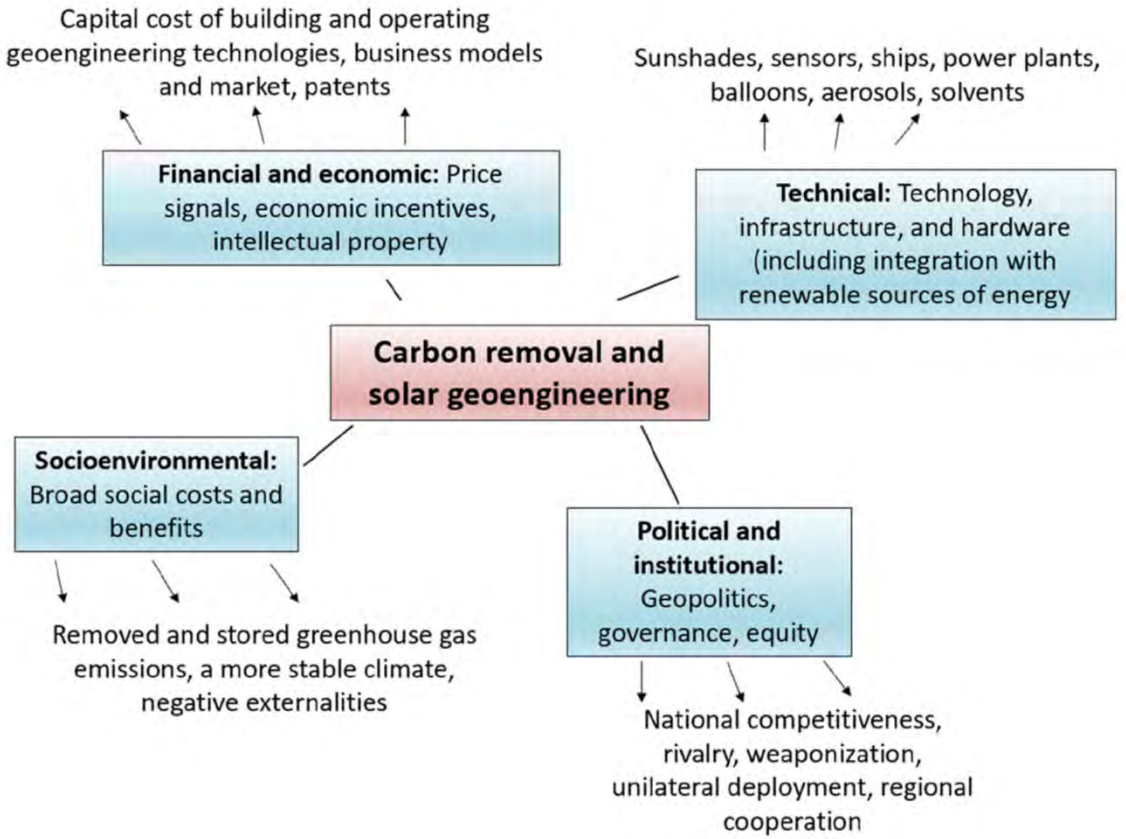
Malaria: Global Trends with Decreases and Increases



Carlson, C. J., R. Colwell, M. S. Hossain, M. M. Rahman, A. Robock, S. J. Ryan, M. S. Alam, and C. H. Trisos. 2022. Solar geoengineering could redistribute malaria risk in developing countries. Nature communications **13:2150.**

Consequences

Sociotechnical co-impacts of carbon removal and solar geoengineering.

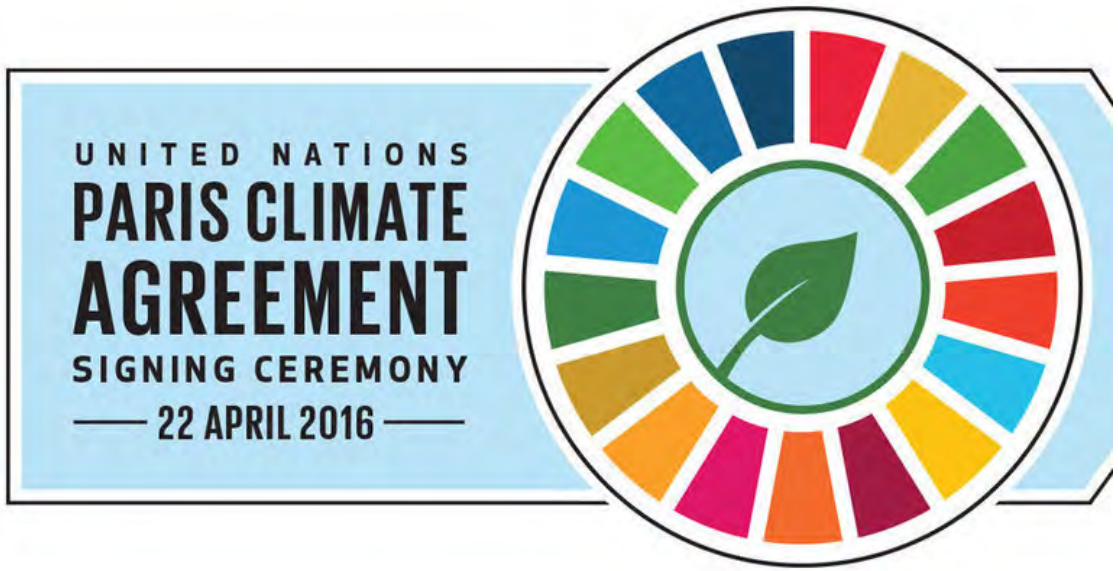


Sovacool, B. K., C. M. Baum, and S. Low. 2023. Beyond climate stabilization: Exploring the perceived sociotechnical co-impacts of carbon removal and solar geoengineering. Ecological Economics **204:107648.**

Governance

Catch 22 involving need for coordinated international program and call to start federally funded US research.

Stephens, J. C., P. Kashwan, D. McLaren, and K. Surprise. 2023. The Dangers of Mainstreaming Solar Geoengineering: A critique of the National Academies Report. Environmental Politics **32:157-166.**



- What is fair?
- A foundation for a predictable policy/economic future

  - Climate justice at home
  - Climate justice around the world