C2G
Carnegie Climate Governance Initiative

An initiative of CARNEGIE COUNCIL for Ethics in International Affairs

POLICY BRIEF

Stratospheric Aerosol Injection and its Governance

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Following the Paris Agreement on climate change, recognition is growing that without a rapid acceleration in action, limiting global average temperature rise to 1.5 – 2 degrees Celsius (°C) above pre-industrial temperatures will not be achieved through emissions reductions or existing carbon removal practices alone.

Some are considering various approaches to altering the climate including Solar Radiation Modification (SRM). This briefing focuses on one of these theorised techniques – Stratospheric Aerosol Injection (SAI). SAI would increase the amount of reflective aerosol particles in the lower stratosphere, thereby increasing the amount of sunlight that is deflected back out into space and reducing the global temperature.

SAI could never be a substitute for reducing emissions or removing carbon dioxide (CO_2) from the atmosphere. The Intergovernmental Panel on Climate Change (IPCC) notes 'SRM could potentially be used to supplement mitigation in overshoot scenarios to keep the global mean temperature below 1.5°C and temporarily reduce the severity of near-term impacts'. At best, SAI may 'buy time' while those essential measures are accelerated. SAI is currently theoretical; however, observations of natural phenomena and modelling research suggest that it could be an effective approach to cooling the Earth's climate, potentially within one-year. SAI could also create large and potentially long-term risks and it presents important governance challenges.

The nature of SAI

Evidence of the effects of stratospheric aerosols on the climate is available from measurements of climate responses to volcanic eruptions. SAI would build on this knowledge, deploying aerosols in the stratosphere, probably with specialised aircraft.

The theoretical relative ease of implementation, combined with the potential radiative efficiency of aerosols, suggests the direct financial costs of SAI deployment might be low relative to other measures to curb warming at equivalent scales. Some research has suggested it may be possible for SAI to balance the anticipated anthropogenic warming over the next 50 years at a cost of $8 billion per year and costs per unit of radiative forcing (Wm^{-2}) are estimated to be between $17.5 and $100 billion - other hidden costs of policy and governance processes, would be additional to these estimates.

SAI potentially has both strengths and weaknesses as a measure to address climate change and many potential risks are associated with its deployment (see table 1). A more detailed analysis is available in the Carnegie Climate Governance Initiative's (C2G) SAI Evidence Brief.

The need for governance

The international community is insufficiently informed about the risks, costs and potential benefits, or governance challenges of the technique. Theoretically SAI may be the only technique for quickly stopping global temperature rise, meaning SAI could potentially reduce the harms of climate change whilst the global economy is decarbonised. However, SAI might affect a diverse range of physical systems including regional hydrological cycles, stratospheric ozone and plant growth. It may also pose profound cultural and philosophical questions, challenging deeply held values. The potential geopolitical and security implications, for example in relation to the implications of different deployment and cessation scenarios, are not well understood, nor are there any governance frameworks in place to effectively explore these issues and address concerns, which in itself is a risk.

Table 1 – Potential strengths, weaknesses and risks of SAI

STRENGTHS	WEAKNESSES	RISKS
High potential for effective planetary cooling.	Although research suggests delivery is technically feasible, the detail of the delivery mechanisms is unresolved.	Debate about and research on SAI may further delay or diminish efforts to reduce greenhouse gas emissions.
The financial costs of deployment compared to other climate-altering techniques are likely to be very low.	Currently there is no clarity about governance.	Which particles to use is not resolved. Some proposed SAI particles may reduce atmospheric ozone, others may enhance it. Some candidate aerosols may cause harm as they drop out of the stratosphere.
Studies of volcanic eruptions and climate models provide some insights into the likely effects of a SAI project.	It is not yet clear how the climate might respond to the large-scale forcing of SAI. For example, there is a potential for changes in precipitation patterns.	A potential for geo-political tensions arising from R&D and planned or actual deployments by a state or group of states.
No restructuring of global infrastructures or energy supply systems would be required.	Research funding for SAI has been limited and fragmented.	Climate termination shock, giving rise to a rapid increase in temperatures, may arise if there were an abrupt termination.
Cooling effects of a deployment may be evenly distributed globally.	Secondary effects are uncertain, for example, on plant growth rates.	Climate risks for some regions could be increased by changes in weather systems.
A deployment could rapidly cool the climate in a controlled way – i.e., it may be possible to cool the global climate within 1-year.	Limited numbers of people and institutions have knowledge about SAI, and it is often framed as socially unacceptable.	Ocean acidification would continue unabated (unless it were addressed by other means).

How SAI might be integrated alongside other climate policies and the Sustainable Development Goals is uncertain. It might, for example, have implications for at least seven of the Goals, and would decouple the links between CO_2 concentrations and global-mean temperature, and temperature and climate change risks. This creates concerns that discussing SAI could weaken the resolve to address both development needs and the need to cut emissions, creating important governance agenda for both climate and development governance.

An immediate challenge is the governance of research, with small-scale outdoor experiments of some methods in development. Research governance could include codes of conduct or independent monitoring and safeguards to ensure research does not change the global climate without appropriate governance and permissions in place, nor lead us down a slippery slope towards deployment.

In the longer term, due to the potential transboundary and global impacts of SAI, international governance may become essential. Fora and processes which could contribute include, for example, the United Nations (UN) General Assembly, the UN Security Council, the UN Environment Assembly, the UN Framework Convention on Climate Change, the Convention on Biological Diversity and the Vienna Convention. Further, regional bodies, governments, civil society organisations, researchers and others might usefully participate in discussions about SAI governance. The extent to which existing measures

are suitable, or already provide some coverage for SAI is uncertain and contested.

The Technique	Technique's Readiness	Governance Challenges
 Injecting reflective aerosol into the stratosphere to increase planetary albedo and thereby reduce temperatures.	Largely theoretical understandings of the technique are available. Small scale experiments to advance understanding of stratospheric aerosols relevant to the technique are planned for 2021. Mechanisms for particle delivery are not yet resolved. It would be challenging to attribute any effects of SAI directly to a deployment.	Raising awareness and access to information and knowledge for stakeholders. Agreeing safeguards and policy direction for research and resolving who decides whether, when, and under what conditions to undertake research. The monitoring and attribution of climate impacts. Resolving which existing governance instruments may apply, be amended, or whether a new mechanism or treaty might be appropriate. Evidence suggests deployment, or deployment plans may strain international relations, institutions and cooperation - mediating geopolitical tensions. Potential for moral hazard and other forms of mitigation deterrence. Assessing and managing any impacts on the Sustainable Development Goals. Agreeing a globally acceptable degree of cooling. Ensuring protection against premature termination. Issues around liability in case of harm and loss.

More detailed information about approaches to altering the climate and their governance is available at C2G's website.

This briefing is based on the latest literature. Please notify contact@c2g2.net of any suggested corrections.
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