

Communication

# Governing Climate Engineering: A Proposal for Immediate Governance of Solar Radiation Management

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Received: 31 May 2019; Accepted: 18 July 2019; Published: 20 July 2019



**Abstract:** Solar radiation management (SRM) technologies would reflect a small amount of incoming solar radiation back into space before the radiation can warm the planet. Although SRM may emerge as a useful component of a global response to climate change, there is also good reason for caution. In June 2017, the Academic Working Group on Climate Engineering Governance released a policy report, “Governing Solar Radiation Management”, which developed a set of objectives to govern SRM in the near-term future: (1) keep mitigation and adaptation first; (2) thoroughly and transparently evaluate risks, burdens, and benefits; (3) enable responsible knowledge creation; and (4) ensure robust governance before any consideration of deployment. To advance the governance objectives identified above, the working group developed twelve recommendations, grouped into three clusters: (1) create politically legitimate deliberative bodies; (2) leverage existing institutions; and (3) make research transparent and accountable. This communication discusses the rationale behind each cluster and elaborates on a subset of the recommendations from each cluster.

**Keywords:** Solar geoengineering; global governance; solar radiation management; climate change

## 1. Introduction

Solar radiation management (SRM) is an umbrella term for a set of proposed technological responses to climate change. SRM technologies would reflect a small amount of incoming solar radiation back into space before the radiation can warm the planet. Leading proposals include introducing reflective particles into the stratosphere (stratospheric aerosol injection or “SAI”) and artificially whitening clouds (marine cloud brightening or “MCB”). Other potential ways to increase planetary albedo range from brightening natural or human-made features at ground level all the way up to introducing mirrors into Earth’s orbit.

SRM has been described as “fast, cheap, and imperfect” [1]. Some computer-based modeling and studies of natural analogues (most notably volcanic eruptions) have suggested that planetary-scale SAI, in particular, could generate rapid and, depending on the magnitude of an intervention, dramatic cooling [2]. This suggests that SRM could be a “fast” response to climate change compared to mitigation. SRM could also be relatively inexpensive, at least in terms of the direct costs associated with the physical act of altering planetary albedo. One study estimated the direct cost of a global SAI scheme at around \$2.5 billion per year for the first 15 years [3], although other studies have estimated costs in the range of \$10–20 billion per year [4] (cost estimates vary depending on assumptions of deployment technique and for given degrees of cooling). This is “cheap” when compared to the costs associated with mitigation, or when compared to the projected costs, including welfare costs, of unchecked atmospheric warming. Note, though, that the “cheapness” of SRM is called into question when the need for monitoring, governing, and insuring against the potential failings of an SRM scheme are taken into account. Finally, SRM is “imperfect.” If deployed, it would not return the planet to some predictable former state. Nor is it a substitute for aggressive greenhouse gas reductions. There are also risks attached to SRM, some that cut across the entire enterprise and some that are dependent on type and scale of use, as discussed below.

Thus, although SRM may emerge as a useful component of a global response to climate change, there is also good reason for caution. A range of questions pertaining to the governance or governability of SRM have been advanced. There are questions about whether SRM should be developed at all, or whether prompting too open a consideration of SRM distracts from mitigation and adaptation. If research moves forward, how ought it to be overseen or opened to societal consideration? What can be done to steer SRM developments towards the climate risks that face the most vulnerable? How can SRM be effectively and fairly managed at all stages from research to potential deployment?

In fall 2018, the Academic Working Group on Climate Engineering Governance (the working group) released a policy report, “Governing Solar Radiation Management”, which considered these questions and made recommendations for near-term SRM governance [5]. The working group consisted of fourteen scholars with a variety of interests and disciplinary expertise in global environmental governance. The working group met for five deliberative workshops between March 2016 and February 2018. The chief findings of the working group’s report are detailed below. All recommendations presented in this article are derived from the working group report.

## 2. Background on the Process

The working group faced significant challenges. The group was tasked with distilling consensus governance recommendations in an area outside their immediate empirical expertise. That is, although working group members are all established experts in various aspects of global environmental governance, they were selected precisely because they were new to the empirical area of climate engineering. The members of the group also, through their respective bodies of work, could be seen to represent a diverse set of perspectives concerning the nature of and prospects for meaningful governance of something like SRM. The Forum for Climate Engineering Assessment (FCEA), which assembled the working group, made the decision to convene such a diverse group in order to address concerns that discussions surrounding climate engineering were too insular (see, for example, [6]). The members of the group had to quickly become experts in the existing SRM governance literature and policy

conversation, so that they could bring their established expertise to the topic (for peer reviewed publications by working group members on SRM governance, produced during the life of the project, see [7–16]).

Throughout the process, the group was divided—sometimes sharply—on the ultimate wisdom of deploying SRM technologies. This reflected the choice to convene a group with diverse perspectives, leading to a very different report and set of recommendations than would have been produced had the group consisted solely of ardent supporters or vehement critics of SRM technologies.

Due to its divided nature, the group decided to leave unanswered the basic question of whether SRM technologies are desirable. Instead, the group’s deliberations started from a shared acknowledgement that SRM research is moving forward, if slowly, and that the largely ungoverned status quo is unsatisfactory. The group bounded its deliberations by focusing on governance of plausible near-term (meaning out to 2025) SRM research pathways rather than on speculative far-term deployment scenarios. As a result, its recommendations focused on what might realistically be done to govern SRM technologies within the current international system.

This establishment of a shared starting point setting aside the desirability of SRM and a bounding of deliberations to focus on governance of near-term research pathways already in motion set the working group’s efforts apart from prior group processes looking at SRM governance. In addition, a briefing paper summarizing prior examinations of SRM governance was prepared for the working group’s second meeting [17]. That report made clear that earlier work on SRM governance had tended to elaborate high-level principles but did not, by and large, set out specific, actionable recommendations. The working group deliberations and report aimed to fill this gap.

### 3. Governance Objectives

Governing the development (or not) of SRM means navigating between sometimes competing potential benefits and risks. When it comes to near-term SRM research, the working group recognized that there are risks associated with allowing research, but there are also risks associated with not allowing research. The working group also identified a range of risks associated with deploying or not deploying SRM and with governing SRM (see Box 1 below).

#### Box 1. Risk–Risk Tradeoffs in SRM Research and Deployment.

Decisions about how or whether to research, deploy, and govern SRM face a series of risk–risk tradeoffs. The working group’s report summarizes the literature on these risks [5] (pp. 4–5).

Some commentators worry that researching SRM creates risks of: a “moral hazard” effect, in which SRM research distracts from mitigation efforts; technological “lock-in” that prematurely focuses research on particular SRM technologies or inappropriately accelerates a drive toward deployment; capture by special interests; and the facilitation of rogue deployment. Others worry that not researching SRM would leave societies without adequate information about SRM and without the ability to deploy SRM quickly or responsibly if that were deemed appropriate.

Commentators have flagged a wide range of potential risks from deployment. These include undesirable environmental impacts and the inequitable distribution of burdens and benefits, as well as risks of geopolitical conflict and technological lock-in. In some circumstances, deployment could create a risk of “termination shock,” in which an abrupt cessation of SRM leads to rapid warming. These risks would need to be weighed against the grave environmental, social, ethical, and geopolitical risks arising from climate change.

Different governance arrangements could create additional risks. Poorly designed or implemented governance mechanisms could channel SRM research in inappropriate directions or make it harder to integrate discussions of SRM into the broader climate policy debate. Since governance could either facilitate or restrain research, governance mechanisms must navigate between inappropriately shackling research and exacerbating the risks of research. Finally, some ways of designing governance could impose undue costs on or exclude those most vulnerable to climate change and the impacts of SRM.

The efforts of the working group were, from inception, meant to be pragmatic and policy-focused. The ultimate goal was to “bridge the gap between the existing academic literature on the governance of SRM and the need for actionable, authoritative advice for governing SRM in the near term,

in particular” [5] (p. 10). With this goal in mind, the deliberations of the working group settled on a set of governance objectives to guide their jointly-authored report. That is, the group asked and answered the questions, “What near term steps should be taken toward the governance of [SRM]? What objectives should those actions serve?” [5] (p. 1).

The working group identified four high-level objectives for SRM governance. In focusing on research governance, anticipatory governance, and building governance capacity for a nascent sociotechnical system, the objectives reflect the fact that SRM is an emerging technology, which presents special opportunities and challenges for governance.

Rather than prioritizing any of these objectives over the others, the working group sees the four objectives as a package that can jointly guide policymakers in developing “effective, participatory, accountable, and transparent multilevel institutions and norms” for governing SRM wisely (p. 17). Most of the working group’s specific recommendations for SRM governance map onto at least two of these objectives, creating a many-to-many mapping between objectives and specific recommendations (p. 29).

### 3.1. Objective I—Keep Mitigation and Adaptation First

Governance must ensure that if SRM is ever considered, it remains subsidiary to mitigation and adaptation measures. There are three main motivations for doing so. The first is that SRM, if deployed, could not exactly restore a preindustrial climate. Regional climatic differences would persist between Earth as it was before the industrial revolution and an Earth that is heated by greenhouse gases and cooled by SRM. Second, SRM would not directly address ocean acidification, which would intensify if carbon dioxide levels continued to rise. Third, because carbon dioxide lingers in the atmosphere for thousands of years, SRM would need to be maintained continuously for an extremely long time in the absence of mitigation, which presents serious institutional challenges. Keeping SRM subsidiary to mitigation and adaptation amounts to avoiding the “moral hazard” of using SRM as an excuse to avoid mitigation and adaptation. This makes this first objective hard to secure through institutional arrangements, as opposed to political decisions. Thus, while it appears only indirectly in the working group’s specific recommendations, it must remain a central goal of SRM governance.

### 3.2. Objective II—Thoroughly and Transparently Evaluate Risks, Burdens, and Benefits

Developing the capacity for broad-based assessment of potential risks, burdens, and benefits of SRM will be necessary to ensure that society can anticipate, understand, reduce, and manage associated risks, which will vary depending on the circumstances of deployment. Importantly, “broad-based” assessment entails an inclusive and transparent approach that allows for meaningful input from diverse voices, including those who are most vulnerable to climate change or any potential risks from SRM research or deployment. This objective is reflected in most of the working group’s specific recommendations, including recommendations to develop best practices for risk assessments, as well as recommendations to establish inclusive deliberative institutions, institutions to ensure transparency and inclusivity in SRM research, and mechanisms to anticipate future risks, burdens, and benefits.

### 3.3. Objective III—Enable Responsible Knowledge Creation

Governance should ensure that any SRM-related research is responsive to societal needs and concerns to the greatest extent possible. This serves two purposes. First, governance arrangements can facilitate research that is transparent, accountable, and socially appropriate, as well ensure that this research can anticipate and is responsive to societal needs and concerns. Second, these arrangements can help to prevent undesirable or irresponsible research pathways and outcomes. This objective is also reflected in most of the working group’s specific recommendations, ranging from recommendations that build transparency and inclusivity into SRM research to recommendations for establishing a code of conduct for SRM researchers. Creating new deliberative bodies and leveraging existing institutions can also promote responsible research.

### 3.4. Objective IV—Ensure Robust Governance Before any Consideration of Deployment

Robust governance institutions should be in place before anyone gives serious consideration to deploying SRM. Achieving that objective in a reasonable amount of time requires taking steps in the near term to establish effective institutions and norms to govern decisions about potential deployment. This near-term work will focus on governance of research, as well as how SRM is deliberated, laying the groundwork for how decisions about potential deployment will be governed down the road. At the same time, any arrangements must remain flexible enough to evolve alongside SRM research and changing societal needs, and there must be a good fit between institutions' mandates and capacity and the demands of evolving SRM governance. This objective is primarily reflected in the working group's recommendations for increasing coordination between institutions, establishing new deliberative bodies, and strengthening existing institutions' respective capacities to govern various aspects of SRM and SRM research.

## 4. Recommendations: Concrete Near-Term Governance Steps

To advance the governance objectives identified above, the working group developed twelve recommendations, grouped into three clusters (Table 1). The recommendations focus on the near term, for two primary reasons. First, SRM technologies are largely conceptual. While there has been computer modelling and examination of natural analogues (e.g., volcanic eruptions), there has so far been only modest interest in outdoor experimentation relating to any SRM scheme that might ultimately have large climatic impacts. Any governance moves at this point would largely be anticipatory, looking to get out in front of an emerging technology that might one day become real. The context in which SRM is evolving is always in flux, making the issuing of firm longer-term recommendations about governance arrangements somewhat premature. Second, if research were to accelerate, there would be benefits in having some clear near-term signposts and rules of the road. Table 1 below briefly summarizes all twelve recommendations.

**Table 1.** Academic Working Group Recommendations.

	Recommendation	Who Should Take Action?	Explanation
<i>Cluster #1: Create Politically Legitimate Deliberative Bodies</i>			
1	Establish a World Commission on SRM	United Nations General Assembly	A high-level representative commission should catalyze dialogue and deliberation around important questions related to SRM research, such as whether a moratorium on deployment is needed, whether SRM research is desirable, and how to ensure that this research is conducted in the public interest.
2	Establish a Global Forum for Stakeholder Dialogue	The World Commission on SRM	A global forum for stakeholder dialogue should be responsible for facilitating a process through which stakeholders who are impacted by SRM governance decisions engage in dialogue on questions related to SRM governance. Careful effort is needed to meaningfully include stakeholders who would otherwise be marginalized in order to ensure that SRM governance processes are responsive to a diversity of voices and perspectives.

Table 1. Cont.

Recommendation	Who Should Take Action?	Explanation	
<i>Cluster #2: Leverage Existing Institutions</i>			
3	Strengthen cooperation between international organizations	Secretariats of relevant international organizations, heads of government research offices, UN Chief Executives Board for Coordination	Mechanisms that facilitate coordination and learning across international organizations should be developed to clarify which organizations currently have capacity to govern SRM research and also to ensure that relevant international organizations are included in governance.
4	Assess and improve capacities for regional coordination and conflict resolution	Regional intergovernmental, scientific, nongovernmental organizations	Regional coordination is needed to better understand how SRM research may have potential positive and negative transboundary impacts, and how any negative impacts can be addressed within other regional environmental governance processes.
5	Continue ongoing assessment role for the Intergovernmental Panel on Climate Change and related processes	Intergovernmental Panel on Climate Change, national governments, relevant technical bodies and participatory processes	Established assessment mechanisms should account for the developing body of transdisciplinary knowledge on SRM to ensure that decisions related to SRM research and deployment are conducted within the context of climate science, and to ensure that mitigation and adaptation remain priorities.
6	Develop foresight capabilities	The United Nations and national governments	SRM governance must be able to anticipate and adapt to developments in technology, climate, and politics.
<i>Cluster #3: Make Research Transparent and Accountable</i>			
7	Report on SRM research and development activities in the Paris Agreement's global stocktake	National governments and the United Nations Framework Convention on Climate Change	For the purpose of increasing transparency of SRM research and development efforts, national and global SRM research efforts should be included in the global stocktake process of the Paris Agreement. Importantly, such reporting under the stocktake does not suggest endorsement of the development or deployment of SRM. Nor does it imply an endorsement of including SRM in meeting the objectives of the Paris Agreement, particularly mitigation.
8	Institutionalize codes of conduct for responsible SRM research	SRM researchers, governance experts, national governments, secretariats of international organizations	The scientific community within nations conducting SRM research should adopt a code of conduct that clarifies what constitutes responsible research on SRM, and funders should require that researchers agree to comply with such a code in order to access funds.
9	Ensure that ongoing research includes international and interdisciplinary collaboration	State and private SRM research funders	Funding should be prioritized for SRM research projects that entail significant partnerships across states and disciplines to ensure that SRM research is not siloed within particular states or disciplines.
10	Clarify funding streams	Public and private funders and SRM researchers	All sources and recipients of SRM research funding should be made public record to promote transparency and responsible research.
11	Develop a publicly accessible clearinghouse	SRM researchers, funders, Nongovernmental organizations, national governments	National clearinghouses should compile information on all SRM research conducted domestically, and should feed in to an international clearinghouse. These clearinghouses should help to identify and coordinate priorities for SRM research.
12	Develop best practices for risk and impact assessments	National governments, experts of risk assessment and Environmental Impact Assessment (EIA), and SRM researchers	Procedures and processes for risk assessment and environmental impact assessment should develop the ability to provide precautionary assessments of potential negative impacts on social and environmental systems from SRM research. Such processes should include opportunities for public consultation.

Although a detailed discussion of all twelve recommendations is beyond the scope of this paper, this section discusses the rationale behind each cluster and elaborates on 1–2 recommendations from each cluster.

The first cluster, creating politically legitimate deliberative bodies, is an essential aspect of developing legitimate processes and arrangements in the near term that enables the high-level international coordination and guidance that SRM demands while providing institutional mechanisms for facilitating meaningful stakeholder engagement. To date, most policy recommendations in this space, including the report summarized here, have come from scientists and other academic experts. The working group recommends creating institutions to enable more broad-based, participatory discussions of SRM as a potential response to climate change.

To this end, the working group recommends that the United Nations (UN) General Assembly should appoint a world commission on SRM with members appointed by the UN Secretary-General based on various diversity criteria. This commission should have the mandate to debate “first-order questions about whether and to what end SRM should be researched and developed, and how it fits within a broader climate response landscape” [5] (p. 30). In the near term, important questions to be discussed by the commission include whether to impose a moratorium on certain forms of SRM research or deployment, and how to develop an intellectual property regime that ensures technological innovation is conducted in the public interest. Such a high-level representative commission will enhance the political legitimacy of SRM research and garner the resources and attention needed to undertake various forms of broad-based engagement. Building on suggestions by Edward Parson [18], the working group identifies design elements for the commission, such as high-level authorization and sufficient staff and resources. The working group refrains from endorsing any specific design because this will be developed through international negotiations.

Central to the world commission’s mandate would be to develop a global forum for stakeholder dialogue to engage a wide variety of stakeholders in “cross-border and cross-scale discussions on SRM and its governance” [5] (p. 32). The forum should identify relevant stakeholders, especially those which might be otherwise marginalized from global governance, such as: local communities, peasant organizations, indigenous peoples, youth organizations, women’s groups, labor unions, and others. The forum’s mandate should include, *inter alia*, engaging stakeholders in SRM research; facilitating debate over SRM governance; and collecting policy preferences from stakeholders and their communities. To this end, the forum should be connected to national and sub-national bodies. Importantly, the working group argues that the purpose of such a forum should not be to arrive at consensus, but to initiate a “learning-oriented dialogue.” Moreover, to make stakeholder engagement meaningful, contentious concerns must not be merely dismissed, but instead all concerns must be addressed and responded to [7]. Finally, although it should be constituted by the world commission, the forum should be independent and empowered to set the agenda of and advise the commission.

The second cluster of recommendations, to leverage existing institutions, is necessary to fulfill the short-term governance objectives developed by the working group. Given their reticence to discuss SRM, it is unlikely that states will create a new institution to govern SRM. Although a new institution for SRM governance may be desirable in the longer-term, existing institutions have the capacity and interest to govern various near-term elements of SRM [15]. These institutions can begin building the foundation for future governance and can achieve short-term governance goals, such as increasing transparency around SRM research.

To this end, cooperation between international organizations must be strengthened, a task that should be pursued jointly by secretariats of relevant international organizations, national heads of government research offices, and the UN Chief Executives Board for Coordination. Increasing coordination between international organizations working in the fields of sustainable development, agriculture, education, human health, and more, helps to ensure that governance: is inclusive of institutional stakeholders, avoids duplication of effort, utilizes resources and expertise efficiently, and helps to identify existing governance capacities and gaps.

The working group also recommends an ongoing role for the Intergovernmental Panel on Climate Change and other relevant bodies in assessing the state of SRM research. Assessing SRM research within the established processes helps ensure that SRM is not discussed in a vacuum, but rather

it is contextualized within current knowledge on climate change and mitigation and adaptation efforts. Furthermore, these assessments should incorporate literature that is critical of SRM and be multidisciplinary, including governance-related research and inquiries in ethics and justice.

The third cluster of recommendations, making research transparent and accountable, is necessary to ensure that SRM research is legitimate and that it is conducted in the public interest, with public participation and steering of research as appropriate.

To this end, the working group recommends that states be encouraged to report on SRM research and development activities under the global stocktake, the primary transparency-enhancing mechanism of the Paris Agreement. The stocktake is intended to assess collective progress towards the goals of the agreement and to inform the pledging of Nationally Determined Contributions (NDCs). Though the stocktake is still being designed, if it receives a broad mandate to assess technologies that may impact the goals of the agreement, the working group recommends that the stocktake include a comprehensive account of SRM research efforts.

Finally, the working group recommends the development of a publicly accessible clearinghouse of all publicly funded and, to the greatest extent possible, privately funded SRM research. Such a clearinghouse would support public engagement in SRM research and help coordinate research priorities. The working group notes that although some actors may refuse to voluntarily contribute information, states should require these actors to participate with reasonable restrictions on the information that needs to be disclosed. The working group recommends a curated clearinghouse model that allows data to be contextualized to assist public understanding and use of the data, as opposed to a research database of individual studies [19].

## 5. Conclusions

The working group argues that SRM governance should begin now. Some members see SRM development as desirable; some as potentially dangerous. Whatever the perspective, governance will be required to prompt the careful deliberation and oversight needed to make decisions about SRM in the societal interest. The working group's recommendations establish essential rules and institutional arrangements for near-term understanding and guidance of SRM research, they also begin building the scaffolding for effective long-term governance.

**Author Contributions:** S.J., S.N., D.M. and Z.D. took the lead in drafting and editing this paper. All co-authors who were also members of and/or advisors to the Academic Working Group on Climate Engineering Governance contributed equally to the intellectual grist upon which the paper is based.

**Funding:** Jinnah's work on this paper was made possible, in part, by a Fellowship from the Andrew Carnegie Corporation. All statements made and views expressed are the sole responsibility of the authors.

**Acknowledgments:** We are deeply grateful to the support staff at the Forum for Climate Engineering Assessment, especially Michael Thompson and Carolyn Turkaly, for their intellectual guidance and administrative support.

**Conflicts of Interest:** The authors declare no conflict of interest.

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