Union of Concerned Scientists

ISSUE BRIEF

Strengthening Public Input on Solar Geoengineering Research

What's Needed for Decisionmaking on Atmospheric Experiments

HIGHLIGHTS

Limiting the risks of severe climate change requires swift and deep reductions in emissions of heat-trapping gases, safe and sustainable removal of carbon dioxide from the atmosphere, and accelerated investments to prepare for unavoidable impacts. It is possible, however, that these essential measures may not be enough to avoid substantial climate disruption. Should societies also assess the potential and risks of using solar geoengineering (SG) technologies to rapidly cool Earth? SG presents profound environmental, ethical, and geopolitical risks and uncertainties. With some researchers now designing atmospheric experiments to assess SG's efficacy and risks, the question of whether and how such research should proceed deserves timely public scrutiny and debate. Researchers and research funders must build inclusive public participation into decisionmaking concerning SG research.

To limit the risks of severe climate change, we need swift and deep reductions in emissions of carbon dioxide (CO_2) and other heat-trapping gases. We also need to remove CO_2 from the atmosphere safely and sustainably. However, even very aggressive measures to do both may not be enough to avoid substantial climate disruption (IPCC 2018). Increasingly, researchers and policy experts are wrestling with the vexing question of whether and how societies should also assess the potential and risks of proposed solar geoengineering (SG) approaches to reflect sunlight and rapidly cool Earth.

It is important to note that SG would not address the primary cause of climate change: emissions of heat-trapping gases from burning fossil fuels. SG would not stem ocean acidification, the disruptive impacts of rising CO_2 levels on terrestrial ecosystems, or the myriad other negative effects of fossil fuel use. SG cannot be a substitute for reducing emissions.

The prospect of SG presents profound environmental, ethical, and geopolitical risks. However, in light of the serious prospect that emissions reductions, CO_2 removal, and adaptation may be insufficient to constrain climate disruption, the Union of Concerned Scientists (UCS) believes that research into developing a careful understanding of the potential and risks of SG merits sober societal consideration (UCS 2019).

Some researchers are now proposing atmospheric experiments to assess SG's efficacy and risks. The questions of whether and how such research should proceed deserve significant public scrutiny and debate. However, to date, SG has received little public attention.

Eric Workman/Museum of Science Boston

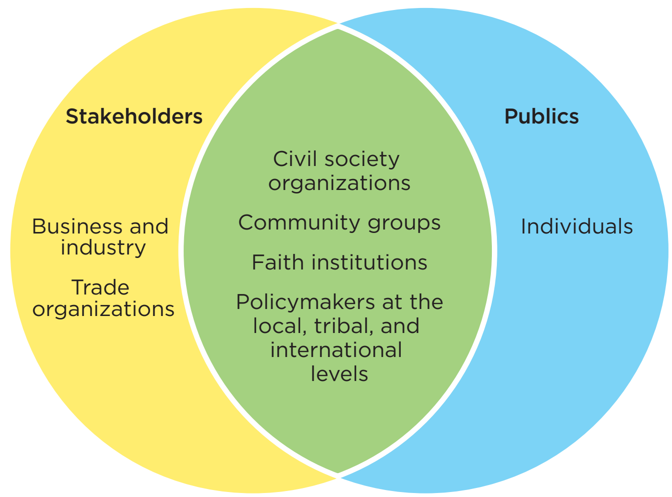
A rare example of public engagement on solar geoengineering: members of the public discuss and debate various issues related to solar geoengineering research and governance at a workshop in Boston in September 2018 as part of a Arizona State University research project.

Definitions

Public and stakeholder engagement is an important yet confusing phrase and can mean different things to different people. In decisionmaking concerning SG, who might the public or stakeholders be? The public is not a monolith. Rather, there are multiple publics consisting of individuals and their communities. Regarding SG, a stakeholder can be thought of as a public- or private-sector group's representative that speaks on the group's behalf. Publics and stakeholders overlap, as shown in Figure 1, but key groups do not fall in this overlap. Private-sector groups—business, industry, and trade associations—are stakeholders in decisionmaking concerning SG, but they represent corporate and shareholder interests rather than the public interest. In contrast, a civil society organization that advocates for the societal good seeks to represent the individuals and communities on whose behalf it is working.

Engagement describes a set of approaches by which researchers, funders, and governance bodies can aim to inform, understand, and draw input from publics and stakeholders. How engagement should be designed will vary across different stages and types, or domains, of SG research. For example, an effective effort to engage stakeholder input on a proposed atmospheric experiment will differ greatly from an effective effort to build civil society discourse about SG research and its governance. The former will likely include a deliberative process to inform decisions on whether and how an experiment should go forward. The latter will engage a much broader group and have accessibility and scalability as goals.

FIGURE 1. The Relationship between Stakeholders and Publics for Solar Geoengineering Research



Stakeholders and publics can overlap. This figure shows examples of the stakeholders and publics that might be pertinent for SG research.

Note: This figure was developed using input from expert interviews and the United Nations Environment Programmes' major groups and stakeholders (UNEP n.d.).

This issue brief draws attention to the need for inclusive public and stakeholder participation in decisionmaking concerning SG research and its implications. Drawing on public participation protocols developed for other domains as well as a series of dialogues with public engagement scholars and practitioners, UCS presents recommendations for how SG researchers and research funders can meaningfully engage the public and stakeholders in this decisionmaking (see box above).

What Would Solar Geoengineering Entail?

The two approaches SG researchers have begun to consider seriously are stratospheric aerosol injection (SAI) and marine cloud brightening (MCB) (NRC 2015). Shown in Figure 2, SAI would simulate the temporary global cooling effects of large volcanic eruptions by injecting sulfate or other aerosol particles into the stratosphere to reflect a portion of incoming solar radiation back to space. If deployed, SAI would have global impacts, reducing temperatures and affecting precipitation patterns across the planet. MCB would involve spraying sea salt into low-lying marine clouds to enhance their brightness and reflectivity, leading to regional-scale cooling.

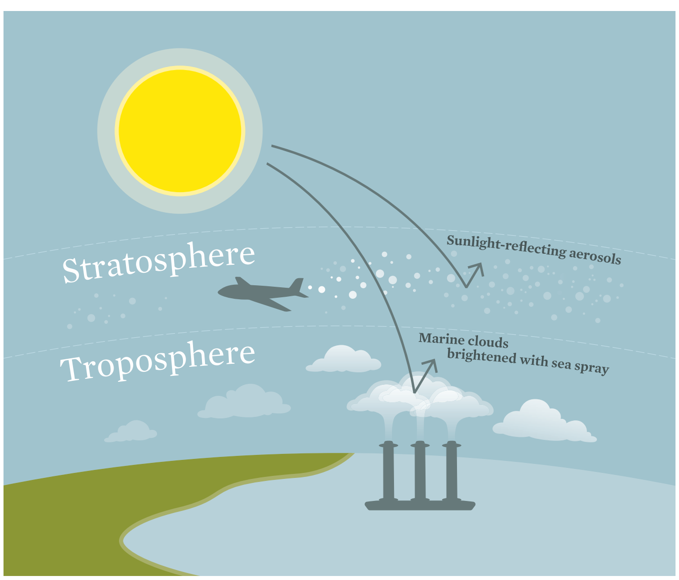
From modeling, basic physics, economics, and observations of volcanic eruptions, we know with high confidence that SAI at scale could rapidly cool Earth at a relatively low direct cost. But significant uncertainties remain, some of which would be difficult to reduce in advance of deployment. These uncertainties include the impacts on regional patterns of precipitation and associated

> ***We know with high confidence that SAI at scale could rapidly cool Earth at a relatively low direct cost. But significant risks and uncertainties remain.***

impacts on agriculture and ecosystems. And although SAI deployment's direct costs may be low, indirect costs, including establishing effective governance and monitoring as well as addressing liability concerns, may be high. As for MCB, further research into the physics of cloud-aerosol interactions would be needed to assess its potential feasibility, efficacy, and risks.

SG raises concerns about "moral hazard" risks of undercutting societies' motivation to reduce emissions; "slippery slope" risks that expanded research could inadvertently accelerate support for deployment; and "termination shock" risks of rapid, disruptive increase in global temperature if SAI were abruptly halted (McLaren 2016; Cairns 2014; Parson et al. 2017). Given that nations and communities across the world have diverse climate goals, interests, and vulnerabilities, SG also raises difficult questions about who gets to make decisions concerning technologies that would heterogeneously affect communities and ecosystems across the planet.

FIGURE 2. Stratospheric Aerosol Injection and Marine Cloud Brightening



A depiction of SAI using sulfates or other reflecting aerosols and MCB using a fine mist of salt water.

HOW MIGHT SG TECHNOLOGIES BE DEPLOYED?

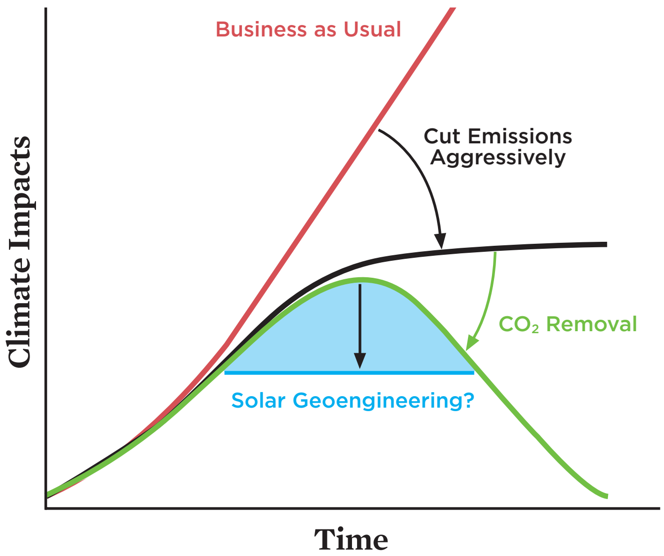
In theory, nations working together—committed to a primary focus on decarbonization and following robust norms of international governance—could use SG to limit climate warming, providing additional time for emissions to be drawn down (Buck et al. 2020). Under such a "peak shaving" or "overshoot" scenario, shown in Figure 3 (p. 4), SG technologies would need to be deployed for several decades or longer (MacMartin, Ricke, and Keith 2018). But other possible deployment scenarios must also be taken seriously. For example, one nation could deploy SG in support of its climate goals without obtaining international consent and governance—even if doing so puts other nations' security and interests at risk.

THE NEED FOR PUBLIC AND STAKEHOLDER PARTICIPATION IN DECISIONMAKING CONCERNING SG RESEARCH

There are sharp divisions within the community of climate researchers and policy experts over whether and how SG research should proceed. To date, questions about the future of SG research have been debated outside of public view with few pathways for publics to provide meaningful input. This is especially true for governments, researchers, and civil society in developing countries. Societal decisions about SG technologies, both their role and research on them, must be built on a more inclusive and deliberative platform. Because the consequences of decisions to deploy SG would have global-scale risks and implications, a core component of such a platform must be robust public and stakeholder engagement on a global scale. Social scientists have identified three core reasons why engaging publics and stakeholders in the SG research enterprise is imperative: *substantively*, public input can shape and inform the research design in ways that better inform societal decisions; *operationally*, public input may enhance the likelihood that society appropriately and responsibly considers SG approaches to limit climate disruption; and *normatively*, it is simply the right thing to do (Frumhoff and Stephens 2018).

Discussions of possible frameworks for the national or international governance of SG research and potential deployment are only just beginning in formal assessments and international forums (Chemnick 2019; NASEM 2018).

FIGURE 3. A Potential Relationship between Different Responses to Climate Change



Reducing emissions, combined with future large-scale CO_2 removal, might stabilize global climate after an overshoot of target temperatures, leading to a bounded period of greater climate impacts. This shows a qualitative, graphical representation of how climate change impacts might theoretically vary over time under business as usual, aggressive mitigation, large-scale CO_2 removal, and potential multidecade deployment of SG as a method for "peak shaving" of global temperature rise.

SOURCE: ADAPTED FROM MACMARTIN, RICKE, AND KEITH 2018.

Although research over the last decade has remained largely confined to computer modeling and observational studies of large volcanic eruptions (for SAI) and ship tracks (for MCB), proposed outdoor experiments deserve particular scrutiny of their potential risks, of the transparency and accountability of the institutions behind these experiments, and of the rules by which these experiments would be conducted.

Harvard University researchers are seeking to launch a small-scale SAI experiment, known as the Stratospheric Controlled Perturbation Experiment (SCoPEx) (KRG n.d.). In this proposed and privately funded experiment, a balloon would disperse a few kilograms of calcium carbonate particles into the stratosphere. Researchers would then monitor how the released particles behave. The experiment itself may pose negligible direct risk, but it has nonetheless received considerable attention and controversy as a potential precedent for more expansive experiments. In response to concerns expressed by UCS and others about the lack of independent review and public participation, Harvard established an independent advisory committee to determine whether and under what conditions, including appropriate public engagement, the experiment should proceed[1] (KRG n.d.).

In addition, outdoor MCB experiments have been proposed in the United States and for Australia's Great Barrier Reef, where multiple coral bleaching events from warming ocean waters pose a major threat to the reef and its globally valuable biodiversity (MCBP 2019; McDonald et al. 2019). Initial tests of the equipment to spray fine sea water mists have already taken place in Australia (McDill 2020). Public and stakeholder engagement has not yet taken place, and large-scale experiments intended to span hundreds of square kilometers are now being planned and partly funded by the Australian government (McDill 2020).

Proposed outdoor SG experiments can serve as tangible touchstones for larger societal discussions of whether and under what conditions SG should be considered. While small-scale experiments of limited duration may pose little direct environmental risk, they raise serious questions about the prospects, risks, and governance of larger-scale tests and potential deployment (Bellamy, Lazaun, and Palmer 2017). This is true for SAI, with its global impacts, as well as for MCB, as sustained regional-scale cooling could have impacts on atmospheric circulation and climate well beyond a targeted region.

UCS believes that small-scale outdoor experiments must meet certain criteria: there should be legitimate governance mechanisms in place; negligible environmental, social, and legal risks; and meaningful public and stakeholder engagement within and beyond the areas where experiments are proposed to take place (UCS 2019). Other prominent experts and organizations have issued similar calls for meaningful engagement (ASOC 2010; Chhetri et al. 2018; Gardiner and Fragnière 2018; Rayner et al. 2012).

In order to develop more specific recommendations for public engagement in SG research, UCS considered two major sources of information: the US Environmental Protection Agency (EPA) *Public Participation Guide* and interviews UCS conducted with experts and thought leaders in ethics, social science, SG outreach, and engagement (see the appendix for more information on the experts and the interview process) (EPA 2018). The remainder of this issue brief draws on these two sources and on the academic literature to discuss the essential role of engagement in SG research, suggest how approaches to engagement might vary across different research domains, and provide recommendations for engagement for small-scale outdoor experiments.

1 *One of this brief's authors, Dr. Shuchi Talati, is a member of this committee.*

A Closer Look at the Public Role in Decisionmaking Concerning Solar Geoengineering Research

Emerging technologies—such as genome editing, nanotechnology, and autonomous vehicles—can provide both innovative promise and immense risks and uncertainties (Stilgoe, Owen, and Macnaghten 2013). For emerging technologies that pose potential societal risks, researchers and those who fund research (e.g., governments, corporations, private foundations, and individuals) must incentivize and enforce rules and practices that prioritize their ethical and social responsibilities. Responsible research and innovation include creating high ethical standards, promoting equity across research domains, and ensuring meaningful public participation (EC 2018). Public participation in the consideration of emerging technologies is by no means a new phenomenon. Rather, it is an essential component that can legitimize (or delegitimize) research and bring new ideas to the fore (*Nature* 2018). The following two examples of scientific advancement conducted with and without public engagement highlight the need for ethically and societally informed experimentation and the consequences of proceeding without proper input.

Positive steps were taken toward early integration of public engagement in the field of nanotechnology. This emerging technology captures the imagination. It is "science, engineering, and technology conducted at the nanoscale" and can be applied to countless other research fields, including medicine, physics, and engineering (NNI n.d.). Nanotechnology holds the potential to drastically change many sectors—for example, it might help renewable energy become more efficient and create innovative paths for medicine. But with it comes large risks for human and environmental health (Bass 2008). In the early 2000s, Congress authorized the National Nanotechnology Initiative in the 21st Century Nanotechnology R&D Act. This legislation aimed to advance the field of nanotechnology and explicitly called for regular public engagement. This call eventually resulted in the National Citizens' Technology Forum (Guston 2010). This deliberative forum took place in six locations and offered laypeople the opportunity to make policy-relevant recommendations for nanotechnology research (Philbrick and Barandian 2009). Research in this field is ongoing, and although further work is needed to enable more societal influence on decisionmaking, this is a rare and positive example of large-scale public engagement integrated early into governance, illustrating that publics can deliberate over complex issues (Powell, Delborne, and Colin 2011).

However, there are also examples of public engagement in emerging technologies being misused or ignored. For example, critical steps have not been taken to ensure effective public participation in decisionmaking over human genome editing using CRISPR (clustered regularly interspaced short palindromic repeat). CRISPR is a relatively new approach to genome editing that has gained attention for its potential to fight a number of diseases (USNLM 2020). A key unresolved question is whether and how CRISPR might be used for editing human germline DNA, that is, the DNA of reproductive cells. Changes to germline cells raise far-reaching ethical concerns and implications (USNLM 2020). Scientific bodies across the world have attempted to create self-governance measures to place limitations on such research, including guidelines written by the US National Academies. However, current frameworks primarily entail self-regulation by scientists, and they have led to limited public awareness and involvement (Jasanoff, Hurlbut, and Saha 2019). In November 2018, a Chinese researcher announced the birth of two genome-edited babies, drawing widespread condemnation and attention to the urgent need for responsible and inclusive governance of human germline genome editing research. Responsible governance of a technology having such deep societal implications requires that decisionmaking be opened up well beyond the scientific community to include robust input from globally diverse publics.

> [*Public participation in the consideration of emerging technologies is an essential component that can legitimize (or delegitimize) research and bring new ideas to the fore.*]

These and other lessons from emerging technologies suggest that public participation must be at the forefront of SG research governance. Internationally inclusive public engagement in SG research and governance can help to reduce inequity, build credibility, and increase legitimacy of future decisions (Stilgoe, Owen, and Macnaghten 2013). Moreover, such engagement can also broaden knowledge through the refining and weighing of research goals and priorities. Although public awareness of SG is currently low, research has found that publics, once asked and informed, provide thoughtful and rational discourse on nascent technologies and their impacts. Research has additionally found that discussions that take place early, while technologies and public attitudes are still fluid, may be more effective than later discussions, as early discussions can help answer key social questions (Corner, Pidgeon, and Parkhill 2012). Such questions include: Why this technology? Who is controlling it? Who benefits from it? Will it improve the environment? What will it mean for people in the developing world? (Carr and Preston 2014).

There are, however, challenges in implementing a meaningful early engagement process. Researchers may have concerns about academic freedom, overly burdensome requirements and related costs, and the inherent challenges of engagement for a technology having global reach and implications. These are important issues, leading to legitimate questions about what success will look like.

CURRENT STATE OF PUBLIC PARTICIPATION IN DECISIONMAKING CONCERNING SG RESEARCH

Thus far, SG research on public participation has largely focused on understanding public opinion about SAI and MCB (Flegal et al. 2019). Studies have found a wide range of opinion, ranging from skepticism to provisional acceptance of SG as a potential option, but with prevailing feelings of ambivalence (Carr and Yung 2018; Kaplan et al. 2019; Sugiyama, Asayama, and Kosugi 2020; Winickof, Flegal, and Asrat 2015). Understanding how different groups and individuals perceive and feel about SG is important—even at this early stage.

Assessing public opinion, however, is only a first step toward a more meaningful participatory process. The EPA *Public Participation Guide* describes meaningful engagement as "seeking public input at the specific points in the decision process and on the specific issues where such input has a real potential to help shape the decision or action" (EPA 2018). Participatory processes can enable the co-design of research priorities, create a pathway to providing input to decisions, and provide feedback to ideas from diverse groups. There has been limited consideration of the specifics of such processes for SG, however (Flegal et al. 2019; Morrow 2017).

Important lessons for public participation in SG research also come from a proposed 2011 outdoor experiment in the United Kingdom that never launched. The Stratospheric Particle Injection for Climate Engineering (SPICE) project experiment was intended to test delivery systems for aerosols using water (SPICE 2020). The Research Councils in the United Kingdom established criteria to "understand public and stakeholder views," and it was found that additional public outreach was needed before the project could continue (Stilgoe, Owen, and Macnaghten 2013). Deliberative workshops took place, although later in the process and used to understand public views rather than to integrate them (Stilgoe, Watson, and Kuo 2013). After the workshops, the project leads wrote, "The strong feelings about the first test of SPICE's equipment show how important it is to have robust governance, and for scientists and funders to ensure that the public and other parties are consulted at the *earliest opportunity*" (Macnaghten and Owen 2011). The experiment was eventually canceled, in part due to outcry from civil society organizations, but its process offers valuable knowledge that researchers can build on when planning for future engagement.

Alexander Gerst/ESA

Injecting aerosols into the stratosphere (the upper layer of Earth's atmosphere captured here from space), would aim to mimic the sunlight-reflecting effects of large volcanic eruptions, which leads to lower temperatures. But this solar geoengineering strategy would not alter the increasing levels of heat-trapping gases in the atmosphere and would carry major environmental and geopolitical risks.

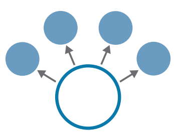
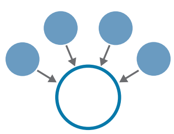
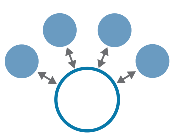
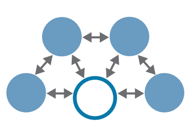
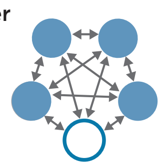
Engaging Diverse Publics in Decisionmaking Concerning Solar Geoengineering Research

There are multiple entry points for diverse publics and stakeholders to contribute meaningfully to decisionmaking about whether and how SG research might proceed and how it should be governed. One entry point is input into public policy decisions about the scope and focus of a US or international SG research enterprise and research governance regime. A second is input into the development of scenarios that researchers and policymakers use to consider the possible future climate and other environmental and geopolitical conditions under which SG technologies might be deployed and how deployment would, in turn, affect the climate, ecosystems, and communities across the globe. A third—the primary focus of this issue brief—is input into decisionmaking about possible atmospheric experiments. As described in "What Would Solar Geoengineering Entail?", SG atmospheric experiments, by their nature, can be expected to draw public attention regarding risks and potential expansion into larger-scale experiments and deployment.

SG researchers and research funders have both an opportunity and a responsibility to help ensure that diverse publics are well informed about the risks and potential of SG in the context of climate change. But, as noted above, meaningful public engagement in decisionmaking about SG research and governance requires more.

Here, UCS adapts the EPA *Public Participation Guide* to consider the different possible levels of public and stakeholder engagement for the SG research enterprise (see the table) (EPA 2018). They range from educating publics about SG research to giving full decisionmaking authority to publics concerning that research. The *Guide* was "designed with government agencies in mind, to help those who must manage the process where public participation is important for decisionmaking, while incorporating fair treatment, meaningful involvement and social inclusion of all people regardless of race, color, national origin, sexual orientation or income." Using the levels described in the *Guide* when determining how to characterize different engagement processes would enable consistency with other major environmental participatory practices and allow for adaptability as governance measures evolve. In addition, the *Guide* offers a simple way to distinguish between different types and levels of engagement that can be implemented across disciplines.

Proposed Levels of Public and Stakeholder Engagement in Solar Geoengineering Research

Level of Engagement	Explanation	Example Methods
Inform 	Provide public and stakeholders with information on risks and potential of SG research in the context of climate change.	Fact sheets, educational webinars
Consult 	Understand public and stakeholder preferences on scope and focus of SG research.	Public comment periods on federal rulemakings, public hearings, focus groups
Involve 	Engage with publics and stakeholders early and throughout a process with multiple opportunities to provide input and nonbinding recommendations on various decisions about SG research design. Provide feedback to show how input influenced a decision or a response as to why it was not used.	Deliberative workshops with a smaller set of stakeholders
Collaborate 	In addition to the engagement in "Involve," include publics and stakeholders directly in decisionmaking with an intention to build consensus/come to an agreement. Ultimate decisionmaking remains with the governance body.	Deliberative workshops building toward consensus agreement with decisionmakers
Empower 	In addition to the engagement in "Collaborate," give the decisionmaking authority to the engaged publics and stakeholders.	Ballot initiatives; informed consent in human subjects research

SOURCES: ADAPTED FROM EPA 2018 AND IAP2 2018.

[*The SG research community has both a responsibility and an opportunity to engage diverse publics and stakeholders in the co-development of SG research priorities and approaches.*]

RECOMMENDATIONS FOR PUBLIC AND STAKEHOLDER ENGAGEMENT IN DECISIONMAKING ABOUT ATMOSPHERIC EXPERIMENTS

UCS firmly opposes outdoor SG experiments that would be large enough to trigger a climate response (UCS 2019). But even small-scale atmospheric experiments can trigger significant public attention and concern regarding risks, implications, and intentions. Researchers and research funders proposing small-scale experiments should involve or collaborate with publics and stakeholders through deliberative approaches across the research life cycle, from design to implementation to evaluation. This could be achieved, for example, through a series of public and stakeholder workshops in the region of the experiment and a solicitation of broader input from publics and stakeholders beyond the region.

Such input should be solicited from diverse publics and stakeholders, including climate-vulnerable and marginalized communities.

The outputs of an engagement process must be responsive to the participants. Participants should be informed of the outcomes of the decisions for which they provided input and how subsequent decisionmaking took place.

These engagement processes should be conducted transparently, and the results should be made public. Transparency of how engagement processes are conducted, who is engaged, and the outcomes of a process are key to both legitimacy and replicability.

Finally, research funders should require and provide resources for engagement in proposed research.

Conclusion

The SG research community has both a responsibility and an opportunity to engage diverse publics and stakeholders in the co-development of SG research priorities and approaches. Inclusive and meaningful public and stakeholder engagement in decisionmaking concerning SG research is essential to ensure the legitimacy and effectiveness of the SG research enterprise.

Meaningful engagement is particularly important for decisionmaking about any atmospheric experiments. Proposed small-scale experiments justify public and stakeholder engagement to determine whether and how they should be pursued.

Appendix: Background on Expert Interviews

In practice, developing recommendations for building and fostering a meaningful stakeholder engagement process in SG research requires substantial forethought and input. To capture nuanced input across a range of views, disciplines, and geographies, UCS conducted interviews with the 10 thought leaders in public engagement listed below. Their perspectives are informed by experience and disciplinary expertise related to engagement in SG, environmental engagement, international governance, capacity building, environmental justice, tribal engagement, and environmental ethics.

1. **Mustafa Ali**, vice president of environmental justice, climate, and community revitalization, National Wildlife Federation
2. **Dr. Holly Buck**, postdoctoral fellow, Institute of the Environment and Sustainability, University of California–Los Angeles
3. **Dr. Wylie Carr**, social scientist, US Fish and Wildlife Service
4. **Dr. Rebecca Colvin**, lecturer, Australia National University
5. **Nikki Cooley**, co-manager, Institute for Tribal Environmental Professionals, Tribal Climate Change Program
6. **Dr. Jane Flegal**, adjunct professor, Arizona State University
7. **Dr. Marion Hourdequin**, associate professor and chair, philosophy department, Colorado College
8. **Andy Parker**, project director, Solar Radiation Management Governance Initiative
9. **Dr. Karen Parkhill**, senior lecturer in human geography, University of York
10. **Pablo Suarez**, associate director for research and innovation, Red Cross Red Crescent

UCS conducted semi-structured interviews consisting of a predetermined set of open questions that sought to obtain a range of perspectives on what an ideal process should consist of and how it should be conducted to ensure diversity, fairness, and meaningful participation. The questions were determined through literature review on this topic, iterations with internal UCS experts, and external capacity from Iowa State University.[2] Key questions were as follows:

QUESTIONS ON SMALL-SCALE EXPERIMENTS

Respondents were asked to consider a small-scale outdoor SG experiment that has been suggested to have minimal environmental impacts and takes place within the confines of a local to state-sized jurisdiction.

- How would you define stakeholder engagement in this type of situation? Is stakeholder engagement different from public engagement for this situation? If so, how?
- Should there be a stakeholder engagement process in place for such an experiment? For public engagement?
- What types of stakeholders should be consulted for such an experiment?
- Do you have any suggestions for how to engage important stakeholders who might not be aware of SG?

QUESTIONS ON COORDINATION, FUNDING, AND DESIGN PROCESSES FOR ENGAGEMENT IN SG RESEARCH

- Should funding and/or coordination of stakeholder and public engagement be the responsibility of the researchers, the research institution, or an independent entity?
- Given the time and resources required by engagement, what mechanisms can be used to enable such a process (especially for researchers who may have financial constraints)?
- At what point in the research process should stakeholders or publics be consulted for outdoor small-scale SG research?
- What are some stakeholder engagement techniques or approaches that you would recommend for small-scale SG research?
- Are there any models or examples of successful engagement situations that you would suggest as a starting point?
- How should the results of stakeholder or public engagement be used?
- How can engagement processes be designed to ensure that input is meaningfully integrated rather than just conducted for the sake of optics or to legitimize the research?
- What are the characteristics of an ineffective or unsuccessful engagement process?
- How should success be defined for stakeholder or public engagement for small-scale SG field experiments?
- What do you think the goal of stakeholder engagement in small-scale SG should be? Is this the same for public engagement?

Subsequent to the interviews, UCS analyzed the output using thematic analysis—the prevailing method for organizing the major ideas arising from such outputs (Braun and Clarke 2006). This analysis was able to highlight the key themes that emerged from the responses to questions about the goals, components, and merits of meaningful stakeholder engagement. These themes included: inclusivity; legitimacy; responsiveness; oversight and transparency; and upstream, deliberative engagement. UCS drew upon these themes, and additional insights from the expert interviews, to construct the public and stakeholder engagement recommendations for researchers and funders discussed in this issue brief. Although UCS invited participants to review our draft report, UCS and the report authors are solely responsible for the findings and recommendations presented. UCS intends these findings and recommendations to serve as a platform upon which to build meaningful engagement across all domains of SG research.

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2 *UCS worked with consultants from Iowa State University to help with the review of interview questions, transcription of interview recordings, and analysis of responses.*

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