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Dear SCoPEX Advisory Committee,

Thank you for proposing a societal review process for SCoPEX. In our view, this is one of the most important aspects of SCoPEX's governance, but also one of the most challenging. We therefore sincerely appreciate your advice on this front.

Thank you also for providing the opportunity to provide feedback. Our formal response is enclosed.

We acknowledge that we are certainly not experts in societal engagement, but, as researchers, we hope we can help shed light on some of the challenges and limitations facing physical scientists studying solar geoengineering. We also hope our experience conducting other small-scale, outdoor, environmental experiments (unrelated to solar geoengineering) can help inform the SCoPEX process.

Lastly, we recognize that our views about our team's own capabilities and resources to carry out the proposed engagement activities may be useful, particularly since we know one goal of the SCoPEX governance process is to develop a model that is not only helpful for our team, but also for others who are looking to carry out small-scale outdoor experiments. We therefore have attempted to highlight the abilities and constraints that our research team will face when trying to implement a societal engagement strategy given that others may have similar limitations.

As always, please don't hesitate to reach out with any questions. I am happy to setup a call to discuss.

Yours,

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Formal Response from the SCoPEX Research Team

Introduction: Public engagement is vital to enabling just decisions about solar geoengineering. We believe deliberative public engagement is essential for developing an agenda for solar geoengineering research. As countless others have underscored, including the [UK Royal Society](#) and [US National Academy of Sciences](#), members of the public, particularly the most vulnerable, should be engaged in solar geoengineering discussions. We enthusiastically support this position. The harder question is precisely when and how to engage various publics.

First Response to Scope: The public would be most meaningfully and helpfully engaged if asked what their values are, and how those values translate into broader research goals and priorities. What does the public care most about? Should there be solar geoengineering research? And if so, what should the goals of a research agenda be?

Scientists have specialized skills and knowledge, but in a democracy the value judgments of scientists or other elite groups should not count more than the value judgments of the general public. For solar geoengineering, this is important because applied science and technology is *driven* by goals that are derived from underlying value judgments and social choices. For example, the goals of solar geoengineering research could be to maximize global benefit and reduce global harm, to return temperatures to preindustrial levels, to return water availability to preindustrial levels, to stop sea level rise, or to maximize agricultural output, amongst many other aims. The public would be the most meaningfully engaged by participating in and influencing these high-level design choices and goals. As David Keith and collaborators put it: “public engagement can help to democratically weigh and refine the objectives that drive [solar radiation modification] SRM research, and help prevent a scenario in which the unstated assumptions of a community of developers ultimately impact the global population” ([Carr et al., 2013](#)). Because solar geoengineering research is a combination of science *and* engineering (towards a potential outcome), it is essential to engage the public in discussions about broad research goals. It is also important to maintain a distinction between research and deployment during these discussions.

Second Response to Scope: There is a semipermeable division between solar geoengineering research and deployment. If solar geoengineering were ever deployed, clearly it would be informed by research. Research may also alter the probabilities of deployment. Therefore, research cannot and should not be divorced entirely from questions about deployment. Yet, we must not lose sight of the fact that research is not deployment, nor does it inevitably lead to deployment. Rather, it delivers *information* that can inform potential deployment—information that may reveal new risks, new benefits, or previously unknown challenges around solar geoengineering. In short, while research and deployment are linked, there is a clear distinction between the two. This distinction is especially true for small-scale, process level experiments that do not have any *physical* impact on the environment, even though they may have *non-physical* repercussions. (We argue later, in our third response, that it is this aspect that can help SCoPEX uniquely contribute to broader governance discussions about research agendas.)

Because of this, we believe that the best chance for legitimate democratic decisions around small-scale solar geoengineering field experiments—and even laboratory and modeling research—is to maintain some (careful and permeable) separation between decisions about research agendas and decisions about potential, ultimate implementation. We recognize that the Committee may also be attempting to make such a distinction by noting that “SCoPEX is a just one small experiment, and it is not appropriate, or feasible to place the responsibility for addressing the full scope of the ethical issues and uncertainties of solar radiation management on a single, small and limited scope experiment.” And to be clear, we do not at all suggest that these broader questions do not provide critical *context* for SCoPEX and other types of

research. Yet, as written, the Committee’s societal engagement process blurs the differences between research and deployment by tightly linking a debate about a specific small-scale experiment with no significant physical impact to big questions about the ultimate impacts of solar geoengineering. For example, the Committee has proposed that participants answer questions such as: Does solar geoengineering research or deployment pose a moral hazard? Is it ethical to deploy solar geoengineering, and who should decide? Can solar geoengineering deployment be governed, and can we trust that governance? Is research a slippery slope to deployment? We do not believe that any one research project, whether it be an indoor climate model or a small-scale outdoor experiment, can or should be able to answer these questions. Indeed, if every decision about solar geoengineering research must bear the weight of all future possibilities of potential solar geoengineering deployment, then no research can reasonably be conducted. Research would have to halt. This has not been the standard for most other areas of environmental research, and it should not be the burden for solar geoengineering research.

We therefore propose the following: (1) Present accurate and unbiased *background information* on all of the potential benefits, risks, and uncertainties of solar geoengineering, including those physical and societal. For example, this information can include a discussion about the potential for a moral hazard and slippery slope, amongst other difficult governance and ethical challenges. (2) Pose *questions* that focus on values and desired research goals. In our view, this two-pronged approach would help ensure that the public is rightfully informed of the range of challenging issues surrounding solar geoengineering when considering research, but also provide them with questions that enable them to engage most meaningfully in discussions—*by focusing on broader research agendas*.

Third Response to Scope: SCoPEX could enable the public to engage in important, concrete discussions about what types of research should be pursued. As noted, we believe the public should be engaged in the development of solar geoengineering research agendas. And we believe SCoPEX can help contribute to these discussions. Yet, just as it is not feasible or desirable for the public to answer all of the big questions related to solar geoengineering when evaluating SCoPEX, it is also not meaningful to ask the public detailed questions about the minutia of the experiment’s science. The latter is likely best reviewed by the Committee’s scientific peer review process. Just as the legal process is likely best reviewed (not, thankfully, by us scientists, but) by the managers and attorneys who have a great deal of experience and expertise in this area. That said, SCoPEX can be used as an example to promote understanding and elicit important responses from the public that might not otherwise be possible through theory. In particular, SCoPEX can be used to help researchers, including, of course, the SCoPEX team, and policymakers understand how the public values and views different *types* of research.

Similar to how [Arizona State University](#) asked participants in their public engagement workshops to describe their preferences for different methods of research, this societal engagement process could ask the public how small-scale experiments like SCoPEX that do not pose significant physical risks fit into broader research programs. For example, in the natural sciences researchers can utilize climate models, laboratory studies, observations, small-scale field research (that do not pose significant physical risks), and larger-scale field research (that have physical impacts) to advance understanding. We assume that most, if not all, members of the public would recommend a (very) different governance regime for larger-scale experiments (as would we), but how do they view smaller-scale experiments? At what scale do members of the public see research choices differently?

This would be an enormously valuable piece of information to researchers, including SCoPEX, and policymakers. The public may argue, for example, that any experiment that is outdoors requires different considerations and governance, perhaps because it increases the visibility of solar geoengineering and therefore increases the risk of moral hazard. Others may conclude the opposite, that climate models

actually pose as large or a larger moral hazard because they may be seen as what an actual future may look like even though they are currently not able to parametrize and account for certain physical risks (without further laboratory or field research), and therefore present better "futures" than may be feasible. And still others may deem the moral hazard as unimportant and arrive at different conclusions.

We do not pretend to imagine what the public will prefer, but to us, the best way to engage the public in SCoPEX specifically is to ask them how it and other small-scale experiments should fit, if at all, into a broader research agenda. As researchers, we are keen to hear and understand the public's perspective on this topic. And we believe it is important to have their views inform broader research agendas.

Fourth Response to Scope: Consider SCoPEX in the context of other environmental science experiments. The Committee's suggestions for societal engagement for SCoPEX focus almost entirely on questions around the long-term future of solar geoengineering. Sharing these questions and issues as *background information* is appropriate. But they are not the only relevant frame. Experiments are done by experimenters and fit into a (sometimes contested) history of other outdoor environmental experimentation. We suggest that when the engagement process addresses questions about SCoPEX and other small-scale outdoor field research, it be concentrated more directly on experiments as *experiments*—activities by environmental scientists that fit (or don't) into a range of other of experiments that environmental scientists do. This is a different frame that would put experiments front and center, while maintaining solar geoengineering as an important background.

Such a public engagement exercise would look quite different from prior exercises which are highly theoretical and concentrated on general nonspecific discussions of solar geoengineering.

This would include other outdoor experiments such as:

- prior or ongoing solar geoengineering experiments such E-PEACE, ICE-911, and those taking place in Australia
- future solar geoengineering experiments that groups like ours might consider
- other balloon experiments by astronomers and geoscientists
- free air experiments that expose crops and forest ecosystems to elevated ground-level ozone and carbon dioxide
- the release of genetically engineered mosquitoes for disease control
- the ocean acoustic tomography experiment that was canceled due to concerns about the impacts on marine mammals

Lastly, it would be valuable to explain how experiments fit into the overall scientific process. For example, it may be helpful for the public to understand how experiments like SCoPEX are necessary for advances in non-perturbative modeling experiments. In other words, some members of the public may not initially understand how experimental, laboratory, and modeling research are related, and would therefore benefit from learning how these different methods can inform one another.

Response to Process: Questions and ideas for managing the societal engagement process. We agree that it would be valuable for an independent team to carry out the societal engagement work. It will not only help ensure that the information presented, questions asked, and responses collected are carried out in a way that minimizes bias, but it will also help address the concerns we had about the limited time, personnel, and expertise we have to carry out the societal engagement work ourselves. If the Committee similarly feels that they do not have the capacity to execute the process, we support this decision to hire an independent entity. It may even make the process more manageable for potential future advisory committees.

We would recommend, however, that the Committee, not the experiment team, hire and manage the independent team. This would not only give the Committee more oversight into the process and reduce our influence, but it would also create a model that others may be more equipped to follow. For example, the Managing Director of Harvard's Solar Geoengineering Research Program (SGRP), Lizzie Burns, has been committed to spending a small fraction of her time managing the governance process for the SCoPEX research team, which is helpful given her background in public policy. But future experiment teams outside of Harvard may not have such personnel. Meanwhile, the Committee has a full time Executive Coordinator who could support the members in driving the process. And SGRP included a line item for societal engagement work when it provided financial support for the SCoPEX Advisory Committee process. We therefore recommend the Committee hire and manage the independent team.

If, however, the Committee determines that the experiment team should manage the third party as initially proposed, it would be helpful to gain more clarity as to the amount of time, funding, and expertise that is expected from our team to carry out this work. For example:

- What role would the research team need to play to support the hired team?
- How many deliberative dialogues are you envisioning?
- What is the budget for this plan?
- What is the timescale of this plan, and are there clear deliverables, goals, and timelines?

We have *some* personnel and financial resources to carry out the societal engagement process, as mentioned. But it would be constructive to gain more detail around the specific resources and work that the research team would be responsible for. For example, the Alfred P. Sloan Foundation [provided \\$299,574](#) to support the public engagement work carried out by Arizona State University, which hosted two workshops. We could work with Arizona State University and others to learn if lower cost options are available, but if the cost is extremely high, or if the personnel effort required is significant or necessitates expertise that other scientific teams may not have, the model that is implemented may not only be challenging for us, but also for others outside of Harvard who wish to carry out small-scale outdoor experiments (particularly if they do not have the same personnel or financial resources for solar geoengineering research as our program). This latter point is important to us. If the process outlined is too time and resource intensive for other teams to follow, it will not be utilized and will not be as helpful to broader governance discussions.

Minor Responses: Small comments on specific points raised in the document.

"Is it ethically permissible to intentionally add chemicals to the atmosphere that are *long-lived*?"

- The lifetime of materials in the stratosphere is about 1.5 years. Is this short or long? We suggest a comparison to other perturbative environmental science experiments or perturbations humanity has done within the context of climate change as most greenhouse gases have much longer lifetimes.

"The briefing book will include...questions designed to guide constructive dialogue about the moral hazards associated with solar radiation management."

- As noted, we believe the moral hazard should be discussed in the background information since it is impossible for SCoPEX to answer this big question. Indeed, since a judgement about moral hazard is a judgement about how political disputes will play out over decades, we are skeptical than anyone can make a confident judgment.

- Moreover, research that studies people’s actual behaviors, or willingness to pay, “observe[s] that people who have been informed about [stratospheric aerosol injection] SAI mitigate more than people who have not” ([Merk, Pönitzsch, and Rehdanz, 2016](#)). This method is quite different (and perhaps more accurate) than asking people to simply estimate others’ future behavior.
- Still, when asking straightforward questions, many studies show that the framing can meaningfully influence responses ([Thaler and Sunstein, 2009](#)). A recent experiment asked one group of participants if they agreed with the statement that solar geoengineering would motivate society to cut emissions “more”, and another group the same question, but “less”; both groups agreed. The researchers concluded that “acquiescence bias appears to be an important factor for attitudes around solar geoengineering and moral hazard” ([Mahajan, Tingley, and Wagner, 2019](#)).

“The briefing book will include...*clear* descriptions of the regional outcomes and impacts...including information about which communities and regions *will* experience disproportionate impacts”.

- Clear descriptions are impossible to provide and attempting to do so would be a disservice to participants. It would give the participants a false sense of certainty about how solar geoengineering could affect specific regions. Indeed, the main reason we (and many others) are carrying out research is because there are still many uncertainties surrounding solar geoengineering’s potential impacts. We suggest that the briefing materials highlight the levels of uncertainty when discussing potential regional and community impacts and compare that uncertainty to the related uncertainties in predictions of the climate impacts of greenhouse gases.
- Similarly, it would be important to explain (in layman’s terms) the model scenarios that have been run when presenting potential impacts so that the participants can understand and interpret the early findings in context. For example, some models gradually introduce solar geoengineering, aiming to halve the rate of warming to bring water availability closer to pre-industrial levels, while others aim to fully offset global warming to bring temperatures closer to preindustrial levels and produce drier climates.