

2. Methods

2.1 Focus Group Outputs

We convened focus groups in Phoenix and Washington in April 2018 to provide independent citizen input to the pTA deliberation design. We used a two-tiered deliberation model to elicit both unstructured and structured responses from participants. The first tier was open-ended with very little background information provided to participants (Table 2.1.1). The second tier introduced information about SRM research, elaborated on concerns that emerged in the first tier, and then mapped them against issues raised by experts and other stakeholders derived from our literature review (Table 2.1.2).

Table 2.1.1: Focus group priority categories following Part 1 engagement (low information, open framing). Each table generated a “Top Five” list of concerns, after which each participant selected three items from among all groups’ concerns as “Most Important.” Results open-coded into thematic categories and displayed below. Resulting categories coding according to common stakeholder concern categories (see Table 2.1.2). C = Climate Risk, M = Moral Hazard, N = Messing with Nature, U = Uncertainty, G = Governance, P = Politics.

Phoenix Priorities	Votes	Washington, DC Priorities	Votes
Public safety, environmental health (U)	19	Unintended side effects (U)	14
Who’s funding/Who has influence (G)	8	Effect on surrounding are of test sire (U)	7
Transparency/Public involvement (G)	7	SRM avoids hard choices (M)	5
Global cooperation difficult (G)	6	“Messing with Nature” (N)	4
Public fear (G)	1	What if we are wrong about geoengineering (U)	3
Willful ignorance of problem (G)	1	Education/Other competing concerns (G)	3
Religious, ethical, and philosophical perspectives (G)	1	Economics influences solutions (G)	2
		How long effective? (“Band-Aid?”) (U)	2
		International agreements difficult (G)	2
		Experimenter motivation? (not care about climate change)	2
		Is it too late already? (U)	2
		Accuracy of reporting data (G)	2
		Reversibility of field tests and deployment (U)	1

Table 2.1.2: A comparison of common expert stakeholder (left) concerns found in the geoengineering literature to the concerns of participants of the open-framing focus groups in Phoenix and Boston. Participant concerns discussed during the focus groups are thematically coded based on common stakeholder concern categories. While all coded stakeholder concerns are all common in expert literature, participants focused on the governance of SRM and perceived uncertainty associated with SRM research.

Common Stakeholder Concern	Phoenix	Washington, DC	Combined
Climate Risk (C)	0%	3.9% (2)	1.9% (2)
Moral Hazard (M)	3.9% (2)	7.8% (4)	5.9% (6)
Messing with Nature (N)	3.9% (2)	3.9% (2)	3.9% (4)
Uncertainty (U)	27.5% (14)	35.3% (18)	31.4% (32)
Slippery Slope/Lock-in (SL)	1.9% (1)	3.9% (2)	2.9% (3)
Governance (G)	56.9% (29)	31.4% (16)	44.1% (45)
Politics (P)	5.9% (3)	13.7% (7)	9.8% (10)

2.2 Deliberation Design Workshop

We hosted a two-day workshop (Table 2.2.1) with expert stakeholders on May 7-8, 2018 in Washington DC. Attendees included a total of 21 external experts, 18 in-person and 4 remotely, and 12 project team personnel and event staff.

Table 2.2.1: Agenda for deliberation design workshop

Monday, May 7: Naming and Framing the Issues		
Time	Description	Presenters
8:00-9:00 AM	Check in and breakfast	
9:00-9:15 AM	Welcome and group introductions	Sarewitz
9:15-9:30 AM	pTA Process, project objective, scope, deliverables	Farooque
9:30-9:45 AM	pTA Forum design principles, workshop objectives	Sittenfeld
9:45-10:00 AM	pTA Design Team Q&A: Project and process	Farooque, Sittenfeld, Tomblin
10:00-10:30 AM	Solar Geoengineering Research Scenarios: Could we develop an engineering response to address climate change? If so, should we do it and under what conditions? What do we need to research to transition from field experiments to potential deployment?	Lightning Talks <ul style="list-style-type: none"> ▪ Dykema ▪ Ackerman ▪ Tilmes (SKYPE: sagtilmes)
10:30-12:00 PM	Deliberation 1: What are the top concerns for solar geoengineering research? How do we map the risks and uncertainties with respect to potential physical and nonphysical harms? Who are the important stakeholders and why?	Small-group facilitated deliberation with stakeholder perspective cards
12:00-1:00 PM	Lunch	
1:00-1:30 PM	Framing the Issues: Summary of concerns from the morning expert deliberation and	Tomblin

	comparison with the Phoenix and Washington focus group results.	
1:30-2:15 PM	Deliberation 2: What concerns are shared between expert stakeholders and the public? What concerns are different, and which ones are missing? What are the cross-cutting themes?	Small-group facilitated deliberation
2:15-2:45 PM	Report out and group reflection	Sittenfeld
2:45-3:00 PM	Break	
3:00-3:30 PM	Governance Scenarios: Global, National, Models	Lighting Talks <ul style="list-style-type: none"> ▪ Pasztor (SKYPE: jpasztor) ▪ Persons ▪ Flegal
3:30-4:15 PM	Governance Panel Q&A: Moderated discussion of governance options	Long, Hubert, Nicholson, Parson (SKYPE: tedparson), Neff (Moderator)
4:15-5:00 PM	Deliberation 3: To what extent do governance approaches address the top stakeholder/public concerns? Where are the gaps and how should they be addressed? Checklist for good governance	Small-group facilitated deliberation with governance scenario cards
5:00-5:30 PM	Report out, group reflection, plans for tomorrow	Sittenfeld
Tuesday, May 8: Designing Public Forums in Boston and Phoenix		
8:00-9:00 AM	Breakfast	
9:00-9:30 AM	Recap day 1 discussion and plan for today	Sarewitz
9:30-10:00 AM	Public Engagements on Geoengineering	Lightning Talks <ul style="list-style-type: none"> ▪ Buck ▪ Bedsted Tomblin
10:00-11:30 AM	Deliberation 4: Who are the relevant publics and what do we want to know from them to make better governance decisions? What information do we provide to the public to gather the necessary response? What would be useful data or analyses for stakeholders?	Small Group Facilitated Deliberation
11:30-12:00 PM	Report out and group reflection	
12:00-12:45 PM	Lunch	
12:45-1:30 PM	“Designer Planet” Demonstration	Anbar and Romaniello
1:30-2:30 PM	Putting it altogether: Organizing the day, listing of questions and content, what’s missing	Sittenfeld
2:30-2:45 PM	Next Steps	Farooque
2:45-3:15 PM	Project Team Q&A	Sarewitz, Farooque, Anbar
3:15-3:30 PM	Final Thoughts	Sarewitz
3:30 PM	Adjourn	

External Participants:

1. Thomas Ackerman, University of Washington
2. Shinichiro Asayama, Waseda University
3. Bjorn Bedsted, Danish Board of Technology Foundation
4. Alexis Bergeron, Leadership Now
5. Holly Buck, UCLA
6. Elizabeth Burns, Harvard University
7. Benjamin DeAngelo, NOAA (May 7)
8. John Dykema, Harvard University
9. Jane Flegal, Spitzer Foundation
10. Peter Frumhoff, Union of Concerned Scientists
11. Steven Hamburg, Environmental Defense Fund (May 8)
12. Anna-Maria Hubert, University of Calgary
13. Andrew Light, World Resources Institute
14. Jane Long, LLNL (Ret.)
15. Simon Nicholson, American University
16. Matthew Nisbet, Northeastern University
17. Ted Parson, UCLA (SKYPE)
18. Janos Pasztor, C2G2 (SKYPE)
19. Timothy Persons, U.S. GAO (May 7)
20. Michael Thompson, C2G2 (May 8)
21. Simone Tilmes, NCAR (SKYPE)
22. Walter Valdivia, GMU

ASU Participants:

1. Ariel Anbar, ASU
2. Nora Buklevska, Syracuse U
3. Sonia Dermer, ASU
4. Mahmud Farooque, ASU
5. Jason Lloyd, ASU
6. Mark Neff, Western Washington U
7. Kimberly Quach, ASU
8. Steve Romaniello, ASU
9. Dan Sarewitz, ASU
10. David Sittenfeld, Museum of Science
11. David Tomblin, University of Maryland
12. Nicholas Weller, ASU

2.3 Background materials

Cognizant of the potential for framing to affect forum outputs (Bellamy & Lezaun 2017), we sought to avoid framing geoengineering as a solution to a climate emergency. Rather we aimed to keep the background materials' statements on climate change

close to mainstream scientific consensus and to highlight areas of uncertainties. We did, however, introduce some general information regarding climate change in order to explain why geoengineering is being considered at all. SRM-specific materials aimed to present proposed SRM methods, possible research initiatives, and potential governance considerations, drawing from a broad sweep of expert proposals and public concerns elicited during prior focus group work. While the background materials may have influenced participants' expressed views and primed them to discuss certain topics, we also incorporated element of open framing into the forum design to counter this effect.

Background material design followed deliberation design, with the background document's structure mirroring the deliberation structure, and content largely expanding upon ideas presented in deliberation materials. The materials were also used as bases for three informational videos played at the beginnings of their respective deliberation sections. The aim of these videos was to review the material, recognizing that not all the participants may have read through the entire background document. Data from participant surveys indicates that participants perceived the prepared background materials as unbiased, and deliberation observer notes indicate that participants frequently referred to the prepared background materials and deliberation materials in discussion.

2.4 Deliberation Overview

Table 2.4.1 Forum Agenda used for the deliberations in Boston and Phoenix

9:30am - 10:00am	Participant Check-In
10:00am – 10:15am	Welcome
10:15am – 12:00pm	Session 1 – SRM Research Directions
12:00pm – 12:45pm	Session 2 – SRM Research Funding
12:45pm – 1:45pm	Lunch & Speaker
1:45pm – 3:15pm	Session 3 – SRM Research Decision Making
3:15pm – 4:15pm	Session 4 – SRM Research Hypothetical Scenarios
4:15pm – 4:30pm	Evaluation
4:30pm	Wrap Up

Results Analysis Methodology

Forum data were analyzed through a mixture of quantitative and qualitative methods. Quantitative analyses included totaling individual and group selections of desired SRM research directions, funders, and decision makers to determine which selections were most and least preferred. On their individual worksheets, participants rated their levels of support for the different research directions and prospective funders on a scale of Very much = 3, Somewhat = 2, Not really = 1, Not at all = 0, Unsure = Null.

We measured participant learning and attitude change by providing participants the same prompts on both the pre- and post-forum surveys. Participants rated survey responses on a scale from 1 (absolutely agree) to 7 (absolutely disagree). We used

two-sample t-tests to compare differences between the pre- and post-surveys and to compare participant attitudes in Boston and Phoenix.

In addition to the quantitative analyses, we performed qualitative analyses on individual and group rationales. These analyses included open and theme-based coding of the rationales. The categories used for the theme-based coding analyses are described in the main text of the report. Responses were non-inclusively coded, meaning that responses expressing multiple themes were coded into multiple categories.

2.5 Participant Recruitment and Demographics

Table 2.5.1: Participant Recruitment Process

Date (2018)	Activity
Mid-July – Mid-August	Citizens invited to apply online via traditional media (press release, newsletter, program brochure, etc.), social media (Facebook, Meetup, Reddit, etc.), Craigslist advertisement, email campaign, direct referrals, and snowball recruitment.
Mid-August – Early September	Targeted recruitment in categories with deficit.
Early September	Selected participants asked to confirm availability.
Mid-September	Confirmed participants provided with agenda, background, and logistical information and asked to complete pre-survey.

Participant Selection

During the application process, participants answered demographic questions related to gender, age, education, income, race, political orientation, and ethnicity. They also answered questions related to their familiarity and affiliation with climate research:

- How familiar are you with climate research?
- Are you involved in climate research issues through work, business or advocacy?
- Are you a member of or involved with a climate advocacy organization?

This information was used to select a pool of participants that met three basic goals:

- Select and confirm 100 participants;
- Maximize the representation of the demographic diversity of the host states (Arizona and Massachusetts); and
- Minimize the representation of climate research professionals and advocates.

A total of 228 applicants applied to participate in the September 15 forum in Phoenix and 379 applicants applied to participate in the September 22 forum in Boston. Demographic categories where the percentage of applicants was significantly less than their respective percentages in the 2012 census data were given higher preferences in the selection process. The selection process for both sites attempted to reach gender parity. Applicants who answered in the affirmative to the three climate research related questions were given lower priorities. In total, 156 applicants in Arizona and 130 applicants in Massachusetts were selected and asked to reconfirm their desire to participate in the forums. The reconfirmation process yielded 110 and 105 confirmed participants for the Phoenix and Boston forums respectively, of which 88 and 83 were present on the forum day.

Table 2.5.2 State level comparison data from U.S. 2012 Census, American Community Survey 5-year estimates

Category	MA Forum			AZ Forum		
	Attended	Participants	2012 Census	Attended	Percentage	2012 Census
Total Participants	83			88		
Male	40	48.2%	48.4%	39	44.3%	49.7%
Female	41	49.4%	51.6%	48	54.5%	50.3%
Non-binary	2	2.4%	n.d.	1	1.1%	n.d.
AGE: 18-24	12	14.5%	13.1%	12	13.6%	13.3%
AGE: 25-44	32	38.6%	33.9%	29	33.0%	35.3%
AGE: 45-64	21	25.3%	35.2%	31	35.2%	32.8%
AGE: 65+	18	21.7%	17.7%	16	18.2%	18.6%
EDUC: No HS	0	0.0%	10.9%	0	0.0%	14.6%
EDUC: HS	6	7.2%	25.9%	11	12.5%	24.4%
EDUC: S Coll	17	20.5%	24.3%	29	33.0%	34.4%
EDUC: B Deg	27	32.5%	22.2%	34	38.6%	16.9%
EDUC: G/P Deg	33	39.8%	16.8%	14	15.9%	9.7%
RACE: White	50	60.2%	76.3%	43	48.9%	57.7%
RACE: Black	9	10.8%	6.2%	12	13.6%	3.8%
RACE: Asian	7	8.4%	5.4%	4	4.5%	2.7%
RACE: Hispanic	7	8.4%	9.6%	16	18.2%	29.7%
RACE: Mixed/Other	8	12.0%	1.7%	6	10.2%	1.7%
RACE: Native American	0	0.0%	0.5%	4	4.5%	4.6%
INCOME: <\$25K	14	16.9%	20.0%	23	26.1%	23.6%
INCOME: \$25K-\$49K	24	28.9%	18.7%	24	27.3%	26.2%
INCOME: \$50K-\$99K	23	26.5%	29.3%	33	37.5%	30.9%
INCOME: >\$100K	22	26.5%	31.8%	8	9.1%	19.4%
Employed	50	60.2%	n.d.	48	54.5%	n.d.
Unemployed	5	6.0%	n.d.	7	8.0%	n.d.
Retired	12	14.5%	n.d.	17	19.3%	n.d.
Student	5	6.0%	n.d.	10	11.4%	n.d.
Other	11	13.3%	n.d.	6	6.8%	n.d.
Politics: Far Left	4	4.8%	n.d.	0	0.0%	n.d.
Politics: Liberal	27	32.5%	n.d.	16	18.2%	n.d.
Politics: Middle	31	37.3%	n.d.	47	53.4%	n.d.
Politics: Conservative	5	6.0%	n.d.	15	17.0%	n.d.
Politics: Far Right	0	0.0%	n.d.	0	0.0%	n.d.
Politics: Don't Know	6	7.2%	n.d.	7	8.0%	n.d.
Politics: Other	0	0.0%	n.d.	3	3.4%	n.d.
Urban	42	50.6%	n.d.	35	39.8%	n.d.
Suburban	39	47.0%	n.d.	44	50.0%	n.d.
Rural	2	2.4%	n.d.	9	10.2%	n.d.

2.6 Participant Perceptions

Participant Motivations

The reasons that people give for attending deliberative exercises vary. To measure what motivated people to participate in SRM Forum, we used pre-forum surveys. People participating in the forums were given 6 potential motivations for attending and asked to rate these potential motivations.

Table 2.6.1: Motivation: A report of the mean responses to 5 potential motivations on a scale of 1-7 (absolutely agree = 1, absolutely disagree = 7) of participants in both Arizona (n=83) and Massachusetts (n=79) to the following prompt in the pre-survey: “What are your reasons for participating in this deliberative process?” The motivations are ranked in ascending order of most influential reasons for attending the forum. Statements with a $p < 0.05$ are considered statistically significant.

Motivation	AZ Mean Response	MA Mean Response	T-test p-value AZ vs. MA
1. To learn more about what can be done about climate change	1.8	1.7	0.38
2. To learn about the subject of Solar Radiation Management (SRM)	2.2	2.3	0.73
3. To hear alternative perspectives to my personal opinion on Climate Change research.	2.2	2.3	0.82
4. To influence research decision making on SRM	2.9	3.0	0.92
5. To discuss with other people, regardless of topic	3.2	3.1	0.53
6. There is no specific reason why I participated	5.0	5.4	0.12

Participant Expectations

We also asked questions about people’s general expectations concerning participation in scientific research decision-making.

Table 2.6.2: Expectations for Public Participation in Decision Making: A report of the mean responses to 5 potential expectations on a scale of 1-7 (absolutely agree = 1, absolutely disagree = 7) of participants at both sites combined pre (n=159) and post survey (n=156) to the following prompt: “Please assess the following statements about the role of citizen participation in U.S. decision-making procedures.” Statements with a $p < 0.05$ are considered statistically significant.

Expectation	Mean Pre-survey Combined	Mean Post-survey Combined	T-test p-value Pre vs. Post
1. In the United States, opportunities for people to influence societal decision making are very limited.	3.8	3.6	0.26
2. Public participation in decision making leads to better research decisions.	2.6	2.1	0.00042
3. Non-experts (the general public) can develop valuable inputs for effective decision making.	2.4	2.2	0.067
4. Decision making on complex scientific or technical subjects should only be made by experts.	4.3	4.1	0.30
5. Experts should heed the opinion of the general public more than they now do.	3.2	2.5	0.000017

Forum Evaluation

Table 2.6.3: Evaluation of the forum experience measured on a scale of 1-7 (absolutely agree = 1, absolutely disagree = 7) of participants at Arizona (n=82) and Massachusetts (n=76).

Evaluation	AZ Mean Response	MA Mean Response	Combined Mean Response
1. The objectives of the whole event were clear to me.	1.6	1.9	1.7
2. The assigned tasks were clear to me.	1.6	1.9	1.7
3. The roles of forum participants, facilitators, and staff were clear.	1.4	1.5	1.4
4. It's clear to me how the forum results will be used.	2.3	3.2	2.7
5. All participants had the same opportunities to voice their opinion.	1.4	1.4	1.4
6. I was able to contribute my ideas and views during general discussions.	1.2	1.3	1.3
7. I was able to contribute my ideas and views while developing our group plan.	1.2	1.4	1.3
8. Participants were treated respectfully by the organizers and forum staff.	1.2	1.3	1.2
9. Participants discussed the topics constructively (active listening to contributions, respectful treatment...).	1.3	1.4	1.3
10. Important societal groups (ethnic minorities, age and income groups, etc.) were appropriately represented at the event.	1.5	1.8	1.6
11. The facilitator(s) effectively moderated discussions.	1.3	1.6	1.4
12. I understood the information in the background material.	1.6	1.4	1.5
13. The background information and video on climate change was unbiased.	1.7	2.1	1.9
14. The background information and video on SRM research was unbiased.	1.7	2.2	1.9
15. Some relevant scientific information and positions were missing from the background information.	3.3	4.1	3.7
16. There was enough time for participants to discuss and reflect on information and arguments.	1.5	2.3	1.9
17. The event provided enough breaks	1.6	1.9	1.7
18. The event used my time productively.	1.6	1.6	1.6
19. Logistical arrangements for the event (travel, accommodation, meals, etc.) were appropriate.	1.6	1.6	1.6
20. I am fully satisfied with the SRM Forum.	1.4	1.7	1.5

Table 2.6.4: Influence of Participation on Perceived Knowledge Gain and Behavioral Change: A report of the mean responses to 12 potential expectations on a scale of 1-7 (absolutely agree = 1, absolutely disagree = 7) of participants at Arizona (n=82) and Massachusetts (n=76). Statements with a p<0.05 are considered statistically significant.

Participation in the forum...	AZ Mean Response	MA Mean Response	T-test p-value AZ vs. MA
1. significantly increased my knowledge about climate change.	1.6	2.6	0.00013
2. significantly influenced my opinion about climate change.	2.3	3.3	0.00041
3. significantly influenced my knowledge about SRM research.	1.5	1.7	0.27
4. significantly influenced my opinion about SRM research.	1.8	2.2	0.034
5. enhanced my understanding of alternative perspectives to my personal opinion on climate change	2.0	2.4	0.069
6. motivated me to follow the development of SRM research and technologies.	1.8	2.3	0.013
7. motivated me to search for more information on climate change issues.	1.9	2.2	0.21
8. significantly influenced my knowledge about specific research.	2.1	2.9	0.0021
9. significantly influenced my opinion about scientific research.	2.3	3.4	0.00014
10. made me feel that my voice is relevant for scientific experts and policy makers in the field of SMR research.	2.1	2.6	0.027
11. helped me learn significantly more about participatory decision making.	2.0	2.2	0.33
12. makes me want to participate in another participatory process that assesses scientific research.	1.3	1.7	0.018