



Open Access This file is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. In the cases where the authors are anonymous, such as is the case for the reports of anonymous peer reviewers, author attribution should be to 'Anonymous Referee' followed by a clear attribution to the source work. The images or other third party material in this file are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/>.

Web links to the author's journal account have been redacted from the decision letters as indicated to maintain confidentiality

2nd May 24

Dear Dr Low,

Your manuscript titled "Public perceptions on solar geoengineering from focus groups in 22 countries" has now been seen by our reviewers, whose comments appear below. In light of their advice we are delighted to say that we are happy, in principle, to publish a suitably revised version in Communications Earth & Environment under the open access CC BY license (Creative Commons Attribution v4.0 International License).

We therefore invite you to revise your paper one last time to address the remaining concerns of our reviewers. At the same time we ask that you edit your manuscript to comply with our format requirements and to maximise the accessibility and therefore the impact of your work.

EDITORIAL REQUESTS:

Please review our specific editorial comments and requests regarding your manuscript in the attached "Editorial Requests Table".

*****Please take care to match our formatting and policy requirements. We will check revised manuscript and return manuscripts that do not comply. Such requests will lead to delays. *****

Please outline your response to each request in the right hand column. Please upload the completed table with your manuscript files as a Related Manuscript file.

If you have any questions or concerns about any of our requests, please do not hesitate to contact me.

SUBMISSION INFORMATION:

In order to accept your paper, we require the files listed at the end of the Editorial Requests Table; the list of required files is also available at <https://www.nature.com/documents/commsj-file-checklist.pdf>.

OPEN ACCESS:

Communications Earth & Environment is a fully open access journal. Articles are made freely accessible on publication under a [CC BY license](#) (Creative Commons Attribution 4.0 International License). This license allows maximum dissemination and re-use of open access materials and is preferred by many research funding bodies.

For further information about article processing charges, open access funding, and advice and support from Nature Research, please visit <https://www.nature.com/commsenv/article-processing-charges>

At acceptance, you will be provided with instructions for completing this CC BY license on behalf of all authors. This grants us the necessary permissions to publish your paper. Additionally, you will be

asked to declare that all required third party permissions have been obtained, and to provide billing information in order to pay the article-processing charge (APC).

Please use the following link to submit the above items:

[link redacted]

** This url links to your confidential home page and associated information about manuscripts you may have submitted or be reviewing for us. If you wish to forward this email to co-authors, please delete the link to your homepage first **

We hope to hear from you within two weeks; please let us know if you need more time.

Best regards,

Niheer Dasandi, PhD
Editorial Board Member
Communications Earth & Environment

Martina Grecequet, PhD
Associate Editor,
Communications Earth & Environment
@CommsEarth

REVIEWERS' COMMENTS:

Reviewer #1 (Remarks to the Author):

This paper represents the best, most comprehensive analysis of public opinion of solar geoengineering to date. The author conducted 2 focus groups each in 22 countries, spanning the entire globe. That puts it a notch above any prior such survey-based analyses. It necessarily presents other challenges, firmly intertwined with the method applied here. Focus groups are better than surveys in some respects; they also have some clear limitations. That said, the study is at once novel and comprehensive, and it adds to the existing literature in important ways.

The conclusions drawn in response to "Does the Global South prefer solar geoengineering (particularly, SAI)?" are but one example of the present study's value: "global South focus groups exhibit greater hope but an arguably richer range of concerns for solar geoengineering, in the context of observable inequities in climate action and potential geopolitical conflict." That sentence alone shows the authors' nuanced approach and crisp writing, and the study's value in the present solar geoengineering/SAI debate.

The study provides nuanced discussions of important issues, including e.g. potential "mitigation deterrence"/"moral hazard". There, the authors appear to miss some citations that might add further nuance. In particular, Merk et al (2016) finds no apparent mitigation deterrence in a revealed preference experiment. Merk & Wagner (2024) similarly find no such effect. Cherry et al (2023) find 'crowding in'. All three ought to be cited in the context of any mitigation deterrence discussion.

Then there are other advantages of focus groups vis-a-vis surveys worth highlighting here. For example, surveys of solar geoengineering have a particular tendency to fall prey to acquiescence bias and other framing issues, given the low familiarity of most with the very term. See e.g. Mahajan et al (2019) and Raimi et al (2019), respectively. Both are already cited in a long list of citations of prior surveys -- though Mahajan et al is missing in the reference list, while Raimi et al is cited appropriately. Both Mahajan et al and Raimi et al should also be called out for providing checks on framing, which the present study is able to add to in significant ways.

Lastly, the mitigation deterrence/moral hazard literature list is incomplete without Lin (2013) and Wagner & Zizzamia (2022), both of which provide the broader framing of how and why to expect one or the other, and how to frame either effect in this context.

All that said, this present analysis stands out for another of other reasons not cited anywhere in the solar geoengineering/SAI literature, and definitely for its comprehensive coverage of diverse global perspectives. It deserves speedy publication.

References:

- Cherry, Todd L., Stephan Kroll, David M. McEvoy, David Campoverde, and Juan Moreno-Cruz. "Climate cooperation in the shadow of solar geoengineering: an experimental investigation of the moral hazard conjecture." *Environmental politics* 32, no. 2 (2023): 362-370.
- Lin, Albert C. "Does geoengineering present a moral hazard." *Ecology LQ* 40 (2013): 673.
- Mahajan, Aseem, Dustin Tingley, and Gernot Wagner. "Fast, cheap, and imperfect? US public opinion about solar geoengineering." *Environmental Politics* 28, no. 3 (2019): 523-543.
- Merk, Christine, Gert Pönitzsch, and Katrin Rehdanz. "Knowledge about aerosol injection does not reduce individual mitigation efforts." *Environmental Research Letters* 11, no. 5 (2016): 054009.
- Merk, Christine, and Gernot Wagner. "Presenting balanced geoengineering information has little effect on mitigation engagement." *Climatic Change* 177, no. 1 (2024): 11.
- Raimi, Kaitlin T., Alexander Maki, David Dana, and Michael P. Vandenbergh. "Framing of geoengineering affects support for climate change mitigation." *Environmental Communication* 13, no. 3 (2019): 300-319.
- Wagner, Gernot, and Daniel Zizzamia. "Green moral hazards." *Ethics, Policy & Environment* 25, no. 3 (2022): 264-280.

Reviewer #2 (Remarks to the Author):

The paper reports findings from 44 focus groups from 22 different countries on perceptions of solar geoengineering to manage climate change.

I do not use qualitative data in my research, so I will not speak to the validity/acceptability of the

approach to establishing overarching themes, coding responses and drawing inferences.

The paper offers important insights on the differing perspectives between Global North and Global South countries regarding solar geoengineering technologies.

What I think the paper is missing upfront is a clear description of the research questions the authors seek to shed light on and the methodological approach used to answer those questions. I've read the methods section, but as a reader of the main manuscript it seems like a very loose way to motivate and present research findings.

The research design was clearly focused on the North/South split (half in each) and the urban/rural split (half in each). Given that deliberate design choice, I would expect clear research questions (hypotheses) focused on those two classifications. Those research questions are motivated by previous research (including the recent paper published in Nature Climate Change by the same authors) and so the authors have strong priors.

The results section should also be structured around the main research questions. I fully expected a table with separate columns for North and South so the reader could easily see similarities and differences. Same with urban/rural, a distinction in the design that does NOT loom large in the results section.

In short, an improved manuscript would clearly state research questions/hypotheses, summarize the methodology used to answer these questions and structure the results so it all matches up. The 3 large results tables should be refocused on the North/South, urban/rural divide.

In general the whole paper could use some proof reading and editing (e.g., "inhomogeneous" in Table 1 should be "heterogeneous), but I will leave it there.

Reviewer #3 (Remarks to the Author):

This manuscript reports the results from focus groups conducted in 22 countries split between the global North and South to evaluate public perceptions regarding three proposals for solar geoengineering (SAI, MCB, and a space-based sun shield). The purpose is to “derive a global, ‘horizontal’ benchmark of hopes, concerns, and principles of assessment and governance for further deliberation” (p. 1), and to compare public perceptions and attitudes towards SG across a diverse range of countries.

This large and impressive dataset with textual analyses of themes that emerged across 44 distinct focus group interviews (with a total N of 323 interviewees) offers a novel and important contribution to the growing literature that has begun to examine public engagement and attitudes on SG, and especially on the topic of SAI. Most of the existing research has taken place in only a few countries in the global North, and only a handful of other studies have used deliberative focus groups as a methodology to better understand public perceptions. This is the largest and most intensive effort to study SG attitudes using this methodology I have seen to date.

The manuscript is extremely well-written and the series of Tables that summarize the results from the analyses are easy to read and helpful for navigating the reader through an array of interesting

findings. Some of the key comparisons in the results section focus on rationales for considering SG, themes that emerged in terms of hopes and fears, and perceptions about governance, intergovernmental cooperation, or industry motives. The finding that the calls for public involvement and topical literacy were offset by strong skepticism over the value of public engagement in both the global North and South was quite interesting. The common themes are organized and highlighted nicely in italics throughout the manuscript.

The concluding section highlights four rationales to guide further assessment based on the focus group deliberations across these countries. I liked Figure 2, which summarizes the key takeaways from this impressive data collection, synthesis, and analysis.

The METHODS section was very helpful, and the time and effort that went into sending the materials a week in advance and organizing and holding these interviews in a variety of settings also was impressive.

On page 24, and perhaps earlier when research mentioning low familiarity regarding SG/SAI is mentioned, it seems worth noting that “what participants are in favor of” (lines 650-660) with respect to either research or deployment can be powerfully influenced by exposure to media coverage and prominent frames that have emerged in different contexts.

E.g.,

Baum, Chad M., Livia Fritz, Sean Low, and Benjamin K. Sovacool. "Like diamonds in the sky? Public perceptions, governance, and information framing of solar geoengineering activities in Mexico, the United Kingdom, and the United States." *Environmental Politics* (2024): 1-28.

Bolsen, Toby, Risa Palm, and Russell E. Luke. "Public response to solar geoengineering: how media frames about stratospheric aerosol injection affect opinions." *Climatic Change* 176, no. 8 (2023): 112.

Bolsen, Toby, Risa Palm, and Justin T. Kingsland. "How negative frames can undermine public support for studying solar geoengineering in the US." *Frontiers in Environmental Science* 10 (2022).

Rosenthal, Sonny, Peter J. Irvine, Christopher L. Cummings, and Shirley S. Ho. "Exposure to climate change information predicts public support for solar geoengineering in Singapore and the United States." *Scientific Reports* 13, no. 1 (2023): 19874.

Overall, this is a very impressive piece of scholarship, and I enthusiastically recommend it be accepted for publication.

Reviewer 1

This paper represents the best, most comprehensive analysis of public opinion of solar geoengineering to date. The author conducted 2 focus groups each in 22 countries, spanning the entire globe. That puts it a notch above any prior such survey-based analyses. It necessarily presents other challenges, firmly intertwined with the method applied here. Focus groups are better than surveys in some respects; they also have some clear limitations. That said, the study is at once novel and comprehensive, and it adds to the existing literature in important ways. The conclusions drawn in response to "Does the Global South prefer solar geoengineering (particularly, SAI)?" are but one example of the present study's value: "global South focus groups exhibit greater hope but an arguably richer range of concerns for solar geoengineering, in the context of observable inequities in climate action and potential geopolitical conflict." That sentence alone shows the authors' nuanced approach and crisp writing, and the study's value in the present solar geoengineering/SAI debate.	We thank the reviewer for their kind appraisal, and especially for suggesting that we expand to address gaps on mitigation deterrence, of which they demonstrate leading expertise. Due to formatting requirements, we remove the Fig 1 from in-text, which is in a Powerpoint separate to the main file. It will be included in-text in the final (published) version. Due also to formatting requirements, all tables are grouped at the back of the paper.
The study provides nuanced discussions of important issues, including e.g. potential "mitigation deterrence"/"moral hazard". There, the authors appear to miss some citations that might add further nuance. In particular, Merk et al (2016) finds no apparent mitigation deterrence in a revealed preference experiment. Merk & Wagner (2024) similarly find no such effect. Cherry et al (2023) find 'crowding in'. All three ought to be cited in the context of any mitigation deterrence discussion.	We thank the reviewer for these suggestions and have added these citations.
Then there are other advantages of focus groups vis-a-vis surveys worth highlighting here. For example, surveys of solar geoengineering have a	We have made a further note in the introduction on acquiescence bias; we also provide further detail on how

particular tendency to fall prey to acquiescence bias and other framing issues, given the low familiarity of most with the very term. See e.g. Mahajan et al (2019) and Raimi et al (2019), respectively. Both are already cited in a long list of citations of prior surveys -- though Mahajan et al is missing in the reference list, while Raimi et al is cited appropriately. Both Mahajan et al and Raimi et al should also be called out for providing checks on framing, which the present study is able to add to in significant ways.	surveys and focus groups relate to one another. Thanks as well for catching the omission of Mahajan et al. from the references – it has now been added. While we agree regarding the importance of framing in this context, and indeed we have added some discussion in this vein in response to a recommendation by R3 as well, we prefer not to go too much into detail here – rather, since this paper is focused more on an evaluation of our focus group results against – broadly – the existing landscape of assessment (including a wide range of public perceptions exercises) and governance.
Lastly, the mitigation deterrence/moral hazard literature list is incomplete without Lin (2013) and Wagner & Zizzamia (2022), both of which provide the broader framing of how and why to expect one or the other, and how to frame either effect in this context.	We appreciate the suggestions - we have added these references and content to the literature review regarding mitigation deterrence.
All that said, this present analysis stands out for another of other reasons not cited anywhere in the solar geoengineering/SAI literature, and definitely for its comprehensive coverage of diverse global perspectives. It deserves speedy publication.	We thank the reviewer again!
References: Cherry, Todd L., Stephan Kroll, David M. McEvoy, David Campoverde, and Juan Moreno-Cruz. "Climate cooperation in the shadow of solar geoengineering: an experimental investigation of the moral hazard conjecture." <i>Environmental politics</i> 32, no. 2 (2023): 362-370. Lin, Albert C. "Does geoengineering present a moral hazard." <i>Ecology LQ</i> 40 (2013): 673. Mahajan, Aseem, Dustin Tingley, and Gernot Wagner. "Fast, cheap, and imperfect? US public opinion about	We appreciate this list of references, which has made engaging with them in our study much easier.

solar geoengineering." Environmental Politics 28, no. 3 (2019): 523-543. Merk, Christine, Gert Pönitzsch, and Katrin Rehdanz. "Knowledge about aerosol injection does not reduce individual mitigation efforts." Environmental Research Letters 11, no. 5 (2016): 054009. Merk, Christine, and Gernot Wagner. "Presenting balanced geoengineering information has little effect on mitigation engagement." Climatic Change 177, no. 1 (2024): 11. Raimi, Kaitlin T., Alexander Maki, David Dana, and Michael P. Vandenberg. "Framing of geoengineering affects support for climate change mitigation." Environmental Communication 13, no. 3 (2019): 300-319. Wagner, Gernot, and Daniel Zizzamia. "Green moral hazards." Ethics, Policy & Environment 25, no. 3 (2022): 264-280.	
--	--

Reviewer 2

The paper reports findings from 44 focus groups from 22 different countries on perceptions of solar geoengineering to manage climate change. I do not use qualitative data in my research, so I will not speak to the validity/acceptability of the approach to establishing overarching themes, coding responses and drawing inferences. The paper offers important insights on the differing perspectives between Global North and Global South countries regarding solar geoengineering technologies.	We appreciate the reviewer's engagement with qualitative research. Due to formatting requirements, we remove the Fig 1 from in-text, which is in a Powerpoint separate to the main file. It will be included in-text in the final (published) version. Due also to formatting requirements, all tables are grouped at the back of the paper.
What I think the paper is missing upfront is a clear description of the research questions the authors seek to shed light on and the methodological approach used to answer those questions. I've	We thank the reviewer for this suggestion. We are held back from a full explication of research questions and methods because of the formatting requirements of CE&E (and all Nature

read the methods section, but as a reader of the main manuscript it seems like a very loose way to motivate and present research findings.

journals), which calls for a short, up-front introduction of research aims, and placing long-form research questions and methods to the Methods section that follows the main text.

The full set of questions that underpinned the focus groups questioning can be found in the discussion guide in the Methods. In the Methods, we also note that the mixed methods framework of our project, while highlighting that this paper concentrates on the focus groups.

However, we take steps to engage with the reviewer's suggestion, and present a "tighter" way to motivate and present research findings.

We restructure the introduction to (1) introduce solar geoengineering, (2) surveys and focus groups as twinned engagement methods in solar geo research, (3) highlight themes from the public perceptions literature that we want to expand upon with our study, and (4) highlight our research aims and foreground results.

In the intro, we expand the leading sentence on the research aim/question to "In this work, we inquire after a range of public perceptions across the global North and global South regarding prospective benefits, risks and corresponding governance of three major types of solar geoengineering."

The intro also explicates: "We map key technical and societal issues that focus groups raise on particular approaches, and how these translate to preferences – and varying degrees of trust – for named actors (expert networks, civic organizations, countries, and intergovernmental frameworks), mechanisms (kinds of assessment, funding, and policy), and rationales (underpinning intents for governance).

	Our discussion further maps gaps and overlaps between how publics view the prospective development or deployment of solar geoengineering approaches, and how they are emerging in assessments and experiments, innovation, and decision-making.”
The research design was clearly focused on the North/South split (half in each) and the urban/rural split (half in each). Given that deliberate design choice, I would expect clear research questions (hypotheses) focused on those two classifications. Those research questions are motivated by previous research (including the recent paper published in Nature Climate Change by the same authors) and so the authors have strong priors.	We thank the reviewer for their suggestions. We have now more clearly inserted reference to global North and global South groupings and dimensions into the introductory text on research aims. We do however note that any prior article, although part of the same project, draws on a substantially separate set of data, given that it draws exclusively on survey data. Moreover, we are not sure how that fact, or a general interest in (emergent) differences between global North and global South, can be construed as our having “strong priors”. We also ask the reviewer to consider that qualitative research questions do not always have to be expressed as hypotheses. Our research questions are more open-ended and inductive, although centered around “key technical and societal issues that focus groups raise on particular approaches, and how these translate to preferences – and varying degrees of trust – for named actors (expert networks, civic organizations, countries, and intergovernmental frameworks), mechanisms (kinds of assessment, funding, and policy), and rationales (underpinning intents for governance).” Finally, we do not refer to urban versus rural dimensions because this is the subject of another manuscript in preparation. We now note this in the Methods.
The results section should also be structured around the main research questions. I fully expected a table with	We ask the reviewer to consider that the multi-component nature of our research question forces choices in reporting

separate columns for North and South so the reader could easily see similarities and differences. Same with urban/rural, a distinction in the design that does NOT loom large in the results section.	structure. There are 3 main components by which we could have structured results reporting as can be seen in the main research aim: “In this work, we explore a range of public perceptions and deliberations (1) across the global North and global South regarding (2) prospective benefits, risks and corresponding governance of (3) three major types of solar geoengineering.” We chose to structure the results headings around (2), while additionally demonstrating nuances on (1) and (3) in the content of the results. The reviewer will note that there is significant documentation on nuances between global North, emerging South, and developing South in almost every subsection. However, what we want to focus on, in conclusion, is “a global benchmark of hopes, concerns, and expectations of assessment and governance for further deliberation.” The way we have structured our results builds more sensibly towards that aim, and is line with the exploratory nature of the research conducted. The tables are formed around (2), and thus reflects them. Relative emphases between between global North, emerging South, and developing South are noted in the second column (noting where the themes of column 3 are mentioned), and also summarized in Figure 1. Again, we do not refer to urban versus rural dimensions because this is the subject of another manuscript in preparation. We now note this in the Methods.
In short, an improved manuscript would clearly state research questions/hypotheses, summarize the methodology used to answer these questions and structure the results so it all matches up. The 3 large results	We agree; we have given our responses to this summary in previous comments. Again, nuances between global North, emerging South, and developing South are present – but in content rather than in the sub-headings structure.

tables should be refocused on the North/South, urban/rural divide.	We ask the reviewer to consider also that the other two reviewers have endorsed the structure of the paper, the reporting of the themes, and the timeliness and novelty of the research. It is not clear how these two reviewers would respond to a comprehensive reorganization of the results section - not to mention, the focus of the current article is fundamentally exploratory in nature.
In general the whole paper could use some proof reading and editing (e.g., "inhomogeneous" in Table 1 should be "heterogeneous"), but I will leave it there.	We have undertaken further proof reading and editing.

Reviewer 3

This manuscript reports the results from focus groups conducted in 22 countries split between the global North and South to evaluate public perceptions regarding three proposals for solar geoengineering (SAI, MCB, and a space-based sun shield). The purpose is to “derive a global, ‘horizontal’ benchmark of hopes, concerns, and principles of assessment and governance for further deliberation” (p. 1), and to compare public perceptions and attitudes towards SG across a diverse range of countries. This large and impressive dataset with textual analyses of themes that emerged across 44 distinct focus group interviews (with a total N of 323 interviewees) offers a novel and important contribution to the growing literature that has begun to examine public engagement and attitudes on SG, and especially on the topic of SAI. Most of the existing research has taken place in only a few countries in the global North, and only a handful of other studies have used deliberative focus groups as a methodology to better understand public perceptions. This is the largest and most intensive effort to	We thank the reviewer for their kind assessment. Due to formatting requirements, we remove the Fig 1 from in-text, which is in a Powerpoint separate to the main file. It will be included in-text in the final (published) version. Due also to formatting requirements, all tables are grouped at the back of the paper.
--	---

study SG attitudes using this methodology I have seen to date.	
The manuscript is extremely well-written and the series of Tables that summarize the results from the analyses are easy to read and helpful for navigating the reader through an array of interesting findings. Some of the key comparisons in the results section focus on rationales for considering SG, themes that emerged in terms of hopes and fears, and perceptions about governance, intergovernmental cooperation, or industry motives. The finding that the calls for public involvement and topical literacy were offset by strong skepticism over the value of public engagement in both the global North and South was quite interesting. The common themes are organized and highlighted nicely in italics throughout the manuscript.	These are helpful insights and comments, which reflects clear knowledge of the field. Regarding italicized themes: Unfortunately, the formatting requirements of Communications Earth & Environment demand that we remove all italics from the text. However, the themes and text remain otherwise unchanged.
The concluding section highlights four rationales to guide further assessment based on the focus group deliberations across these countries. I liked Figure 2, which summarizes the key takeaways from this impressive data collection, synthesis, and analysis.	We are happy that Figure 2 (now Figure 1) makes sense!
The METHODS section was very helpful, and the time and effort that went into sending the materials a week in advance and organizing and holding these interviews in a variety of settings also was impressive.	We thank the reviewer for this appraisal of the methodological design.
On page 24, and perhaps earlier when research mentioning low familiarity regarding SG/SAI is mentioned, it seems worth noting that “what participants are in favor of” (lines 650-660) with respect to either research or deployment can be powerfully influenced by exposure to media coverage and prominent frames that have emerged in different contexts. E.g., Baum, Chad M., Livia Fritz, Sean Low, and Benjamin K. Sovacool. "Like diamonds in the sky? Public perceptions, governance, and	Thanks for raising this point – we agree on the relevance of media framing for these technologies, particularly given the present lack of familiarity. We are happy to engage with these articles in this vein, and we have added this content and the suggested citations.

information framing of solar geoengineering activities in Mexico, the United Kingdom, and the United States." <i>Environmental Politics</i> (2024): 1-28. Bolsen, Toby, Risa Palm, and Russell E. Luke. "Public response to solar geoengineering: how media frames about stratospheric aerosol injection affect opinions." <i>Climatic Change</i> 176, no. 8 (2023): 112. Bolsen, Toby, Risa Palm, and Justin T. Kingsland. "How negative frames can undermine public support for studying solar geoengineering in the US." <i>Frontiers in Environmental Science</i> 10 (2022). Rosenthal, Sonny, Peter J. Irvine, Christopher L. Cummings, and Shirley S. Ho. "Exposure to climate change information predicts public support for solar geoengineering in Singapore and the United States." <i>Scientific Reports</i> 13, no. 1 (2023): 19874.	
Overall, this is a very impressive piece of scholarship, and I enthusiastically recommend it be accepted for publication.	We thank the reviewer again!