Review of Co-Reviewer #1 and #2

Of “Resilient Stratospheric Aerosol Injection is Cooperative”

Authors: Jared Farley, Douglas G. MacMartin, Daniele Visioni, Ben Kravitz, Temitope S. Egbebiyi, and Burgess L. Power

Both co-reviewers: General comments:

This piece attempts the outline of different SAI imaginaries without any clearly outlined method. The scenarios the authors invent and assess vary by deployment volume, location, and timing. Using an emulator of two Earth system models (CESM2-WACCM and HadGEM-GC3.1) that have some capability to represent SAI climate effects, the authors evaluate the climate effects in terms of global mean temperature and hemispheric temperature gradient changes. In an irreprehensible or freely rambling manner, they discuss certain desirables or non-desirables in the scenarios.

Key assumptions in scenario development include antiquated and un-evidenced conceptions of a world of global “great powers” and “middle powers,” as well as the equivalence of cooperative and globally balanced deployment. Nations are loosely associated with deployment latitudes. These assumptions are all hidden and not clearly stated. The finding the authors present in the suggestive title and abstract is unfounded in the novel evidence and inference presented.

None of the sections of this piece fulfil the standards of a scientific research paper. The introduction does not introduce a research gap and how the authors attempt to fill it but is a lengthy abstract of what the authors ensue to do. The entire method section does not include a single mention of how they test the reliability of different scenarios they claim to assess in title, abstract and introduction, and only offers a cursory (several line) discussion of the setup’s limitations. Sections 3 and 4 discuss findings mostly without stating the underlying result of physical modelling with the help of the emulator, replacing such result statements with numerous references to figures and subfigures. Section 5, apparently conceptualized as discussion section is a seemingly unstructured glance at different intentions and preferences of the authors, skipping any contextualization or discussion of methods, reliability of analysis or limitations. The implied underlying motivations of the authors—to provide pseudo-scientific rational for SAI deployment across geopolitical scenarios rather than a hypothesis-driven investigation—become evident throughout the piece.

We recommend rejection without reservation.

Co-reviewer #1: Line-by-line comments:

Lines 6-7: Do you really? It seems like you show that SAI that mitigates certain physical effects requires certain deployment patterns. From our understanding, this work lacks social science that actually shows that this deployment needs to be cooperative.

Lines 7-9: In our understanding (that lacks a formal background in social sciences) this statement and related elaborations in the main text are unproven hypotheses that would require actual dedicated investigation with methods of social sciences and humanities.

Line 11 “method that injects” is a jargonized, wrong expression. Correct for precision.

Line 13: A sentence introducing the attention to SAI at the scale to lower global near-surface temperature in the orders of magnitude 0.1-1 K would benefit readers new to SAI research.

Lines 15-16: This sentence could be reformulated from a partly tautological conditional sentence to a much clearer wording: A statement of the obvious possibility of deployment intensity reduction by certain actors under stress. We propose something along “Naturally, stress by e.g. natural disasters, logistical difficulties, or political changes, could lead to reductions of deployment intensity by affected actors.”.

Line 24 “simulated SAI scenarios”: Again, highly jargonized language that might be difficult to understand outside climate science. We propose “Most scenarios constructed for climate model simulations …”

Line 27 Diao et al. 2024: reference it preprints of published paper. Use the latter.

Line 28-30: Where do you prove that a coalition is more reliable than a single actor? And if this is state-of-the art knowledge in game theory and international relations, why do you present it as key finding in your title and abstract?

Line 28-40: the style of this introduction is confusing to us. You provide a surprisingly detailed outline of highlighted findings without establishing and promising to fill a research gap.

Line 38-39: the wording here is very unclear given the dual use of "deployment" for a cooperation strategy and the actual injection.

Line 41: The entire method sections does not include a single mention of how you test the reliability of different scenarios you claim to assess in title, abstract and introduction.

Line 47 “emulated”: “its emulation being presented”

Lines 47-54: Providing this information in one sentence only makes it unreadable. Split up please.

Line 56 “which mostly holds”: When does it and when not (beyond the later mentioned AMOC changes)? Provide the key information summarized and not let the reader trust you or read another entire paper.

Line 59 “does not have variability`, but we are controlling …”: Please reformulate to a sentence that does not have a different grammatical subject every few words and provide a reference for the statement about negligible impact of variability on the

Line 61-62: this is hard to understand and contextualize in this brevity and without reference. Do you mean the challenging and maybe impossible evaluation of CESM2-WACCM6 response to large-scale SAI?

Line 65: Do I understand correctly that these are the lengths of orthogonal vectors in gridded temperature space and therefor can be targeted independently? And if so, this might help to explain what you try to convey in lines 63-64.

Formula T_0 and T_1: please enumerate all formulas. I highly recommend to use discrete notation as this is what you actually do, given the discrete nature of the ESMs behind and CIDER.

Line 72 “this strategy”: which strategy?

Section 3: this entire section is written in a very uninformative way. It does not state results, it follows the pattern “<Fig. XYa> shows that <high-level finding>”. This way, from the text, it is impossible to understand what the authors find in terms of emulation results. Instead of presenting results and discussing them, the text outlines a seemingly arbitrary number and composition of scenarios and their potential effects on T_0 and T_1.

Fig. 1: The choice of colours in not colour-blind friendly despite the relative simplicity given the simple structure of the plot. Different line styles or a brightness/saturation gradient from North to South would also make the picture clearer for colleagues able to see colours. The vertical axis labelling would profit from a label “northern hemisphere warmer” vs. “southern hemisphere warmer”.

Figure caption: “for 35 years” leaves unclear whether the lines are interpolation between T0, T1 = 0 and the values at t = 35 years in the plotting or whether you are visualizing results of CIDER over time. What is the comment “Although there exists uncertainty…” doing in the figure caption? It sounds like a statement for a discussion section.

Line 85: “N-S” was never introduced as abbreviation.

Section 4: This section seems to completely overcome the discussion of results and their interpretation in this order. Assumptions, results, findings, limitations, findings without the presentation of results seem to mix over the entire stretch making it impossible for a reader of an adjacent field in climate science to tell which of the findings follow from scenario assumptions, which of them are deducible from emergent properties of results across scenarios, and which of them are true but not novel statements. As the authors state in lines 119-120: “A myriad of additional variations arise when considering alliances of middle powers, or low-capacity actors sponsored by great-powers, enabling them to engage in deployment beyond their individual capacity.” However, this section fails to structure the myriad of scenarios and justify sub-selections or to scan them systematically.

Section 5: This section is a messy collection of statements ranging from personal preferences, personal intentions with this piece, and subjective, intuitive comments about SAI geopolitics. Its far from what a discussion section is established as a good practice for: the contextualization of findings in light of related work and methodical limitations.

Line 131 “this strategy”: Here, you suggest the output of this paper to be a specific strategy. This sounded differently above.

Line 134-136: Here you seem to role out intentions that are unrelated to knowledge gain, very surprising to find as research article. Maybe these intentions point to another publication format than a research article?

Line 137 “strategy is particularly user-friendly”: How can a strategy be user-friendly?

Line 138 “with an understanding … to be pursued”: I do not understand what you mean.

Line 139 “G6-SAI-1.5K”: not introduced term.

Line 140 “X°N+Y°S”: term not introduced.

Line 144 “This does not mean we like the notion of power grabs” is exemplary in tone and intention for how this piece discusses the work put forward: in a rambling discussion of what might be desirable or undesirable procedures or outcome without clearly presented research methods from fields that address questions around procedures, power dynamics, and game theory (see comment on method section).

Line 145-146 “this control algorithm”: where do you clearly define a control algorithm? We have not seen this in the paper.

Line 156 “N-S strategy”: Abbreviation not introduced. In the context of geopolitical strategies, this is particularly confusing.

Co-reviewer #2: Line-by-line comments:

Line 13. Do they also not have other cooling/warming effects in the atmosphere as well as the surface?

Counter global warming – is that a fair assessment of what it does? “Counter”?

Line 14-15. This sentence doesn’t make sense. SAI strategies must contend with the fact that they rely on themselves? (i.e., the presence of aerosols?). Rephrase. SAI is dependent on continuous aerosol deployment.

Line 15-16. Odd formulation. Frame around the deployment, not the actor. If deployment is interrupted.

Line 17. Biggest physical risks according to whom?

Line 21. What is a climate velocity?

Line 24. Most simulated SAI scenarios make efforts to avoid? What does this mean – that they do not propose differentially-deployed SAI?

Line 30. Don’t know what this means either – “chosen objectives?”? Very vague language.

Line 37 – “Common issues in geopolitics.” This is a four-letter phrase with gigantic implications qualified only by vaguely that follows, with no attribution or citation. Common among whom? What is a “great power” (why are we using what might be considered 19th century colonial language?)? Alignment among a global community along what lines? Conflict meaning war? Disagreement? What “strategy’s development”? Clear discussion of the envisioned actors here rather than coded language is needed. What is a middle power? If you’re modeling a “real” earth system you should include real actors in your scenario development.

Line 98 – Unclear what this means.

Line 101 – “While latitude doesn’t matter…” is this because of the varied deployment strategies shown in Figures 2 and 3?

Line 102 – What is a “climate distribution?”

Line 105 – a linear addition of available latitude… i.e., there are only so many latitudes over which SAI could be deployed?

Line 108 – (and above) – I don't understand the implied cone.

General Comment to this section: If SAI is deployed by airplanes, which is it only the case that countries can deploy in specific latitudinal bands? Can't airplanes cross latitudes? Or are we assuming that a nation will not be allowed to deploy SAI in another nation's airspace? What about the ocean? That seems like a large scenario assumption that should be clearly stated.

Line 112 – Where are these classifications of low-, middle- and high-capacity coming from? Why is Germany, for example, separated from the European Union? Why are UK and Germany separate from NATO? Why do you choose nation states rather than coalitions? Fine to do so, but certainly this should be stated for your scenario justifications.

Line 120 – Absolutely no citations in this section, or elsewhere. I have a strong feeling that social scientists, economists, political scientists—all would take great issue with the unjustified assumptions made here. This reads like an op-ed with modelling attached.

Line 132 -- "In a world where SAI is deployed, bad actors must be taken as seriously as a global threat as climate change itself; after all, they can try to cause it." I honestly don't even know what this means. My understanding of SAI is that the intention is to change climate? (i.e., cool it?)?

Line 133 – 134. I wanted to believe that this was perhaps at least a hypothesis driving this work, but this line "If geoengineering is deployed, we believe the ones who should get to control the climate are those with an interest in global well-being. We wanted to encourage cooperation, coalition, and democratic decision-making, rather than control by a hegemonic superpower. In fact, we wanted a strategy that would be difficult for a single actor to shut down (whether from fear of chemtrail conspiracies or fear of something being outside its control)" demonstrates to me not only the problematic nature of this study, but one I've seen within the broader SAI research community. This "research" is meant to be proscriptive, designed to prove a point, not to test a hypothesis. It underscores the highly flawed and potentially politically-motivated nature of this study, which had its whispers throughout the text but becomes abundantly clear in the discussion. The authors are seeking out strategies for deployment of SAI that is "resilient" (it is not clear that they conceive of resilience as it is conceived of elsewhere in the Earth system resilience community"). They make no (or at least little, nominal) acknowledgement of the risk of SAI deployment itself. They likewise make no pretenses that this study has been conceived of as hypothesis-driven research at all.

Line 137 – "this strategy is particularly user-friendly". Who is the user? As a reader, very little about the work presented here was user-friendly. Rather, the contrary.

Line 143 – "we wish to avoid global risks once this meets the real world". Again, I'm left with serious concerns about the motivations behind this work.