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Earth System Dynamics
Discussions

Interactive comment on "Expanding the Design Space of Stratospheric Aerosol Geoengineering to Include Precipitation-Based Objectives and Explore Trade-offs" *by* Walker Lee et al.

Walker Lee et al.

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For convenience, we reproduce the original reviewer comments in **bold**. Our responses are provided in plain text.

Reviewer's general comments: In this study, the authors explore how different climate objections could be met by injections of sulfate aerosols at four locations, based on theories developed in previous works. Different climate objections are represented as the 2-D surface in a 3-D graph, and the possibility to achieve multiple goals is evaluated by the relative relationship among these surfaces, which are further evaluated using model simulations. This work offers a

new way to examine the relationship between experiment designs and outcomes and help evaluate limits and trade-offs of aerosol injection geoengineering. I just have some minor comments:

We thank the reviewer for their assessment of our work, and respond to each of their comments individually below. For convenience, we repeat each of the reviewer's comments here, with our responses provided after each comment.

I would appreciate it if the author could provide more explanations or details about how the form of Eq.1 to Eq.3 in the paper is derived based on previous literature. Accordingly, I am not sure I fully understand how the mathematic form of the constraint (line 125) is derived. I would like to see this if possible.

We have added more detail to the paragraph preceding Equations 1-3 to explain the derivation and physical interpretation of these equations in greater depth. Additionally, we have added more detail to the relevant paragraph to describe how the constraint equation is derived from Equation 4.

Line 249: The global mean T and P cannot be managed at the same time using current injection design, but might be possible under other frameworks (e.g., Cao et al. 2017), which could be made clear here. REF: Cao, L., Duan, L., Bala, G., Caldeira, K. (2017). Simultaneous stabilization of global temperature and precipitation through cocktail geoengineering. Geophysical Research Letters, 44(14), 7429-7437.

We thank the reviewer for bringing this manuscript to our attention. We have added a reference to these results and their implications to the relevant paragraph.

Line 420: The author conducted simulations that attempt to simultaneously restore three different climate variables, and evaluated the percent restoration in Eq.5. Since nor of these simulations are able to restore all three climate goals, I think this raises the question about "what's the most optimized climate state

that has the smallest damages to the society". I am not saying this should be done in this paper, but later maybe consider to balance different climate goals and use an overall restoration score for all these climate goals (and maybe also consider side effects on other variables, such as precipitation) would be helpful.

We thank the reviewer for raising an important point of discussion. As discussed in line 420, we do not include an overall "score" for how well each simulation performed in meeting its goals. This is because we do not wish to claim that a simulation performed "better" or "worse" than another, even if one came objectively closer to meeting its goals. This is because such a score would either require weighting of climate goals by relative importance, or the implication that all goals considered in this study are equally important. Such judgements are inherently subjective; even though financial impacts might be quantifiable, there are many other impacts to consider when determining if one outcome is "better" than another. However, it is an important topic to consider, and as such, we have added some text emphasizing the diversity of SAI strategies and some commentary on the weighting or aggregation of impacts.

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