Earth System Dynamics Discussions

Earth Syst. Dynam. Discuss., referee comment RC2
https://doi.org/10.5194/esd-2021-70-RC2, 2021

Comment on esd-2021-70

Anonymous Referee #2

Referee comment on "How large is the design space for stratospheric aerosol geoengineering?" by Yan Zhang et al., Earth Syst. Dynam. Discuss., https://doi.org/10.5194/esd-2021-70-RC2, 2021

The manuscript provides and demonstrates a mathematical method to quantify the degree of freedom of stratospheric aerosol injection (SAI) geoengineering. The authors transform the simulated AOD pattern and temperature and precipitation responses to the vectors in multi-dimensional spaces and explore their relationship, then use it to search the meaningfully-independent injection choices. As there are lots of possible injection choices in SAI geoengineering research, the manuscript will be useful to guide future SAI studies, although the sample space used in this study is limited due to available SAI simulations and all samples are based on a single earth system model. In general, the manuscript is well written and fits the scope of the ESD. However, the manuscript uses some specific mathematical tools, it is necessary to make the manuscript more readable for a wider geoscience community.

Minor points:

1. As similar AOD patterns yield similar climate responses but different AOD patterns do not guarantee different climate responses, how does this might affect searching the meaningfully-independent injection choices?

2. The AOD patterns are constrained by the stratospheric circulation and lifetime of the aerosol. Is it feasible to explore more possible AOD patterns by using widely available non-geoengineering CMIP simulations? With more AOD patterns, the sample space can be well expanded.

Technical points:

L34-35: Please clarify why the number of independent injection choices is equivalent to the number of independent climate goals.

L136-139: Please clarify the definitions of the length of vector and the angle between the vectors.

L261: Do the vectors of T and P responses adopt similar definition for the vectors of AOD pattern? If yes, it is better to explain them together.

L263: Define the abbreviation "EQ" at its first appearance.

L429: Extreme events can be part of future consideration due to their profound impacts on social and economic activities.

Figure 9, 10 and 11: Please explain their x & y axes.