Response to Reviewer 3

We thank the reviewer for careful reading of our manuscript and constructive comments. Our responses to the reviewer's general and specific comments are given below in italics following each comment. Considering the issues raised by the reviewer has allowed us to improve our manuscript by clarifying these issues in the text. We are grateful for the reviewer's time and thoughtfulness.

- This study investigates the implications of using SO_3 or H_2SO_4 instead of SO_2 in deliberate emissions in the stratosphere in order to modify Earth's climate. Using SO_3 or H_2SO_4 would produce smaller particles (accumulation mode – AM-H_2SO_4) which are more radiative effective than those formed from emissions of SO_2. The effects of geoengineering with AM-H_2SO_4 is investigated using three global climate models. The effects on the stratospheric size distribution, aerosol load, temperature, water vapour and ozone as well as the radiative effects are investigated. All models show that there is increased radiative efficiency using AM-H_2SO_4 but there are large intermodel differces.

  The study is well performed and many different aspects of using AM-H_2SO_4 instead of SO_2 is investigated. This type of investigation using three models in one study has not been performed before. The three models used in the study have different strength and weaknesses in their representation of the stratosphere which gives relevant information of the uncertainties in the modelling geoengineering in the stratosphere with AM-H_2SO_4 and SO_2. The paper is well written in general and has a clear structure. The paper is well within the scope of ACP and I recommend publication after the following comments has been addressed.

  General comments:

  It would be interesting to include a short discussion on the feasibility of using SO_3 or H_2SO_4 instead of SO_2 and whether one of the options is more technically challenging than the other one.

  We have added a sentence regarding the technical and engineering challenge of using SO3 or H2SO4 and included two references, Smith et al., 2018 and Janssens et al., 2020.

  Specific comments:

  Page 6, line 27: Why were the emissions released at different heights in the different models?

  This was a function of the model's vertical grid resolution and necessary conversion from altitude to pressure level.

  Page 6, line 30: I miss an explanation or motivation of the choice of the different injections and injections points. What was the scientific motive for choosing those emissions and emissions points? Which scientific questions could be answered with these?

  We added more explanation of the injection patterns in the scenario descriptions in Section 2: "The regional injections are designed to utilize the Brewer-Dobson circulation to distribute emissions globally and maximize their residence time, as has been observed for volcanic aerosol clouds (Dyer, 1968; Grant et al., 1996). The 2point injections occur outside the tropical stratospheric reservoir (Grant et al., 1996; Tilmes er al., 2017) and are meant to concentrate geoengineering impacts at higher latitudes and to explore microphysical differences when injections are more concentrated spatially."

Page 12, line 26: “main particle size distribution from an R_g”. What is the main size distribution R_g? R_g was defined as the mode radii value, but the main size distribution cannot have one mode radii value.

Corrected to be the accumulation mode.

Page 24, line 11-16. There is quite a lot of discussion here that has not been included previously in the manuscript. The section head should perhaps be changed from “summary and conclusion” to “summary and discussion.”

Adopting this suggestion.

Technical corrections:

Page 9, line 7: It is a bit vauge to start the sentence with ”This figure” no figure has been mentioned for several sentences.

Replaced “This figure” with “Figure 2”.

Page 10*, line 10-14. This sentence is very long. Please divide it.*

Done.

Page 13, line 7: This sentence is awkward, please revise.

Revised to read: “The size distributions respond differently to 2point rather than regional injections depending on whether SO_2 gas or AM-H_2SO_4 particulate is injected. These results suggest the way aerosol microphysics drives differences between AM-H_2SO_4 and SO_2 injection scenarios (see Table 3).”

Figure 11: The legend in this figure uses SO_2 and H_2SO_4 to denote the simulations rather than AM-H_2SO_4as in the rest of the manuscript. Please revise for consistency.

Corrected.

Reply

Citation: https://doi.org/10.5194/acp-2021-569-RC3