EGUsphere, referee comment RC1
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Comment on egusphere-2022-401

Anonymous Referee #1

Referee comment on "Climate response to off-equatorial stratospheric sulfur injections in three Earth system models – Part 1: Experimental protocols and surface changes" by Daniele Visioni et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-401-RC1, 2022

Review of Visioni et al. Climate response to off-equatorial stratospheric sulfur injections in three Earth System Models – Part 1: experimental protocols and surface changes

General comments

In this study, the authors investigate how stratospheric aerosol intervention (SAI) using SO_2 injections at different latitudes affects the aerosol distribution, aerosol optical depth, and surface climate (temperature and precipitation) in three different Earth System Models. The authors find differences between the models and also between different aerosol setups in the same model. The authors then describe the development of feedback algorithms to be used in future simulations to manage injections of SO_2 to meet temperature targets as the runs proceed. In general, the paper is clear and easy to read, and the analysis is logical. The results will be of interest to the geoengineering community and the paper is well-suited to ACP. I have two main comments that I suggest the authors consider before publication:

Given the focus on aerosol microphysics driving differences between these results, can the authors highlight how the aerosol schemes differ between the models, not just in terms of the modal properties (Table 1), but how the aerosol processes are treated? It's mentioned on L145 that condensation is treated differently in GISS, but how? Given the differences found for effective radius, it would be useful to show (perhaps in the SI) some of the other aerosol metrics such as SO_2 conversion (highlighted on L419 as an important discrepancy), the nucleation, condensation and coagulation rates, and fluxes between the modes, and explain how these parameterizations differ between the models. Can we learn more here about these uncertainties compared to multi-model volcanic eruption studies that have already shown that differences in AOD are due to different microphysical schemes? What specific areas of improvement have been found in this work as stated in the conclusions at L395?

Section 5 - without going back to previous references (such as Kravitz et al., 2017), this section was hard to follow, especially for someone not familiar with such feedback algorithms. It would be useful if the mathematical relationships were described further in the text and that all letters and symbols were defined and listed immediately after the equations – for example, *q* and equations for T0 – T2. It would also be helpful if the section was more explicit with signposting to the relevant subplot or line on Figure 10 – e.g., expanding L374 to 'pattern 'of AOD' similar to the target (black dashed lines)', or similar. It was also not clear to me how the feedback algorithms are different/similar to previous work and what the implications are.

Specific comments

Abstract: an extra sentence at the end summarizing the overall implications of this work would be useful. It was also not clear whether all models included modal aerosol microphysics schemes. I would suggest introducing the 4 model setups at the start

L30-L35: A few more relevant references could be added here e.g., Zanchettin et al. (2016; 2022).

L82: It was unclear at this stage what these targets are

L121: What are the differences in the aerosol scheme?

L149: Please clarify what you mean here

L181: Why AOD and not SAOD? Please also describe the overall evolution of this figure – i.e., the ~2 years of adjustment and therefore why the last 7 years are used in subsequent averages

L235: How is the lifetime defined? Please remove 'obviously'

L253: Is this wet or dry radius? Fig. SX --> Fig. S1.

L263: What are the dynamical differences? Do the authors have an explanation for the

stronger poleward transport in CESM given also the differences in particle size? Why is the transport in the 15S case more similar to GISS modal?

L279: The initial results shown between the global mean AOD and global mean temperature in Figure 1 could also be discussed here.

L289 – L305: I found this hard to follow. Has the sensitivity to aerosols in GISS been increased or not?

L310-311: Unclear exactly what you mean here

Figure 7: What's causing the different response for CESM2 and UKESM for 30N compared to the other injection locations?

L314: I would suggest moving the overall description of the precipitation changes from the second paragraph to here as it is a long time before the results are described. What about the global percentage changes shown in Figure 8?

L336: shown on left hand side of Figure 8?

L338: There are several newer studies on the impact of eruptions on the ITCZ that could be cited here. Please see Marshall et al. (2022) for some examples.

Figure 10 caption: Please explain what L0, L1 and L2 are and label the black dashed lines.

L346: I think it would be helpful to state what these are here, as is done in the conclusions

L399: This paragraph focuses on the methods, but what are the actual results? How do the results differ depending on the injection location?

L447: This last sentence is difficult to follow

Technical corrections

L3: occurs

L23: please add numbers for the three items in this list

L69: only --> one

L71: a --> the

L84: impacts

L86: in --> with?

L120: eruptions

L208: shows

L209: standard deviations

L211: check commas

Figures: please check all x and y labels are present (missing from 2, 6 and 8) and remove red/green line combinations

L312: 2020 --> 2021

L318: clouds --> cloud

L320: is --> are

Figure 8 caption: five --> seven

L441: insert ‘than’

L444: seems

References

Marshall, L.R., Maters, E.C., Schmidt, A. et al. Volcanic effects on climate: recent advances and future avenues. Bull Volcanol 84, 54 (2022). https://doi.org/10.1007/s00445-022-01559-3

Zanchettin, D., Khodri, M., Timmreck, C., Toohey, M., et al. The Model Intercomparison Project on the climatic response to Volcanic forcing (VolMIP): experimental design and forcing input data for CMIP6, Geosci. Model Dev., 9, 2701–2719, https://doi.org/10.5194/gmd-9-2701-2016, 2016.

Zanchettin, D., Timmreck, C., Khodri, M., Schmidt, A., et al. Effects of forcing differences and initial conditions on inter-model agreement in the VolMIP volc-pinatubo-full experiment, Geosci. Model Dev., 15, 2265–2292, https://doi.org/10.5194/gmd-15-2265-2022, 2022.