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Geoscientific Model Development Discussions

Interactive comment on "Improved tropospheric and stratospheric sulfur cycle in the aerosol-chemistry-climate model SOCOL-AERv2" *by* Aryeh Feinberg et al.

Claudia Timmreck (Referee)

claudia.timmreck@mpimet.mpg.de

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The paper describes the various improvements and development steps from the aerosol-chemistry-climate model SOCOL-AERv1 to its updated version SOCOL-AERv2. In SOCOL-AERv2 several updates to the model have been implemented, e.g. interactive deposition schemes have been added, sulfate mass conservation has been ensured, and the tropospheric chemistry scheme has been extended. Results of both versions as well as of intermediate steps are compared with each other and to observational data in a sufficient manner. While the SOCOL-AERv2 results show with respect to stratospheric aerosol observations similar levels of agreement as SOCOL-

AERv1, the interactive deposition schemes in SOCOL-AERv2 lead to a much improved agreement with observed data. Overall SOCOL-AERv2 seems to be better suited to study the atmospheric sulfur cycle as its predecessor version.

This is a really nice paper and it was a pleasure to review it. In my opinion it is an excellent example how a paper in GMD should look like. The paper is well written, the abstract provides a concise and complete summary and the figures are nicely prepared. The different model steps are clearly outlined, scientifically sound and the applied methods and assumptions are valid. The different development steps are well documented and sufficiently explained. The reasoning behind the described procedure is clear. All model updates have a beneficial impact and make sense. Critical issues as deterioration from SOCOL-AERv1 to SOCOL-AERv2 for the extinction in the lower stratosphere and possible reasons for it are discussed as well.

I recommend the paper for publications after minor revisions

Specific comments:

Page 3, line 14: Please cite Zanchettin et al. (2016) as VolMIP reference

Page 4, line 11: If you give a reference for MEZON, please add also a reference of MA-ECHAM5 e.g. Giorgetta et al., (2006)

Page 17, line 14-18 wonder if the agreement between OPC data and model results for the larger particle sizes could be improved if one compare for Laramie not only the annual mean but also seasonal averages

Page 21, section 3.4.1.: As the authors mention, the precipitation fields in the model might not be correct. Thus, in order to avoid misinterpretation of the simulated station data, it might be worth to compare not only the total amount of the wet deposition flux but also a normalized one with respect precipitation (fraction of total wet deposition and precipitation).

Page 27, 1st para.: I suggest to discuss the weaknesses of the model not in the middle

of the paragraph but at the end. It might be worth to briefly discuss further possible improvements. A link to the ongoing ISA-MIP intercomparison (Timmreck et al., 2018) might also be useful as the multi-model approach (13 model groups have signed up incl. ETHZ) and the required detailed output diagnostics might be beneficial for further model improvements and a general assessment of the SOCOL-AERv2.

Figure 4: The figure is certainly very busy, but maybe it is possible to include also the uncertainty range of large particles

Figure 5: Please indicate also the uncertainty range of the model simulations

Figure 7: The accumulated lines are confusing and need a better explanation in the figure caption

Table 2: Please specify also the observational uncertainty range

References: Please revise the list carefully, often information about DOIs or pages are missing as for example for the two Deshler papers

References:

Giorgetta, M. A., Manzini, E., Roeckner, E., Esch, M., and Bengtsson, L.: Climatology and forcing of the quasi-biennial oscillationin the MAECHAM5 model, J. Climate, 19, 3882–3901, 2006.

Zanchettin, D. 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.

Timmreck, C. et al.: The Interactive Stratospheric Aerosol Model Intercomparison Project (ISA-MIP): motivation and experimental design, Geosci. Model Dev., 11, 2581-2608, https://doi.org/10.5194/gmd-11-2581-2018, 2018.

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