Review of GMD-2021-24 - ChAP 1.0: A stationary tropospheric sulphur cycle for Earth system models of intermediate complexity.

This paper describes a simplified model of the Sulphur cycle that can be implemented in Earth system models of intermediate complexity. The scheme appears to be very fast and to be able to reproduce the broad patterns of SO_2 and SO_4 burden and surface concentration. The paper is well written, and describes in details all of the aspects of the scheme, as well as the tuning method. The fact that ChAP 1.0 is very fast to run allows for an easy tuning of all parameters, and make it well suited also for sensitivity studies. A number of hypothesis and simplifications are made; most of them are discussed in Section 6. I think the paper reaches its objectives in describing ChAP 1.0 as well as its limitations, and providing a basic validation of its approach compared to more complex models. I have a few minor remarks, as well as a few suggestions (which can tried later on and don't have to be mentioned in the manuscript, if the authors think them useful). Remarks:

- I may have missed it but I didn't find the information about what time step was used in the simulations shown in the manuscript: if it is not present, could you please add it?

- In the discussion of the limitations (Section 6), I think two major assumptions should be at least mentioned: that of the fixed lifetime of SO_2/SO_4 as well as the vertical length scale. While the values chosen appear sensible and in line with results from more complex models, the fact that the spatio-temporal variations of these parameters is not accounted for could have an impact on the results of ChAP1.0. The vertical length scale for example probably varies a lot between day and night (in clear-sky conditions), while the lifetime of SO_4 is heavily impacted by its main sink, wet deposition, and in turn by the occurrence of precipitation. It is possible that the tuning stage compensated partly for not taking these into account. (and the other hypothesis outlined in Section 6).

- The tuning procedure (Section 4, line 240): where does the observed SO_4 burden per unit come from?

Suggestions:

- For SO_2 lifetime, the authors may think of using the very simple parameterization from Huneeus et al. (2007), as a function of latitude only: (from Remy et al. : 2019): "The conversion rate (per second) can be written as $C0 = \exp - \delta t (C1 - C2 \cos \theta) \delta t$, (16) where δt is the time step, θ is the angular latitude, and C1 and C2 are e-folding times in days representing the lifetime at the pole and the Equator set to 8 and 5 days, respectively, for operational cycles up to 43R1."

- For dry deposition: to use different values over ocean and land (and possibly, ice/snow). That would be quite simple to implement and test and could give a bit more variability to the model.

- For wet deposition, to distinguish between solid and liquid precipitations, ie to split kSO4,wet in kSO4,wetrain and kSO4,wetsnow, and then compute kSO4,wetrain,0 and p0 specifically for both rain and snow. Wet deposition by snow is generally much less intense than by rain, so this again could make a difference.