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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Model physics and chemistry causing intermodel disagreement within the VolMIP-Tambora Interactive Stratospheric Aerosol ensemble" *by* Margot Clyne et al.

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The paper discusses diversity in the calculated aerosols of several models that simulated a volcanic event based on the 1815 Tambora eruption. The goal of the paper is to understand the reasons for this diversity by looking at specific processes as they are represented in the various models. Simulated stratospheric sulfate mass loading is found to peak at different times in the months following the eruption in the various models, although the total loading reached is generally similar. Peak AOD is found to have similar diversity in the timing in which it is reached, but also the magnitude is found to be very different between the models despite the similar mass loading of

sulfate. Particle effective radius simulated is identified as a key player in the AOD diversity because of sensitivity of extinction efficiency to particle size. Nucleation rate in the LMDZ-S3A aerosol is identified as a significant driver of its outlier performance, but the key difference among the models is between those with interactive OH chemistry (leading to slower conversion of SO2 to sulfate, and so a later peak in AOD) and those without. Simplifying assumptions in some of the models, e.g., relationship of water to optical properties are also highlighted, as are missing processes within the models, including aerosol effects on photolysis and the confounding impact of volcanic ash or water (although since none of the models included either of these it is not a source of discrepancy here but inevitably would be when they start introducing those aspects). For the MAECHAM5-HAM model point versus band emissions of the volcanic injection revealed large differences in both the AOD and effective radius, which is related to its lack of depletion of OH due to using prescribed fields; the SOCAL-AER model (with interactive OH) performed similar injection experiments and did not find significant differences in AOD or effective radius, indicating that in both cases chemistry was slow relative to dynamical transport.

The paper is well written and does not require any major updates. I think it is a useful addition to the community. I suggest mostly minor points to be addressed.

I do agree though with one of the other reviewers that the introduction is a bit wonky going right into the VolMIP protocols and gets kind of technical. I agree that some further context on why any of this is done would help motivate the important results that follow.

Table 1: Please explain/distinguish what is meant for CCM versus AGCM. For example, LMDZ-S3A does not include interactive OH, per Table 2, so why is it a CCM?

Line 131: Requested wavelength of output is 525 nm, but no model provides that, per Table 1 all but SOCOL-AER provide 550 nm. Is there a typo in one place or the other?

It is implied in a few places, but do all the models account for a full suite of tropospheric-

sourced aerosols? Dust, sea salt, carbonaceous, surface SO2 sources? Nitrates too? And to the extent it matters to the results, have you considered interactions of those aerosol sources with the volcanic plume, maybe especially for the modal models? Also, do all the models include an interactive Junge layer aerosol? How about meteoritic smoke?

Line 245 and Appendix A around eqn. A3âĂŤ This is pedantic, but I got a bit confused following the variable naming and subscripting. Maybe it is all very clear, but it wasn't to me. In A2 I understand reff to the effective radius at a given grid point and moment in time. In A3 Reff is the global averaged effective radius, but curiously Reff appears on both sides of the equation. So I think this is just a typo and "reff" is what is supposed to be on the right side. But A3 pertains to the vertical integration, and the horizontal integration is described somewhat strangely in lines 728-734. I'm not sure if this discussion about gaussian weights is illuminating or necessary consequence of the model output presented on zonal mean grids or what's going on. It might be more clear if A3 were written with the expression wrapped inside of some horizontal integral, is that what's going on?

Line 277: It is interesting to find a statement like "The goal of this paper. . ." in Section 4 of the paper. I think such a clear statement belongs also in Section 1, right before the sentence on line 86 beginning "In this paper we go further. . ."

Line 291: The use of "omega" in a discussion of optical properties could be a bit confusing as it is frequently associated with single scatter albedo. I suggest another symbol. But it's not a big deal, I follow just fine.

Line 300: Speaking of the particles picking up water I presume the hydrated properties are diagnosed and water is not transported on the particle by any of the models. Am I correct?

Figure 5: I was curious what this figure would look like if the circles were sized by effective radius instead of age. Did you make such a plot? I get this is what Figure 6

shows, but on different axes.

Line 359: I note that Figure 9 is introduced before Figure 8, which comes in several pages later.

Line 535: If LMDZ-S3A computed optics assuming omega = 0.75 why does it's internal AOD track so closely with omega = 0.9 curve in Figure 9?

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