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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Global 2-D intercomparison of sectional and modal aerosol modules" *by* D. K. Weisenstein et al.

Anonymous Referee #1

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Paper Overview:

This paper intercompares 5 different model parameterizations of the stratospheric sulfate aerosol layer using a two-dimensional atmospheric chemistry and dynamics model. Two of the parameterizations represent the aerosol using either 40 or 150 aerosol size bins. The other three represent the aerosol by tracking the evolution of the lower order moments of a combination of several aerosol modes. Two of these modal parameterizations contain 3 modes (differing in the assumed width of the largest mode), and one contains 4 modes. By intercomparing these parameterizations in a single model, it is possible to understand the sensitivity of the model results to differing representations of aerosol size distributions, all other factors being held constant. The 150-bin parameterization is considered to be the standard. The paper concludes that

there are only modest differences between the 40-bin and 150-bin parameterizations, that 4 modes usually is better than 3 modes, and that in the 3-mode case, results are very sensitive to the assumed width of the largest mode.

General Comments:

I found this paper to be relatively interesting to researchers concerned with how to appropriately represent the stratospheric sulfate aerosol distribution, and in particular to tropospheric aerosol modelers who want to intelligently extend their aerosol parameterizations into the stratosphere. It is well-written and suitable for publication in ACP. My strongest criticism of this paper is that it does not sufficiently compare the simulation results to observations from the SAGE II satellite. Such comparisons would indicate whether the primary difficulty in representing the stratospheric sulfate aerosol layer is the representation of the size distribution, or if there are other more fundamental problems. I also think that the paper could explore the aerosol parameterizations more generally than it does. For instance, the paper could attempt to establish the minimum number of sections required to adequately represent the stratospheric sulfate aerosol. The paper currently shows that 40 bins is adequate, but how much worse is a, say, 20-bin parameterization? A 10-bin parameterization? It might be that a 20-bin parameterization represents the aerosol layer well enough and requires fewer computational resources than the 3-mode parameterization. I hope that the authors consider broadening their perspective a bit by including a more extensive set of parameterizations than the 5 considered here, in addition to more substantial comparisons to observations.

Specific Comments:

Page 2:

Please provide some details about the OH, O, O3, and NO3 distributions used in the model. How were they generated, and how do they vary?

Please discuss the way the UMaer models move mass from mode to mode. Are any

ACPD

6, S6310–S6313, 2007

fundamental microphysical principles involved?

Page 4:

Aerosol burdens are not included in Table 1, as stated in paragraph 1 of section 3, but is rather included in Table 2.

Figure 1: I think the paper would be improved by including a comparison of the AER150 surface area density or optical depth with SAGE II observations. Is the agreement good or bad, and where? This would give an idea if the representation of the size distribution is the most important factor for accurate modeling of the stratospheric sulfate aerosol, or if other factors, such as sulfur emissions, are more important.

Page 5:

Is the anomaly in Figure 3b at high latitudes in the Southern Hemisphere at ˜35 km positive or negative, and to what is it due?

Figure 4: I would like to see a figure like this for one of the UMaer parameterization, unless the effect of sedimentation for the UMaer parameterization is the same as for the sectional parameterizations.

Page 6:

End of first full paragraph: Can you indicate when the difficulty the modal parameterizations have reproducing the lower size cutoff would be a significant problem?

Figure 9: I am confused by the results above 30 km and why 4 mode results are worse than 3 mode. My expectation is that agreement between sectional and modal parameterizations should converge as the number of modes increase. The paper states that the differences between the modal parameterizations are due to differences in evaporation. How does this relate to the number of modes chosen?

Page 7:

ACPD

6, S6310–S6313, 2007

Figure 10 (as well as later figures): What is the point of showing only equatorial results separated by only 6 km? The differences between the two altitudes don't appear to be significant. I would like to see comparisons in significantly older air, such as at higher latitudes - say, at 60 degrees latitude and 30 km altitude. Such a comparison might provide a different perspective on the performance of the different parameterizations.

Page 8:

I would like to see some additional comparisons with SAGE II observations of extinction, surface area, and optical depth. I am particularly interested in the time-dependent comparisons following Pinatubo. I know that the paper is mostly concerned with determining how well the less time-consuming parameterizations compare with the 150 bin parameterization, but I don't think that the comparisons shown are extensive enough to adequately characterize the agreement between the AER40 and UMaer-3mb parameterizations. More extensive comparisons may suggest that a 3-mode parameterization is insufficient to adequately represent the decay of the Mt Pinatubo aerosol at all latitudes and altitudes, or that the distribution widths which provide good agreement in the Tropics result in poor agreement at high latitudes. The way to resolve these questions is to compare the parameterizations to observations at more latitudes and altitudes, and to include more than the five cases examined in this version of the paper.

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6, S6310–S6313, 2007