Atmos. Chem. Phys. Discuss., 5, S1751–S1754, 2005
www.atmos-chem-phys.org/acpd/5/S1751/
European Geosciences Union

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Piecewise log-normal approximation of size distributionsfor aerosol modelling" *by* K. von Salzen

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Received and published: 25 July 2005

Thanks to Steve Ghan for noticing that Zenders et al.'s (2003) approach for mineral dust aerosol has been overlooked in the paper. The oversight will be corrected in the revised version of the paper. Similar to the PLA method, Zender et al. use a piecewise-analytical representation of the aerosol size distribution (specifically, they assume that the aerosol mass is log-normally distributed in each section). However, their approach is quite similar to the single-moment sectional approach. In particular, the assumption of time-invariant size distributions within each section, with the mass being the only predicted variable, clearly distinguishes their approach from the PLA method. Consequently, aerosol number (or any other moment) will generally not be conserved in simulations with Zender et al.'s approach. Additionally, the assumption of a time-invariant

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size distribution could be quite problematic at small to moderate numbers of sections. For example, this assumption does not work very well for gravitational settling of mineral dust particles which typically causes large variations in the particle size distribution with height. In contrast to Zender et al.'s approach, the PLA method can be used to account for changes in the size distribution at any given particle size scale.

I also agree with Steve Ghan that comparing the PLA method to the single-moment sectional scheme cannot produce a comprehensive evaluation of the method. However, I think that the comparison to this scheme is an important first step because of its simple and well understood features and widespread use in aerosol modelling. Given the relatively large number of conceptually different approaches that are used in models, it is less obvious which other schemes should be considered. The paper will be modified to emphasize this point.

On the other hand, it appears that the method proposed by Tzivion et al. (1987) is an interesting method to compare with since it is also based on the assumption that aerosol number and mass concentrations can be used to constrain the size distribution within sections of the size distribution. I have used Tzivion et al.'s approach for comparisons with the observed size distributions (as in Figs. 3 and 4). I have also done additional simulations based on Tzivion et al.'s approach using the single column model (as in Figs. 7 and 8). Interestingly, according to these results, their method produces even larger rms errors than the simple single-moment sectional approach! I will explain the reason for this in the paper in detail and possibly in an additional discussion, if requested. However, a rather minor modification of Tzivion et al.'s approach leads to considerably improved results for this method. Generally, the improved version of Tzivion et al.'s method produces rms errors in Figs. 4 and 8 that are somewhere between the results of the PLA and the single-moment approaches. Results of Tzivion et al.'s and the improved method will be included in the paper.

Since it can still be argued that additional comparisons should be performed for the PLA method, I have also tested an approach that uses a representation of the aerosol

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size distribution in terms of second-order polynomials. For example, von Salzen and Schlünzen (1999) have used second-order polynomials to represent aerosol mass size distributions based on the approach that was proposed by Bott (1989). It turns out that this approach gives very good results when applied to the observed size distributions for 10 or more sections. However, the rms errors are considerable for the number size distribution at smaller number of sections if the method is applied to the mass size distribution (and vice versa). A more substantial problem with this approach is that it can produce negative values of the size distribution. Although there are techniques that can be used to prevent negative results in applications of the method to tracer advection (Bott, 1989) and coagulation (Bott, 1998), it does not seem straightforward to come up with a correction that is general enough for applications of this approach to all relevant processes (e.g., including gravitational settling).

Finally, I disagree that negative values of ψ_i are non-physical. Owing to the multi-modal nature of aerosol size distributions in the atmosphere, it is necessary to account for the possibility of local minima in size distributions. These can only be done by allowing ψ_i to become negative. As demonstrated in the paper, negative values of ψ_i do not cause any mathematical or physical inconsistencies.

Thanks to the referee Steve Ghan for his helpful comments!

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