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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A parameterization of size resolved below cloud scavenging of aerosols by rain" *by* J. S. Henzing et al.

J. S. Henzing et al.

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Referee #3

Specific comments 1) The referee states that an interested reader should be able to implement the parameterization introduced in the paper. We agree. A list with the coefficients is therefore now provided at www.knmi.nl/~velthove/wet_deposition. 2) The referee asks us to be more complete on what has been done on the field of below-cloud impaction scavenging. We included references to recent works done on the below-cloud scavenging and we included references that introduce the process itself. Included new references: Andronache (2004), Zhang et al. (2004), Stier et al, 2005, Tost et al. (2006), and Mircea et al. (2000). Referee #3 asks how our scheme compares with others. As the referee mentions in his/her general comments, we use previously published expressions for our calculations. Our differential scavenging coefficients are therefore identical to e.g. Andronache (2003, 2004) and Zhang et al. (2004). Our paper deals with how to implement such schemes in a global chemistry model. The referee asks if we can mount an argument that a size resolved scavenging scheme is more accurate than a bulk scheme. If several bulk schemes are applied to a number of lognormal distributions for which the schemes were designed (e.g. Stier et al., ACP, 5, 1125-1156, 2005) the aerosol spectrum is represented by the superposition of the lognormal distributions. Using a bulk scheme for the treatment of impaction scavenging below the cloud does not exclude keeping track of the aerosol size distribution. In this manner bulk schemes and "size resolved schemes" can be just as accurate in resolving the size distribution. 3) Referee asks us to describe how the fractions Vi in equation 5 are determined in section 3.2.1. The manuscript has been modified accordingly. Referee asks to include a discussion on the estimation of the precipitating fraction. We included the given reference and included a few lines of discussion in section 5.3 (top of first paragr.) 4) Referee mentions: "The authors remove the possibility of impaction scavenging within clouds by assuming, as others have, that all of the aerosol within the cloud is already in the aqueous phase (presumably by nucleation scavenging". We feel that this is not completely true. We do not remove the possibility of impaction scavenging within clouds. We just assume that the net effect of impaction and nucleation scavenging is such that all aerosol particles are in the aqueous phase (scavenged). The reason for this assumption is that we cannot distinguish between the two scavenging mechanisms. Indeed a fraction of the aerosol particles may not be scavenged by nucleation because they are too small or hydrophobic. The smallest particles may then be collected by impaction scavenging. The remaining interstitial fraction in warm clouds in terms of aerosol mass is a subject of intense continuing research and discussion. Moreover, aerosol particles eventually scavenged may be released in the interstitial phase in mixed phase clouds because crystals and flakes may grow at the expense of the water droplets (supersaturation with respects to ice but subsaturated with respect to liquid). Henning et al. (2004) investigated aerosol partitioning between cloud and interstitial phases in natural, mid-latitude, mixed phase clouds using in situ measurements. The fact that their observed fraction of interstitial aerosol is rather insensitive to particle sizes, allowed us to use their numbers to estimate the amount of aerosol mass that remains interstitial, and that is therefore not removed from our model atmosphere. We performed these calculations that are included in Henzing (2006, chapter 5, http://alexandria.tue.nl/extra2/200610067.pdf). Although not shown we found a net increase in aerosol lifetime and indeed the relative contribution aerosol removal by below-cloud scavenging as presented in this paper is underestimated as compared to that in Henzing (2006). We feel however that including a discussion on interstitial aerosol in this paper would divert the reader<92>s attention and moreover it would not change our conclusion that below-cloud scavenging is important and should be accounted for in global models. 5) We have now included a comparison of model simulated sea salt with observations in section 4.1 paragraph 4. We also included new figures (Fig 5a-h) and a table containing the measurement locations (Tab. 1). 6) The referee asks to specify what is meant by average and spread in sea salt lifetimes as mentioned in section 4.1 paragr. 3. Text has been changed for clarification. The referee states: "If indeed the models differ so much, can the authors draw any conclusions about how the differences in model formulation of scavenging may contribute to disagreement between models" We start our introduction with the following: "Aerosol removal processes remain an important source of uncertainty in global aerosol transport models (Rasch et al., 2000). Recent aerosol model intercomparisons such as AeroCom (AeroCom, 2005; Textor et al., 2005) show significant differences in modeled atmospheric aerosol concentrations that might be due to differences in the model representations of wet removal of aerosols." So yes, we and others think that a large portion of differences between models may be caused by differences in model formulation of scavenging. We included comparisons with observed values as requested. See also remark 5.

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 1355, 2006.

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Interactive Comment