Atmos. Chem. Phys. Discuss., 9, C714–C718, 2009
www.atmos-chem-phys-discuss.net/9/C714/2009/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Aerosol size-dependent below-cloud scavenging by rain and snow in the ECHAM5-HAM" *by* B. Croft et al.

Anonymous Referee #1

Received and published: 11 May 2009

In this study the authors treat the aerosol below-cloud scavenging by rain and snow formulation in detail. The paper is well written and contains enough technical details to reproduce / recode these parameterisations in other models or applications. The implications of these new model developments for global aerosol concentrations are as well analysed as the aerosol – cloud feedback mechanisms. This paper should be published in ACP after addressing the aspects mentioned below:

This aerosol cloud feedback is the major aspect for criticism. Even though it is shown that the large scale phenomena concerning cloud properties are not strongly affected by the modifications in the aerosol distributions, they nevertheless impact the local / smaller scale phenomena or specific events. Due to model non-linearities these small changes can quickly increase and impact the climate system. The analysis of this

aerosol cloud feedback is important and therefore it definitively should remain in the paper, but the authors claim that a feedback study (referring mainly to the direct aerosol effects) goes beyond the scope of this study. Therefore, the exclusion of aerosol – cloud feedbacks would seem a logical step. A simulation similar to the BCS2, but without the aerosol – cloud feedback would consequently only show the impact of the new parametrisations and would be highly appreciated. Furthermore, the natural aerosol emissions for sea-salt and dust (it is not obvious from the paper if they are also taken from the AEROCOM data (Dentener et al., 2006), since it is referred to the "nudging" for similarity between the simulations) are in general similar due to the large – scale dynamics, but especially for the dust it is crucial if there has been rainfall recently, or not (and the hydrological cycle is usually not nudged). Consequently, small local changes due to the cloud properties would have a much stronger impact on the dust mobilisation.

Specific comments:

Terminology: What exactly is the meaning of "below-cloud scavenging"? Should it not better be called "impaction scavenging"? As far as I understood it, the processes all deal with the collection of small particles (aerosols) by bigger collectors (precipitation droplets/crystals). This does not necessarily occur only below the cloud base, but usually also within the cloud. Especially, if the cloud has a large vertical extent, the "impaction" scavenging occurring in the cloud, collecting lots of unactivated (and also activated) aerosols, contributes substantially to total wet deposition. Consequently, this processes should better not be referred as a "below-cloud" process (except if in the model study the process is only calculated below cloud base).

p. 7877, l.19-20: Which emissions are taken from the AEROCOM project? All aerosol emissions or only the anthropogenic fraction?

p. 7882, l.2-5: What is the implication for the higher scavenging coefficients both on small and global scale? Since these particles do not contribute significantly to mass, the importance with respect to this is small. But what about the tendency to enhance new particle formation in the lower troposphere, since without condensation surfaces the H2SO4 cannot condense on those particles? The numbers in Table 10 differ only by a small amount (but are for the nucleation mode anyhow dominated by the UTLS concentrations in the sulphate layer)?

p.7884, l.3-5: The scavenging coefficients for the two snow parameterisations have only a similar shape, but they differ substantially. Both, in Fig. 1a and 2a+b the "Greenfield" gap is at a different aerosol radius, which deviates one order of magnitude. Additionally, SNOW-B has a width of one order of magnitude in radius as well. Consequently, I cannot confirm the statement that the two coefficients are similar. It is not obvious which of them is used in the BSC2 and corresponding simulations. The sensitivity to the choice of these can have a huge impact on transport of pollutants into the polar regions and on the winter hemisphere.

p.7884-7885, l.10-6: The convective fraction is chosen with a relatively high vertical velocity, and therefore it is relatively small. This also explains the small contribution to the total atmospheric deposition. It should be considered, that the convective transport usually uses the grid box mean mass flux to transport tracers into the upper troposphere. Consequently, restricting scavenging to a small fraction of the grid box might overestimate the total vertical upward transport, i.e. the compensating downward transport in the precipitation flux might be underestimated. A more realistic treatment would be the upward motion and the scavenging both taking place only in the smaller subgrid area of the model grid cell. This should be mentioned in this section or the discussion later on.

p. 7885-7886, l.20-5: Some of the more regional effects are related to the aerosol-cloud-precipitation feedbacks, which are difficult to analyse (see general comment above).

p. 7886, l.6-26: It is very surprising, that all changes by enhanced impaction scav-

enging is compensated by reduced nucleation scavenging. Can this be related to the process order calls in the model or is there a physical explanation for this (that should be mentioned in the manuscript)? A lower sedimentation and dry deposition contribution is to be expected as well, if the aerosol burden is reduced by enhanced impaction scavenging, since all of the processes depend directly on the atmospheric concentrations, i.e. a fraction of the atmospheric burden is removed with a (relatively) fixed loss rate.

Section 3.2: For the title "Column burden" would probably better than "Mass burden".
p.7887, l.24-30: Is there an explanation why sea salt is affected much stronger than the other aerosol types? Especially, dust particles have a similar size and solubility is not of importance for impaction scavenging. Consequently, the impaction scavenging of dust should be similarly affected. Looking at the lifetime reduction (for dust 7% reduction, for sea salt 15%) it is not obvious where this difference originates from, but the geographic location of the sources. Please check the tables accordingly, since in Tab. 8 (supposed to be dust) an emission number is given for sea salt (in the caption).

p.7888, l.4-20: The prognostic rain scheme has a much stronger effect on the impaction scavenging, due to the subsequent evaporation of rain below the clouds. However, this is as in the control simulation to a large extent compensated by the nucleation scavenging. This should be pointed out better.

p.7890, l.11-15: According to the cloud scheme presented by Lohmann et al. (2007), the hydrophobic particles act as ice nuclei. Do you use a modified version of the scheme, not using the ICN prognostic equations?

p.7890-7891: The description of Fig.12 and Fig.13 leads to the conclusions that the cloud properties are less affected by the aerosol, except for the IN (see comment above). Can this be affected by nudging as well, e.g. the aerosol effect on a cloud would like to cause a cooling, but the nudging pushes the temperature towards a heating and thus a dissipation of the cloud? Therefore the effects might be underestimated.

Alternatively an analysis of the magnitude of the “correction term” of the nudging can give insight into the issue. In general, using nudging in “feedback” studies might cause misleading results due to compensation of effects by the nudging itself.

p.7892, l. 7-14: How does the comparison look like for the other simulations, e.g. does the implementation of the thermophoresis effects improves the representation of the (mostly fine mode) sulphate particles? Is the application of the prognostic rainfall scheme useful for the representation of sea salt (in terms of Na+ deposition) or is the representation of sodium getting worse. A table with correlation, slope and intercept numbers for all simulations would be useful to estimate the value of each of the schemes (at least for the NDAP network area).

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 7873, 2009.