Atmos. Chem. Phys. Discuss., 11, C10591–C10593, 2011
www.atmos-chem-phys-discuss.net/11/C10591/2011/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "On the discrepancies between theoretical and measured below-cloud particle scavenging coefficients for rain – a numerical study" *by* X. Wang et al.

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Received and published: 19 October 2011

We appreciate the reviewer's comments, which improved the clarity of the paper. We have addressed the reviewer's specific comments and revised the paper as detailed below.

Review Comments:

While conceptually this MS does not say something new, it can be interesting as a numerical exercise if the results will be presented in a more explicit way, showing the difference in the production (P) and loss (L) terms induced by the changes in vertical diffusion coefficient. It will be also useful to see how change the in-cloud scavenging

and its contribution to below-cloud scavenging, the evaporation below cloud, the in-cloud supersaturation and cloud water. I suggest to the authors to add in the title that the numerical study was performed with the one dimensional cloud model since numerical studies can be performed in many ways in general.

Authors' response:

In a previous study, Wang et al. (2010) speculated that "the vertical turbulent diffusion that influences field data collected near the surface but is not taken into account in the current theoretical scavenging coefficient formulation might explain their larger differences". This is in consideration of the fact that the field data were mostly collected in the surface layer and vertical diffusion is nearly omnipresent in the surface layer. As a consequence, the comparison of theoretical scavenging results with field data is in many case an "apples and oranges" comparison since the contribution of vertical diffusion is neglected in the theoretical formulations but is present in the field data. The major goal of the present study is to test this assumption through numerical methods because a detailed microphysics model can separate the effects of each individual physical and chemical process and can include a parameterization of the vertical diffusion process.

We have added a table (Table 1 in the revised paper) that lists the net changes (as percentages) of the aerosol concentrations and the corresponding scavenging coefficients for five representative particle sizes after each precipitation event (a total of 12 model runs). Now the results can be discussed in a more explicitly way. The discussion on this Table has been added in the revised paper to support our conclusions.

Since the focus of this paper is aerosol scavenging in the sub-cloud layer, raindrop spectra and precipitation intensity near the surface control the rate of aerosol scavenging. Thus, in-cloud scavenging plays only a little role in the results near the surface as long as the initial CCN spectra and supersaturation are the same (which will produce the same raindrop spectra and precipitation intensity). In-cloud supersaturation and cloud water content will affect raindrop spectra and thus indirectly affect aerosol scavenging, but their effects are reflected in the change of precipitation intensity. That is why we considered different precipitation intensities when investigating below-cloud aerosol scavenging.

The below-cloud evaporation process does affect aerosol scavenging due both to reductions in the number and size of raindrops and to the creation of new aerosol particles associated with complete raindrop evaporation as evidenced by both theoretical and field studies. For example, numerical studies in Zhang et al. (2004) using the same cloud microphysics model as the one used here can produce a negative scavenging coefficient for submicron particles (new particles evaporated from raindrops were distributed as a log-normal distribution to avoid accumulation into one size bin). A recent field study conducted by Defence Research and Development Canada Suffield (Jim Ho, personal communication, August 2011) also showed a negative scavenging coefficient for submicron particles. Theoretically (and also confirmed by our previous numerical experiments), below-cloud evaporation has its largest impact at the beginning of the precipitation. When relative humidity (RH} reaches 100% at the surface, the effects of evaporation on the change of aerosol concentration is minimum. In the present study, we first let the rain develop and fall for sometime (so that the precipitation intensity reaches a preferred value and the surface RH also approaches 100%); only then did we introduce the vertical profile of aerosol concentration distribution into the model column to investigate aerosol scavenging. As a consequence, with this experimental design any impact of below-cloud evaporation should be minor.

We have added many discussions based on the above explanations in the revised paper.

We have changed the title of the paper as recommended by this reviewer.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 20375, 2011.