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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Global simulations of aerosol processing in clouds" *by* C. Hoose et al.

C. Hoose et al.

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Reply to Referee #2

We would like to thank the referee for the thorough reading and critical questions. We reply to the individual comments below.

Page 13557: Line 2: Sentence needs to be rewritten: use larger instead of bigger and I suggest you modify it as "Hygroscopic particles and those that are large (give size)) act...";

Changed to "The large and hygroscopic particles act preferably ...". (The best CCN are both large and hygroscopic at the same time. We cannot give a size cutoff here because this strongly depends on the supersaturation, i.e. on vertical velocity.)

Page 13558: Toss et al. (2007) explicitly "compute".....

Corrected.

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Interactive Discussion

Discussion Paper

Page 13559: Line 14: "represent"

Corrected.

Page 13560: Line 16: How sensitive would your results be to this assumption of 50 um per rain droplet ?

When setting up this test, we discovered an error in the previous calculation of below-cloud evaporation. In consequence, we have modified the assumed rain droplet radius to 100μm, such that the corrected results are very close to the previous results. The numbers in the text and tables and the figures have been updated. The conclusions are not affected. Comparing sensitivity simulations with a radius of 50 μm instead of 100μm have shown that the overall results are rather insensitive to this assumption, although the coarse mode number concentrations are significantly affected. When assuming a smaller rain drop radius, more but smaller particles are re-emitted into the coarse mode. These particles subsequently have a longer lifetime, which increases the aerosol optical depth, and they can nucleate more cloud droplets. With an assumed rain drop radius of 50 μm instead of 100 μm, the global number burden of the soluble/mixed coarse mode is increased by 40.8%; the global mean aerosol optical depth is increased by 4.87 %, and the global mean cloud droplet burden is increased by 1.05 %. The effects on the LWP and the radiative fluxes are minor. The mean radius of evaporating rain droplets is a very uncertain parameter and is likely to vary strongly both spatially and temporally. This uncertainty could be reduced with a prognostic treatment of rain, from which the mean diameter can actually be calculated.

Page 13561: Eqs 4 and 5 are not clear.

The label (4) has been removed because this is only one equation, extending over 2 lines. Furthermore we have inserted a missing "and" in "valid for ql in gm-3 and Nl in cm-3", and a missing subscript dql/dt|aut in the first line of equation (4). The second line of equation (4) is obtained by substituting dql/dt|aut from equation (3) into equation (4), and Qself as given by Beheng (1994). It is beyond the scope of this paper to go

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into details about how this parameterization and the coefficients were derived.

Page 13563: Line 25. Change the sentence "investigate in how far" to something like to "investigate the extent to which the ...."

Corrected.

Page 13565: Line 18: Remove a before too

Corrected (and changed burden -> burdens).

What does mis-predicted (aerosol size distributions) and incorrect parameterization of optical properties mean?

We have modified this sentence to "incorrectly simulated aerosol size distributions or incorrect assumptions on the aerosol optical properties. For example, too large aerosol particles or an overestimation of aerosol water uptake can result in an overestimation of AOD".

Page 13566: Line 22: Is it possible to quantify what this change in model weather due to aerosol feedback on clouds is? What is the difference in average wind speeds?

See also a comment to referee #1 and the figures on http://folk.uio.no/corinnah/plots/dust_emission_difference.pdf . The difference in average 10m windspeed is rarely more than 10 cm/s in the dust source regions. The maximum wind speeds, which are the main contributers to the dust emission (which is roughly proportional to the third power of the windspeed), can not be inferred from this plot, but it is likely that they are also higher in simulation AP than in CTL. In the revised simulations (compare comment to below-cloud evaporation), the dust emissions are much more similar in CTL and AP (722 vs 719 Tg/yr), which reflects that the wind-related emissions are sensitive to small modifications in the model.

Page 13570: Line 12: Missing "on" before their. Use "of" instead of "on" before global.

We have modified this sentence to "P&J based their estimates of these time scales on

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global mean values of cloud parameters".

Line 19: use "of" instead of "to".

Corrected.

Line 25: Use forms and not forming

Corrected.

Page 13571: Line 14: How reliable is it to scale the LWP?

As Pruppacher & Jaenicke's calculations are linear in LWP and condensation rates, we think that scaling the LWP is a meaningful way to correct their calculations for the outdated value of LWP which they had used. Arguably, the aerosol emissions and mean aerosol mass concentration would also have to be scaled to more recent estimates. However, we have removed these calculations (column 3 from Table 6 and 7 and the respective discussion) in order to shorten this paragraph, as requested by reviewer #1.

Page 13573: Line 11: Sentence is odd. Please rephrase.

The explanation on the homogeneous/inhomogeneous mixing assumptions has been moved to section 2 (model description) and reformulated.

Page 13575: Line 11: "to a too". Please rephrase

Corrected to "This points to an underestimation of the scavenging in cold clouds, or to an overestimation of the emissions."

Page 13578: Why do you use this assumption "Only grid- points with more than 10 days with a low cloud fraction higher than 80% are considered in the analysis"? These criteria are used to ensure a meaningful comparison between the observational data and the model. Because of constraints in computation time, the observational data were created based on 1x1 degree gridded satellite data (as opposed to the native

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satellite swath resolution of 1x1 km coordinate system), see Bennartz (2007). In cases were only very few days with sufficient cloud cover are found results might be unreliable. We (R.B.) anticipate to overcome this limitation in the near future when resources become available to re-process satellite data in their native spatial resolution of 1x1 km. It will then be possible to derive meaningful values for N also in areas with much lower temporal and spatial coverage with low level stratiform clouds.

1. Table 5: Remove the last 2 columns

The last 2 columns are included here because we would like to have tables 4 & 5 (and also tables 6 & 7) put together to one larger table in the portrait version of this paper. They were only too long for the ACPD landscape format.

2. Fig 12 should come before 10 and 11

Changed.

3. Figure 13: Differences between simulations and observations are strikingly large? Were simulations analyzed similar to the way satellite data was processed? More details should be provided in the text.

The model does not include a satellite simulator for MODIS and AMSR-E radiances, which would have been the best way to compare the model with MODIS. Instead, here we attempt to compare a physical variable (the droplet number concentration) with the same variable as retrieved from the satellite data by Bennartz (2007). Of course, this retrieval comprises uncertainties, which are discussed in detail in Bennartz (2007). Here we start from the final product and compare it to in-cloud droplet concentrations in the lowest 900m over ocean. Therefore the processing method is inherently different. The amount of data available for the simulations is much larger because the in-cloud droplet concentrations are sampled every 12 hours, at four model levels.

4. I don't understand Fig. 15. 2 different sets of regions are indicated in Fig. 15, off the coast and over remote oceans. Fig. 14 shows ocean regions only, with and without

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drizzle. The legend in Fig. 15 does not match what is shown in Fig. 14. It is better described in the text. Please improve the legend description. In that sense, in Fig. 14, it might have been better to show the values separately for the off-coast and remote ocean regions.

We have modified the title of the left plot in Fig. 15 from "selected study regions" to "off-coast regions" and have introduced open and filled symbols in Fig. 14 to distinguish between off-coast and remote ocean regions.

5. Fig. 17 a looks too busy and is not useful as presented. Please redo it so it makes more sense to understand what is depicted there.

As suggested by referee #1, we have removed the upper parts of Fig. 16 and 17.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 13555, 2008.