Atmos. Chem. Phys. Discuss., 8, S8858–S8863, 2008
www.atmos-chem-phys-discuss.net/8/S8858/2008/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Sensitivity of aerosol optical thickness and aerosol direct radiative effect to relative humidity" *by* H. Bian et al.

H. Bian et al.

Received and published: 5 November 2008

We thank Michael Schulz for his stimulating comments and the thorough review with many suggestions for improvements. In the revised manuscript we shall make all suggested changes. Page and line numbers are referred to the previous version of the paper.

General Comments

1. The real reasons why models diverge are not found in this article. Humidity differences among models with different resolution might indeed be a reason. However, it would be slightly more convincing to real dig them out from the AeroCom models.

Reply: A lot of factors might result in models’ divergence as pointed out in a series of AeroCom studies. Humidity difference among models is one of the factors

which has not been extensively analyzed before. The AeroCom models obviously provide a good platform to explore divergence in models. However, there are several ways through which RH differences among models could impact AOT simulations, such as, (1) the ability of the parent general circulation model to correctly capture the shape of RH and its dependence on time and space; (2) the application of RH in CTMs with different spatial/temporal resolutions due to RH sub-grid variation; (3). the relationship between MEE and RH adopted in a specific aerosol model due to the complicit of aerosol composition and aerosol hygroscopic growth. These potential impacts would be compounding together in an AeroCom exploration. Our approach presented here using GMI model allows testing of such impacts from an isolated factor (in this paper the second way as mentioned above) while holding the others unchanged. This work is a first step in an effort to address an overall impact of RH on AOT simulation and provides a complimentary study of AeroCom activity.

2. Resolution differences might not be as easy to translate into AOD differences as suggested by the authors in the conclusion.

Reply: We fully realize that the translation of resolution differences into AOD differences is not straightforward. In our conclusion we stated that the complexity of an aerosol physical and chemical system makes getting a conclusion more difficult. Nevertheless, we believe that one way to improve the performance of a system is to better understand each process as we did in this paper, although the intricate nature of simulating the aerosol system where balances/amplifications between different processes can obscure the physical nature of relationships within the system.

3. Nudged GCMs for instance compute RH fields every 30 minutes even if the resolution is in some of the models coarser than that of GMI. RH variability might be higher in a free running GCM than in reanalysed RH fields as used here. The spatial and temporal variability of RH might be very different even if the resolution would be the same. Finally, one day it has to rain even in the coarsest GCM model.

ACPD

8, S8858–S8863, 2008

Reply: The reviewer is right in that RH could be changed through various ways to influence AOT simulation. For example, the various GCM moisture parameterizations and model simulation modes (e.g. a free running GCM, a running GCM with reanalyzed data, etc) might also result in different RH distributions. Our study contributes the overall understanding of this issue by focusing on the application of GCM data into CTMs with different spatial/temporal resolutions.

4. I wonder how much the RH pdf distribution in a balanced GCM depends on its resolution. May be not too much? I could think of a RH histogram. Please add one for the three GMI experiments. It would be easier for other modellers to compare their results with yours.

Reply: The probability distribution functions (PDF) of RH at 930 mb in three resolutions are shown here over land and ocean between 60°S and 60°N. The PDFs were calculated with RH averaged over 3 hours (or 6hours) period for the April 2001. Polar regions were avoided to eliminate the possible high RH which was induced by cold temperatures. The RH PDFs show a similar pattern although the magnitudes differ. A small peak of PDF occurs around 90-95% and a large peak around 100% where oversaturation was also accounted for. Since the RH PDF is sensitive to time and space and since the PDF is distorted by clouds at super saturation conditions, we prefer not to include the RH PDF in the paper.

5. What if large domains are near the 100% RH level in a given model?

Reply: Tables which list the MEEs at 21 RH levels for various hydrophilic aerosols were used in GMI. These RH levels start at 0 with an increment of 5% except the last level, which is 99%, not 100%. The MEEs will be linearly interpolated at other RHs less than 99%. The MEEs at the RH between 99%-100% were calculated as MEE(99%) + x/4 *[MEE(99%)-MEE(95%)], where x is the deviation of RH from 99% and should be in the range of 0 to 1. This clarification has been added into the paper (revised version section 2.1 last 5 lines).

ACPD

8, S8858–S8863, 2008

Interactive Comment

Other remarks which might be included in a slightly enhanced discussion:

1. In the Kinne et al AeroCom paper mass extinction coefficients are listed. Funny enough the model with the coarsest grid shows the highest MEE for sulphate, followed almost immediately by the one with the finest grid.

Reply: Yes. This is because different aerosol models may adopt different empirical relationships between MEE and RH, i.e. given a certain RH, different models may have different MEEs. As pointed out by Textor, a host model in which a specific aerosol module is embedded may react differently to the same meteorological fields and thus the relationship between RH and AOT. The reviewer’s point confirms that RH influence on AOT simulation is a broad issue. We added this discussion in section 3.4 (paragraphs 4 and 5 in the revised version) and conclusion (paragraph 2 last 3 lines in the revised version). The present study addressed another issue, i.e. with a specific function of MEE on RH used in GMI, what the change of MEE may be due to the change of RH resolution.

2. The differences in the vertical distribution of the RH was mentioned in the Schulz et al 06 paper to be one possible reason for the anticorrelation of MEE and residence time of sulphate. Such vertical distribution differences of water vapour might co-vary with resolution changes.

Reply: Very good point. The influence of vertical resolution change should be our next step of work because this possible co-vary as mentioned by the reviewer. We started to explore the issue of AOT change with the change of RH horizontal/temporal resolutions based on the consideration of our practice application. Our CTM usually uses the underlying GCM data in different horizontal/temporal resolutions, but normally keeps the vertical tropospheric resolution.

Small more technical comments:

1. Figure 1: How is the humidity region close to 100% handled? Is there a kind of

ACPD

8, S8858–S8863, 2008

constant MEE for high humidities? Would be nice to document this region. The figure is white above 98 (?) % RH, does it mean there is a maximum humidity growth? Please clarify.

Reply: Please refer to general comment 5.

2. Figure 3: Why is the comparison shown only for one month? I would prefer a one year comparison. Is the relative bias the bias between the means of model and observations? Why not computing RMS including all data points in addition?

Reply: A one year statistics analyses were given in Figures 5 and 7. In addition to the analysis for the annual data, we would also like to choose one month to give a deeper discussion as shown in Figure 3, 4, and 6. The reviewer gave the right definition of the relative bias (also see the paper P13240 L3-4). The RMS has been added for Figure 3 in Table 2.

3. Title 3.4: Factors controlling xx the variation of ? 4. Page 13242, last line: Inflow OF hydrated aerosols… 5. Page 13243: Many factors involved in A weather system…

Reply: Done for 3-5.

6. Page 13245: “Considering anthropogenic aerosols”… It is not totally clear how the anthropogenic aerosols is singled out in the model and experimental setup. May be I missed it.

Reply: The influence of anthropogenic aerosols on DRE was calculated by the DRE with all aerosols minus the DRE with natural aerosols. This clarification has been added in the revised version section 3.5 paragraph 5 line 3-5 .

7. Conclusions “Note that the magnitude of spatial resolution is twice…” I wonder if that can be inferred like that. Where is the RH variance located – in space or time? It depends on the change in the RH pdf in combination with the total AOD magrnitude. However, it would be nice to quantify the

ACPD

8, S8858–S8863, 2008

change of the RH pdf in between the different experiments. Maybe you find a good way how to characterize that.

Reply: Please refer our reply to general comment 4.

8. Conclusions Reword phrase: “On a regional scale, the influence…”

Reply: Done.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 13233, 2008.