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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.

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General Comments

The paper shows the effects of better resolving the variations in RH on the AOT and the DRE. The subject is very timely and highly interesting, the manuscript is suitable for publication. However, I would suggest to extend the analysis somewhat and to improve the explanations. For example, the effects of aerosol composition should be explored. Please find more specific comments below.

Specific comments

Abstract: The comment on the AeroCom should be rephrased as this model intercomparison highlights the differences between models including their very different resolu-

tions and the effects of such differences. One of the major outcomes of the AeroCom initiative is exactly that model results should be taken with caution. The present study is a very valuable addition to AeroCom as it emphasizes again how uncertain the results from aerosol simulations still are.

Introduction: The sentence on the relevance of this work to AeroCom confirms what I said above.

P 13235, l 8: AeroCom showed differences of MEE among models of a factor of 2, see aerocom web site.

P 13235 , l 20: *This study helps us to estimate the extent to which the AOT diversities in the AeroCom models may be caused just by different model resolutions*. How do you want to seperate this effect that you investigate from others you do not consider (e.g. composition, transport in the different models), and how can you know that other models react in the same way to the modifications?

P 13236, l 24: Another model environment would react differently to the same meteorological fields. Please add a remark that the host model in which a specific aerosol module is embedded also effects the RH fields and thus the aerosol properties.

P 13238, l 1: *The size distribution and the hygroscopic growth factors for internally mixed fossil fuel and biomass burning particles, as well as for natural sulfate and organic matter, are described in Liu et al. (2007)*. This parameterization will determine the sensitivity of your model to RH and should briefly be summarized here.

P 13238, radiative transfer model: Please explain briefly the relation between MEE, AOT, DRE and the link to RH.

Table 1: Please exchange *spatial* with *horizontal* resolution, since you do not modify the vertical resolution.

Table 1: I I would suggest to add a run with fine horizontal resolution and 6 hours RH update, and also run with maybe 1.5 hours temporal resolution and a factor of 2 coarser



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horizontal resolution. This way one would better understand if the observed effects are of systematic nature.

P 13239, l 17 *Overall, the GMI captures the main features of the observed AOT*. Very optimistic statement. Please add at least *apart from the Americas*.

Figure 2: Have the model results been filtered for the presence of satellite data? You could give the correlation and biais for MODIS and MISR at each grid point vs the model (this might require interpolation to the same grid resolution), as you did for AERONET.

Figure 3: Is the correlation line forced to go through 0, i.e. model=B*Aeronet + A with A=0 ? Please add in the figure caption the temporal resolution of the data (monthly average at XX AEERONET stations?)

Figure 4: Please show also the maps of RH in the different resolutions, are they very different? This would show the locations with strong RH gradients and changes, and also the higher values in the higher resolutions. It would also be interesting to have a map indicating spatial distribution of hygroscopic aerosol, for example a map of the growth factors at a given RH. Please add such a map and discussion on the composition effects.

P 13240 l 22: *A feature revealed in the figure is that the AOT is always enhanced when the RH horizontal resolution is increased*. I assume that you mean that larger values of RH occur in the runs with high resolution because the sub-grid behaviour is captured? Please improve clarity of explanation.

Figure 5: Caption: vertical bars: standard deviation, range? *seasonal variations*: what is the temporal resolution of the data on which these bars are based?

Figure 6: Please use the same color scale as in figure 4. It would be interesting to see where the RH changes are larges. This would explain for example the change in AOT over the SH storm tracks in response to the change in the temporal resolution but not to that in the spatial resolution is a direct consequence of the spatial distribution of RH



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changes. Please show 3 additional figures with the RH in the different runs (the fine resolution run on the coarse grid).

Figure 7, p 13242, I do not understand where you discoverd the seasonal pattern, please explain.

Figure 8: for the BASE run?

Figure 9: I do not think that these figures are best suitable to show the effect of different RH*AOT regimes that are linked to figure 1. (But I cannot suggest a better one ad hoc.)

P 13243, l 9: *comparable absolute AOT differences* differences in which of your runs BASE*CTRT?

P 13243, l 15: *These opposite effects compensate each other; ultimately their overall impact on the simulated AOT at the two sites is very similar*. I do not agree with the wording. This is not a compensation effect, you are in different RH-regimes with different AOT sensitivity. In A, small variations in RH have a large effect on AOT as RH is already high. In B, RH is lower, but Delta-RH is larger, this leads to a similar impact on AOT.

P 13245, l 15 *Nevertheless, the change is systematic: the higher the resolution, the higher the TOA DRE*. This sentence does not correspond to table 2, the unit of the change is different: The DRE for the CTRT runs is always less negative than in the BASE case, where as the CTRH runs show increased negative DRE. Units should be added to the percentage changes. How do you explain this behavior?

P 13245, l 18 *These changes are larger than those contributed from all aerosols even over oceans*. Do not understand what is meant here.

Conclusions: DRE is less negative for increase of temporal resolution, it is by 9% more negative for + spatial res. but by 3% less negative for + temporal res. Or do I miss something substantial here?



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P 13246, l 10 Comment on AeroCom model diversity: our analysis did not show a systematic model behavior*performance dependent on the resolution.

P 13246, l 19 *In other words, a high resolution model should have a larger, yet close to reality, AOT simulation than a low resolution model, and vise versa*. Such an analysis was made in AeroCom, but AOT did not increase with model resolution, nor did we find any other clear and systematic indication of model resolution on model performance. This does of course not mean that such effects do not exist, it just shows again the complexity of the system, as the authors state in their conclusions.

P 13248, end of conclusions: You may want to find a more finalizing last sentence of your paper?

Suggestions for additional analyses: Standard deviation of RH fields for different resolutions Diffenrence between RH fields for different resolutions Correlation between RH and AOT differences? Correlation between RH variations and AOT differences?

Technical corrections

Please check if all the abreviation are explained, e.g. TOA DER, omega, etc.

Figure 2: Remove country-lines in the satellite plots.

Figure 4: Lower panel: give values in %, use a more linear scale like 5-50 % in steps of 5.

P 13243, l 3 *In addition to the RH magnitude and the atmospheric aerosol composition, the variation of RH in spatial and temporal distributions is also a key factor in determining where and when a large AOT change occurs*. ARE a key factor

P 13243, l 5 *An overall explanation of how these two 5 factors in determining the AOT changes is given in Fig. 9*. Please correct sentence.

P 13245, l 5 nature aerosols -> natural aerosols



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P 13246, l 5 * is likely depends on* -> depending on

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