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Interactive comment on "Simulating aerosol microphysics with the ECHAM/MADE GCM – Part I: Model description and comparison with observations" *by* A. Lauer et al.

A. Lauer et al.

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Response to anonymous referee #2

We also want to thank the anonymous referee #2 for carefully reading through our manuscript and helping us to improve our paper with his/her comments.

General comments

The referee points out the importance of secondary organic aerosol formation. Actually, we did not neglect the SOA formation completely, but included this process in a rather simplified manner. To give some more details on how we handle SOA formation in our model, we inserted the following lines into section “2.2.3 Aerosol physics”, “Condensation”:

> *In the MADE version applied here, the production secondary organic aerosols by condensation is considered in a simplified manner. Following (Cooke et al., 1999) we estimate the amount of secondary organic aerosols to 50% of the total mass of organic aerosols emitted. We further assume, that 99% of this secondary organic aerosol mass condensates onto pre-existing particles and 1% of this mass generates aged nucleation particles (Aitken mode) by new particle formation. The accumulation mode mostly dominates the aerosol surface area. Thus we assume that the total mass of secondary organics available for condensation increases the accumulation mode mass only. The accumulation mode particle number concentration remains unchanged (see Tab. 2). This results in a reasonable good agreement with measurements of particle number concentration in regions, where organic matter is most dominant.*

We completely agree with the referee that the current model configuration is well suited to document the progress of the aerosol module MADE in comparison to the mass-based module FL96. Thus, we included the new subsection “Comparison with FL96” to section “3.1 Global aerosol distribution” and extended the conclusions:

> *Comparison with FL96*

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In the model configuration used for this study, the mass based aerosol module FL96 and the aerosol dynamics module MADE use the same emission inventories for aerosol mass. The meteorological conditions such as temperature, relative humidity, wind fields, and clouds are identical for both aerosol modules. This allows a comparison of the aerosol mass simulated by MADE and FL96 for all aerosol components, which are dominated by submicrometer particles (i.e. SO_4, BC, and POM). The climatological annual averages of the geographical distribution of the near-surface aerosol concentrations as well as the zonally averaged latitude-height cross-sections are almost identical in a qualitative manner. Nevertheless, the zonal averages of the SO_4 concentrations calculated by MADE are about 10% to 20% higher than that by FL96 in the lower troposphere, and even higher in the upper troposphere. However, the mass concentrations of SO_4 in the upper troposphere calculated by both modules are about two order of magnitude smaller than that in the lower troposphere. In case of POM, the mass concentrations calculated by MADE are about 20% higher than that of FL96 in the regions with significant POM mass concentrations (about 50°S-60°N). In contrast to SO_4, these differences do not vary much with height. For BC, the differences between FL96 and MADE are less distinctive. Whereas MADE shows lower BC concentrations in the northern hemisphere (up to about 20%), MADE shows higher BC concentrations in the southern hemisphere (about 10%). However, the total burdens of these aerosol components simulated by both modules are quite similar. For SO_4, MADE calculates 2.25 Tg vs. 2.18 Tg (FL96), for BC 0.26 Tg (MADE) vs. 0.23 Tg (FL96), and for POM 1.77 Tg (MADE) vs. 1.46 Tg (FL96).

Thus, the calculation of aerosol dynamical processes seems to be less essential for the simulation of the total aerosol mass than for the simulation of particle number concentration and size-distribution. This will

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be discussed by the separate paper mentioned above in more detail.

We added to the conclusions:

> *The total mass concentrations of the submicrometer aerosol simulated by MADE and the mass-based aerosol module FL96 using the same emission inventories are similar, differences in the total burdens of SO_4, BC, and POM are below 20%. Nevertheless, significant progress was achieved by the implementation of MADE compared to the previous model version: In addition to the aerosol mass concentration predicted by FL96, MADE provides information about particle number concentration and size-distribution. The wide variability of aerosol size-distributions simulated all over the globe shows that assuming a constant size-distribution to estimate particle number concentration from aerosol mass gives only a crude estimate. The prediction of particle size-distributions strengthens the ability to calculate size-dependant processes such as wet deposition on a more physical basis instead of using rather simplified parameterizations (e.g. assuming constant scavenging factors). The more physical treatment of aerosol-related processes is needed to make further progress in understanding the effect of aerosol on clouds, atmospheric chemistry and climate.*

However, since the differences in the burdens calculated by MADE and FL96 are not that large, we decided not to include FL96 in the figures of the comparisons with observations.

The referee notes, that we did not show any comparison for NH_4. For the measurements sites of the IMPROVE network in the U.S., data on NH_4 are not available, so we could discuss ammonium only for the European stations of the EMEP network (section “3.2.2 Europe”). To provide more insight into this comparison including NH_4, we inserted the corresponding figure (now Fig. 7), which was not shown previously.

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Specific comments

In the specific comments, referee #2 states that the abstract could be shortened. However, referee #1 recommends us to give some more details about current model limitations in the abstract. In our opinion, the length of the abstract corresponds well with the length of the full article. Thus, we decided to follow referee #1 and added some more details in the abstract instead of shortening.

We thank the referee for checking the URL of the reference of the IMPROVE data, which was in fact incomplete. We corrected this.

We agree with the referee, that figure 6 should be enlarged. This issue will be forwarded to the ACPD production office to be considered for the final layout.

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