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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Aerosol indirect forcing in a global model with particle nucleation" *by* M. Wang and J. E. Penner

M. Wang and J. E. Penner

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We are grateful for the evaluations of the reviewer, which have allowed us to improve and clarify the manuscript. Below we address the reviewer comments. The reviewer comments are in italics and our response is in bold.

Anonymous Referee #3

The authors examine how CCN concentration and the first indirect effect may change due to nucleation mechanisms considered (boundary layer nucleation and binary homogeneous nucleation) and how these may depend on the primary particles emitted and SO2 emissions. This is an important topic and the papers offers a detailed outlook on the various aspects of nucleation. The main drawbacks are that only the first indirect effect is studied and only sulfates are considered.

We do agree that only the first indirect effect is included, but as pointed out by Referee #2, this allowed us to do a wide range of sensitivity experiments and gave us more insight into what occurs when different nucleation treatments are used.

In our model, we include not only sulfate but also all other major aerosol species: black carbon, organic matter, dust and sea salt (section 2.1) and study how different treatments of aerosol nucleation mechanisms affect CCN concentration and the first aerosol indirect effect. Only sulfate nucleation is include since our understanding of nucleation for other species is still very poor.

The paper is well written and all mechanisms are described and analyzed in great detail. Some important conclusions are shown regarding the spatial distribution of the indirect effect and how these may change depending on changes in SO2 and primary particles. This paper is certainly acceptable. Below are few suggestions for modifications.

Minor corrections:

Line 17 , Sec. 2.1: Change "is capable to " to a more correct phrase "is capable of capturing"

Changed to "is able to" following the suggestion of Referee #2.

Suggest replacing PAR in BHN_PAR to something more suitable.(SUL ?)

This is changed to "PRIM" (see our answer to Referee #2).

Sec. 4, page 13960: How would the inclusion of other primary particles change your conclusions regarding CCN concentration differences for your different simulations? Results appear to be very sensitive to sulfate emissions (primary) and so if you include other aerosols, your results would change quite dramatically?

Our model did include primary particles of black carbon, organic mater, dust and

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sea salt as we described in section 2.1. We also listed emissions, size distributions and burdens in section 3, in Table 1 and Table 4. We do agree that primary particles other than sulfate primary particles will also affect the effects of different boundary layer nucleation mechanisms. We emphasize this point now in paragraph 5 of section 4: "Our results suggest that the effects of including boundary layer nucleation on the CCN concentrations depend on both the rate coefficients (as shown by Spracklen et al., 2008), and in an important way on the assumed and simulated primary particles. "

Section 5 is very compelling and here it would have been very useful to compare your CCN concentrations with measurements. CCN measurements are hard to make, but they exist and the comparison would be helpful to see how vertical and horizontal variations compare and which mechanism does best (if at all one captures everything). This would greatly improve the paper since changes in CCN is the main mechanism identified that connects the nucleation schemes with the indirect effect.

In the manuscript, we did not compare CCN concentrations with measurements, but we did compare simulated droplet number concentration with observations (MODIS) and pointed out how different treatments may improve the simulated droplet number concentration in section 6. Also, in Wang08, we compared simulated aerosol size distributions (accumulation mode particles are included) with a variety of observations from ground observations to aircraft field campaigns for all major cases included in this study as we pointed out in section 2.5. In section 2.2, we cited Wang08 to show that the inclusion of the boundary layer nucleation mechanism improves the comparison of simulated aerosol size distributions in the marine boundary layer with observations. We do agree with the reviewer that it would be helpful to compare CCN concentration with CCN measurements. But since CCN measurements are highly variable, to collect and to summarize CCN data involves a significant amount of work, which is beyond the scope of the present manuscript.

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Sec. 6: What was the temporal resolution used to sample model fields when comparing them to MODIS.

Model fields are sampled every time step (30 minutes). We added this to the text.

Table 4: What are the size ranges for the dust and sea-salt?

We added the size information for dust and sea-salt to table 4.

Figure 3: Is this the model level with the highest CCN concentration?

This model level is chosen to represent the boundary layer. It is not necessarily the highest CCN concentration. Over continental polluted sites, the highest CCN concentration is usually located at the lowest model level.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 13943, 2008.