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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Aerosol indirect effects in a multi-scale aerosol-climate model PNNL-MMF" *by* M. Wang et al.

Anonymous Referee #2

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General Comments:

This is a study on aerosol indirect effect based on results simulated using an aerosol-coupled multi-scale modeling framework (MMF). The aerosol-coupled MMF is a novel and innovative tool for modeling the aerosol-cloud interaction phenomena and then its simulated results are unprecedented. In this paper, the authors describe general features of the model's results regarding the aerosol-cloud interaction in comparison with traditional climate model (CAM5) and satellite observations. I think the results shown here are worth publishing although I have several specific concerns listed below. I'm especially concerned about a lack of discussion on relationships and/or consistencies among some parameters (e.g. relationship between cloud fraction and cloud radiative forcing, and consistency between the models and satellite observations regarding the

CCN concentration and the cloud droplet number concentration; see below for details). If the authors appropriately address these concerns, I would recommend publication of this paper in ACP.

Major Point:

P.3405, L.15-17: I don't understand how the ECPP approach treats the interstitial aerosols and cloud-borne aerosols separately in the framework where aerosols are represented only at GCM grid. Although readers should refer to Wang et al. (2010), can you briefly explain this?

P.3408, L.27-28: Why is the ice crystal number concentration in MMF larger than in CAM5 even though the heterogeneous ice nucleation process is omitted in MMF?

P.3409, L.11-17: Although the numbers for cloud fractions and radiative forcing are listed here, I don't understand how they are related to each other. Can you explain or discuss their relationships?

P.3409, L.28 – P.3410, L.3: Although the authors state that "Rain formation over the high latitudes is likely dominated by warm collision-coalescence processes and drizzle from low clouds", the warm rain processes should be important over tropics rather than high latitudes. Is your statement correct?

P.3410, L.17-18: What is the reason for this threshold value (1gm-2) that defines the cloudy column? Please provide any references if any.

P.3410, L.20-27 and Figure 3: It would be desirable to provide low, middle and high cloud fractions separately from MMF in comparison with ISCCP to understand the relationships between cloudiness and cloud radiative forcings (shortwave and longwave) shown in Figure 4. It would also be useful to compare the results with corresponding statistics from CAM5.

Figures 3 and 4: It would be desirable to show zonal mean latitude-pressure cross sections of cloud fractions and radiative forcing to make it easy for readers to identify

similarities and differences between MMF and satellite observations.

Figure 6: How is the cloud-top number concentration computed from MODIS retrievals? Do you assume adiabatic model?

P.3413, L.21-23: "Simulated aerosol number concentrations in the MMF are higher than that in CAM5 and agree better with observations." What observations do you refer to here? Do you claim that the aerosol number concentration in the MMF is more realistic than in CAM5 here?

P.3414, L.2-4 and Figure 9: How is the supersaturation computed in the models? Does this invoke the Abdul-Razzak-Ghan parameterization? Can you briefly explain how to compute the supersaturation here?

Figures 6 and 9: It is obvious that larger CCN concentrations in MMF than CAM5 (Fig. 9) corresponds to larger CDNC in MMF than CAM5 (Fig. 6) and that the CDNC in CAM5 (Fig. 6 middle) is closer to MODIS (Fig. 6 bottom) than in MMF (Fig. 6 top). The authors, however, seem to claim that the aerosol and CCN concentrations in MMF are closer to observation than CAM5. That is confusing. How do the authors make a consistent picture between the CCN concentrations and CDNC for the models and observations? Otherwise, are they inconsistent or still puzzling?

Figure 16: I don't understand what the difference between blue and red curves is. Can you explain it more clearly?

P.3423, L.23-25: "the much smaller increase in LWP in the MMF is caused primarily by the much smaller response in LWP to a given change in CCN" Is this consistent with the sensitivity analysis in Figure 11b? Figure 11b shows that the MMF sensitivities of LWP to aerosol amount shown in Fig. 11b have opposite (positive and negative) values over land and ocean, and it looks like that these opposite tendencies tend to cancel each other to provide small response in LWP to CCN change when merging the land and ocean analyses. Is this interpretation correct? Even when this interpretation

is correct, the sensitivities over land (Fig. 11b) are larger in MMF than in CAM5. Does this imply that the anthropogenic response of LWP is also larger in MMF than CAM5 when limited to land area? I'm wondering how the results in Fig. 11b and Figs. 17b,c are consistent.

Minor Point:

There still may be a lot of grammatical errors in the manuscript. I would recommend to thoroughly check the text to make sure that all of the errors and/or typos are corrected. Listed below are only some examples I have found in my review.

cloud lifetime effects -> aerosol lifetime effects (Although this may be an issue in terminology, I believe that "aerosol lifetime effects" is more appropriate term to represent the second kind of indirect effect of aerosols first suggested by Albrecht [1989].)

P.3404 L.23: homogenous -> homogeneous

P.3411, L.5: -0.5 -> -50.5

P.3414, L.2: show -> shows

P.3416, L.2: LWP and AOD -> LWP and AI

P.3422, L.2: less than 50gm-2 -> greater than 50gm-2

P.3427, L.2: clear-sly -> clear-sky

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 3399, 2011.