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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Development of a cloud microphysical model and parameterizations to describe the effect of CCN on warm cloud" *by* N. Kuba and Y. Fujiyoshi

Anonymous Referee #1

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In this study the authors developed a detailed cloud microphysical model, and then applied the detailed model in parcel mode to generate cloud microphysical parameterizations for use in regional and global models. The detailed model consists of two parts: (1) a Lagrangian parcel for the calculation of CCN growth and determine their activation into cloud drops, and (2) a binned drop size framework for calculating the evolution of cloud drop size distribution due to condensation and collision-coalescence. The parameterization scheme is described in similar settings: first determine the creation of cloud drops through CCN activation, and then describe the evolution of cloud drop size distribution using gamma distribution functions. Both the detailed model and parameterized models are applied in a dynamic model to demonstrate the influence of aerosols on cloud formation and rainfall. Some interesting and reasonable results are presented. But some of the descriptions in the text are not clearly presented and difficult to follow.

First, it is not clear whether their model carries a separate CCN size distribution, which is modified by condensation, activation and advection? Does it keep track of the CCN lost due to activation, and does it handle CCN recycling when cloud drops evaporate? These CCN-related model setups are critical to this study and therefore need to be more clearly described.

The parameterization scheme described in Section 4 is incomplete. If it is for use in cloud resolving models, then formulas for condensation/evaporation (to resolve supersaturation) and collision processes need to be supplied. I also did not see any formula related to rain (size distribution, autoconversion, fall velocity, etc.). I don't think the authors meant to apply Kessler's formulas that given in Section 3.1. If the parameterization scheme is designed for use in global climate models, then the authors need to mention how to predict supersaturation in Eq. (3), and how to calculate rain formation (such as Eq. (1)).

The appendix seems to provide no additional information than those given in Chen and Lamb (1994). I would suggest deleting it.

Specific comments:

1. p. 1417, line 18˜22: The description here seems to suggest that no activation is allowed if the grid already has a few cloud drops present. However, activation is not an abrupt or instantaneous process. Near the cloud base, the whole process might take a few tens of seconds (across many time steps) to complete. Even inside the cloud, activation is still possible if the updraft is strong and the cloud drop concentration is low.

2. p. 1418, line 1˜3: This sentence is confusing. Do you mean that the resolution of the size bins should be fine enough to resolve the cutoff size to a certain precision?

3. p. 1418, line 5˜7: It is physically possible to activate all CCN, and the simulation results should not be invalid it that does occur.

4. p. 1418, line 8˜12: This seems to be a reasonable assumption, but it might be better for the authors to provide its basis (references or some discussions) to aide general readers' understanding.

5. p. 1418, line 22˜25: The description is rather confusing. Are the authors talking about cloud drop advection in the Eulerian framework? If so, then shouldn't your advection scheme handle this automatically?

6. p. 1420: The results presented in Fig. 4 are quite interesting, particularly the large difference in rainfall spatial patterns. But the discussion provided by the authors seems too brief. It would be nice to show the two dimensional structure of cloud and rain field, and how the surface rainfall is related to them.

7. p. 1425, 10˜13: I am not sure in which way is the proposed scheme more convenient than the conventional parameterizations of Twomey's or other modal type schemes. Is it in the mathematical formulation or computation efficiency?

Interactive comment on Atmos. Chem. Phys. Discuss., 6, 1413, 2006.