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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Application of a new scheme of cloud base droplet nucleation in a Spectral (bin) Microphysics cloud model: sensitivity to aerosol concentrations" *by* E. Ilotoviz and A. Khain

Anonymous Referee #2

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The study is about testing a new scheme of droplet nucleation at cloud base using HUCM with spectral (bin) microphysics. The goals of the study are to test effects of the improved calculation of supersaturation maximum near cloud base (new approach-NA) at different aerosol loadings, and to evaluate sensitivity of cloud microphysics to concentration and shape of size distribution of aerosol particles. The goals are achieved generally but some conclusions need to be refined with additional investigation (see the comments below). The introduction is very simple can be expanded as well. The paper is well written, despite some grammar errors. Therefore, revisions are needed before being accepted by ACP.

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Major comments, 1. The Introduction is short and sounds incomplete. It can be expanded to include (1) the importance of droplet nucleation to cloud properties and precipitation, (2) the description of the current approach (ST) and its limitation.

2. If the authors want to claim that the NA method gives more realistic droplet nucleation than ST and also to better evaluate both the ST and NA, it is necessary to conduct a benchmark test in which very high vertical resolution is used to resolve the maximum supersaturation and compare the supersaturation and droplet concentration with those from the benchmark test. In addition, the authors have a statement that the NA can be applied to any vertical resolution. By comparing Smax parameterized with the model predicted in such a test can help support that conclusion as well. This test should not be difficult to do with the idealized 2-D model.

3. Some clarification is needed for the description of NA method (Section 2) and additional discussion is needed throughout Section 4 (see the specific comments below).

Specific comments,

1) Line 134-139, for Eq (3), I am confused here, how did you solve three unknowns (Smax, the critical radius of the aerosols activated, and the nucleated droplet concentration) with Eq. 3? 2) Line 142, what is the new microphysical scheme? A little more details are needed here. 3) Line 147-151, do you mean the simulation is not initiated with a real sounding? Then I would like to see some justifications how the used dynamics and thermodynamics are close to a realistic atmosphere condition. 4) Line 161-162 and Line 167-168, for the clean conditions, why the minimum CCN radius is set to be a little smaller than the polluted conditions? 5) Line 196-200, Figure 2 does not show the results of Sw and droplet concentrations. Please present the results. 6) Line 253-256, the statement about “the decrease in the snow mass content” in the more droplet nucleation condition is not what Fig. 6 shows. Snow water content in EN3500-S is larger than E3500-S. Also, the NA method produces such greater graupel water content than the ST when shape parameter is 0.9. Is this related to a certain threshold used in the

riming processes to form grauple? In the tests with the shape factor of 0.5, the increase is not as dramatic. Why? 7) Figure 8 and Line 272-276, the discussion here should be compared with Figure 4 which shows that results for the high CCN condition. The differences between NA and ST in droplet number concentration are smaller, which is limited by available CCN. Also, CWC peaks at very different height compared with the high CCN condition. 8) Figure 9 and Line 297-298, the statement is not right about hail. The hail mass content is the largest in the E100 and EN100 where no smaller CCN exist and droplet concentration is the lower than others. In addition, please discuss such high sensitivity of graupel to the small CCN (i.e. droplet number concentration under the maritime cloud condition and give possible reasons about it. 9) Figure 10d and line 315-319, why does the hail precipitation in EN100-S-0.5 is much less than E100-S-0.5 since effect of small CCN is also included in this set of tests? 10) Line 345-347, I do not understand this statement, the small CCN increase droplet concentrations at the much higher levels, not around cloud case, how can it be made up by using the NA method? I did not see such results from Figures 4 and 8. I think the conclusion should be in-cloud nucleation has to be considered in the case of existing small CCN. 11) Line 366-368, see my comment in #8. 12) Line 382-383, the statement "It can be used in cloud-resolved models with different vertical grid spacing", is not supported by the content yet. By adding the benchmark test in which Smax calculated with NA can be compared with the model predicted Smax would address this problem.

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