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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A continuous spectral aerosol-droplet microphysics model" *by* Z. J. Lebo and J. H. Seinfeld

Anonymous Referee #2

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In this manuscript, the authors describe detailed formulations of a new double-moment spectral microphysical scheme that explicitly treat aerosol particles and cloud droplets. The scheme is evaluated against some other microphysical schemes (bulk and spectral schemes that only deal with cloud droplets) with large-eddy simulations (LES) of marine stratocumulus clouds using the Weather Research and Forecasting (WRF) model. One of the great advantages of this new spectral scheme is to track aerosols all the way from activation to regeneration, which is not explicitly considered in most microphysics schemes currently used in numerical models. The manuscript is well written. I recommend for publication in ACP after the following comments/questions are addressed upon revision. Some are potentially major.

1. The behaviour of this new microphysics scheme ought to be fully evaluated. In this

study, it's evaluated in the 3-D WRF simulations, in which the effects of the new microphysics are hard to be differentiated from dynamical effects or feedbacks by looking at mostly domain-average cloud properties. The model domain (1km x 1km) is rather small and the simulation time (2 hours) is likely to be too short. I understand that this new spectral microphysics is computationally expensive, but it can be better tested in 2-D WRF LES or some simple kinematic framework.

2. In the Results section, results from the LES_2D simulation (with the new microphysics) are treated as "truth", and then saying that other schemes "overpredict" or "underpredict" some cloud properties might be inappropriate. After all, the new microphysics scheme hasn't been fully evaluated and there are limitations in it.

3. Equations (1) and (2): does the first bin start with i=1 and k=1? If yes, it should be i-1 and k-1 on the right hand side.

4. P23664, L3-4: it's hard to understand why the smallest bin for cloud droplets can have the same size as the smallest aerosol bin. If this is the case, can there be any droplets in the smallest bin? Any aerosols smaller than typical accumulation-mode particle sizes covered in the new scheme?

5. Is the equation (3) for droplet size? There are many other variables in equations are not defined, including qv and ql in equation (9). The coefficient in equation (10) doesn't seem to be right, and N and Ni,k may be confusing.

6. P23667, section 2.2: the description of sedimentation is quite simple. I would expect that sedimentation is critical to drop evaporation and aerosol regeneration. Please comment on this.

7. P23667, L9: This seems to be different from that described on P23664 (L5-7). Please clarify.

8. Equations (14) and (15): Do you assume that smaller droplets can collect larger ones? Where are (n, m) from, and how are they related to (i, k) and (j, l)?

9. P23670, L1: is x' size or mass?

10. P23673: any surface fluxes and large-scale forcing applied to simulations?

11. P23675, section 4.1: the discussion of the LES_bulk_NoReg case seems to be irrelevant. Issues in the cases are obvious. For a simple bulk microphysics without regeneration or source of aerosols, cloud droplet number concentration is usually fixed.

12. Using qt for both total water mixing ratio in Fig.1 and the total condensed water Fig. 6 is very confusing.

13. In Fig. 4 (P23676), why Nd decreases so fast with time (somewhat unrealistic) in the cases with bin microphysics, especially in the 1-D bin case?

14. P23677, L1-14: do these explanations supported by your model simulations? Evaporation of aerosol particles?

15. P23677, L20-22: need to clarify. I had a hard time to imagine.

16. Related to Fig. 9: if the simulations were run for a longer time, all aerosol particles might go into bin #14 (I guess in the microphysics it might have been assumed that no aerosols go to bin #15.), which means that the results are largely influenced by the total aerosol bin number. Please comment on this.

Minor edits:

1. P23666, L13: comma between qv and T.

2. P23680, L20: remove "is"

3. P23672, L22: change "are" to "is"

4. P23668, L11: "no" to "not"

5. P23681, L9: "yellow" to "red"?

6. P23685, L23: "once" to "one"

7. Fig. 2 caption: (4)?

8. Figs. 4, 5: the current arrangement of case names, panel numbers and colors in the caption is confusing.

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