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

Anonymous Referee #1

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Review of ACPD-11-23655 manuscript: "A continuous spectral aerosol-droplet microphysics model" by Lebo and Seinfeld.

Recommendation: accept with major revisions.

General comments:

This manuscript presents a novel two-dimensional aerosol-drop bin microphysical scheme coupled with WRF to explicitly investigate how cloud processed aerosols affect marine stratocumulus. By comparing LES results from 2-D, 1-D and bulk microphysical schemes with different aerosol regeneration assumptions, the authors demonstrated the capability and superiority of the new 2-D scheme and concluded that regenerated aerosols have significant impacts on simulated clouds.

The authors developed one of the very few existing 2-D bin schemes, which by itself is already a big achievement. One of the greatest potential of this scheme is to build parameterization of regenerated aerosol size distribution for 1-D bin or bulk schemes. This manuscript was well organized and written. However, some major points need to be addressed.

1. Collision-coalescence (CC) is indeed the most important microphysical process to shift the aerosol mass to large end of the spectrum. However, the kinematic collisions between very small aerosol particle (< 0.2 μm) and cloud droplets are very inefficient. In this size regime, Brownian, phoretic (both thermophoresis and diffusiophoresis) and turbulent collections of aerosols by drops become more active and important. To more accurately simulate the in-drop solute mass, these processes should be included in the model. If implementing such processes is difficult for now, the authors need to point out this deficiency of the current 2-D bin model and discuss the impact of missing these processes on the results in the manuscript.

2. The 3D LES test case is very expensive for this 2-D bin scheme. The 40 m vertical resolution is probably not enough to investigate entrainment process. The analyses of 2 hour data, in my opinion, are not very sufficient for such kind of simulation. 1D/2D kinematic/dynamic setups might be better choices to test the scheme in the first place. I suggest the authors to analyze a 2D LES test case with higher resolutions and longer simulated period in detail to present the advantages of this 2-D bin scheme and to analyze the 3D LES results briefly to demonstrate the capability of this scheme in 3D applications.

3. Because the aerosol activation, regeneration assumptions, terminal velocity calculation, diffusion growth calculation, drop size range and even the numerical approach are different between 2-D and 1-D bin schemes (flux method for 2-D and method of moment for 1-D), the opposite sign of pollution effect on LWP between these schemes might not be solely attributed to the representation of aerosol regeneration. A more appropriate and consistent strategy of testing regeneration effect is to use the same

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2-D scheme with different regeneration assumptions (probably in 2D LES case to save time). âĂČ

This manuscript is worthy of publication on ACP subject to the points discussed above and some minor points listed below:

1. The upper limit of drop size is 205 μm. Is it big enough to cover the size range of clean clouds? A droplet size distribution plot at the end of simulation can answer this question.

2. Similar to point 1, is the upper limit of 1.6 μm for aerosol enough? I noticed that from figure 9, there was no change at bin 15 throughout the entire simulation. How could bin 14 change a lot but bin 15 change none?

3. What is the background aerosol chemical composition? Ammonium sulfate, sea salt or others?

4. What is the upper limit of the initial aerosol size distribution? This is related to point 2. If some aerosol particles existed in bin 15 at the beginning, the number concentration of bin 15 should increase as for bin 14. Even there was none in bin 15 at the beginning, with more droplets activated by aerosols in bin 14, CC can easily generate aerosols in bin 15.

5. Page 23666, line 9. The number of ordinary differential equations should be less than N*M+3. For droplets in bin i = 1 to M, there are at most i aerosol bins associated with it. Droplet cannot contain aerosol greater than itself. Thus, (1+M)*M/2+(N-M)*M+3 should be the number.

6. Page 23672, lines 22 - 23. Xue et al., 2010 dealt with orographic clouds not MSc.

7. Page 23673. How did you treat surface fluxes? Fixed values or explicitly calculated by surface schemes?

8. Page 23674, last sentence. Do you mean when there is supersaturation in a grid

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box, you use 95% RH to calculate the equilibrium size of wet aerosol? How did you initialize the wet aerosol when RH is between 95% and 100%?

9. In results section, many statements like "bulk scheme overpredicts LWP" exist. Please mention at the beginning of this section that "hereafter, results from 2-D bin scheme will be treated as truth because . . .", so that "underpredict" and "overpredict" have reference.

10. Page 23676, lines 4 – 6. It is not clear which case you refer to.

11. Page 23676, lines 13 – 15. Sandu et al., 2008 and Chen et al., 2011 showed that increase of LWP with increasing aerosol is associated with drizzling or precipitating clouds not the non-drizzling clouds as examined in this manuscript.

12. It is also informative to show drop size distributions besides the radar reflectivity plot.

13. Page 23685, lines 23 – 28. For MSc, it might be true that aerosol regeneration is not important in thick clouds. But for cumulus and deep convective clouds, the clouds are essentially turbulent. In-cloud downdraft can cause complete evaporation of drops and hence regenerated aerosols can be very crucial in these thick clouds. âĂČ

Technical comments:

1. Page 23658, line 14. ". . . aerosol particle grows within . . ."

2. Page 23659, line 14. "left to right, red, solid"

3. Page 23660, line 18. "since the critical . . ."

4. Page 23662, last paragraph. Please use either "Sect." or "Section" throughout the manuscript.

5. Page 23665, line 18. Is "ρ_w" missing in the equation (10)?

6. Page 23680, line 20. "cases; Z increases at .."

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7. Page 23681, line 9. “(red)”

8. Page 23685, line 23. “To answer the second question, one can . . .”

9. Page 23694, line 13. I think the first author is Xue, L. not Xue, H.

10. Page 23701. The unit of time should be minute not hour.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 23655, 2011.