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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Turbulent collision-coalescence in maritime shallow convection" *by* A. A. Wyszogrodzki et al.

Anonymous Referee #1

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This paper uses a LES model with bin microphysics to investigate the effects of turbulent collision-coalescence under a range of CCN concentrations. A highly simplified experiment using a warm bubble is first used to illustrate that, as well as there being a microphysical enhancement to the formation of rain that occurs when turbulent collision kernels are use, there is also what appears to be a dynamical enhancement due to the suspected unloading of water from updrafts. The BOMEX case study of shallow convection is used to examine these enhancements and it is shown that in the high CCN experiments the effects of turbulent collision-coalescence is to increase drizzle within clouds. In the low CCN experiments there is a significant increase in surface rainfall in the turbulent coalescence cases and no impact on the cloud water contents. It is suggested that this is due to a dynamical enhancement. An interesting result shown

in the paper is that the effect of subgrid scale TKE dissipation intermittency due to the different resolutions of DNS and LES is roughly negligible. This is an important result that means using mean TKE dissipation rates from LES grid boxes to calculate the turbulent collision kernels that are derived from much higher resolution DNS dissipation rates is an appropriate strategy, at least given our current knowledge and numerical capabilities. The paper is generally well written and contains new results that should be of interest to the general cloud modeling community. The discussion of results includes a critical assessment of the limitations of the methodology applied and future directions for numerically investigating turbulent collision-coalescence. I recommend publication of the paper after the comments below are addressed.

Comments:

1. Have you investigated the sensitivity of your results to the cloud/rain threshold radius? The value you use of 25 microns is small, was this chosen to maximize the rain water since this case is a non-precipitating case? I wonder whether this could be a reason why you do not produce larger cloud water contents for the turbulent collision-coalescence cases.

2. To support your argument for a dynamical enhancement that comes from using turbulent collision kernels, it would be useful to provide some evidence in the form of a figure that shows something even as simple as vertical velocity statistics from your simulations.

3. Some discussion is warranted on the reasons why you simulate deeper clouds through some suspected dynamical effects compared to the results of Seifert et al. (2010) who found small reductions in the height of the inversion, which as they discuss is consistent with the findings that more precipitation leads to a shallower boundary layer.

4. The abstract states that this paper is focused on a quantitative assessment of the effects of turbulence on rain formation and in the introduction on page 9221 it says

that the analysis of results in this paper will “unambiguously” evaluate the effects of turbulence. However, the conclusions then state that the results presented “have to be considered as just an initial step” towards quantifying turbulence effects on rain development and describe reasons why a quantitative assessment is very challenging. I agree with the conclusions and suggest that you tone down the previous descriptions in the paper that claim this is a quantitative study.

5. The appendix should be removed as it does not contain anything that is not repeated in at least 2 other papers. The results presented in Appendix A appear exactly in the same form as the original paper by Ayala et al. (2008b), as well as other papers by this group such as Xue et al. (2008).

6. Page 9228: What does “almost converged” mean?

7. Page 9228: Details of the domain size should be given here and included on Figure 4.

8. Page 9230, lines immediately after (12): Please provide numbers to define small and larger droplets.

9. Page 9240: Can you provide some ideas as to how one should go about using remote sensing observations to validate the modeled effects of turbulence on rain formation?

10. Discussion of Figures 9 and 10 should be expanded to include some description of the cloud water content being similar between the simulations with and without turbulent collisions and the effect of turbulence on rain water appearing to be larger for low CCN as compared to high CCN.

11. There is no need to include both Figures 13 and 14, just show one of these.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 9217, 2013.