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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The propagation of aerosol perturbations in convective cloud microphysics" *by* Max Heikenfeld et al.

Anonymous Referee #3

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Review of Heikenfeld et al., "The propagation of aerosol perturbations in convective cloud microphysics"

General comments

The authors present an analysis of microphysical processes in idealized simulations of deep convective clouds for different aerosol concentrations and three different microphysics schemes. Novel visualization techniques are presented to show the temporal and spatial evolution of the processes and the associated latent heating. A focus of the analysis is whether the "invigoration hypothesis" by Rosenfeld et al. (2008) can be confirmed (and in can not).

This last point is quite interesting and the main reason why I recommend this paper

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Discussion paper

for publication. The manuscript is very well written, and the plots are clear (though a bit small for my taste). The comparison of the microphysics schemes doesn't go into depth, and it is a bit unclear what the intention behind the presentation of three schemes is. In particular, the third scheme (SBM) is only shown for a subset of the analyses, although it deviates substantially from the other two. I recommend changes to clarify these points.

Detailed comments

- The abstract mentions that three schemes are used, but not what the benefits of the comparison are. Do they give consistent results regarding the invigoration effect? Can anything be learned from the comparison (e.g. regarding depositional growth of different ice species, which has caused a huge difference)?

- page 3, line 11-16: here the logical flow is unclear. Why is there a separate paragraph on Glassmeier and Lohmann? This needs an introductory sentence.

- The (main) text is not very clear about how many cells are simulated and how the analysis is done when there are two cells. (I assume that you have always either one or two cells, and that the properties of the two cells are averaged, but I have not found this clearly in the text. Maybe I just missed it.)

- The model setup description needs more information to make the study reproducible. In particular, Weisman and Klemp (1982, 1984) describe several versions of their idealized sound (different values of qv0), which one is used here? and how exactly is the warm bubble defined? What boundary conditions (open/fixed/periodic) are used? Such information could be given in the appendix.

- What regions/clouds are the two different model setups representative for?

- Can you comment on whether the CDNC concentrations as listed in Table 1 are actually prescribed at all grid points where there is liquid water, or only at cloud base/when new droplets form?

- Figure 2 and others: some of the pie charts are very small. Is the reader expected to read these?

- Figure 2: “contour lines for . . . ice (grey) content”: Is this just cloud ice or cloud ice + snow + graupel + hail?

- Figure 2(e): It looks like there is melting above the melting level?

- Why is there no plot as Fig. 2/3/4 (and more) for the SBM scheme?

- page 11, line 31: Can you comment on which parameterizations are used for rain freezing vs. cloud drop freezing, and why one is more CCN-dependent than the other?

- Figure 10: There is a substantial difference in evaporation between the two schemes. Why is this? Mixing assumption?

- Page 18: Why is the cloud dissipating with Thompson microphysics? This is a very substantial difference that should be discussed more.

- It remains a bit unclear to me what the conclusion from the second case is. Are the result regarding the invigoration hypothesis robust? Or is everything so different that not much can be concluded from two cases and one would actually need many more?

- The conclusions could be more quantitative regarding the invigoration effect by giving number for the percentage change in latent heating.

Technical comments:

- page 1, line 24 and many other occurrences: I think it is common to list multiple references for the same statement either in chronological or in reverse chronological order, not in arbitrary order as here.

- page 5, line 6: scheme -> schemes

- page 6, caption of Table 1: “10 g/, kg-1”: change “/,” to the latex command “\,”

- page 14, line 8: “The differences are in part caused by . . .”: This seems to be a

repetition, the same was already said in line 4.

- page 23, line 15: full stop missing after “framework”.

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