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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Theoretical basis for convective invigoration due to increased aerosol concentration" *by* Z. J. Lebo and J. H. Seinfeld

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We would like to thank Dr. Fan for his thoughtful comments. We would like to address each of Dr. Fan's comments.

First, we address the issue of the resolution of the simulations. There are multiple considerations in determining an appropriate resolution that often depends on the type of simulation being performed, e.g., cloud resolving, large eddy simulations, etc. One seeks a resolution that optimizes the ratio of model resolution to computing time. Changes in model resolution alone are not the whole story since one can increase the model resolution while decreasing the domain size in order to maintain the ratio of model resolution to computing time. However, domain size is critical for simulations of transient deep convective clouds so that the single cell or cloud system is able to

fully develop within the domain, unaffected by boundary conditions that may skew the results. In the current work, we maintain a sufficiently large domain such that boundary influences are minimal while increasing the horizontal and vertical resolution beyond that which has been used in previous, analogous studies. Furthermore, the duration of the simulation plays a significant role in the ability to explore fully the relevant cloud response to aerosol perturbations. We note in the manuscript that we chose a simulated time of 12 hours to model the cloud through its full lifetime until the precipitation rate becomes zero. This ensures that conclusions drawn are based on the full cloud lifetime and not on the initial effects on cloud development.

We note that it is irrelevant to compare the resolution used in the current study with that of prior work that used bulk microphysics and/or modeled stratocumulus clouds. Our work, based on 3D simulations using bin microphysics, can be compared only with analogous studies. In the revisions, we will clarify the statements regarding the model resolution to stress that we compare only 3D bin microphysics CRM simulations on a comparably extensive domain.

Our understanding regarding the effect of vertical shear in the horizontal wind on the aerosol-induced changes in precipitation from deep convective clouds from the study of *Fan et al.* (2009) was incorrect and will be corrected in a revision of the manuscript. We thank Dr. Fan for pointing this out.

In regard to wind shear, we chose to use the standard quarter turn shear wind profile of *Weisman and Klemp* (1982) following previous studies (e.g., *Khain and Lynn*, 2009). Fig. 2 demonstrates that the initial profile provides for vertical shear in the zonal wind that is not negligible but is less than that chosen by *Fan et al.* (2009). One purpose of our study was to evaluate dependence of aerosol-induced effects in deep convective clouds on changes in ambient relative humidity. We did not intend to focus on the response of deep convective clouds to aerosol perturbations in under high wind shear conditions.

The effect of IN on the cloud development in the bin microphysics scheme is computed by doubling the number of immersion IN (hence increasing the number of droplets that freeze) as well as doubling the number of deposition/condensation IN (hence increasing the number of ice crystals that form directly from water vapor). This point will be made more clearly in the revisions to the manuscript.

Lastly, in reference to Fig. 19, the curves shown are only for the simulations with bin microphysics.

References

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