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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Thunderstorm and stratocumulus: how does their contrasting morphology affect their interactions with aerosols?" *by* S. S. Lee et al.

Anonymous Referee #2

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By means of model simulations, the study demonstrated that clouds and precipitation response differently due to differences in the morphologies of convective and stratiform clouds to increasing aerosols. In convective clouds, aerosols suppress the autoconversion rate, increase cloud number concentration, and enhance evaporative cooling. The enhanced cooling leads to an increase in the intensity of downdrafts, gust fronts, and updrafts, which enhance condensation and precipitation. Such results are consistent with other studies. The authors also argue that this process is more important than the latent heat release from freezing in terms of rainfall enhancement following experiments with and without ice. In stratiform clouds, the acceleration of downdrafts is less significant due to smaller clouds depths, therefore, the suppression of precipitation by

aerosols dominants. The underlying physical processes are clearly elaborated. I would recommend the paper for publication after addressing the following comments.

My main concerns are the conclusions drawn from the experiments with and without ice that the aerosol effect on gustiness plays a much more important role than that of freezing and freezing. While it is well known that evaporative cooling is an important factor to enhance precipitation based on both previous studies and the present study, the evidences presented here to support the argument concerning its relative importance are not sufficient. There are two issues involved:

1) In the no-ice experiments, cloud top is over 10km and there is no ice, which means the liquid clouds are extremely thick. According to this study, cloud thickness plays a very important role in determining the aerosol effect on the acceleration of downdrafts. Thicker clouds provide longer paths for cloud particles to evaporate. Therefore, the aerosols effect on gustiness may be overestimated in such idealized thick liquid clouds.

2) In the case DEEP, CAPE is increased by increasing the humidity forcing. This reduces the rain suppression effect by aerosols due to increases in available water vapor. Therefore, warm rain processes may not be suppressed effectively and may still be the dominant mechanism to generate precipitation (similar to the TOGO COARE case in [Tao, et al, 2007]). In such a scenario, freezing is certainly not as important as the evaporative cooling. In the Case MID, the humidity forcing is reduced and the aerosol effects on precipitation through freezing could show up. If this is the case, the relative importance of evaporative cooling and freezing is not really determined by cloud thickness but humidity. What if CAPE is increased by changing vertical temperature gradient instead of the humidity forcing? Will this lead to significant enhancement of precipitation by freezing while the cloud is still deep in CASE DEEP?

Specific questions and comments:

1. Page 4318 line 19, "The reduction of heat within the system by the evaporation of cloud liquid due to the reduction in aerosol concentrations is $\sim$40 times larger than that

released by cloud liquid freezing as shown in Table 2." It's not clear which two numbers were compared. "due to the reduction in aerosol concentrations" should be "due to the increase in aerosol concentrations"?

2. Table 3. The numbers in the third row shift to the left.

3. Vertical profiles of latent heat absorption and release will be more useful to demonstrate the influences of evaporative cooling and freezing on cloud development.

4. Fig.5. Some lines are difficult to identify. It is better to use thicker lines or different symbols.

5. Fig.8. Need to clarify whether the results are from the experiments with-ice or no-ice.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 4305, 2010.