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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Factors determining the effect of aerosols on cloud mass and the dependence of these factors on liquid-water path" *by* S. S. Lee and J. E. Penner

Anonymous Referee #3

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This paper examined the impact of condensation and sedimentation on LWP of marine stratocumulus clouds. The authors used Goddard Cumulus Ensemble (GCE) model, and simulated a case of thin marine stratocumulus cloud located off the coast of the western Mexico. The LWP of simulated marine stratocumulus was varied from 73 to 36 g/m^2 by modifying the surface latent heat flux. Through a budget analysis of the source and sink terms, the authors found that condensation and evaporation are 1 to 2 orders of magnitude greater than sedimentation, and the effect of aerosol on cloud LWP (mass) is mainly through its impact on condensation instead of sedimentation. The topic of the paper is well suited for Atmospheric Chemistry and Physics, but I have some questions, which are outlined below. I recommend the authors take into

consideration the comments and revise the paper.

Major comments:

The current study is quite similar to an earlier paper published by the authors (Lee et al., 2009). Both studies presented simulations of marine stratocumulus with different LWP, and reach the conclusion that for thin marine stratocumulus clouds, the effect of aerosol on cloud LWP (mass) is mainly through its impact on condensation instead of sedimentation. In addition, the discussions of the cases in which LWP decreases with increased aerosol concentration (case LH-D5 in current study, and DRY case in earlier paper) are nearly identical. I'd suggest the authors include more analysis to better understand the physics processes that control LWP as described in the next comment.

The impacts of aerosol on both condensation and sedimentation/precipitation can change the updraft velocity, which in turn influences condensation. The change in updraft velocity can also influence the entrainment rate. Depending on the RH at the top of the boundary layer, an increased updraft velocity can either increase or decrease LWP. The interactions between microphysics and dynamics are complex. For example, increased aerosol leads to higher LWP in some cases (e.g. LH-10D), but lower LWP in others (LH-5D). To convincingly demonstrate the importance of condensation on LWP, the authors may need to carry out additional simulations to separate the effects of different processes, including using fixed droplet number concentration for condensation (as done in Lee et al., 2009), turning off precipitation/sedimentation, and using same entrainment rate for both low and high aerosol concentration cases .

Minor comments:

In abstract, the sentence "...the role of the feedbacks between microphysics and dynamics becomes more important with the lowing level of LWP" is misleading. Whereas the impact of aerosol on condensation is more important than precipitation/sedimentation, Table 2 shows that the impact of aerosol on condensation (i.e. the difference in condensation rate between PD and PI aerosol cases) deceases with decreasing LWP.

Page 19319, Line 15, please show CCN spectra for both PD and PI emissions.

Page 19324 Line 15-16. I disagree that the role of sedimentation is not important. In case LH-5D, the impact of sedimentation on updraft velocity leads to reduced LWP at high aerosol concentration instead.

Page 19325, Line 15-16, I would expect the difference in F_{Re} is also important as it scales with droplet diameter. What is difference in F_{Re} between PD and PI aerosol cases?

Figure 9 shows that supersaturation is the highest in the case LH-M5. Why is the cloud droplet number concentration in case LH-M5 the lowest among all cases (figure 8)?

Page 19327, Figure 12c and 12d: There appears to be some inconsistencies between figure 12c and 12d. The potential temperatures are the same at the surface for both PD and PI aerosol cases (Fig. 12d). If $d\theta/dz$ is consistently lower for the PI aerosol case (as shown in Fig. 12c), I would expect the potential temperature at the top of the boundary layer for the PI aerosol case will be lower than that in the PD case. But Fig 12d shows the potential temperatures are the same for both cases at the top of the boundary layer.

Page 19328, Line 9-11. Why does stronger vertical motion lead to increased condensation (at same altitude) in this case? As long as the droplet number concentration is lower in the PI case, should the smaller droplet surface area lead to a higher supersaturation (i.e. water vapor mixing ratio), and a lower liquid water content when compared to the PD case at the same altitude?

Table 2: In control case, the different in <Qevap> between high and low aerosol scenarios in control case should be 0.41 instead of 0.38.

Reference:

Lee, S. S, Penner, J. E., and Saleeby, S. M.: Aerosol effects on liquid-water path of thin stratocumulus clouds, J. Geophys. Res., 114, D07204, doi:10.1029/2008JD010513, 2009b.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 19313, 2009.