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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Aerosol effects on the cloud-field properties of tropical convective clouds" *by* S.-S. Lee and G. Feingold

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The authors analyze the effect of aerosols on cloud microphysical and dynamical properties and precipitation from tropical convective clouds using 2-d model with bulk-parameterization scheme.

Traditionally tropical convective clouds are considered as the most sensitive to aerosols. The authors found a comparatively low effect of aerosols on accumulated precipitation: even ten-fold increase in aerosol concentration results in a similar temporal evolution of mean precipitation and a small (9%) difference in cumulative precipitation between the high- and low-aerosol cases. At the same time the sensitivity of other parameters, such as total mass of condensate, mass fluxes, etc. were found to be very sensitive to aerosols.

The paper is of interest and can be accepted for publication after *major revision*. The

comments and remarks are presented below.

1. Figure 12a. It is not clear why the sum of liquid and ice contents is equal to zero below ~500m. Under such profiles surface precipitation should be equal to zero. I suspect a mistake in the figure.

2. It seems that the authors believe that the small effect of aerosols on accumulated rain is the result of the averaging over many clouds and over long time. Note that ccomparatively low (5-15%) sensitivity of precipitation to aerosols was found earlier in simulations of single clouds (Khain et al.2008; Khain 2009; Fan et al. 2009), squall lines (Khain et al. 2009; Tao et al. 2011), supercell storm (Khain and Lynn 2009), etc. Moreover, it was stressed in many of these studies that the comparatively small changes of relative humidity, surface temperature, wind shear and other parameters affect precipitation much stronger than aerosols. Moreover, the change in these parameters can lead to the change of the sign of precipitation response to aerosols. It is desirable to add this comment into the paper.

3. the sensitivity of results to the model resolution should be also stressed.

4. This comment concerns the accuracy of the results. In the survey by Khain (2009) it was shown that surface precipitation is a small difference between two large values: generation of condensate (condensation, deposition) and the loss of condensate (evaporation, sublimation). A small error in calculation of any of the components may lead to a very significant change in surface precipitation. Taking into account that any model and any microphysical scheme are not perfect, the conclusion about the negligible effects of aerosols on precipitation amount should be treated with caution (as well as the opposite conclusions about dramatic effects of aerosols on precipitation).

This comment is especially applicable to the bulk-parameterization models which, according to results of many studies, tend to significantly underestimate aerosol effects on precipitation. The errors of different bulk schemes in reproduction of different physical processes are well known. For instance, the errors in reproduction of sedimentation lead to significant errors in calculation of surface precipitation (e.g., Milbrandt and Yau, 2005, Li et al 2009). The huge difference in sensitivity of the mass fluxes to aerosol effects obtained in this study and that of Morrison and Grabowski (2011) supports the statement that different bulk-schemes produce very different results in simulations of the same case studies. Thus, the estimation of 9% precipitation increase that can be obtained by increase in aerosol concentration can be considered as an estimation by order of magnitude.

5. As regards to the model and the bulk-scheme used, it would be important to present some results characterizing the accuracy of the method. For instance, DBZ-height histograms (see eq. Iguchi et al 2012) would be useful. What is the relation between convective and stratiform rain in the simulations? Can the authors to compare their results with observations?

6. The process of the cloud-aerosol interaction is not described in the paper. How are aerosols activated? Aerosols are depleted by nucleation scavenging. The process of the scavenging is very efficient. The authors use the periodic boundary conditions. So, the boundaries are not serve as the aerosol sources. Does the aerosol concentration decrease with time in the computational area? If so clouds become more and more "maritime", and effects of precipitation on aerosols decreases. Does a source of aerosols exist in the model? The treatment of aerosols can significantly affect the results.

7. How do the results of this study compare with the observed data by Koren et al. (2012) showing a significant increase in precipitation in Tropics with the increase in aerosol concentration?

8. The authors explain relatively low sensitivity of precipitation to aerosol by the compensation of the decrease in autoconversion rate by the increase in the accretion rate. What are values of ice content in this case? It seems that Figure 12 does not show a significant increase in ice mass content with increase in the aerosol concentration.

9. Last question. Why 9% increase in precipitation over large area is considered as negligible? The increase by 9% means the increase in the latent heat release by 9%. While this value is negligible, when we are talking about the weather forecast, this effect on climate can be significant.

Minor remarks:

1) The sentence: "Two-day two-dimensional simulations of an observed mesoscale cloud ensemble (MCE; Houze, 1993) are performed over a two-day period. "two day" is used twice .

2) The text said: "Cloud system studies of long duration or encompassing large domains have demonstrated that total precipitation amount is predominantly determined by radiative-convective equilibrium (RCE) or the applied large-scale forcing, which leads to negligible variations of the precipitation amount with varying aerosol". This statement is not obvious, because aerosols represent not a passive component, but possibly an important component affecting radiative-convective equilibrium. You simulate a hypothetic scenario when aerosol concentration increases ten times in Tropics (or in some region of Tropics). In this extreme case the radiative-convective equilibrium will be different.

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