Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2017-396-RC2, 2017

Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Understanding aerosol-cloud interactions in the development of orographic cumulus congestus during IPHEx" *by* Yajuan Duan et al.

Anonymous Referee #2

Received and published: 1 July 2017

This study attempts to reach closure between simulated and observed relationships among CCN, cloud base updraft, drop concentrations, cloud mixing extent with ambient air, supersaturation at cloud base and above it, and condensation accommodation coefficient. This is a worthwhile and ambitious goal, but unfortunately the available measurements are insufficient for achieving any unambiguous closure. The authors are aware of this and attempt to supplement the missing measurements with assumptions that cannot be supported. This undermines the basis of the validity of the claimed closure.

The specific problems with the basis of the study are:

1. Are these really cumulus congestus clouds? The nature of the clouds does not appear to be cumulus congestus, but rather deep precipitating clouds, at least by the radar data shown in Figure 2. Panel b shows an intense downdraft with Doppler folding velocity well exceeding 10 m/s. The reflectivity at that time, as shown in panel a, is so large that the radar echo at that time is fully attenuated above 3 to 4 km.

2. Is cloud base updraft 0.5 m/s? The cloud base updraft for convective cores should be taken as the peak and not average values. During the time before 12:31 they reach values between 1 and 2 m/s. Cloud base is where the green changes to white between 2.5 and 3 km MSL. The green indicates the fall velocity of the light precipitation from the clouds below their base.

3. The updraft vertical profile. The stable stratification implies that the updrafts were forced mainly by orography and/or gust front from the nearby strong downdraft. Therefore, a parcel model of convective updraft is hardly applicable for this situation.

4. CCN concentrations at cloud base. The CCN at cloud base is not measured, but rather assumed. It is assumed that the surface measured CCN decays exponentially with height with a scale height of 1 km. However, in convective clouds the boundary layer must be well mixed, with a constant aerosol mixing ratio. It must be so with updrafts rooted near the surface in the solar heated boundary layer, if we take as a valid the assumptions of the convective parcel.

5. The supersaturation in clouds. The authors report measured supersaturation (SS) in clouds. However, measuring SS in clouds is highly challenging, because in cloud temperature has to be measured at a very high accuracy as well as mixing ratio of water vapor. A major issue of measuring temperature in clouds is the effect of wetting of the temperature probe and the resultant evaporative cooling, which is far from being completely solved in reversal flow thermometer. To convince us that SS can be measured with a useful accuracy the authors have to provide the full description of the method of its calculation along with error calculation. They report SS=3% in a cloud

with drop concentration of about 400 cmˆ-3 and updraft speed of nearly 1 m/s. This is physically impossible. The SS in such conditions must be a fraction of 1%.

6. The cloud drop size distribution widened in places unrealistically for convective clouds, as in ECR (Figure 8a). I strongly suspect that the clouds had precipitation falling from above, or recirculating cloudy downdraft air which had already produced precipitation. This increases the question about the applicability of a parcel model for these clouds.

On top of these problems, there are many issues, including:

Page 14 line 27: The text reads: "Consequently, smaller aerosol particles with high concentrations are activated due to a higher Smax further up from the cloud base, resulting in a direct increase in cloud droplet numbers (Fig. 11c)." However, the parcel model shows a decreasing drop concentrations with height for all scenarios. There is no closure here. Furthermore, Smax is a property of cloud base, not well above it.

Page 14 lines 30-33: There will be always a value of accommodation coefficient that matches the observed drop concentration. It can only be constrained if both cloud base updraft and CCN are known, because an increase in cloud base updraft has a similar result as of decreasing the accommodation coefficient. The same ambiguity applies to increasing CCN vs. decreasing the accommodation coefficient. A closure cannot be possibly reached with such uncertainties with respect to both cloud base CCN and updraft speed.

Because of the problems with the basis of the paper as well as with its implementation, the conclusions of the paper cannot be supported.

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