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Atmospheric Chemistry and Physics Discussions
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Interactive comment on "How do changes in warm-phase microphysics affect deep convective clouds?" *by* Qian Chen et al.

Anonymous Referee #1

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This manuscript presents an analysis of aerosol effects on tropical deep convection using the WRF model with detailed bin microphysics. It emphasis the zero degree level as explaining the system wide behavior. It adds analysis of the velocity center of gravity (VCOG) to help explain the aerosol invigoration of deep convection, which is a hotly debated topic in the cloud physics/dynamics community.

I have a few comments that I think will make the paper much more persuasive.

1) A counter argument to invigoration is that the added mass loading reduces the buoyancy and offsets the higher condensation/latent heating. Please show analysis (e.g., profile time series) of the components of the buoyancy (thetav' and mass loading) for all cases. Mass loading should be broken down for the different hydrometeors. This is important in explaining why the added mass loading does not seem to make much

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difference. Can it be tied to the hydrometeor mobility? This perspective would make the paper much stronger.

2) There is emphasis in the tone of the paper (even the title) on understanding the warm phase and transport of water across the ZTL and how that affects the mixed phase above. But I didn't find this persuasive. E.g., On page 14 it is stated: "most of the cloud drops that grew by condensation above the ZTL originated in the warm part of the clouds. Therefore, we can clearly state that an important part of the enlarged liquid mass generated below the ZTL in the more polluted cases (as shown in Figure 6a,b) was transported upward with the stronger updrafts.." However, a more straightforward interpretation is that the stronger updrafts, which extend above the ZTL, generate more cooling, higher supersaturation and therefore more condensate. The 'transport' argument doesn't seem particularly clear or strong. On this point the figures need some work (see # 9 below). My suggestion is to either strengthen the argument of why a stronger mass flux at ZTL necessarily carries up through the depth of the cloud, or alternatively remove the emphasis.

3) Perspective that is missing: Some model studies don't show invigoration in tropical convection. Is this case-dependent, or microphysics-dependent, or something else? A few simulations with a standard 2 moment WRF microphysics scheme would be a quick test that would help clarify. You don't need to reproduce the entire analysis for a bulk scheme – just a few key fields.

4) The polluted cases have different distributions of surface precipitation (Fig. 2) but how different are the total surface accumulations?

Other Comments:

5) Please explain the reason for the model feature in the CFAD at 5-8 km where there is significant difference from the radar.

6) Line 175: 'may represent'. The model can tell you whether this is the case.

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7) Lines 278 and 296: ‘exact’ is too strong for a model

8) Line 293: ‘overall effect’ (of what?)

9) Fig. 7: As mentioned above, the third column is apparently only at ZTL but the caption says ‘over all cloudy areas’. Throughout the paper please check figure labels so that this is unambiguous.

10) Line 332: ‘extremely’ should be removed.

11) Some shortened labels are a bit strange (‘pollu’, ‘depo’, ‘frez’). ‘pol’, ‘dep’, ‘frz’, ‘sub’ would be better.

12) Please mark the approximate height of the ZTL on the profile figures. I think it is only on Pg 14 that it is stated that ZTL is at $\sim$ 4.8 km.

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