Reviewer B

Title: Aerosol concentration determines the height of warm rain and ice initiation in convective clouds over the Amazon basin.

Submitted: Braga et al

To: ACP

Date: March 30 2017

Decision: Rejected

Summary:

This manuscript studies the effects of aerosol particle number concentration on the initiation of raindrops and ice hydrometeors in growing convective cumulus over the Amazon. Data from aerosol and cloud probes on board of the HALO aircraft are used. The values of the estimated *Na* at cloud base were applied to classify the atmospheric conditions where convective clouds developed as a function of aerosol particle number concentration (i.e., clean, polluted, and very polluted regions). Main conclusion was that cloud depth, assuming adiabatic assumptions) is related to aerosol characteristics at the surface.

Major issues:

This paper claims that cloud depth and precip initiation are related to aerosol number concentrations at the cloud base. I argue that precip formation in the clouds are related to saturation rate, updrafts and shear (turbulence), T gradients, stability, and particle type. I really do not like simplified convective clouds dependency on only aerosol concentration at the cloud base. Doing this you ignored non-adiabatic terms that include radiation, turbulence, and mixing can play important role for cloud structure. In fact difference between the adiabatic ref and observed indicates that. There are several issues with figs such as averaging time, RWC but images do not show any, and Fig. 1b concept.

Why this work uses reff rather than use of full spectra for precip? Ref can be 12 micron but no droplets can be at that size range. Is this for a climate study or cloud study? Author should emphasize this.

Ref usually is almost constant above 3000 m in the plots but you show like exp curves.

You mention rain water content but none of the images is shown for rain droplets.

You are using different time segments for each case that is not acceptable (see figures top titles).

You need to show time series of ref, lwc, nd and ni for 2 cases (polluted and clean and pitch angle). Your physical values can be affected by aircraft INS system conditions.

Fig. 1b; shows a conceptual sketch but I feel that is not true. Droplets cant grow continuously to the cloud top level. Any work that reference the similar conditions cannot be considered for publication.

Major issues can be listed as

1. DWC=0.01 g m-3 used for DWC to get rain out of the cloud. What this is selected not clear. DWC can be 0.01 g m-3 but 5 droplets ot 100 of droplets. I argue that this is not an acceptable assumption for cloud structure?

2. You say that rain occurred at higher levels in more polluted clouds; no RH profile is shown or icing detector (pg 10) ; how do you know the cloud structure and particle phase? In fact none of your figures show rain or cloud droplets at larger sizes.

3. Figure 1b; this figure really mean nothing for me, and doesn't help anything about understanding of cloud macro structure. We know that aerosols can play significant role in cloud development, specifically for stratiform clouds. Below the cloud base aerosols act as nuclei, and they are activated within the cloud base, then dynamics of the system play a role faster that diffusional growth of particles. Certainly mixing happens at the base and edges of the system. Conditions are not adiabatic clearly. In fact if saturation is high enough and lots of moisture exist, many droplets forms. Do you show any vertical profile of the cloud T, w, and qv? In fact when cloud top increases at the upper troposphere not many particle reach to cloud top. Therefore, cloud depth is not only function of Na but vertical air velocity which is lowest at the cloud top at the upper troposphere. In fact because of collision/coalescence/aggregation processes, many particles fall down as precip before reaching the cloud top. Therefore, I will not accept your claims here for your work.

4. Fig.2; most of ref is between 11-14 micron for precip occurrence>50%; then how accurate to use ref as a precip condition. Precip is function of Nd, Vt, wa, and shape. Differences of these parameters at various T, can affect reff strongly. Suggests that cloud depth is not only function of Na but other physical and dynamical para,eters.

5; I like to see time series of Nd, Ni, RH, and ref for clean and clean cases. Use of reff for a cloud microphysics case study may not be appropriate. Ref can be 15 micron with no rain or with rain depends on psd.

6; fig 4 may not be needed, this is well known.

7; figure 5;

I like to see time series of Nd, showing about 2000 cm-3, also Na, please provide.

This figure shows that Nd is constant above 0C, and increases to warmer T. To me this is an artifact. Please also show LWC time series. Also show the weighted line on the plot.

Fig. 6a; thi is shown for 25 sec but others are for 656 sec, please be consistent.

Fig6b; looks like no changes in reff are for T<0C. For a given T difference is about 2-3 micron; it means that uncertainty in reff can be up to 3 micron, then how can someone use your method for cloud depth.

Fig. 7a; Combination of cip and cdp? Based on image shown, there are cloud droplets, CIP doesn't show anything.

Fig 7b; doesn't show droplets or drizzle? Where is the rain water come from?

Fig 7c; same again where is the RWC come from? Image shows ice crystals or rimed particles.

Fig. 9; again for Dc>3000 m, re is constant. This shows that re-Dc relationship doesn't hold.

Fig. 10a; Nd is constant within the cloud, looks like well mixed layer. Then how ref increases with depth? Flight is only 3 mins? Looks like ref increases with LWC. Can you show reff versus LWC?

Fig 11a; assumed that drizzle has sizes >50 micron why we don't have RWC? Or precip?

Again image shows ice crystals, not drizzle.

Fig. 11b; image shows graupel, where is the rain coming from, you say 0.27 g m-3?

Fig. 12:

I really have issues with this figure. If you look at the lines for a given Na say 1 or 100; and then check the Da. Not easy to make any conclusion based on this figure. In fact any uncertainty for less than about 20 cm-3 can results no discrimination among these cases.

Fig 13; same as before. How do you know they are droplets?

13a; again like rimed particles. RWC=0 but you show only 5 sec spectra, you are not consistent with time averages.

13b; again not rain water but mostly they are graupel or rimed particles. Only 4 second average? Not consistent. If CWC=0.247 and RWC=0.27 and DWC=0.16, then rain amount is more than cloud water content? How do you explain this over 4 sec?

Fig. 16; why there is no RWC? You have particles more than 100 micron but not rain?

Fig. 17; Dc versus Na relationship can't be a linear relationship. Increasing aerosols doesnt result in larger Dc values. Other factors should be considered e.g. updrafts, stability, diabatic heating etc.

Fig. 18; as noted previously above 3000 m, ref is almost constant but here you show all DC values increase with increasing ref exponentially. This figure should be discussed based on my previous points.

Other point I am not comfortable is that almost largest WC is at the cloud top which cant be correct. This is function of Vf, and you never mentioned this.

Discussion section should focus on the uncertainty of the observations and method. Presently it is not focusing on observations/analysis uncertainties such as averaging over various time segments.

Conclusion section should have clear findings that are related to observations collected from the field project. It can be good idea to list them.

Minor points are not considered in this point.