Title: Further evidence for CCN aerosol concentration

By Braga et al

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Decision: Rejected

I do not think that this paper can be improved over a short time period. Issues are very serious for data analysis and organizing of the paper, and simplification of a research area related to aerosol-precipitation and cloud depth.

General comments

This paper focuses on precip initiation related to CCN in convective clouds, and its impact on cloud depth. This is an interesting research area but manuscript needs major improvements related to introduction, observations, and method sections, as well as figures. My previous points are not considered properly in this new version. Provided figures are not representative of the real conditions because of analysis issues. The Nd, LWC, and ref time series are not shown for at least for 1-flight that can be used to interpret analysis. How vertical profiles obtained using 1 Hz data are not presented properly for averages. Nd and ref profiles using T in y axis should be weighted over similar dNd or dref intervals, and sd should be shown. Then fits should be applied because of inhomogeneity of the data collected. Why LWC profiles are not given is another issue in this paper. If you are talking about adiabatic assumption, why LWCa and LWCm are not shown? In supplementary plots, specifically vertical air velocity plots means nothing unless aircraft position angles are shown, and time periods during turns are taken out of the analysis? Better provide time series of segments to represent real conditions.

Flight patterns are shown taken along the edges of Cbs where heavy mixing occurs, and suggest that data don't represent adiabatic conditions based on figure you provided; probably, because of this reason, LWCa and LWCm profiles are not likely provided. Also, some figures represent only 3 seconds of intervals (Fig. 14) or some represent only 247 seconds (Fig. 11). Therefore, one cannot make a decision or provide objective analysis. Also, in Fig. 11, Nd decreases with decreasing T (or Z), but ref increases with increasing Z. Usually reff increases with decreasing Nd (see Gultepe et al 1996). In this figure, # of points is about 247 (assuming 100 m/sec and using 247 sec flight duration). Can you explain how aircraft can climb up from 20C to -15C over 4 minutes? How accurate are these measurements when aircraft makes quick returns?

Na in same figure (11) is given as Nd which is 566 cm-3. But Nd is found less than 600 cm-3 at the cloud base, are you using instantaneous value here? Why not use averages ?. This analysis is very confusing and figs are not given properly. Weighted averages should be used not a max value or min value. In fact, Fig. 11a should show bin averages of Nd (dNd~50 cm-3) or similar

ones. In that plot, you also need to show LWC-T plot. Without this info, it is not possible to make fair conclusions.

Clearly, sampling of data and presenting observations are not presented properly (this is also valid for Fig. 12 in which dt=5 sec and 4 sec.). Gultepe et al 1999 suggested that variability over an averaging scale is an important issue for analyzing observations.

An article on aerosol effect on precip is also given by Menon and Delgenio (2007, chapter 3 of DOI: 10.1017/CBO9780511619472.005) where regional changes in precipitation, examined over India and China, were found to be *related to the amount of atmospheric heating, with higher atmospheric fluxes corresponding to larger changes (positive) in precipitation*, though we do not discount the influence of surface and meteorological conditions that may also lead to similar changes. This work clearly suggests that heating processes within the cloud important and that specifies precipitation and depth of convective system. I think only use of ref or Na at the cloud base can be very simplistic way to consider cloud top height changes. Therefor, authors should show relationships among ref, Nd, and LWC within the cloud system in their work.

Introduction section; some observations and part of method are given here but these need to move into proper sections. Text flow is not clear and very vogue in intro and method sections. Method section needs to be improved and explained properly as suggested above. I see method section is very poorly designed, providing these equations dont help for the comprehensive analysis of observations. See below for details.

Major/minor issues:

Abstract

LN31; Is this for only pollution aerosols or all "aerosols"?

Define ACR….CHUVA campaign.

LN 34 Provide method/assumptions first before providing results

Dr is confusing for defining height? Why not use Z, or h etc for height.

Also Na is used commonly for aerosol # concentration, please use Nd for droplets and Na for aerosols. If adiabatic droplets used for Na then show it as Nda.

Rain initiation is not only microphysics issue but dynamic of the system and environment. Changing of cloud height is related heat released in each layer because of mass change. Need to discuss this later.

Provide what assumptions are used first.

Measured ref was close to its adiabatic value? I understand that is possible in convective clouds but if mixing and precip occurs, it will cause to non-adiabatic conditions. In fact, size>50 micron can result in precip. Please clarify this in manuscript.

Biomass burning aerosols assuming darker and resulting heating may not be good nuclei in the convective systems anyway. Then, they do not play a role in rain initiation. Needs to be clarified with refs. Not all aerosols are good CCN and variability can be large, see above .

1. introduction

LN 55; change to "cloud droplets form when humid air becomes supersaturated wrt water".

LN60, Rosenfeld and Woodley 2000, provide earlier reference for this, it is well known over 100 years.

LN65; Provide a reference as Gultepe and Isaac (AMS J of Climate, 1999) for Nd variability and Nd-Na relationships. This paper clearly shows Nd-Na variability in the clouds representing various cloud types, clean and dirty environments. But most important it provides variability in Na versus Nd. Gultepe et al 1996 (AMS JClimate) provides Nd-Na relationships and k coefficient from various projects between rv and reff. These are earlier than references you provided, and earlier refs should be cited. k in this paper is given as 0.90 But it becomes reff=1.11rv that is ~10% larger than MVR. Clearly, variability in Na and its relation to Nd are critical for many applications and these relationships are not unique.

LN70; are formed or formed?

LN 115; top parag; I feel this belongs to Observations section.

LN 120: This paragraps describes the goal of the paper, needs to be provided in the end of intro.

LN125-130; again this should be in the end of intro section. This is the goal of the paper.

LN 130, this parag belongs to observations/data section, not here.

LN135-145; this parag belongs to method section, not here.

LN 147; The DWC is defined……..as the mass of drops integrated over diameter range of 75-250 micron. This is not right, as you said it is drizzle water content (DWC), and therefore it is the water content of drizzle that is obtained by integration of (Nd xMd) over the spectral range representing CDP size range. Needs to be corrected.

What happens particles between 50 and 75 micron size range?

Page4; section 1.1 The scientific motivation for this study; take out "for this study".

I think no need for section 1.1 title, you don't have others anyway.

LN160; Say “The aircraft based in-situ measurements collected within convective clouds over the Amazon region of Brazil were used to study precipitation initiation related to aerosol properties”.

LN160-175 is too long; you said these before, and needs to be shortened.

Section 2. Instruments; LN176

This section should be “2. Project design and observations”, briefly describe project location and flight patterns. Then go to observations, including instruments.

LN 178; 2.1 cloud particle measurements; 2.2.1 and 2.2.2 are ok, how about 2.4??? isn’t that aerosols are part of cloud?

Section 2.3; please provide synoptic info on CCS, how and where they happened exactly.

3.Method

a) The relationship between ref and the probability of drizzle is defined???? This is not clear. You mean ref and drizzle LWC is described/analyzed? In what content?

b) That is not clear and based on what?

Goals of c) and d); these needs to be better organized/provided

You provided four steps here, but only 3.1 and 3.2 are given, they are not consistent with 4 steps given above. Need a road map here, confusing the way done.

Page 6; LN245; CWC using Eq. 2 is not clear? How probes data are used? From what channels?

Page 9; LN 375; Analysis of ref and D……..; analysis should be in the method section not here. You should refer the analysis for the results given here.

4.2.3 Discussion should be a section on its own, not a subsection.

I am just passing results sections because of issues with other parts.

Other points from Gultepe et al (1996) suggest that ref max is about 12 micron which is obtained from fssp probe similar to cdp. If CIP is used, this increases to higher values of ref (>12 micron) for precip particles, as in your paper. Then, critical point for cloud depth is related to values of updrafts. Droplet spectra changes although ref can be same, then this can affect D-ref or Nd relationships. This means that depth of the cloud is related to updrafts and latent heat released due to cooling/heating processes, not only cloud base max aerosols concentration or effective size. In fact your data do not represent characteristics of convective clouds properly because flights are not from core of Cbs and dt time periods used for plots are different for collected data.

5. Conclusions

I suggest that you provide your findings in itemized way, what are they? As you said clouds are not adiabatic identities; agree that they are usually non-adiabatic in nature. Means these linear relationships suggested by you will not hold. Specifically convective clouds are usually non-adiabatic systems because of strong wind/turbulence effects, heating, and mixing and precip. Unfortunately, these are not discussed in the paper.

Figures:

Figure 1a; conceptually this figure is wrong, droplets do not grow continuously to the top of a convective cloud. Also, based on this, your measurements are not in the cloud but in the edges. This suggests your results may not represent adiabatic conditions. You need to show LWCa and LWCm profiles for an entire flight.

Figure using a satellite/synoptic map/image will help to visualize the system. A figure is needed.

Fig. 3; like to see particle Nd, aircraft heading, and wind time series for this time period. To me 2000 cm-3 is an artifact or just aerosols.

Figure 4; a plot for 25 second is statistically meaningless, please provide longer data set.

Figure 5a-c; why don't you say CIP images rather than CCP-CIP images.

Figure 7a; reff increases with height but LWC decreases, usually LWC increases with reff, explain (see Gultepe et al 1996).

Fig. 8; Nd~100 cm-3 but ref increases with height. No aerosol effects, needs clear explanation.

Fig. 10; Around 1 micron, no diff among the cases; Nd more than Na at larger sizes, how that happens? Sensor issues?

Fig. 11a; need to show same way for LWC, Nd, and Ref, otherwise no idea what is going on. Also, dt=247 second for flying from 20C to -20C, how good is the data?

Fig. 15; this plot should be taken out, fit is useless based on # of points and issues stated above.

Fig. 16; how those lines with color are obtained? What equation is used?

Fig. 17: caption; "As continental are the convective clouds?????" Not right sentence. This conceptual figure is also having issues similar to Fig. 1. Is this correct that more aerosols results in higher cloud tops? I don't think so. If stable environment exist, doesn't matter what you have as Na, especially if they are small. Other point, you have rain drops but do not fall????? Certainly they fall.

Supplementary material;

Fig. 6a; These figs need to show mean values over the x bins. Say 100 cm-3. Like to see time series of data for at lears 1 flight, with aircraft headings.

Profiles/time series should have LWC, Nd, and Reff, and mean/sd need to be shown for at least one flight. Providing 1 sec max values do not make sense.