Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2017-185-RC3, 2017

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Illustration of microphysical processes in Amazonian deep convective clouds in the Gamma phase space: Introduction and potential applications" *by* Micael A. Cecchini et al.

Anonymous Referee #3

Received and published: 9 August 2017

Review of "Illustration of microphysical processes in Amazonian deep convective clouds in the Gamma phase space: Introduction and potential applications" by Cecchini et al.

Recommendation: Requires revision before publication

This paper uses fits of measured cloud droplet size distributions (DSDs) in gamma phase space to investigate warm-phase microphysical cloud properties and the role of "pseudo-forces" in affecting the evolution of the gamma parameters and the DSDs.

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Overall, I found the description of a unique set of data interesting and formative, and hence believe that the paper is worthy of publication. However, there are some issues that should be addressed in order to improve the presentation before the paper is published as discussed below.

Major Comments

1. The authors segregate the flights that are flown into the different regions of the Amazon where they are flown. Although changes in surface conditions are no doubt important for affecting the cloud properties, meteorological conditions can also have an important impact on cloud properties. Some comments about this should be added to the manuscript and some analysis of the meteorology on the different days should be added to see if such differences can also explain some of the variation in cloud properties. I think attributing much of the changes to aerosols is not fully justified until the meteorological context is further explored.

2. I was a bit surprised on page 6 where the authors described that they were focusing on the CDP measurements where D < 50 micrometers. It would seem to me to be quite important to also examine the drizzle sized drops measured by the CIP, as when drizzle was present it would seem to be very important to account for that in the analysis. How are flights handled when there was some precipitation-sized drops? Were these larger drops incorporated into the analysis of simply ignored? Further, for Eq. (2) to Eq. (4) should the incomplete gamma function rather than the gamma function be used to account for the fact that not the complete size range of particles were measured?

3. I think some more comments on the quality of the microphysical measurements are needed. How did the CAS and CDP probes compare? What are the estimated uncertainties in the size distributions? How did the LWC integrated from the CAS or CDP compare with bulk measurements from a hot-wire probe, which I am assuming were made. I am assuming that fits were only done to the liquid distributions, or do you use all the distributions? This should be clearly stated when discussing the phase

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partitioning at the bottom of page 8.

4. The implicit basis of the analysis presented in the Gamma phase space is that one is dealing with a Lagrangian case. But, inevitably, with any sort of microphysical measurements different samples of particle populations are being sampled. Further, there can be mixing and dynamic motions in clouds that would affect how the DSDs vary in the gamma phase space. Is there any way of representing these mixing processes on the diagram? I also think the action of the pseudo-forces and the impact of condensational growth and collision-coalescence could be better illustrated on the diagram. Can you show an example size distribution (it can be a theoretical rather than observed distribution if it is easier) and show how the size distribution would change due to simple model calculations of either condensational or collision-coalescence growth. Then, illustrate the location of all 3 DSDs (original, one undergoing condensational growth, and one undergoing collision-coalescence growth) on the gamma phase space and it will be easier for the reader to appreciate how these forces are represented on the diagram. Such simple theoretical/modeling calculations may also help you assess how the DSD characteristics are being affect by homogeneous/inhomogeneous mixing (discussion at top of page 12).

5. I'm wondering if some different terminology could be used to refer to the different flights. Although referring to flight numbers (e.g., AC19, AC18, AC12, etc.) might be very informative for people who were involved in the field program, I continually had to refer back to the table to remember the regions in which the flights were conducted to help interpret the data. Can you refer to them as maybe AC1 (AC19 for Atlantic coast 1), RA1 and RA2 (AC09 and AC18) for remote Amazon, and AD1, AD2 and AD3 (for AC07, AC12, and AC13) so that it is more easy to remember the flights going through the manuscript. Or, maybe some other terminology would also work.

6. With regards to the depiction of the DSDs in phase space, I would find it much easier is some 2-d cross sections were presented in addition to the 3-d volumes (it was hard to follow some of the discussion on the contrasts between clean and polluted trajectories).

It is very hard to visualize how the different parameters are changing on these 3-d plots, so some 2-d cross sections would also offer some supplementary information. Further, what are the uncertainties or range of possible values in the gamma parameters.

Minor Comments:

Page 2, Line 20: I was surprised to see that the undisturbed portions of the rainforest are said to have homogeneous surface properties: compared to oceanic surfaces surely the nature of the forest is somewhat inhomogeneous? On page 5 (lines 20-25), the authors talk about differences in surface and thermodynamic conditions on more of the disturbed areas of the Amazon, so I found that this comment was a bit misleading.

Page 3, Line 1: Typically the term ice nucleating particles (INPs) rather than ice nuclei (IN) now. See Vali (2015).

Page 4, line 9: Unless specific numeric values are quoted, the parameters of the gamma function (or any parameter in general) do not have units associated with them. They could be given in any unit with an appropriate conversion being made. Recommend removing the units in parenthesis.

Page 5, line 23: if the convective clouds were growing, how could you ensure that the third stage was always flown through the growing tops? It would seem that different altitudes below cloud top might have been sampled for the different population of clouds.

Page 7, Eq. (7). I don't think this equation is correct (the factor of 10ˆ-9). Any equation must be unit-independent. Constants for conversions between specific unit sets hence don't belong in equations as those factors will automatically appear when converting between the different units of the variables.

Page 8, line 4: If the fact epsilon obtained by the gamma parameters does not match those from the DSDs suggest that the gamma distribution does not give a good fit to the DSD?

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Page 9, line 12: Can you use a different word rather than “phase transitions?” there is some confuse about whether you are talking about phase space or the phase (liquid, mixed or ice) of the cloud particles.

Page 11, line 16: “from drier air”, can you list the humidities in Table 1?

Page 11, line 23: Do you mean average RH? Clouds do not form in an environment where the relative humidity at their location is between 60% and 90%. Can you also give some indication of the thickness of the different cloud layers?

Page 12, lines 13-14: How do you know the observations were obtained close to cloud top? Unless you have remote sensing data or some ascents out of cloud, is it conceivable the particular cloud you were sampling extended to a higher height?

Page 13, line 1: What is classified as a significant difference? Was some sort of statistical test applied?

Page 14, line 12: What statistical test was applied to know that the res

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