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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 #4

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This paper used in-situ data from six flights collected during the ACRIDICON-CHUVA field campaign to explore the linkage between gamma distribution parameter phase space and underlying microphysical processes. Three different environmental conditions, the Atlantic Coast, the remote Amazon, and the Arc of Deforestation were studied, and the differences in the underlying microphysical processes among these regions were compared. The paper fits into the scope of ACP and is generally well written, however, the approach used in this study has severe scientific flaws. Therefore, this paper needs to be revised considerably before it can be published in ACP.

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Discussion paper

Major comments: 1. Page 5, Line 15-18. Are there only six flights during the whole field campaign focusing on clouds? If not, why other flights are not used? Especially for Atlantic Coast, there is just one flight used. 2. Page 6, Line 22-24: Why PSDs from CIPgs is not used? Only using CDP to create PSDs with D<50um will miss out lots of water mass, therefore the third moment used for fitting will be much less. 3. Page 7, Line 3-14: Incomplete gamma distribution should be used here since only a limited range of particle size is used for fitting. I believe this is the reason why fitted Gamma DSDs are narrower (Page 8, Line 1-4) 4. Section 2.3. I have four major concerns for this method, and will elaborate them in next four points. As stated in Page 9, Line 9, this approach is suitable for the study of the same particle population, which is under Lagrangian framework. Therefore, aircraft dataset at different levels sampling different particle population cannot be used to track the change of cloud PSD gamma parameters, since they are not the same particle population. In addition, the PSDs at the same level are not the same and exhibit large variations. So, the best use of this technique will be for the parcel model if the authors can address the following three comments. 5. Even for the same PSD, there are large uncertainties as stated in Page 6, Line 27-Page 7, Line 1. McFarquhar et al. (2015) studied the uncertainties of counting statistics, and found that all the parameters within an ellipse in Gamma distribution parameter phase space are equally realizable. The displacement of gamma distribution parameters could be just random values in the ellipse unless the ellipse of equally realizable solutions are defined for each PSDs. 6. As for the “pseudo-forces”, or microphysical processes which I prefer, this study decomposed it into two components: condensational growth and collision-coalescence growth. Due to the complex microphysical processes occurring in the clouds (as is discussed by the authors in Page 9, Line 21 – Page 10, Line 2), the evolutions of PSDs are very complex as some simulations using bin microphysics show. Simply relating a change of gamma distribution parameters to either condensational growth or collision-coalescence is not justified. Especially for any volume of air the aircraft sampled (or numerical models in Eulerian framework), the horizontal and vertical advection are very important. 7. The directions

and magnitudes of “condensational growth pseudo-force” and “collision-coalescence pseudo-force” are uncertain, which means that the influences of each individual microphysical processes on PSD evolutions are not studied clearly. The descriptions of “favors high value of mu while slightly increasing lambda” (Page 10, Line 4) and “lower values of lambda and mu, the former decreasing at a faster pace” (Page 10, Line 13-14) are not precise and not justified. The change of N_0 as described are wrong, since if condensational growth increase both μ and λ while keeping the same total number concentration, N_0 should also increase. In addition, if collision coalescence lower both μ and λ, and total number concentration of course, then N_0 should be also decreasing. Besides, I would say that evaporation “pseudo-force” acts the opposite way as “condensational growth pseudo-force” instead of “collision-coalescence pseudo-force” in this study. Anyway, the directions of these “pseudo-forces” are totally unknown, and the change of gamma distribution parameters could be any microphysical processes since relating the change of gamma distribution parameters (or equivalently PSD moments or bulk properties) to any single microphysical process is impossible.

Minor comments: 1. Page 4, Line 24-25. This sentence needs to be elaborated. 2. Figure 1. Add flight height and temperatures for each flight. 3. Page 5, Line 23 – Page 6, Line 10. The three regions used in section 3.2 should be introduced here clearly. Furthermore, the cloud characteristic for coastal region and remote Amazon should be described here, similar to what has been written for the Arc of Deforestation. 4. Figure 5-8. The y and z axes (μ and λ) don’t need to be taken logarithm for easy comparisons with previous studies. In addition, the projection of the 3D trajectories in N_0-μ, N_0-λ, μ-λ planes will make readers to follow easier. 5. Figure 5-8. Add raw PSDs with different colors showing different time, so the change of PSDs is clear to the readers. As shown in many previous studies (e.g., Heymsfield et al. 2013), the gamma distribution parameters can compensate with each other, therefore, the different points in the gamma distribution parameter phase space could mean the same PSD. 6. Page 14, Line 23-27. Recommend removing these sentences. As stated in Major comment #7, the quantitative descriptions of these “pseudo-forces” are lacking.

Besides, the method may just work for Lagrangian framework. I cannot see how this could be used for bulk microphysical schemes. 7. Page 17, Line 10-21. According to Equation 9, this is similar to fix μ which is adopted in lots of numerical schemes. Actually, the small range of μ is due to its scale, and could mean large variations of PSDs. 8. Page 19, Line 11-12. The sentence that "The characteristics of the clouds warm layer. . .should have a determining role in the glaciation initiation". I would argue that the IN and the ice microphysics above are more important. The characteristic of IN between the remote Amazon and the Arc of Deforestation are not studied. The number concentration of ice particles above should also be analyzed, which may explain the differences in glaciation.

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