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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 #2

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General Comments:

This manuscript introduces a technique for describing cloud processes using the drop size distribution gamma fit coefficients, and the trajectory of these coefficients in three-dimensional space. Comparisons within this phase space are made among clouds with different environmental conditions and linked to various cloud processes. While the manuscript is well written, I think some aspects of the paper need further work.

First, the physical insights that are provided are not closely linked to the coefficients

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themselves, and instead are reworked into pseudo-forces related to condensation and collision processes. However, the method used to decompose the trajectories into these pseudo forces is not clearly described, and as a result I find it difficult to accept many of the explanations behind the patterns in the data.

Secondly, gamma functions often provide good mathematical fits to drop size distributions, but attempting to understand cloud processes using the fit coefficients is fraught with difficulty, which I don't think is addressed sufficiently in this manuscript. Gamma function coefficients can vary substantially depending on the fit method used, the size range over which the fit is made, and the suitability of the underlying size distribution shape to be fit with a gamma. Many of these issues were addressed in the recent publication by McFarquhar et al. (JAS 2014). Using different fitting methods they found that the N0 coefficient, for example, can vary by many orders of magnitude, even when the same moments (1, 2, and 6) are used to make the fit. Using a different set of moments, like the 0th, 2nd, and 3rd used in this manuscript would likely result in even larger changes. Furthermore, the coefficients N0 and mu are inextricably linked, with N0 having the units of mˆ(-4-mu). So as mu changes, N0 will respond mathematically, even though such a change may not represent a physical process.

A more effective method may be to plot the moments themselves in 3D space rather than first fitting them to a gamma function. The moments are more easily linked to known microphysical processes, and if they are computed directly from the distributions do not suffer from the complications of poor fitting. The moments can always be computed from modeled DSDs as well, which would the avoid the further complications introduced when models use restricted gamma parameter spaces. At the very least, I think the authors should investigate the sensitivity of the observed phase-space patterns to different gamma fitting methods, and more clearly identify the source and interpretation of the F_cd and F_cl pseudo-forces.

Specific comments:

Section 2.2: How were DSD shapes that are not well fit by a gamma function handled in the analysis (e.g. bimodal or skewed distributions)?

Section 2.3: The introduction of the F_cd and F_cl pseudo-forces seem incomplete and leaves many unanswered question, such as: How were they determined, i.e. can they be presented mathematically? Do they completely describe the total force F? Are they orthogonal, if not, in which direction in the phase space does each force point?

Figures 3,5,6,7, and 8: It is difficult to determine where the lines and points are in 3-D space. A projection of the fit lines onto the X, Y, and Z planes would greatly help with the visualization.

Section 2.3: Given the sensitivity of N0 to the mu parameter, the speculations regarding N_0 would be much more convincing if N_d (or 0th moment) were used instead.

Section 3.2: The manuscript states that measurements were taken 'close to cloud top', but more information is needed about the placement of the measurements in the cloud. Was the aircraft making multiple passes to a fixed location, or attempting to intercept the same visual position in the cloud on mulitple passes? How long did the aircraft pattern take relative to the lifetime of the cloud, and at what point the life cycle of the cloud were the measurements taken?

Section 3.3: How were the clean and polluted clouds determined? Were the flight patterns and environmental conditions for each of these clouds comparable?

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