Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2017-185-RC1, 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 #1

Received and published: 8 July 2017

This paper describes an attempt by the authors to use gamma function fitted using cloud macro- and microphysical observations to analyze microphysical growing path and particle size distribution evolution within deep convective clouds. The data used in this study are from ACRIDICON-CHUVA field campaign over Amazon, primarily six flights focusing on cloud microphysics measurements over regions with different aerosol background profiles. The findings of cloud properties under different environments appear to be very interesting. However, the method in using gamma function to interpret cloud microphysical growing path contains serious issues.

The description of the closure of gamma function was firstly given by Eq. (2) - (4), where the closure variables were the zeroth, second, and third moment. The three undetermined parameters of gamma function would be defined by these moments. However, the actual closure variables, as described in Eq. (6) – (8) are liquid water content, cloud droplet number concentration, and effective droplet diameter. The former two were equivalent to the third and zeroth moment, respectively, while the effective droplet diameter was mostly equivalent to the first moment. To the least, these two descriptions are redundant. In fact, in many places of the paper including the Concluding remarks, the authors were still referred to the second moment. Indeed, the procedure of fitting gamma function with observations was never clearly described.

The most serious flaw of the proposed method exists in the procedure to interpret microphysics in the phase space of size distribution function. For a given air parcel, the ternary group of closure variables (mostly moments in different order) and undetermined parameters are bonded by mass conservation applied to the prognostic procedure of the former group, this defines the unique solution of both groups through the evolution of the air parcel, and they change accordingly due to the variations of the closure variables induced by dynamical and microphysical processes. Note also that the closure variables must be conservative ones with well-defined sink and source besides advection and mixing terms. When fitting gamma function with multiple observations, however, one should realize that these observations are multiple snapshots likely represent different air mass origin either unmixed or mixed, therefore, they mostly reflect different ternary groups of the closure variables and hence their paths in the phase space are irrelevant microphysically speaking unless a strong isentropic assumption (at least for any given horizontal plane) is made. This is why even in analyzing Eulerian modeling results, modelers usually derive microphysical and size distribution evolution within a parcel framework (can be conveniently derived from Eulerian grid parameters though), e.g., the "Twomey model". Only within such a framework does the analysis of size distribution evolution become meaningful.

By the way, many comments made by the authors are not accurate. For example, in the Abstract, the opening statement seems attempting to link our lack of understanding of the "tropical clouds" solely to the model representation issue of certain physical processes. The statement of "there is almost no study dedicated to understanding the phase space of this function…" is not accurate too. The properties of Gamma function along with many other probability distributions have been well studied and documented in statistics and applied mathematics literature. In the cloud physics and modeling field, the evolution of conservative moments (mostly in the format of LWC, number concentration, and spectral disperse) have never been a rare topic in various mostly modeling studies.

The observations are invaluable for further our understanding of cloud physics and for evaluating models. Applying derivatives of these data, however, warrens special cautiousness.

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