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Interactive comment on "Cloud-top microphysics evolution in the Gamma phase space from a modeling perspective" *by* Lianet Hernández Pardo et al.

Anonymous Referee #1

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This manuscript presents a numerical exercise that adjusted the gamma size distribution parameters in a bulk microphysics scheme based on the fitted gamma parameter values simulated by a 1D kinematic framework using the TAU bin microphysics scheme initiated by a sounding from the ACRIDICON-CHUVA (what is the full name it) campaign. The authors claimed that the so-called "gamma phase space" is useful for evaluating and improving microphysics schemes.

I found many aspects of the manuscript such as assumptions, concepts, logics, interpretations and presentations are questionable. I do not recommend this manuscript to be published in ACP. The main concerns and some technical comments are listed in

the following:

Major points:

1. The concept of using "pseudo forces" representing microphysical processes and cloud dynamics to explain the trajectory in "gamma phase space" (Cecchini et al. 2017) makes zero sense for the observational data. The cloud samples measured by the instruments at different times are combinations of hydrometeors experienced so many different microphysical and dynamical pathways. The derived gamma parameters based on these measurements are in no way determined by the "pseudo forces" that are only meaningful in a Lagrangian sense. It is ok to show the derived parameter values in the phase space. But it is not appropriate to interpret the relationships among them using the "pseudo force" concept. 2. As shown in McFarquhar et al. (2015), just one part of the observational uncertainties (counting uncertainty) lead to big ranges of gamma parameter values that describe the same equally realizable particle size distribution (PSD). The parameter uncertainty ranges can be comparable or greater than the differences between those derived by different measurement points, especially when PSD deviates from gamma distribution. 3. The authors may argue that McFarquhar et al. (2015) focused on mixed-phase while Cecchini et al. (2017) focused on liquid phase. However, the small range of the cloud droplet size (< 50 micron) should apply the incomplete gamma distribution fit rather than the complete gamma fit. Using the complete gamma fit results in higher uncertainties in the phase space. 4. The ranges of the fitted mu and lambda parameters based on TAU simulation span at least an order of magnitude wider in the phase space compared to the observed counterparts (Fig. 2). These high simulated values are unphysical and never observed. How can such unphysical representations of clouds serve as a base to improve the bulk microphyscs? 5. Bin microphysics schemes are conceptually more realistic but not practically more realistic. The bin microphysics intercomparison study by Xue et al. (2017) demonstrates that the uncertainties associated with bin microphysics schemes are similar if not greater than those in bulk schemes. A new study by Morrison et al. (2018) (JAS

under review now) shows that the combined advection in space (Eulerian framework) and in bin dimension (either mass or diameter) of the cloud droplet condensation process inevitably broadens the simulated PSD while the liquid water content and mean droplet diameter are accurately predicted. The model setup is similar to what is used in this work. The derived gamma parameters based on the TAU simulation did not correspond to the actual physics that lead to the observed values. 6. How is the cloud top defined in this work? All discussions and analysis are around "cloud-top" but no clear definition is stated. A profile plot of the initial relative humidity is helpful. The time evolution of the simulated cloud water and rain water profiles should also be provided (profiles of qc, nc, qr and nr in every 5 minutes would work). 7. Without knowing how the data were calculated in Fig. 5, I am still surprised to see the author claim that the advection increases the number and size of the cloud droplets in the cloud top (Fig. 5c and d). Where are the sources of these large droplets? 8. The mu-qc relationship (Fig. 7a) was found in the TAU data at cloud top. Was Eq. 11 applied to the Thompson scheme everywhere or just at cloud top in the simulation that generates Fig. 8? The mu-qc relationship outside of cloud top can be completely different. The observed mu-qc relationship can be very different than the bin results. The way to "improve" the bulk scheme does not necessarily need the gamma phase space concept.

Technical points:

1. Please add projections on the 3D plots. 2. More plots on the simulated cloud properties will be helpful.

References:

McFarquhar, G.M., Hsieh, T.L., Freer, M., Mascio, J. and Jewett, B.F., 2015. The characterization of ice hydrometeor gamma size distributions as volumes in N 0–λ–μ phase space: Implications for microphysical process modeling. Journal of the Atmospheric Sciences, 72(2), pp.892-909.

Morrison, H., M. Witte, G. H. Bryan, J. Y. Harrington, and Z. J. Lebo, 2018: Spurious

broadening of modeled cloud droplet spectra using bin microphysics in an Eulerian spatial domain. JAS, in review.

Xue, L., Fan, J., Lebo, Z.J., Wu, W., Morrison, H., Grabowski, W.W., Chu, X., Geresdi, I., North, K., Stenz, R. and Gao, Y., 2017. Idealized Simulations of a Squall Line from the MC3E Field Campaign Applying Three Bin Microphysics Schemes: Dynamic and Thermodynamic Structure. Monthly Weather Review, 145(12), pp.4789-4812.

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