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Comment on acp-2021-443

Anonymous Referee #2

Referee comment on "A strong statistical link between aerosol indirect effects and the self-similarity of rainfall distributions" by Kalli Furtado and Paul Field, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-443-RC2, 2021

Summary

This study describes what the authors term a "universal" self-similar probability density function of re-scaled rainfall rate/intensity and its invariance under aerosol perturbations. It is an intriguing idea that seems to be well-supported by the analysis of a single large-domain simulation. While I agree with the authors that it is beyond the scope of this work to simulate a multitude of cases with a variety of models, etc., I find the assertion of "universal" scaling from one simulation to be quite a stretch. Either the language needs to be changed, or some other evidence given that the "universal function" will hold for different storm types/climatological contexts. Another obvious perturbation that would increase confidence in the universality assertion would be to perturb sensitive parameters of the microphysics scheme (akin to what the authors did in Furtado et al. 2018). As it is, I believe the title puts it best: there is evidence for a strong statistical link between AIE and self-similar distributions, but I am not convinced that this is the last word on the characteristics of the underlying distribution. I recommend the study for publication pending the authors' response to the above critique and several minor and typographical comments below.

Minor/typographical comments

- L118: "were performed" instead of "where performed"
- L182: "suppression become*s* stronger"
- L199: "referred to *as* rainfall intensity"
- L200: "where rain *is* falling"
- L201: "CDNC-condition*ed* mean rainfall rate"

- L208: "up to four orders"
- L252: "the sum *of* CDNC-conditioned"
- L270: "assumption corresponds *to* the simplification"
- L292: "fewer than *n* two moments"
- L301: I am confused – the parameters in Table 1 have different symbols. Please correct.
- L301: Do you mean Figure 6b? Hard to tell because it looks like the axis labels are wrong.
- L305: There is no factor of $M_2(n)$ in Eq. 7. Do you mean $M_1(n)$?
- L310: I think you mean "M_0,…,M_3"
- L319-321: What is your metric for "capturing the trends" in Fig. 7? It looks to me like you get a great fit for M_0 and then the fit degrades with increasing moment order. Even M_1 is pretty far off for single moment N_a=1.
- L351-353: Scale breaks are common in systems like these due to both statistical noise *and* violations of scaling laws. Can you rule out the latter?
- L391: "the probability distribution of"…of what?
- L396: "We do not if the distribution is…"
- L404: Should there be an "and" between the definitions of r_1 and r_2?
- L414-415: This sentence is confusing. I suggest you break it into two and reword.
- L416: "a family of power-law relationship*s*"
- L424: "a detailed understanding *of* how aerosols…"
- L427: "rather than seek*ing* a physical reason *for* why aerosols…"
- L434: "choose these moments"
- L460: "next" instead of "nest"
- Fig. 4 caption: "and hence the sensitiv*ity* of…"
- Fig. 6a: should axes read "M1,fit" and "M1" instead of referencing M2?
- Fig. 9: I am confused about which regime is which in the figure. Could you descriptively label the x-ticks instead of the visually-distracting cloud fraction bounds?