Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., referee comment RC1
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Comment on acp-2021-443

Anonymous Referee #1

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-RC1, 2021

The manuscript describes the derivation of an invariant distribution of surface rainfall rate as a function of the precipitation flux. The derivation is based on a set of numerical model simulations where the aerosol number concentrations are varied. The resulting invariant distribution appears to be independent of the amount of aerosol and has the ability to predict the response of the rainfall statistics to a perturbation of the aerosol. The manuscript describes an interesting work to construct such an invariant and fits into the scope of ACP. I recommend the manuscript for publication after the authors have addressed the following comments and revised the manuscript accordingly.

General comments:

- In the manuscript, you state at multiple locations that you construct a universal distribution for the rainfall statistics. However, the whole analysis is based on three simulations of one case. At the very end (starting at line 455) you mention some of these serious assumptions that might limit the conclusion to only this single simulated case. At the moment, your results show that for your model and for this simulated case there is a universal distribution. To get an idea about the true universality of the result, one should
  - simulate more cases with your model
  - in particular also at different locations in the world (maybe the universal distribution is different in the tropics or in the arctic?)
  - ideally using also different models.
  I know that this is maybe far too much work, however I think at least a second case should be simulated and the predictions made with your present universal distribution be compared to the actual rainfall statistics in the second scenario. But even then, the rainfall statistics might be much more dependent on the implemented microphysics scheme.
- Reading through your data analysis, I wondered how robust the statistics are, i.e. are there enough clouds to sample from in each of the regimes you mentioned?

Specific comments:

- Line 25 to 28: There are also studies that indicate that, on average, the amount of precipitation is not influenced due to the buffering effect of clouds. The idea of buffering is described in Stevens and Feingold (2009) and a study indicating that there might, on average, be no influence is Seifert et al (2012) (although the latter study is based on an operational NWP model, i.e. the coupling to aerosol is limited). Hence at this point it is important to state the context more clearly: Do you ask the question for a specific cloud? Do you ask the question for the amount of precipitation averaged over an area? See also the paragraph starting at line 90.
- Line 30 to 32: I do have problems understanding this sentence. Not every cloud produces rain and a cloud is an example of a system with unbalanced sources and sinks (otherwise the cloud would not have formed)? Please clarify.
- Line 120 to 121: You refer to the domain of your simulation by pointing the reader to a plot of radiative fluxes. You should either only state the domain of your simulation by indicating the geographical coordinates or adding a geographical map. I prefer the latter.
- Line 127 to 128: To which degree do your results degree on the choice of the lateral boundary conditions for the aerosols?
- Line 296: You refer the reader to a figure in the supplementary material; please include the figure in the main text.
- Line 317: The predictions do not always reproduce the simulated values, e.g. the black circle in panel b is off; also in panel d a more stagnant behaviour is predicted instead of the decrease that is visible in the solid line.
- Caption of Figure 4, fourth line: The sentence within the brackets appears exaggerated to me. You can only assess the sensitivity to your experiments, which is different from a "universal" sensitivity.
- Figure 6: Is there a motivation for the thresholds used? Why not use "simpler" values, e.g. 0.5 instead of 0.4 or 29 instead of 28.7?

Technical corrections:

- Line 36: "it is" should read "is"
- Line 86: interpreted
- Line 118: "were" instead of "where"
- Line 175: based on
- Line 182: becomes
- Line 221: "colored lines in figure 4"
- Lines 248 and 288: The section numbering should read 5.1 and 5.2 instead of 5.0.1 and 5.0.2
- Line 267: There is a period missing after the equation.
- Line 292: In particular
- Line 310: It should read M_0, ..., M_3
- Line 323: fractions
- Line 331: Delete one of the "because"
- Line 343/344: It should read "...precipitating (and highly cloudy) regime, ..."
- Line 356: that the universal

- Line 363: It should read \gamma_0 - \gamma_3 instead of \gamma_{0-3}
- Line 366: Index k should only range between 0 and 3.
- Line 387: "...parameter space is a..."
- Line 392: Delete "of"
- Line 396: "if the distribution"
- Line 460: next step
- Figures 1, S1, S2, : There are missing labels for the axes.
- Caption of Figure 2, second line: column-averaged
- Figure 2b: Units are missing in the legend. I suggest to add the units in the caption.
- Caption of Figure 4, fourth line: "sensitivity" instead of "sensitive"
- Figure 9: I suggest to also indicate the regime in the axes label instead of only the values for L, M, H.
- Caption of Figure 9, third line: distribution
- Caption of Figure S4, first line: M_1 should read M_0?

References:

- Seifert, A., Köhler, C., and Beheng, K. D.: Aerosol-cloud-precipitation effects over Germany as simulated by a convective-scale numerical weather prediction model, Atmos. Chem. Phys., 12, 709–725, https://doi.org/10.5194/acp-12-709-2012, 2012.
- Stevens, B., Feingold, G. Untangling aerosol effects on clouds and precipitation in a buffered system. Nature 461, 607–613 (2009). https://doi.org/10.1038/nature08281