Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., referee comment RC3
https://doi.org/10.5194/acp-2022-623-RC3, 2022

Comment on acp-2022-623

Anonymous Referee #2

Referee comment on "Evaluation of aerosol–cloud interactions in E3SM using a Lagrangian framework" by Matthew W. Christensen et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-623-RC3, 2022

The proposed paper evaluates the E3SM model skill at representing aerosol-cloud interactions (ACI) in warm rain clouds. The E3SM model is compared against the satellite as well as the ground based measurements from the ARM site in the Azores using a Lagrangian framework. The paper is well written and skillfully uses many different observations and an impressive number of trajectories to evaluate the E3SM model. I suggest that the paper should be published after some minor revisions.

Main comments:

- I think that the amount and synergy of the observational data used to evaluate the E3SM model is really impressive, and it would be great to highlight it even more. Would it, for example, be possible to add an infographic summarizing all the lines of evidence used in this work? If not, then maybe a table summarizing all the used data could be included in the main text?
- It would be helpful to the reader to explain in more detail how the ACI are represented in the E3SM model. The references to the papers describing different parameterizations are provided, but the description of how the coupling between them works is missing. That would be useful to understand, especially when later trying to reason about the E3SM results for different aerosol scenarios and the lack of the desired connection between aerosols and precipitation.
  Could the following be described:
  - How is the microphysics scheme coupled to CLUBB, deep convection parameterization and the large scale flow?
  - And a clarifying question: is the KK2000 scheme part of the Gettelman and Morrison 2015 scheme?
  - How is the MAM4 aerosol model coupled to the microphysics scheme? This includes describing (i) how the available aerosol number concentration is translated into CCN and cloud droplet number concentration in the CLUBB+KK2000+MAM4 framework; (ii) how rain affects the aerosol number concentration in different MAM4 modes in the CLUBB+KK2000+MAM4 framework?

- For completeness could the formula for accretion rate also be provided (around page 6 line 185).
- Could an example of the current clean, polluted and pre-industrial aerosol size distributions be plotted as seen by MAM4 model?

- How were the values of the autoconversion and accretion parameters chosen for the sensitivity experiments? What is the (micro)physical interpretation of the different setups?
- As shown in Figure 5 (b) and (d) and discussed in text: The ARM observations show more gradual rate of CCN decrease before t=rain. In contrast, E3SM shows some CCN buildup and then a very sharp decrease before the t=rain. After t=rain the ARM measurements show a sharp but steady CCN rate of increase. In contrast, E3SM predicts a very sharp initial CCN increase, followed by a much slower growth. Is the CCN buildup in E3SM before the t=rain explained only by the lack of efficient wet deposition? Are there other possible issues related to the MAM4 model, and the way it is connected to KK2000 and CLUBB, that would explain this? What is the possible explanation for the differences after t=rain?

Minor comments:

- Would it be possible to keep the y-axis the same between the observations and E3SM model results? (For example Figures 3, 5, 8)? Maybe providing additional zoom-in for cases where the model and observations are too far apart? I think it would make the comparisons between the model and observations easier.
- Fig 4a: The legend font is too small.
- Fig. 6 and following: It is hard to tell the pink and red colors apart.
- Fig. 6 and following: It is hard to tell the stars and circles apart, especially in the areas where they are clustered. Maybe some different shape or solid vs not-filled shape would be better?
- Fig. 7: The yellow color is hard to see.
- First line in section 3: - Should it be 3 exceptions?
- Page 9 line 281: Either "are" or "may"?