Review of Niebaum et al. "Constraining Rain Evaporation"

Niebaum, Bayley, Poydenot, et al. present a convincing and well-written investigation of rain evaporation profiles simulated with SDM, based on trade cumuli observed during EUREC4A and following the simulation setup described in Sarkar 2023. The study is well-written, and they pose an interesting secondary research question (whether collisional processes impact rain evaporation) and do a good job discussing the albeit underwhelming finding. Beyond this collisional impacts finding, the current manuscript does not offer substantially novel techniques or findings from the original Sarkar 2023 study, but I believe there are several easy opportunities to capitalize on use of the SDM in this work to build a more substantial study. With some clarification and additional probing of cloud microphysical responses under rain evaporation, I believe this study will be suitable for publication.

Major points & suggestions:

- **Suggestion #1: show and investigate DSDs or surface raindrop spectra.** You compare and contrast the findings of this study with those of Sarkar 2023, who used bin microphysics to investigate a different field campaign. However, no attempt has been made to investigate specific below-cloud DSDs, and whether the improved representation offered by SDM has a notable benefit in representing DSD *shapes* compared to prior results. It would be interesting to see a few instances of the DSD and the competing rate of change / balance between evaporation, breakup, and coalescence as it impacts various particle-size regimes. This would strengthen the findings of the study as well as utilize the novelty of the SDM. It would also help bolster the argument in L295-297 regarding deeper clouds and wider DSDs.
- **Suggestion #2: explore sensitivity of evaporation rate and profile to sedimentation parameterizations**. I enjoyed Figure 9 and the associated discussion of the importance of ventilation to the evaporation fraction, particularly because the original Shima 2009 study, and many related SDM implementations, do not include ventilation in their representation. The parameterization of sedimentation velocity for raindrops similarly has variation in the literature, and might be expected to impact the resulting evaporation profiles – I suggest that you take advantage of the SDM capabilities to perform this sensitivity study, and further comment on the role of sedimentation parameterization uncertainty in evaporation and cold pool formation.

- **Suggestion #3: remove some redundancy in the section 3 discussion**. Many of the results described in section 3.1, such as the impacts of RWC, humidity, and rm on evaporation, or the impacts of coalescence and breakup on the DSD and rm, follow directly from theory and are therefore more of a sanity check than a novel finding. (The bottom-heavy evaporation profile, however, is interesting, and could be an opportunity to investigate DSD variation in altitude.) In order to enable inclusion of additional content suggestions, these discussions could be made more concise.
- **Concern: Repository and archive**. The repo/archived data are in github, not a FAIR repository. Consider archiving the specific code versions in zenodo. Furthermore, consider pointing to the specific setup used by this study within the CLEO code base (CLEO/examples/eurec4a1d) to be very specific. As it stands, the documentation in the sdm-eurec4a codebase is not sufficient to replicate the results of this study.

Minor points:

- "Observation-based Superdroplet Model" is a misleading concept in the title. While the steady-state thermodynamic profiles and cloud-base DSDs are prescribed based on observation, the SDM itself is based purely on the representation of Shima et al. 2009 and uses empirical process rates explained in Bayley 2025, but does not derive any of its included process rates or representations from the EUREC4A campaign. Furthermore, these results do not strictly "Constrain" rain evaporation, since only a single field campaign with relatively shallow trade cumulus is considered. I recommend being more precise in the title, something like "*Investigating* Rain Evaporation…using *Observation-Informed Simulations with Superdroplet Microphysics*"
- L27: Please clarify, do cold pools occur 7.8% or 73% of the time? Or are these metrics taken over different spatiotemporal scales? The current statement is confusing.
- Figure 1 / L123-125: Please be more specific about the relative weighting of humidity profiles in order to make this study replicable. Additionally consider coloring the thin lines in Figure 1b according to their weights.
- Section 2: Please organize and clarify this section to more clearly explain the simulation setup at the start. As it stands, cloud-base DSDs and fitting procedures are introduced first (section 2.1) before the reader has a chance to understand what the actual parameters and setup of the 1D case are. It wasn't until deeper into section 2.2 that I understood that the 1D setup simulates below-cloud base rain droplets only, as I kept waiting for a discussion of the in-cloud humidity and aerosol

concentrations before understanding. A schematic could be one helpful option to illustrate the test case.

- Section 2 / Table 1 / fv study: Please describe in section 2 how the no-ventilation study is performed and include it in Table 1.
- L114 “fitted cloud RWC” – is the RWC included as a quantity to establish cloud base DSDs? Or is it only use ex post facto to eliminate outlier simulations? If the former please clarify; if the latter, please don’t refer to it as “fitted” (appears elsewhere too).
- L183: could you add the MS Merian RR to the distribution plotted in Figure 3?
- Please add a legend to Figures 1 and 10.
- Consider creating an idealized deeper cloud case (higher cloud-base height, larger cloud-base RWC) to validate the argument in L295-297 regarding the importance of collisions in deeper precipitating clouds.