Response to the Referee 2

Thank you for your suggestions. We have responded to the questions and suggestions below. Our response is provided in red text. In addition to the revisions to the manuscript based on reviewers' suggestions, we also incorporated the momentum feedback from SDs to fluids in all SDM runs (see, e.g., Eq. (81) of Shima et al. (2020)), which was unintentionally ignored in the previous results. All the SDM plots are replaced by the new results. However, since the effect of the momentum coupling is not significant for this case, this modification does not alter the main conclusions of the present study.

Our main emphasis in this paper is on the study of the numerical convergence characteristics of SDM and SN14 for stratocumulus. While we do examine the differences between these two schemes, it's essential to recognize that this examination is not the primary focus of our research. We aim to convey this distinction to ensure a clear understanding of our research priorities.

1. The super-droplet simulations show convergence at around 16 SDs/grid for this case. It's a small SD number. But I wonder if this could apply only to this case where precipitation formation is extremely low. This low super-droplet number per grid box may not be sufficient for cases with significant precipitation formation. It may affect the precipitation formation rate and the spatial structure of the rain and cloud water fields. Similarly, for a polluted case with GCCN, a sufficient number of super-droplets might be needed to appropriately sample the aerosol size spectrum and capture the effect of GCCN on precipitation initiation. I recommend the authors clarify this point at appropriate places in the manuscript or present a convergence test for a precipitating case.
   Reply: We agree that such a small SD number concentration would not be enough to simulate the formation of heavy precipitation. We have clarified this point in the manuscript (Page 11, Line 353-357). However, since the main purpose of this study is not the sensitivity of precipitation to SD numbers, and adding such numerical simulation experiments would take a long time, we did not consider presenting a convergence test for a precipitating case.

2. 335-340: This argument about a higher droplet concentration for lower SD numbers could be improved. A higher droplet concentration for lower SD numbers may result from a higher multiplicity of SDs and associated statistical fluctuations in the activation process (not a longer phase relation timescale). A lower SD case will have more fluctuations in the phase relaxation timescale, with some grids having extremely short timescales and some with cloud-free conditions. Thus, a higher probability of large positive supersaturation excursions.

Reply: In fact, your point is consistent with the explanation in our manuscript. We apologize that we did not explain it clearly enough in the manuscript to create an ambiguity. We have improved the explanation of this part of the mechanism by referring to your formulation (Page 11, Line 344-347 in the revised manuscript).

3. Could some of the differences in the cloud field between the SDM and bulk runs be due to the spurious in-cloud activation and the Twomey scheme in the bulk run compared to an explicit activation scheme in SDM?
   Reply: We agree that the Twomey scheme adopted in SN14 has a possibility to overestimate the activation/deactivation of aerosols. We speculate that the difference of CCN activation/deactivation treatment in the two schemes would be playing some role which may affect liquid water and buoyancy production, but the mechanism is still unclear, and we will leave it for future study. We add the discussion regarding to activation/deactivation treatment in the revised manuscript (Page 15, Line 500-504).

Reference

Shima, S.-i., Sato, Y., Hashimoto, A., and Misumi, R.: Predicting the morphology of ice particles in deep convection using the super-droplet method: development and evaluation of SCALE-SDM 0.2.5-2.2.0, -2.2.1, and -2.2.2, Geoscientific Model Development, 13, 4107-4157, https://doi.org/10.5194/gmd-13-4107-2020, 2020.