Response to the Referees

Thank you for your insightful comments. Our answers to your questions are shown in red below.

1. Is the momentum feedback from SDs to fluid important? It seems like it would be a small term in the total budget?

   Reply: We assert that while the momentum feedback is indeed a minor term in the overall momentum budget for stratocumulus clouds, it is significant. This is particularly true in the context of deep convective clouds, where mass loading from precipitating particles critically influences cloud dynamics by altering buoyancy calculations (Grabowski and Morrison, 2021). This indicates that accurate representation of this momentum exchange is essential for realistically simulating the buoyancy forces.

2. The authors highlight the benefits of no numerical diffusion associated with the SD method. I was wondering if there is space for actually adding some diffusion into the scheme. For example to represent the effects of the unresolved fluctuations in the sub-grid scale. Based on your intuition, would that be useful?

   Reply: Our initial tests involved introducing minor artificial perturbations to the motion of SDs to simulate sub-grid scale fluctuations. However, in the specific case of DYCOMS-II (RF02), these perturbations had minimal impact on the simulation outcomes, suggesting a relatively minor influence of unresolved turbulence under these conditions.

   Nonetheless, as you correctly pointed out, representing the effects of unresolved fluctuations is crucial for a comprehensive modeling approach. Inspired by the feedback and insights provided by studies such as Chandrakar et al. (2021) and Chandrakar et al. (2022), we recognize the significant value in integrating this SGS model into our SDM framework. These advancements could substantially enhance our model's ability to capture essential dynamics not directly resolved at present, particularly in more turbulent environments.

   Moving forward, we plan to explore the potential benefits of a more sophisticated SGS modeling approach within our SDM framework to address the complexities of cloud microphysics more effectively.

Reference

Chandrakar, K. K., Grabowski, W. W., Morrison, H., and Bryan, G. H.: Impact of

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Chandrakar, K. K., Morrison, H., Grabowski, W. W., Bryan, G. H., and Shaw, R. A.: Supersaturation Variability from Scalar Mixing: Evaluation of a New Subgrid-Scale Model Using Direct Numerical Simulations of Turbulent Rayleigh–Bénard Convection, Journal of the Atmospheric Sciences, 79, 1191-1210, https://doi.org/10.1175/JAS-D-21-0250.1, 2022.
Grabowski, W. W. and Morrison, H.: Supersaturation, buoyancy, and deep convection dynamics, Atmospheric Chemistry and Physics, 21, 13997-14018, https://doi.org/10.5194/acp-21-13997-2021, 2021.