Review: **Breakups are Complicated: An Efficient Representation of Collisional Breakup in the Superdroplet Method**

Emily De Jong et al.

This is a revised submission. The authors have made efforts within the scope of the study to enhance the coherence and provide more concise explanations regarding the collisional breakup process compared to the previous manuscript.

Considering the minor comments provided below, I recommend acceptance with minor revisions.

<u>Minor comments:</u>

Introduction:

- L37: In principle, it is clear the conservation of total droplet/drop number is fundamentally independent of scalability. These are distinct physical and technical aspects, respectively. It is an optimization problem: (a) the fundamental collisional breakup has the potential to generate new droplet sizes explosively; (b) the physical process needs to conserve mass and number reasonably well; (c) applying (a) & (b) together in an atmospheric numerical model requires some technical adaptation. The manuscript presents an algorithm with some associated assumptions that optimize the above requirements. Please refine/clarify the text.
- L45: I think that these sentences are written primarily for warm rain scenarios. In modeling mixed-phase microphysics, it becomes evident that large snow aggregates and/or graupel/hail entering the melting layer can lead to the formation of aerodynamically unstable large drops.
  Additionally, due to the short time scale and very (very) low concentration of these drops, applying standard (unit volume wise) collision algorithms may not be fully applicable. These drops are also important for radar-based analysis and are associated with constraining maximal dimension (please refer to the references below). Please refine your text. You may consider simply saying that spontaneous breakup is not included in this version of SDM (as I think you points out later on in the manuscript).
- L170: Please correct the typo "The simulations are performed for 2048**s with** 1s timesteps …"

Section 4.1.1:

- L240: relative **terminal** velocity

Section 4.1.2:

- L277: Droplets are referred to cloud droplets. 1-mm particles are rain **drops** (throughout the text).
- **Figure 9**: Overall, I do not see any good reason to keep this figure. Presenting number size distribution clearly needs to have better agreement with the reference's small diameter modal size, particularly in logarithmic scale.
  The significant increase in the number concentration at modal size of ~6-mm is concerning and is physically unrealistic as drops becomes increasingly unstable at these sizes. If the authors were to present the data in terms of mass size distribution, it would demonstrate an explosive mass of (unrealistic) drops.
  Lastly, the reader lacks an effective means to evaluate why the multiplicity-limiter favors coalescence rather than breakup, which is related to the disclaimer at L289.
  Out of respect to the authors work, I kindly defer the decision on the relevance of this figure to the authors and/or editor.

References:

Kacan, K.G. and Lebo, Z.J., 2019. Microphysical and dynamical effects of mixed-phase hydrometeors in convective storms using a bin microphysics model: Melting. Monthly Weather Review, 147(12), pp.4437-4460; https://doi.org/10.1175/MWR-D-18-0032.1

Carey, L.D. and Petersen, W.A., 2015. Sensitivity of C-band polarimetric radar–based drop size estimates to maximum diameter. Journal of Applied Meteorology and Climatology, 54(6), pp.1352-1371; doi: 10.1175/JAMC-D-14-0079.1