# Response to Suggested Minor Revisions

June 2023

## Anonymous Referee #2

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.

Thank you for suggesting this clarification, which we now have incorporated into lines 34–40.

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).

We now clarify in lines 46–48 that we refer to liquid microphysics and do not include spontaneous breakup.

L170: Please correct the typo "The simulations are performed for 2048s with 1s timesteps . . . "

L240: relative "terminal" velocity

Thank you, the corrections have been made.

L277: Droplets are referred to cloud droplets. 1-mm particles are rain drops (throughout the text).

We have chosen to use the term "droplet" throughout the text (and have removed two instances of the term "drop" referring to a hydrometeor) for consistency. Where comments regarding precipitation or a rain size threshold are pertinent (ex. section 4.2.1), we use the term "rain droplet". Otherwise we prefer to refer to all liquid hydrometeors as droplets considering ongoing debate about size cutoffs in determining hydrometeor categories (see, e.g. Igel et al. 2022).

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.

Thank you for pointing out these concerns. We have chosen to include figure 9 in the final publication, as we believe it best addresses previous reviewer comments requesting a comparison of our method against a "ground truth". We clarify in line 277 that number distribution is plotted to be consistent with previous publications presenting steady state size distributions. We additionally temper the language about the multiplicity limiter (line 287) and clarify the relevance of the rainshaft simulation results in lines 291-294.