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# *Interactive comment on* "Improving Collisional Growth in Lagrangian Cloud Models: Development and Verification of a New Splitting Algorithm" *by* Johannes Schwenkel et al.

**Anonymous Referee #1**

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Lagrangian cloud microphysics models use relatively few computational droplets (also known as super-droplets, SDs) to represent huge number of real droplets that clouds are made of. This simplification makes it difficult to model coalescence of droplets and artificialy amplifies fluctuations associated with transport and coalescence. The paper presents a novel method of mitigating these issues and is of potential interest for the GMD readers. The method proposed is to split computational droplets that represent large fraction of liquid water into couple computational droplets, each representing a smaller amount of liquid water. This new aproach is shown to improve results of simulations, especially in the idealized box models. However, some non-trivial results are only vaguely discussed, or their analysis is arbitrary. Therefore I suggest including a



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more detailed discussion of the results, that would address the following points:

1. Single cloud simulations of cumulus show, that splitting increases the amount of rain water. This increase is not seen in the cloud field simulation. Authors conclude that there is no increase in rain water because of averaging over a large cloud field (p.15 l.4). I do not understand how this is relevant. If amount of rain water in each cloud is increased, the average should also be increased.

2. Judging from single cloud simulations, merging increases radar reflectivity and amount of precipitation (see Fig. 13, especially for the S20 case). I suppose that this is not the case, but that the difference comes from different model realisations. This could be clarified if a small ensemble of single cloud simulations was ran for each case discussed in the section 4.2.

3. In single cloud simulations without splitting, amount of precipitation decreases as the number of computational droplets is increased (Fig. 13). Simulations with splitting are in better agreement with $N_p = 15$ than with $N_p = 186$. Why is it so?

4. In box model simulations without splitting, largest droplets produced in LCM are larger than the Smoluchowski equation predicts, especially if number of computational particles is large (Fig. 5). On page 9, line 26, Authors argue that this is because there are few large SDs with high weighting factors. If this is the case, then shouldn't the effect decrease with increasing number of SDs? The opposite is observed - this effect is more pronounced as more SDs are added. Moreover, if the Authors' argument was correct, splitting of SDs should also fix this problem. On the contrary, LCM with splitting also produces too large droplets, as seen in Figs. 7 and 10.

Comments to the "Conclusions" section:

5. In the first paragraph of "Conclusions", Authors claim that LCMs are "known to insufficiently represent" coalescence. I suppose that they are refering to results of box model simulations, shown in Fig. 1. Not all LCM insufficiently represent coalescence, but only those that initialize SDs in the same way it is done in the paper. Other initialization procedures give much better box model results, e.g. Dziekan and Pawlowska 2017.

6. In "Conclusions", cloud field simulations are claimed to show similar effects of splitting on the production of rain as single cloud simulations. This is not true - splitting increases the amount of rain in single cloud simulations, but does not affect the amount of rain in cloud field simulations.

7. A short discussion of potential impact of SD merging on aerosol processing would be desirable.

8. Authors write that merging of SDs reduces computing time by $18\%$. How does splitting affect performance?

Technical comments:

9. In lower panels of Fig. 15, precipitation rate from vanZanten et al. 2011 should be shown.

10. Throught the paper, large variability in results is alternatively called "oscillations" or "fluctuations" (e.g. p. 8, l. 19). Oscillation is a periodic process, so I suggest the word "fluctuations" to be used.

11. In the last line on page 3, Authors write that splitting makes their approach "fundamentally different". To me this seems to be a too strong statement - "different" would suffice.





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12. Why is the blue line in Fig. 16 discontinuous?
13. In Fig. 5 spectra for 512 and 1000 SDs have a local maximum on the large end. What is the cause?

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