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Interactive comment on "Collection/aggregation algorithms in Lagrangian cloud microphysical models: Rigorous evaluation in box model simulations" *by* Simon Unterstrasser et al.

Anonymous Referee #1

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The authors compare three different Langrangian Cloud Model (LCM) implementations with a focus on collection using three different collection kernels. Analytical solutions as well as previous bin model results are used as references. Additionally, sensitivity of the LCM implementations with respect to the initialization of the simulation particles (SIPs) as well as to different numerical features (resolution, time step, ...) is tested.

This results in a large amount of model runs with a great variety of possible parameter and configuration combinations which sometimes makes the manuscript difficult to read.

General comments

Each of the LCM implementations shows rather strong shortcomings:

- RMA cannot deal with realistic kernels (Long, Hall) and shows spurious oscillations.
- AIM systematically underestimates the collisional growth.
- AON always needs an ensemble of at least 50 realizations to reach a representative average result for the final drop size distribution since individual realizations deviate considerably from the average (in contrast to RMA and AIM). This severely limits the potential to be used in 2- and 3-dimensional models with a large number of grid points.

Additionally, sensitivities with respect to initialization of SIPs are shown to be high at least for some configurations. This problem is discussed towards the end of the manuscript where also more mature drop size distributions are used for initializations. Within a full microphysics description including drop nucleation and condensational growth, it should be harder to control the DSD at the moment when collisions become important. This discussion should be extended.

Compared to spectral bin models the accuracy of all LCM implementations shown seems to be lower with at least comparable computational costs. One could conclude that LCMs are of no practical use. Nevertheless, LCMs are valuable tools. Please discuss critically advantages and disadvantages of LCMs.

The quality of some figures is poor. Most of them are too small, lines are too thin and sometimes too many. Specific comments are given below.

Specific comments

l. 154-157: What is the reason to switch from mass doubling (which is often used) to a tenfold increase as a basis for bin resolution?

l. 238: If the probabilistic version of the singleSIP-init is used, dots are not distributed uniformly!

Fig. 1: upper left and below: difference between red and green lines is misleading since the higher density of dots wrt the x-axis is not resolved. upper right: threshold radius line barely can be seen; lines for alpha-values are also misleading, can be confused with legends. Values should read $N10^{\alpha}$. Last but one row: Is there a systematic difference between the symbols and the lines due to plotting issues? If not, a better initial agreement should be reached. Cp. also l. 268-270.

Algorithm 1: What do k++ and i++ stand for? loops over k/i?

Algorithm 2: l. 13: Please exchange gain and loss term due to consistency with l. 12 and eq. (22)

Fig. 3: Top: It is difficult to see what happens in the left part of the spectrum (<20 μm). Bottom: It is confusing to normalize one ratio to t=0 and the other one to t=3600. Please redo the black curve with $\nu_i(t = 3600)/\nu_i(t = 0)$

l. 559 and Figs. 6, 9, 11, 13, 15, 17, 19, 22: The third moment λ_3 should not be shown in the figures since the behaviour is very similar to λ_2 (which should be stated in the text). The space saved can be used to extend some other figures in order to improve their readability.

Fig. 5: Use full lines with enhanced line thickness for RMA results and dotted (or dashed) lines for analytical solutions. Otherwise, all plots look identical at first glance.

l. 564-575: The discussion of the RMA Golovin results is very short and misses several aspects, e.g.: Why are the results for RedLim worse than the regular ones? What are the reasons for the relatively large differences between the two OTF versions?

Fig. 6: Are there any lines missing? Variation of η only for $\kappa = 60$ in the left and the middle column? No $\kappa = 60$ for OTF at all? Which lines fall together and which runs are carried out at all?

Fig. 7: see Fig. 5: full lines for the RMA results.

l. 595: Compared to the regular version (and to bin model results) I would not call the RMA RedLim results "perfect". The same holds for the OTF$_s$ results; only OTF$_l$ is almost "perfect".

Figs. 8, 10, and 12: see Fig. 5: full lines for the AIM results.

Fig. 14: see Fig. 5: full lines for the AON results. Results plot for disregarding self-collections is missing.

l. 739: Is this restricted to AON results or do the other methods show similar robustness wrt to the small tail of the distribution? In reality very small drops similarily do not contribute substantially to the growth of the large mode due to their low number and small individual mass. This should be reflected in model sensitivities.

l. 746: This is in contrast at least to the Golovin RMA results. Why is it reasonable for AON? Is this due to the lower number of collision events realised because of the probability restrictions?

l. 766: When p_{crit} is smaller, less collection events can be expected (see lines 469/470). A spread in ν-values leads to smaller and larger ν-values. Does this mean, that the largest ν-values are responsible for the enhanced collection?

l. 902ff: It should be critically mentioned that AON always needs an ensemble of at least 50 realizations to reach a representative average result for the final drop size distribution since individual realizations deviate considerably from the average (in contrast to RMA and AIM). This leads to a large effort in terms of computational resources.

Technical corrections

l. 18: ... are important processes ...

Table 1: mean mass: M/N

Fig. 1 caption: alpha should be (-2, -3, -7)

l. 256: values of $N10^{\alpha}$ ...

l. 276: However, it is ...

l. 371: rather "proposed" than "discussed"

l. 410ff.: The terms "larger SIP" and "smaller SIP" are used here with the meaning "SIP with larger/smaller drops(=higher average drop mass)". Please define whether "large SIP" indicates large drops or a large number of drops within the SIP (cp. l. 510).

Fig. 3 caption: ... function of their initial radius ... Please add that it is an AIM simulation.

l. 434: ... of each droplet within the SIP ...

l. 435: Figure 3

l. 510: In contrast to l. 410ff. smallest SIP refers to the size of the droplets not the weighting factors;

Fig. 11 caption: ... black curves with triangles ... green lines for ν_{random}; α should be (-2, -3, -7)

l. 658: green lines

l. 792: check the meaning of "large SIP", also l. 824 "heavy SIP"

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