review of manuscript egusphere-2023-2507 submitted to Geosci. Model. Dev.
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Outline of the contents

The reviewed paper focuses on numerical modelling of particle coagulation in a Cumulus cloud typical of fair-weather convection. The focus is on studying the effects of droplet charges on the effectiveness of coagulation, and the resultant changes in rainfall properties. The study employs a two-dimensional idealised fluid dynamics setup resolved on a grid with 50m spacing, with no subgrid-scale dynamics representation. The particulate phase is represented with simulation point particles, each representing a sample of modelled droplets. The simulation particles undergo collisions (only with other simulation particles, not within the subpopulation represented by each of them), and the resultant coagulation efficiency is parameterised taking into account theoretical considerations for the enhancement of collisions probability due to the particles being charged. The simulations do not involve tracking particle charges - these are a priori determined as a function of the droplet size. Particle collisions are treated employing coagulation kernel approach, without assessing the inter-particle distances. Besides collisions, the particles are subject to condensational growth and evaporation, sedimentation and advection with the flow. The representation of collisions and the initial sampling of the simulation particle population is probabilistic, and the study analyses 50-member ensembles for each setup.

Overall impression and suggestion of a major revision

Unfortunately, it is hard not to begin with pointing out that the lax approach to text and figure composition, reference consistency and equation typesetting distracts from the paper's content and tarnishes overall impression. The manuscript was submitted prematurely and calls for a major revision. There are (details below): unlisted and uncited references, symbol conflicts, omitted symbol subscripts, unreadable figure elements, and large parts of text that repeat from literature descriptions of model details that are of little relevance to the study (e.g., sections 2.3 and 2.5). There are several aspects which warrant elaboration or more substantial grounding (and literature references):

- The choice of the particle-resolved method is not explained - what are the benefits, tradeoffs, limitations as compared to other modelling techniques, in the very context of modelling charged-particle interactions?
- What are the implications of one of the key assumptions, namely that the drop charge is merely parameterised as a function if its size?
- Unlike the velocity-differential driven gravitational coagulation, the Brownian mode applies to same-sized particles, and thus should occur also within particles represented by a single simulation particle, which IIUC is not the case in the model?
- Despite the whole paper focuses on fair-weather convective cloud simulation, and only the very last sentence of the Discussion section relates to fog, the Conclusions section puts forward a hypothesis that "Electro-coalescence has a larger impact on highly polluted warm clouds or fog" - are there grounds for this statement in this study?
- More background on electro-coalescence would help to cater to readers not acquainted with the earlier works of the authors, and to highlight the importance of the results by explaining a broader perspective on the challenges in this domain, from measurement, theoretical and numerical modelling perspectives.

The paper clearly matches the journal scope. The paper is accompanied by open-source code and execution scripts fulfilling the journal requirements (although, there is certainly room for improvement - see comments below).

Abstract

- the first sentence of the abstract does not seem to apply to this paper - the analytic expression is not established here, it is used here? (if not, please clarify in the text)
- the abstract should clearly state what kind of simulations are done (2D, flow-coupled, capturing aerosol microphysics, warm rain, no subgrid dynamics, ...)
- it should be indicated that despite employment of a particle-resolved microphysics representation, the particle charges are not among the particle attributes
- similarly, worth clarifying that despite calculating drop trajectories, collisions are modelled assuming well-mixed coalescence volume assumption
- worth iterating the considered options of assumptions regarding charge treatment (e.g., charge polarity always opposite, ...)
- provision of numbers with 3 significant digits in the abstract (e.g., 5.42% higher) seems overzealous
- it is worth to highlight the probabilistic nature of the simulations and the number of realisations employed in the study
- usage of the word "treatment" in the abstract suggests that CS is an alternative to super-droplet method (line 17)
- according to the GMD guidelines (`https://www.geoscientific-model-development.net/submission.html#manuscriptcomposition`), references should not be included in the abstract unless urgently required - suggest removing the reference to Khain 2004 (retaining the rest of the sentence)

Code and data availability

- the Zenodo archive contains four 9GB tar files without any annotation or metadata, with two-letter file names – one can guess that these contain simulation output, but provision of a description that can be accessed prior to downloading it would be helpful;
- the referenced source code archive on Zenodo contains spurious non-portable compiler output (*.o, *.a, and *.mod files) which should be removed
- the title mentions v0.2.5-2.3.0 but the README.md file gives v0.0-2.2.2 - please make it consistent and add to Zenodo metadata
- the "The data ... are available from the corresponding author upon request" statement is not in line with the journal policies - the statement implies lack of anonymous and persistent access to the data and should be removed, while clarification on what is included in the multi-gigabyte datafiles on Zenodo provided
- Trying to understand the contents of the provided `contrib/SDM/sdm_coalescence.f90` file, I became puzzled with why all the electro-coalescence efficiency calculation lines (824, 825, 828, 830 and 834) are commented out, only to realise that the **README.md file hints that such code blocks need to be manually uncommented if trying to reproduce the simulation results** - it seems to be quite an obscure way to provide the code. Please provide the source code in a way that no manual alterations are needed to reproduce the results and that the version identifier provided matches the unmodified code used for simulations.

Figures

- Fig 1: the kernel dimensionality should be volume over time, not volume over inverse-time
- typo in Fig 3b and 5d: "Liquid" not "Liquit"
- font sizes in the figure labels (incl. axis tick labels) should match text size, and be uniform, currently these span all sizes from unreadable small (Fig. 2!) to unreasonably large
- the employment of a multiplication factor given above Y axis in figs 3a and 6-8 is misleading, non-standard and hard to notice, please use intuitive units instead
- labels are missing spaces between quantity name and unit parentheses, parentheses are sometimes "()", sometimes "[]"
- the choice of X and Y axis ranges in figs 3a, 6-8 seems awkward (vast majority of the plot area is left blank for no good reason)
- some units are typeset in italics, some in normal font
- the "*10^{-12}" multiplication factor for Y axis in Fig. 1 is awkward given the 10^{-4} - 10^{2} axis range - please avoid using scaling factors in labels
- X axis in figs 6-8 would be more intuitive if presented in minutes/hours, while Y axis in mm
- figure quality is poor due to choice of inadequate raster graphics format, please use vector graphics

Equations

- eq. 27 - split into two equations - the comma is hard to interpret
- parentheses in equations are typeset with misleading sizes (small parens surrounding large parens)
- using almost identical "a" and "α" right next to each other is very misleading (e.g., eq. 17)
- suggest avoiding defining parameters with their units, e.g.: "α (cm-2)" and mentioning unitless values in the text – it is clearer to write "rate α ... with a range of 0.1 – 0.6 cm^{-2} ..."

Text comments

- line 26: "electrostatics on charged droplets" seems awkward - please rephrase
- line 37: cite Rayleigh 1879 (https://www.jstor.org/stable/113853)?
- line 62: suggest replacing well-known with so-called
- line 72: 0-dimension but 4-dimensional
- line 91: remove "accurate"?
- line 100: why the radius is "equivalent"? (+unintentional "::" at line end?)
- line 104: replace "floating in the atmosphere" with "in the domain"?

- line 109: "sediments" -> "sedimentation"
- line 114: likely worth referencing Montero-Martínez et al. 2009 (https://doi.org/10.1029/2008GL037111)
- line 126: "heat conditions" -> "latent heat release"
- line 131: mixing coefficients, units and functional dependencies in one expression leads to ambiguities - e.g., what does K means here - thermal conductivity (should be in italics) or Kelvin (all units should not be in italics, but with upright font)
- line 134: the water density was already defined in line 111
- line 143: parenthesis in eq. (5) suggest at first sight that π is a function and E is a constant, while the opposite holds - please try to format the equations intuitively
- line 146: the single-particle size is given along with "mean" charge of particles - how the mean is defined, why isn't it a mean size as well? Should it be characteristic instead of mean? - please elaborate on the assumptions needed to define the notion of the kernel in four dimensional attribute space
- line 175: eq. (16) is referenced before being given
- line 183: different symbol used for terminal velocity than before
- line 184: collision -> colliding
- line 185: Fes -> F_{es}
- line 206: K was defined differently in line 133
- line 236: element -> elemental (also in lines 418 & 437)
- line 257: "the interception effect" was never mentioned before
- line 302: please rephrase "number and size distribution are made"
- line 304: the composition was already given in line 301
- lines 305-307: subscripts, units with upright font; also: worth mentioning that these parameters are actually altered across simulations (section 3.3)
- line 310: it would be worth to clarify that Shima et al. (2009) includes warm-rain algorithm definition, while the 2020 paper includes mixed-phase extension (not used here) and coupling with SCALE (used here)
- line 312: IIUC, the employed/developed SDM code is not available at the provided riken.jp URL - worth clarifying
- line 313: provide reference for the lower cost mention
- line 330: this reads as if the fluid dynamics were not influenced by the latent heat budget of the particles, but surely are - should there be a third step defined?
- line 333: I fail to understand the "Process lags in time is calculated preferentially" statement
- line 340: refer to Lu & Shaw 2015 (DNS study, https://doi.org/10.1063/1.4922645) and elaborate on the implications of lack of small-scale turbulence representation

- line 351: please underline that this is just one of 50 realisations simulated, and given that and the fact that these plots are hardly distinguishable, are the conclusions really supported by this figure?
- line 363: should be "standard deviation", not "standard deviation error", right?
- lines 365-366: are three significant digits for a percentage increase meaningful here?
- line 388: is it both domain- and ensemble-averaged? (same remark for lines 397, 405, 410, 421, 471, captions of Figs 3, 5, 6, 7 & 8)
- line 389: "droplets with higher charging rate" suggests that within one simulation, different droplets have different charging rate, which is not the case, right?
- lines 406-407: four significant digits for percentage change grossly contrasts with the idealised setup of the simulations, with relatively small ensemble size, and with the (chaotic) nature of the modelled system
- line 494: check sentence grammar
- caption of Fig. 5: should be "water path", not "water precipitation" (three times)

References

- Forbes & Clark is cited but not listed in references
- Zhang et al. 2019 cited in line 38 but not listed in references (likely meant to be Zhang et al. 2018 which is listed but not referenced in the text)
- Frederick et al. 2018 should be Frederick and Tinsley 2018 in line 42
- Beard (2004) should be Beard et al. (2004) in line 48
- Tripathi et al. (2006) is cited (in line 58) but not listed
- Andronache et al. (2004) should likely be Andronache (2004) in line 77
- Köhler et al. 1936 should be Köhler 1936 in line 122
- Bott 1998 is cited in line 152 but not listed in the references
- Seeßlberg should be Seeßelberg in line 152
- Seinfeld and Pandis is cited in line 155 but not listed in references
- Fuchs 1964 is cited in line 156 but not listed in references
- Shima et al. 2014 is missing a permalink: http://hdl.handle.net/2115/55063 (it would also be worth indicating that it is in Japanese)
- Davis 1964a and Davis 1964b are cited but not included in the references (lines 208 and 210)
- "Zhang,2023" reference given in line 507 is not listed in the references
- Rogers & Yau is cited but Yau & Rogers is listed
- Pruppacher & Klett is cited but Pruppacher, Klett and Springer is listed (BTW, the DOI is 10.1007/978-0-306-48100-0, please also double check the year)

- Sato et al. 2017, 2018 and VanZanten et al. 2011 have doubled journal names in the reference list
- Sate et al. references are not listed in chronological order
- VanZanten vs. van Zanten
- Lasher-Trapp vs. Lasher-trapp
- Tinsley & Zhou 2006 is listed but not cited
- some journal names are abbreviated, some are not
- some surnames are in ALL-CAPS, some not
- some journal names are ALL-CAPS
- some titles are typeset with All Words in Caps, some with just the first word capitalised
- if citing a work with parentheses, avoid double "))" - lines: 86, 213, 500