The paper discusses extension of the DALES moist boundary layer simulation framework to cover multicomponent aerosol budget. The extension is based on externally developed model M7. Simulations using the RICO shallow-cumuli-field setup are used to showcase capabilities of the coupled framework.

The paper reads well and the topic matches GMD scope. I am listing below some major and minor comments, which shall be helpful when revising the manuscript. In general, model development description requires less refinement than the discussion of the results as these seem often premature given the relatively small set and coarse resolution of the documented simulations.

## Simulation resolution and length

A major concern that I would like to highlight is the limitation of the discussion of sample simulations to a single LES resolution, notably a relatively coarse one for a shallow cumulus case. In the 2011 study of Matheou et al. (doi:10.1175/2011MWR3599.1) it was shown that for the RICO simulation setup used in the present paper, even significantly finer grids and larger domains were not enough to achieve convergence in terms of cloud characteristics (see also Sato et al. 2018, doi:10.1029/2018MS001285). While, arguably, such analysis and discussion is not directly related to the scope of the manuscript, it would be of great value for potential users of the developed aerosol module. Moreover, having the limitations of the resolution in mind, and given the absence of convergence tests in the paper, I strongly encourage the authors to critically revisit all parts of the paper commenting on the match with observations.

Similar concern applies to the length of the simulation. The original RICO setup featured 24 hour simulations, of which several first hours were treated as spin-up, while output result for model intercomparison was carried out using the last four hours of simulation only. In the present paper, 6-hour long simulations are presented (and the conclusions section enumerating the main findings of the study, comments on processes with multi-day timescales). It is essential to point out this difference, provide the reason for shortening the simulations, and comment on it.

How does the intensive precipitation in the second half of the first hour of the RICO case affects the budget of remaining aerosol, and hence how different are the conditions in which clouds form here with respect to those found in models with infinite CCN reservoir? Please discuss.

## Aerosol processing nomenclature and background information

Aerosol-cloud interaction, as a main theme of the manuscript, is always stated in singular form (i.e., interaction, not interactions). First, in general plural would sounds better in my opinion. Second, it would be worth to elaborate in the paper on the different kinds of interactions, also those beyond the processes covered in DALES-M7. It is striking that aerosol distribution changes through aqueous-phase oxidation are not mentioned in the paper, the mention of chemistry in the penultimate sentence is unclear. Please comment on it and clearly position the capabilities of the introduced model among other available aerosol-cloud interactions modelling frameworks; see, e.g., Ovchinnikov and Easter 2010 (doi:10.1029/2009JD012816) and Jaruga et al. (doi:10.5194/gmd-11-3623-2018) and references therein. Aerosol nucleation processes are also reported to be influenced by clouds (e.g., Wehner et al. 2015, doi:10.5194/acp-15-11701-2015).

On a related note, while the authors claim "resolving most of the turbulence" (worth rephrasing), there is little discussion on how it affects the modelled collisions among aerosol, cloud and precipitation particles - worth mentioning. In general, perhaps putting together a summary of omitted/largely-simplified processes would be a good idea (in-cloud activation, aerosol sedimentation, influence of turbulence on collisions, chemistry, etc)?

Please also make sure it is clear what "explicit" means in different contexts in the paper. In principle, it should be clear (also to readers from neighbouring domains or those focused on largely different scales) what the opposite – implicit – would mean.

Could "free aerosol" when referring to out-of-cloud-or-rain-shafts aerosol be named somehow differently? Ambient aerosol?

## Statements calling for references

- p6/l4-5: "...cloud and rain droplet modes do not have a lognormal shape...", see:
  Clark 1976 (doi:10.1175/1520-0469(1976)033<0810:UOLNDF>2.0.CO;2) and
  Feingold and Levin 1986 (doi:10.1175/1520-0450(1986)025<1346:TLFTRS>2.0.CO;2)
- p10/l11: "but the measurements were fitted to a bimodal lognormal dist." – in which work?
- p11/l7: "corresponds to the actual observed mean values" – which day, which aircraft, which sensor, which sampling rate, what kind of analysis, which paper...
- p12/l1: "which is in accordance with observations" – ditto
- p12/l22: "campaign in-situ observations show values" – ditto

## Paper structure

Several suggestions and comments to the paper structure:

- Section 3.1 is introduced, but there is no 3.2
- Section 5 "Results" should be somehow linked with the setup (as these are not general results)
- Appendix material fits well into the simulation setup section
- Code availability section does not need a number (format as acknowledgements)

Here is a possible rearrangement:

| | |
|---|---|
| 1 Introduction | 1 Introduction |
| | 2 Model description |
| 2 Model description | 2.1 DALES dynamics and moist processes |
| | 2.2 M7 aerosol framework |
| 3 Aerosol framework | 2.2.1 Overview |
| 3.1 Microphysical processes | |
| 3.1.1 Activation | 2.2.2 Activation |
| 3.1.2 Scavenging | 2.2.3 Scavenging |
| 3.1.3 In-hydrometeor processes | 2.2.4 In-hydrometeor processes |
| 3.1.4 Evaporation and aerosol... | 2.2.5 Evaporation and aerosol... |
| | 3 Sample simulations |
| | 3.1 Model setup |
| 4 Case and simulation setup | 3.1.1 RICO case |
| | 3.1.2 Aerosol initialisation |
| 5 Results | 3.2 Results |
| 5.1 Cloud microphysics | 3.2.1 Cloud microphysics |
| 5.2 Aerosol microphysics | 3.2.2 Aerosol microphysics |
| 5.2.1 Contribution of indiv... | 3.2.3 Contribution of indiv... |
| 5.2.2 Changes in the aerosol... | 3.2.4 Changes in the aerosol... |
| 6 Discussion | 4 Discussion |
| 7 Conclusions | 5 Conclusions |
| 8 Code availability | Code availability |
| A Aerosol initialisation | |

## Code availability

In which branch of DALES github repo one can find the code of DALES-M7?
Is M7 an external dependency or was it incorporated into (or reimplemented?) DALES codebase?
What is the license of M7? is it compatible with DALES's GPL?
Which version of M7 was used/incorporated/reimplemented?

## Minor or technical comments

- p1/l4: "The feedback of ACI on the aerosol population remains relatively understudied" – within the abstract, please concentrate on describing the contents of the paper, and not motivation
- p1/l18-19: please clarify if "larger" refers to size or mass
- p2/l10: "missing atmospheric context" – please rephrase
- p2/l28: given the paper discusses aerosol-cloud interactions, mentioning also 2D-bin (e.g., Lebo and Seinfeld 2011, doi:10.5194/acp-11-12297-2011) and particle-based methods (e.g., Grabowski et al 2019, doi:10.1175/BAMS-D-18-0005.1) would be apt
- p3/l3-4: recent advances in representing aerosol in LES are not limited to these two works! please be more comprehensive or rephrase
- p6/l13-17: unlike in a basic single-particle model as $\kappa$-Köhler, activation in clouds happens on populations of particles and with complex supersaturation dynamics related to small-scale fluctuations and drop-growth feedback, please acknowledge what is simplified when just considering a critical supersaturation
- p7/l12: please clarify if this is peak or equilibrium in-cloud supersaturation
- p8/l7: first mention of KAPPA, not introduced as an acronym before, please define
- p9/l6: final $\rightsquigarrow$ last
- p9/l11: add "and" before "is calculated"
- p9/l22: "their Eq. 4" $\rightsquigarrow$ "Eq. 4 therein"
- p10/l18: being over an ocean is not the point, the point is from where the wind blows and how far from the sources it is
- p10/l22: shouldn't the concentrations be expressed in the units of $mg^{-1}$ (to reduce variation from density changes)
- p11/l14 "beautifully display the richness"... please refrain from vague statements
- p12/l8: "at left" $\rightsquigarrow$ "at the left"
- p14/l22: "mighty" $\rightsquigarrow$ "might"
- p16/l15: perhaps worth commenting on how in-cloud activation was modelled (or neglected)
- p19/l13: are 4 significant digits needed?
- p20/l5: ditto
- references: please be consistent in using journal name abbreviations vs. full journal names

Hope that helps.