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Comment on acp-2022-152

Anonymous Referee #2

Referee comment on "Sensitivity analysis of an aerosol-aware microphysics scheme in Weather Research and Forecasting (WRF) during case studies of fog in Namibia" by Michael John Weston et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-152-RC2, 2022

This paper presents an analysis of two well-observed fog cases over Namibia with multiple versions of an aerosol-aware microphysics parametrization in WRF. The result show some interesting issues with the microphysical parametrization and its representation of fog, which are certainly worth reporting, although the manuscript could be clearer in explaining what these issues are and identifying possible further work to address them. I suggest the paper could be suitable for publication with some revision to improve this aspect.

Major points:

The authors appear to view the minimum updraft speed used for CCN activation as a tuning parameter. It is not. Whilst it is fine to adjust this parameter as part of a sensitivity analysis, the authors need to be clearer on the reasons for doing this, i.e. it is highlighting deficiencies elsewhere in the model. If insufficient activation is achieved for the physically-based default setup (obtained from parcel model analysis), then one of 2 things must be happening:

- The model updrafts themselves are underestimated. This point is not mentioned at all in the paper, and should be. Whilst I suspect (as usually happens in fog), the model updrafts are correctly small, it would be worth discussing - especially if you have

observations of the near surface vertical velocity variance available.
- The updraft is not the process causing the aerosol activation. Whilst this point is mentioned briefly in the paper, it needs to be made clearer, and could be further discussed, e.g. what cooling rate does the change in minimum updraft velocity they try imply, and is this realistic?

Some specific (but not exhaustive) examples of text that needs addressing in this regard:

- L260-267 - this could be clearer in explaining the motivation, i.e. you're picking the minimum updraft to achieve the observed activation, but this doesn't imply that the updraft is the reason for the activation, i.e. it achieves the right answer but for the wrong reason
- L450-457 - again, need to be clearer here that the right answer is being achieved for the wrong reasons, and add some discussion on what the right way to achieve the desired result could be

Minor points:

- L14 - I'd say "is used" rather than "is parametrized".
- L73 - spelling of "Boutle"
- L112 - is 34m really low enough for the lowest model level in fog? Some more discussion on this might be useful - did you do any sensitivity studies to this? It implies that the fog must be at least 34m deep before it is present in the model, which could have significant effects on its early development. I'd suggest the authors look at https://acp.copernicus.org/articles/22/319/2022/ to see what effect the lowest level height can have on model development, e.g. the FV3 results with a lowest level at 21m are quite poor.
- Fig 3, 6 etc - it's usually helpful to plot visibility on a logarithmic axis, due to its highly nonlinear nature, to better show the low visibility events.
- L300-315 - I don't really understand here how the CCN is evolved in time in the different experiments, so it would be useful to explain this further. My assumption was that it was a prognostic variable, advected by the flow and processed by the physical parametrizations? But the text seems to suggest that it is somehow diagnosed from the boundary layer depth over land - why? And why is this not applied in the simulations where the CCN is initialised from a climatology - What happens to the CCN when the BL depth adjustment is not used? If it's important enough to discuss, why not process the CCN in the same way in all experiments (with or without this BL depth adjustment) for consistency? I think this is just complicating the results for no good reason, and would be better to be consistent.
- Fig 10 - would be helpful to use the same scale for panels a-d, rather than varying the left and right columns
- Fig 10 - it would be worth discussing somewhere why there is such a large discrepancy

between the simple initialisations and the analysis - are the simple setups just really bad for this area of the world, so the analysis is the correct thing to use, or how much do we trust the analysis for fog initialisation?