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Comment on acp-2022-152

Anonymous Referee #1

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-RC1, 2022

The manuscript *"Sensitivity analysis of an aerosol aware microphysics scheme in WRF during case studies of fog in Namibia"* investigates how droplet activation of cloud condensation nuclei (CCN) affects simulated evolution of fogs. The analysis is done for two observed fog cases which are simulated using different assumptions for initial CCN concentrations affect the evolution of fog properties. The paper presents a thorough investigation of the topic and is within the scope of Atmospheric Chemistry and Physics. The main issue with the paper is that it is not clear to me, what is the scientific value of the study and in order to be published, this shoud be clarified.

In addition, the following points should be addressed:

Major comments:
- In many cases, the model setups and their effects on results are explained too ambiguously to be understandable for the reader. I was not able to understand properly the description of the setup for initial CCN concentrations. Section 3.3.2 discusses the vertical profiles of CCN and refers to the WRF user guide for an explanation. However, it is still unclear to me how this initial vertical distribution results in such a large difference in CCN over land and over ocean for Case CCN_300. Is the initial column intergral of CCN concentrations (CCN burden) significantly different depending on the terrain? Is the CCN concentration initialized in the beginning of the spin up or at the beginning of the actual simulation?

- Page 15, Line 310 says that *"The initial CCN concentration for scenario CCN_300_landsea shows a clear contrast, with lower concentration over the ocean than the land (Fig. 10c). The lower concentration over the ocean counteracts the accumulation of CCN over time, as seen in CCN_300, resulting in a more balanced mean CCN concentration between land and ocean (Fig. 10d)."* Is the accumulation of CCN in CCN_300 only because there are more CCN than in CCN_landsea? In what way there is a more balanced mean CCN concentration between land and ocean? The land-sea contrast

at the south boundary seems quite high also in CCN_300_landsea.

The droplet activation parameterization is shown in Figure 2 to be sensitive to CCN concentration and updraft velocity. However, fog formation is also affected by non-adiabatic cooling. Poku et al., (2021) have suggested that instead of using simulated updrafts, it would be better to calculate the change in saturation due to non-adiabatic processes. In the current paper, only the effect of changing the minimum updraft speed was tested. Wouldn't it have been fairly straight forward to for example convert the cooling rates to corresponding updraft speeds to have a more physical representation of fog droplet activation? On Page 21, Line 392 it is said *"Their proposed work around is to include cooling tendency as proxy for updraft speed and then assigning a speed that will activate the appropriate number of droplets. This may come with a new set of problems in terms of early activation but this remains to be seen."* To me this seems a very good approach and if there is a new set of problems, would that point to problems in other physical processes of the model and in itself is not a good justification for not using this approach?

Minor comments:
Page 6, Figure 2: Is the activation sensitivity the activated fraction of CCN?

Page 11, Line 266: *"Therefore, assigning a minimum updraft speed of 0.1 m s-1 can be a reasonable assumption, as it falls within the median of activation at the site 0.56"* Did you compare the distributions of activated fractions for different minimum updrafts?

Page 15, Line 307: *"Furthermore, the boundary conditions for scenario CCN_300 had relatively lower concentrations of CCN."* Lower concentrations compared to what? Why are they lower?

Page 21, Line 391: *"In addition, the threshold updraft speed is often higher than the 0.01 ms-1 used in the T14 scheme, which effectively results in a higher super saturation and excess droplet activation than would be expected for a fog event."* Please add references to such studies / approaches.

The motivation for showing Figures 13-16 is not clear to me.

Techical comments:
Fonts in figures are extremely small.