Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., referee comment RC2
https://doi.org/10.5194/acp-2022-242-RC2, 2022

Comment on acp-2022-242

Anonymous Referee #2

Referee comment on "Aerosol characteristics and polarimetric signatures for a deep convective storm over the northwestern part of Europe – modeling and observations" by Prabhakar Shrestha et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-242-RC2, 2022

Review of Shrestha et al,

In this study a convective situation is simulated with an ensemble of TSMP-ART runs over the Bonn region of Germany. The simulations are validated using the Bonn Polarimetric radar, aeronet and modis observations. In general, the ensemble runs are able to simulate the convective cell structure reasonably well, while the aerosol concentrations and precipitation are underestimated. When the model runs are run through a Forward Operator, difference between the simulated and observed cloud structure are presented. The paper is extremely well written but the story line and figures are very complex. I recommend the article for publication in ACP once the comments below are addressed.

General comments:

The paper is quite technical with lots of details (e.g. discussion about specific features in the plots), which often distract from the overall research questions and ending conclusions.

The main research questions are not really answered and it comes off more of as, "we have these observations, let's see how our more complex model is doing" rather than geared to address a particular research question e.g. does using prognostic aerosols improve the reproducibility of the storm, does constraining the cloud droplet distribution improve storm signatures, does a Forward Operator allow us to understand model deficiencies more easily? Especially as research question 2) is never really answered, as it is not clear if the "capabilities" lead to an improvement to simulations without these additions. There is no doubt that getting these components of the model to run together is a complex and cumbersome process, but without showing that this is an improvement or how the Forward Operator polarimetric variables improve the assessment of aerosol-cloud-precipitation interactions, the paper is lacking a clear direction.

One of the main findings from the aerosol module is that the convective updrafts produce aerosol towers and that the properties of the aerosols change after cloud processing. However, these themes are not carried through the manuscript. There is also very little discussion on how the aerosol cloud processing is parameterized or compared to previous studies. Also, it is not immediately clear if these aerosols will remain interstitial when exposed to such high updrafts. If they are activated as cloud droplets/nucleated into ice crystals, will they be scavenged and removed?

Are the polarimetric variables actually helping point to why the model is not matching the observations? There is a lot of discussion on how these variables differ but not to what questions they can answer. At the same time, as the Forward Operator introduces many uncertainties in itself as mentioned in the discussion, is it worth including it as a diagnostic tool? Consider building on the advantages of including this in the modelling process/ post processing.

At the same time, one of the main hypothesis for the discrepancy between observed and simulated polarimetric variables is the cloud droplet size distribution. Even though this explicitly tested, the discussion on this topic is not well connected. Even when running this sensitivity study, the polarimetric variables do not improve significantly. Does this really mean it is necessary to run simulations with prognostic aerosol as stated in the conclusion? Rather is it better to further adjust the cloud droplet size distribution?

Many of the figures are poorly labeled and described in the captions as noted below. This makes the discussion difficult to follow.

Minor comments:

Line 60: remove “s” from lightning.

Line 63: would be nice to have a domain of the modelling in the manuscript, rather than just a reference to a previous study.

Line 137-149: As this study looks at the aerosol transport in convective updrafts, the description on aerosol activation (both CCN and INP), subsequent removal via precipitation and aerosol scavenging should be described. There is no doubt that updrafts help to lift boundary layer aerosol into the free troposphere but the fraction of these aerosol, especially large ones that do not act as CCN/INP should be discussed.

Line 163: “the” -> “that”

Line 179: remove “this”

Figure 1: please add a and b in the caption

Figure 3: In panel (a) add units for number conc. Panel (c), is that the 0 degree isotherm? Why is the center latitude for the cross section not at the center of the box? Legend for altitude lines are very hard to see. Also, is crust meant to be dust? Make it clearer that the same colored lines are from ensemble runs, especially in the PM2.5 vertical distribution in panel (d).

Line 267: Is the storm/ air flow moving to the north east? So the wind would be southwesterly or in a northeasterly direction? If this is not the case, would be nice to have sort of meteorological overview e.g. wind barbs to understand the direction of the flow.

Line 268: Why However? Are the updrafts not also helping to distribute the aerosol. Additionally, it looks like the role of updrafts is far more important at heights above 2km. That's probably not important, but it begs the questions as to why the 2 km height is chosen for this analysis (later in the text the 6 km level is discussed).

Figure 4: the legend should reference Figure 3 and see comments for Fig. 3. CRUST seems cutoff in panel (b).

Line 269: "to determined" add "be"

Line 287: Please define “ABL”, is this aerosol boundary layer?

Line 288-290: But on the previous day, the peak occurred earlier and lasted well into the early morning hours. It is not evident that this statement is supported from this two-day simulation period. At the same time, it is not really clear why this is important.

Line 295: should it be PM2.5 mass (concentrations) or is PM2.5 concentration always reported in mass?

Figure 10: panels a and b the colorfill units are not immediately clear. Why are there so few aerosols in the vertical cross section at ranges less than 10 km in panel f at the 6 km height while in panel e, the concentration at 6 km is close to 2000 cm-3?

Figure 11: Please label the red gamma distribution as the CDSD. Also, it is hard to easily compare the CFAD ensembles with the CDSD and lognormal droplet size. Consider making a difference plot of the CFADS.

Line 441-442: it would be nice to have a discussion about how changing the cloud droplet size distribution assumptions had on this here.

Line 445: second Poll ref is missing a year.

Line 458-460: Again here, did things improve when a different cloud droplet size distribution was assigned? This is touched on later in the section but the discussion could be shortened to combine the influence of the CDSD runs.

Line 484-486: There is no doubt that the strong updrafts help to loft aerosols to higher levels. However, with such strong updrafts (e.g. > 10 m/s), is it realistic that the aerosol are still interstitial and not activated as cloud droplets?

Line 492: Consider rephrasing to: "…can also not be neglected"