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Comment on acp-2022-242

Anonymous Referee #1

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-RC1, 2022

The manuscript, "Aerosol characteristics and polarimetric signatures for a deep convective storm over north-western part of Europe – modeling and observations," details the development and evaluation of an extended modeling system. This enables high-resolution modeling of aerosol-cloud interactions in the Terrestrial Systems Modeling Platform (TSMP), after extension with a chemical transport model and the polarimetric radar forward operator. The TSMP was evaluated at convection-permitting horizonal resolution against observations of a thunderstorm which took place in July 2015 over northwestern Germany. Overall, the extension of the model with the chemical transport model and polarimetric radar forward operator adds valuable capability to model predictions.

Beyond this, however, this reviewer found it difficult to pull out what the key conclusions of this study actually were, and what benefits the extended TSMP platform provided. The manuscript suffers from too much unnecessary detail, and sometimes repeated itself, and not enough necessary detail. Not only did the lack of clarity and explanation make it difficult to identify the key findings of the study, it also made it difficult to evaluate the claims and evidence that were more clearly presented.

For example, none of the polarimetry aspects of the study were clearly explained; prior knowledge of both polarimetric radar and how they are interfaced to/emulated by models seems to be necessary. Even more specifically as an example, polarimetric radar

measurements such as horizonal reflectivity, differential reflectivity, specific differential phase, and the cross-correlation coefficient are introduced and the TSMP's performance evaluated for these parameters, but the manuscript does not explain to which meteorological or chemical parameters they relate, what these parameters tell us about the atmosphere and the model's performance. This reviewer is familiar with regional and high-resolution modeling and aerosol-chemistry-convection interactions but not polarimetric radar, and assumes that this will be the case for at least some readers, so that much of the manuscript dealing with the polarimetric model implementation (even how it's interfaced with the model is unclear) and the related results are a bit shrouded in mystery. As a somewhat less critical example, the manuscript does not define what it considers to be northwestern Germany for the purpose of the study, and later on adds in mention of two additional German cities/radar sites, with insufficient location information for the deep convective event itself; a map may have been useful. Methods and results are not clearly explained – how are the column NO2 observations from satellite swaths and AERONET point observations compared to a model grid box, as another example. Why was this study undertaken in the first place is also left unclear (though such a modeling platform does have great potential).

These examples are meant to be illustrative, as this problem is ubiquitous in the manuscript, and greatly impedes identification, interpretation, and evaluation of results.

Two Specific Comments:

Line 111: It is not really accurate to say that AERONET is considered to have a better accuracy than MODIS – one instrument is essentially a point-based observation and so is often likely more accurate for that specific location than a satellite, while the other observes over a larger swath and so loses some of the horizontal detail but can fill in the gaps between AERONET instruments. And both require a retrieval to turn the raw observations into useful measurements of aerosol properties, which introduces its own uncertainties. Which instrument is "better" for a study depends on what you're trying to compare or investigate. It's more accurate to say that MODIS and AERONET are complementary, and each has its advantages and disadvantages.

Line 245: Comparison of satellite-based column observations to the NO2 columns computed from the model output is more than simply a first-order evaluation, but this again depends to an extent on what exactly you want to evaluate and be able to say with your study. Column quantities are quite useful for many applications, and again, the satellite-based column observations fill in gaps between ground-based or other types of *in situ* instruments and can, for example, provide information on chemical transport and transformation. The brief evaluation of the NO2 column comparisons already demonstrate a number of potential results and areas for model refinement that could be classified as more than first-order. Also, why were other trace gases not evaluated, such as O3 or HCHO which are available from satellite data products? And equally importantly, the satellite products come with specified uncertainties and data flags, so it is not enough to only acknowledge the uncertainty in the satellite estimates – the uncertainty in the comparison can therefore be quantified and would facilitate evaluation of the comparison.