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Interactive comment on "Value-added by high-resolution regional simulations of climate-relevant aerosol properties" *by* P. Crippa et al.

Anonymous Referee #2

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Summary

The present work investigates how an increase in spatial (horizontal) resolution from 60 km to 12 km improves the ability of a mesoscale simulation with the WRF-Chem model to reproduce satellite observations of aerosol optical depth (AOD) and column concentrations of chemical species, and of key meteorological variables (relative to a reanalysis product). The WRF-Chem model is run for the year 2008 on a domain that covers the eastern USA, a region with strong emissions of natural and anthropogenic aerosol precursors.

The motivation of the work is established in the introduction. Simulations, observations,

and reanalysis data are subsequently introduced with select relevant details, such as uncertainties in the satellite observations. The authors then provide an overview of the statistical methods used to evaluate model performace relative to observations and reanalysis in a succint but effective way, which can serve as an introduction to novices to the subject. In the main part of the work the results are presented and analyzed, and the authors carefully quantify and discuss the improvements from an increase in resolution. It is found that a higher simulation resolution improves model fidelity in reproducing observed AOD as well as the ability of the model to identify extreme AOD values. The analysis reveals that the improved performance of the model at higher resolution can in part be attributed to improved agreement in meteorological quantities, in particular boundary layer specific humidity, which contributes to aerosol growth. The model is also shown to better reproduce satellite observations of chemical species at higher resolution. The authors do not fail to identify instances where a higher resolution does not result in an improvement: While model skill (measured by the Brier skill score) in reproducing AOD improves in seven out of twelve months, the model shows improvements in detecting extreme AOD values only in the warm season. In all this, statistical methods are used effectively to quantify model performance.

The work addresses an interesting question of general importance in atmospheric modeling - what improvements can be expected from an increase in model resolution? The authors answer this question in exemplary fashion for aerosol properties, chemistry, and meteorology in a mesoscale model. The key insight is that increased spatial (horizontal) resolution clearly improves model performance but is not a panacea. Model aspects other than resolution need attention as well to improve model fidelity.

The manuscript is thorough, clear, compelling, very well written, and presents the results with good figures and tables. I recommend publication after attending to the following detailed comments.

Detailed comments

Line 51-52: Please give references for the possible range of values for the direct and indirect aerosol effects.

Section 2.1: Aerosol size distributions are generally log-normal, not power law functions. The upper tail of a log-normal distribution does, however, behave like a power law distribution. The discussion here is therefore not incorrect, however, it should be modified to assume a log-normal distribution (also because the aerosol scheme used in the WRF-Chem simulations assumes log-normal distributions).

Line 417-418: "Further, the seasonal average spatial patterns of the total columnar concentrations, expressed in terms of z-scores, also exhibit high qualitative agreement with the satellite observations (Fig. S4-S7)."

It is a stretch to write "high qualitative agreement" here. Comparing the OMI, WRF60, and WRF12-remap panels in Fig. S4-S7, my impression is that omitting "high" and leaving "qualitative agreement" is a more accurate assessment.

Table 1: A factor of 9 is placed in the denominator of the Bonferri correction, but the data at the different wavelenghts, resolutions, and remappings would not seem to be truly independent significance tests. For example, WRF12 and WRF12-remap would seem to be very dependent. Please carefully consider (and justify) whether the factor of 9 should be used or rather omitted.

Figure S5: OMI, WRF60, and WRF12-remap panels (or panel titles) are shuffled relative to the panel order in Figures S4, S6, and S7.

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