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Interactive comment on "Development studies towards an 11-year global gridded aerosol optical thickness reanalysis for climate and applied applications" *by* P. Lynch et al.

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Response to review #2 on "Development studies towards an 11-year global gridded aerosol optical thickness reanalysis for climate and applied applications" by P. Lynch et al.

We would like to thank the anonymous reviewer for their comments on this paper. We are very happy to hear that "The manuscript is well written, well-structured and enjoyable to read." Here are our replies to the reviewer's specific comments (Original comments are in italic. Replies are in normal font).

General comments: 1. I did not find description about dust and sea salt bins. Does the model has multiple bins for dust and sea salt aerosols? If it is true, can you add lines about that (i.e., number of bin and radii of each bin)?

Answer: the model does not have multiple bins for dust and sea salt aerosols, instead it has single mass bin for each specie. Section 2.2.2 states “Aerosol microphysics are treated relatively simply in NAAPS. This is in response to the computational needs of an efficient operational forecast model, its operational requirements (e.g., forecast severe visibility reducing events) and the fact that in comparison with the uncertainties in source functions as well as transport meteorology, microphysics is relatively well constrained. Dry mass concentrations are forecasted with Equation 1 and AOT for each aerosol species is computed assuming an effective particle size with respect to mass. Aerosol particles in NAAPS are treated as external mixture of the aforementioned species and do not interact with each other. With these assumptions, extinction and AOT can be calculated using bulk values of optical properties that have been derived from theory and observations.” And “The bulk mass extinction, scattering, and absorption efficiencies, along with single scattering albedo and asymmetry factor for the four aerosol species at wavelength λ = 550 nm are given in Table 1.”

2. (If the model has multiple dust and sea salt bins,) How did you separate dust and sea salt bins into the fine and coarse-mode particles when you derive the fine and coarse AOT? Finer dust and sea salt bins should be considered as the fine-mode.

Answer: please see the reply above and also the introductory part of section 3. “Dust and sea salt are considered coarse-mode aerosols and the ABF and smoke aerosols are considered fine-mode aerosols, given the simple microphysics of the NAAPS model.”

3. The tuning concluded a great variation in some parameters. For example, in some regions, smoke emissions became less than half, and dust erodibility was doubled. I imagine that the tuned parameters raises a large increment in simulation results, but

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there was no information about that. Can you show how much the tuning modify model results (e.g., total emissions of smoke and dust, and distribution and mean value of AOT)? Moreover, the readers will be interested in how much impact the tuning process has comparing to the assimilation process.

Answer: Thanks for raising this question. To answer this question, we have included in the appendix a discussion about the tuning impact on the natural model and its impact compared with the AOT data assimilation process. 4 model runs with different configurations were conducted for a year, including NAAPS without tuning, NAAPS with tuning, NAAPS without tuning but with AOT data assimilation, and the reanalysis version, which is with both tuning and AOT assimilation. A table is added, showing the 550nm modal AOT bias, RMSE, r2 and linear regression slope against AERONET from the 4 model runs. The seasonal mean global distributions of the total, fine and coarse AOTs are also shown in two figures in the appendix. The values of total emissions, and the global mean values of AOTs are also given. Basically, with the sources and sinks tuning, RMSE decreases about half, bias and r2 also significantly improved for the natural model. The numbers are comparable with those of the DA run without tunings. AOT partitioning between the fine and coarse mode AOTs are also better in the runs with the tuning.

Specific comments: Section 2.3.1: Its my understanding that you updates the 3-dimensional NAAPS mass concentration in the assimilation process. Why did you use the 2-dimensional AOT vector as control parameter (or state vector) instead of the 3-dimensional mass concentration vector in equation (14)? What is the advantage of you using this method?

Answer: This is because the 2-dimensional AOT can be obtained from vastly available observations (e.g., from MODIS, which has a global daily coverage). But 3-dimensional mass concentration is not available from observations. Direct observations of mass concentrations are limited with sparsely distributed ground-based surface measurements and flight measurements during field campaigns. The 2-D data assimilation of

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AOT is to take advantage the superior spatial and temporal coverage of the satellite observations.

P10481, L15: Did you have a criteria for iterations of the tuning?

Answer: No specific criteria, but no more than five times of tuning for one region and one aerosol specie. The tuning is empirical and it differs for regions and species.

P10483, L14: Does the tuning factor has seasonal variation or temporal trend during the reanalysis period?

Answer: The tuning factor does not have seasonal variations. The calculated factors for each species and regions are based on two seasons of 3 years. For a single tuning factor, it differs slightly from year to year and season to season to a certain range. An average over the 6 seasons was taken to generalize this tuning factor for the reanalysis. This information is already included in section 2.4.1. The tuning factor for dust erodibility changes twice over the 11 years to accommodate the land surface parameterization changes in the meteorological analysis. This information is now included in section 2.4.1.

Section 4.4: There is another limitation. The satellite observations provide a column amount of total aerosols (i.e. AOT), but has difficulty to get vertical profiles and information about each aerosol component.

Answer: This is true. The paper is about reanalysis on AOT, not the 3-dimensional mass concentrations of each aerosol species, so this point was not originally mentioned. But it is now added in section 4.4.

Figure 10-12: They are interesting, but some results are put outside of the frame. Answer: Figures 10-12 are replotted with all results inside of the frame.

Interactive comment on Geosci. Model Dev. Discuss., 8, 10455, 2015.