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Geoscientific Model Development Discussions

Interactive comment on "Development of a three-dimensional variational assimilation system for lidar profile data based on a size-resolved aerosol model in WRF-Chem model v3.9.1 and its application in $PM_{2.5}$ forecasts across China" *by* Yanfei Liang et al.

Anonymous Referee #1

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The study of Liang et al. developed a 3-Dvar assimilation system for lidar aerosol extinction coefficient (AEC) data assimilation coupling with WRF-Chem model. To avoid complex Tangent linear /Adjoint development, the IMPROVE algorithm converting PM mass concentration to aerosol extinction coefficient were used. Three assimilation experiments with Lidar AEC, surface PM concentrations, and both Lidar AEC and surface PM were conducted and compared. The analysis and forecast show that PM simulation and forecast skills, especially the vertical profiles were improved in eastern China

with additional AEC assimilation. The publication is well written, clearly structured, and the analyses are comprehensive. I support publication of this manuscript and have only a few small comments and clarification that may require minor revisions.

1. L257-261. It seemed the vertical resolution of Lidar data is much finer than that of the model. Can you add a few words on the uncertainty of the Lidar AEC data? And also clarify how many data were filtered out? Thus the readers may get some more ideas why the complex data preprocess is necessary here.

2. L285-287. It may worth trying to test the different thinning (grid-averaging) approach, from 5x5 to 1x1. As you mentioned that the spatial resolution of the model and the representativeness of Lidar AEC and surface PM data are important, since the inconsistency may cause the adjustments in two directions. It might be interesting to check if no grid-averaging is done before assimilation, but it's only a suggestion for your future study.

3. Section 2.3. It would be nice to add the information of observational errors for AEC and surface PM.

4. L370. Actually the application of IMPROVE algorithm is very important in this study since it simplify the complex adjoint process in the system which is innovative and interesting. However as you discussed, it may bring some uncertainties too (from observed AEC to constrain model species' concentration) since the verification of the IMPROVE parameters hadn't been thoroughly conducted for the locations where Lidar data is provided. Due to different biases between the Mie algorithm in the model and the IMPROVE algorithm in different regions, different assimilation performance may be achieved at different locations. It's suggested to clarify this point more clearly here or in the discussion.

5. L543-546. Does it also indicate different model performances for the vertical profiles at different locations? Or is it related with the different IMPROVE parametrizations for those locations? Some discussion may be nice to help the readers understand more

clearly.

6. L571 Figure 6 -> 7? Please clarify

7. L599. Actually large changes were expected to occur after sunset since PBLH and hence PM concentration change dramatically in a few hours later. For 12UTC (20LST) , it's only 2-3 hours after sunset, thus continuous DA for nocturnal period should be conducted.

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