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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.

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Responses to the comments of Reviewer #1: We are truly grateful to yours' positive comments and thoughtful suggestions. Those comments are all valuable and very helpful for revising and improving our paper, as well as the important guiding significance to our researches. Based on these comments and suggestions, we have studied comments carefully and have made correction which we hope meet with approval. All

changes made to the text are marked in red color. Below you will find our point-by-point responses to the reviewers' comments/ questions:

Specific Comments: 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 ïňĄltered out? Thus the readers may get some more ideas why the complex data preprocess is necessary here.

Response: We followed the suggestion, and the following information has been added in the revised manuscript (L226-234 and L257-260). The relative standard deviation of the aerosol parameter profiles captured by the lidar over Beijing was 20.4% in the height range of 1-2 km. This lidar was calibrated via comparative observation of several lidars (Chen et al., 2019). The precision of the AEC profiles released by the other four lidars was below the quality margins (25% of the typical AEC observed in the planetary boundary layer or $\pm 0.01 km^{-1}$), as defined by Matthias et al. (2004). However, the relative standard deviation of the aerosol parameter profiles in the height range of 2-5 km released by lidar over Beijing was 35.9%. After the quality control process, 84.32% of the original AEC data from the lidar over Beijing were accepted as valid data, and 88.75%, 54.10%, 26.74%, and 10.95% of the data from the Taiyuan, Wuhu, Shijiazhuang, and Xuzhou lidars, respectively, were valid.

2. L285-287. It may worth trying to test the different thinning (grid-averaging) approach, from 5×5 to 1×1. 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.

Response: We really appreciate your valuable suggestion. Actually, the scale of averaging observation data is one of the important parameters that we need to determine. More detail please see the supplemental file.

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

Response: Thank you for your suggestion. Please see the supplemental file.

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.

Response: We really appreciated and followed the suggestion, and have added the following words in the revised manuscript (L763-769). On the one hand, datasets from which the IMPROVE parameters were determined in previous studies were measured in specific regions and near the ground. The veriïňĄcation of the IMPROVE parameters had not been thoroughly conducted for the locations where lidar data were provided. Therefore, there may have been different biases between the Mie algorithm and the IMPROVE algorithm in different regions, inducing inconsistent assimilation performance.

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.

Response: We are so sorry for that the description in L543-546 is not clear enough, which increases reading difficulties for readers. What we are concerned about here is that while the lidar data are not available at surface, the DA_Ext could adjust the surface PM MCs significantly, but the adjustments could not always have positive effect. The

effects of the different model performances and the different IMPROVE parametrizations at different locations are also discussed in chapter 4. The following words have been added in the revised manuscript. Please see the supplemental file.

6. L571 Figure 6 -> 7? Please clarify.

Response: We have revised the legend, notes, and clarified the description of the content, hoping that it will make the article clearer for readers to read.

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.

Response: The characteristics of PBLH and hence PM concentration changes provide us with an important reference for design the applied assimilation scheme. The following words have been added in the revised manuscript. In addition, because the 1200UTC (2000LST) was only 2-3 h after sunset, so large changes of PM concentration profile may occur due to large changes in the PBLH after sunset.

We would like to express our great appreciation to you for the valuable and pertinent comment on our manuscript, which is crucial to improve the quality of our work. We hope that these revisions are satisfactory and that the revised version will be acceptable for publication in Geoscientific Model Development. Thank you very much for your work concerning my paper.

Please also note the supplement to this comment:
https://gmd.copernicus.org/preprints/gmd-2020-223/gmd-2020-223-AC1-supplement.pdf

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