Authors responses to reviewers' comments

Comments from reviewer #1

General Remarks

The current study provided a gap-free AOD dataset with daily 1-km resolution between 2000 and 2020 in China, the first long-term gap-free high resolution AOD dataset, which would be a fundamental step forwards in analyzing air pollution and public health. A big data analytics framework integrating multimodal aerosol data acquired from different sources was built and the data quality was fully validated by ground measurements. $PM_{2.5}$ and PM_{10} concentration data were then estimated using an ensemble learning approach by taking advantage of the generated gap-free AOD imageries. Besides, the temporal and spatial variations of proportion of population exposed to unhealthy $PM_{2.5}$ was presented. The manuscript is substantial and well-written. It is recommended to be published after a minor revision.

Reply: We highly appreciate your constructive comments and suggestions in helping improve this manuscript. Below gives our point-to-point reply to your comments, and the manuscript will be revised per your suggestions.

Specific Comments:

1. Line 85-86, there seems to have spelling mistake and grammatical problem. " Aa typical datasets, the one generated by" should be "Some typical datasets, generated by " ?

   Reply: Thanks for pointing out!! We have correct it in Line 108–109 in the revised manuscript.

2. Line 264-273, what is the meaning or reason of 5% randomly selected AOD_{M2} data? Why only the site-specific AOD estimates and AOD_{M2} data were merged with valid AOD_{Terra} when you form a new image on each date? Besides, "5% randomly selected AOD_{M2} data" in Line 264 is inconsistent with "1% randomly selected AOD_{M2} data" in Line 271; please verify it.

   Reply: Thanks!! Firstly, we randomly selected 5% AOD_{M2} data and used in concert with valid AOD retrievals from Terra on each date to identify historical AOD_{Terra} images with similar AOD distribution over space. The

reason to use only 5% AOD_{M2} data is to balance with the mean data coverage ratio of AOD_{Terra}, and the ultimate goal is to avoid biased identification of historical AOD images when more AOD_{M2} data were used.

When reconstructing AOD fields, only 1% randomly selected AOD_{M2} data (over each scene) were used as input to supplement observational AOD data, since the latter suffers from significant data gaps. This allows for a quick convergence during the iterative learning process while avoiding introducing large uncertainty to the final reconstructed product. Consequently, these two numbers are used for different purposes.

In lines 471–503 in the revised manuscript, we have reworded this paragraph to better describe the logical flow to avoid misleading.

3. Line 411-418, may the relative contribution of near-surface air pollutants concentrations from state-controlled monitoring sites and atmospheric visibility data from weather stations be provided?

Reply: Thanks!! Actually, the relative contribution of in situ measurements was calculated. The reason why we did not provide is due to unbalanced number of data samples between in situ measurements and gridded AOD products. The current relative contribution estimation model accounts for the number of data samples from each product, thus the weighting scheme greatly underestimates the relative contribution of in situ measurements. Consequently, we only compared the relative contribution of gridded products in Figure 5.

In lines 715–720 in the revised manuscript, we have added more sentences to discuss this issue.

Comments from reviewer #2

By fusing multisource aerosol data with different resolutions via a tensor completion approach, the authors generated a spatially complete AOD dataset with daily 1-km resolution in China from 2000 to 2020, from which gap-free PM2.5 and PM10 concentration data were estimated using an ensemble learning method. Such gap free and high-resolution aerosol data would greatly benefit aerosol radiative effect diagnose and PM2.5 pollution exposure assessment as well as haze

pollution management. Overall, the paper is well written and the quality of these datasets are properly validated. Some minor revisions are required before the acceptance of the current manuscript.

Reply: Thank you for your copious comments and suggestions, which greatly help improve the quality of this manuscript. We will the manuscript by following your comments, and our point-to-point reply is given right beneath each individual comment.

Specific comments:

1. Section 2.1: Given there exist many versatile AOD products, why did the authors choose to use these six AOD datasets, how about those from geostationary satellites, any specific reasons?

   Reply: Thanks for your insightful comments. In the current release, we only used six gridded AOD datasets retrieved from polar orbiting satellites with a relatively long temporal coverage (>5 years) as observational data to reconstruct AOD fields, whereas AOD retrievals from geostationary satellites were not employed. The main reasons can be attributed to the follows. First, only geostationary satellites such as FY-4 and Hamawari-8 have a coverage of terrestrial over China. However, there is no operational AOD product publicly available from FY-4 till now. For Hamawari-8, the AOD product cannot provide observations over the northwest regions of China. Secondly, AODs retrieved from geostationary data are often at different local solar time, differing from AODs derived from polar satellites. Given these potential drawbacks, AODs from geostationary satellites were not applied when generating the current dataset. We appreciate your constructive suggestions and will attempt to include geostationary AODs in our future datasets.

   In lines 264–267 in the revised manuscript, we have added more sentences to clarify this issue.

2. Section 2.2: since atmospheric visibility data are continuously gauged, why did the authors only use data before 2014? Please clarify this in the manuscript.

   Reply: Thanks!! Atmospheric visibility data from 2000 to 2013 were used as a critical indicator to infer pollution levels at a site level before 2014, at which the national ambient air quality monitoring network has not been

established and thus site-based PM2.5 observations were lacking. After 2014, given the availability of substantial PM2.5 concentration observations, visibility data were not used anymore. This not only helps reduce the computational burden but avoid the propagation of uncertainty from visibility-inferred PM2.5. Another issue is tied to the massive instrument replacement and changes in the observing criterion of visibility after 2014 in China. Consequently, we only used visibility data before 2014.

In line 321–323 in the revised manuscript, we have added more contents to clarify this issue.

3. The full name of key parameters should be given in figure 1 captions

   Reply: Thanks for your suggestion! The full names of these abbreviations have been provided in the caption of figure 1 in the revised manuscript.

4. Lines 205,314: PM should be PMx

   Reply: Thanks!! It has been changed to PMx throughout the paper.

5. Figure 2: the gap filled AOD in SC had a relatively low accuracy compared with other regions, what are the possible reasons?

   Reply: Thanks!! This is mainly due to limited satellite-based AOD retrievals in South China due to frequent and extensive clouds over there. In other words, few observational AODs are available for tensor completion and the reconstructed results are thus dominated by historical AOD observations and numerical AOD simulations. These collectively result in large uncertainty to the reconstructed AOD fields in South China.

   In lines 607–612 in the revised manuscript, we have discussed the possible reason for this issue.

6. What is the unit of shading value in figures 2 and 6? e.g., %?

   Reply: As indicated in the colorbar, the shading values show the number of scatters (no unit), and thus the larger the value, the more the data points falling within the given location.

7. Figure 3: had these AERONET AOD observations been used as input when filling gaps in satellite AOD retrievals?

Reply: All AERONET AOD observations were not incorporated as inputs when reconstructing AOD fields. Rather, these observational AODs were simply used as the ground truth to validate our reconstructed AOD fields. We have emphasize this point in lines 565–573 and 646–647 in the revised manuscript to avoid misleading.

8. Figure 5: how about the contribution of in-situ measurements?

   Reply: Thanks!! In Figure 5, we only estimated the contribution of gridded AOD products, and the contribution of in situ measurements were not calculated because the used method needs to account for the number of valid observations. Compared with gridded AOD products, the volume of in situ measurements is a bit small, and the estimated contribution is thus incomparable to those derived from gridded products. Given this reason, we did not plot the contribution of in situ measurements in Figure 5.

   In lines 688–691 in the revised manuscript, we have added relevant contents to clearly discuss this issue.

9. Wintertime (September to February) should be winter-half year. Please check it though manuscript

   Reply: Thanks for pointing out, it has been corrected in our revised manuscript in section 4.3.