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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Constraining Chemical Transport $PM_{2.5}$ Modeling Using Surface Monitor Measurements and Satellite Retrievals: Application over the San Joaquin Valley" *by* Mariel D. Friberg et al.

Anonymous Referee #1

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The paper provided a rigorous and detailed analysis of using satellite data (MISR, MODIS), surface observations (AERONET, PM2.5 and aerosol speciation), and CMAQ to derive surface PM2.5 and surface PM speciation. The novelty of this paper, as pointed by the authors, is the use of aerosol type information retrieved from MISR research algorithm. This, however, is really not new, which is also acknowledged in the paper - past work by Liu et al. has used MSIR aerosol type already. The paper also developed several methods for data gap filling, data fusion, and reconstruction of surface PM2.5 and total AOD from CMAQ. To this reviewer, the most interesting part is

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Discussion paper

indeed the latter, as it has been vague in past studies on how PM2.5 mass is indeed computed with CTM outputs.

The paper has done an excellent job in organizing its structure and presenting the detailed analysis. The paper, however, can be further improved by acknowledging other work done in the past that used satellite observations and CTM together to improve estimate of surface PM2.5. In various places, simplification and summary of the results (from the supplements) can make the paper more easier to read, keep the text flow smoother, improve the clarity, and ultimately enable more readability.

The paper can be published after the following concerns/comments are fully addressed.

General concerns/comments:

1) The title of the paper. The work of this paper in essence is data fusion and statistical analysis by combining data from various sources. While CTM outputs are used, the satellite data here really didn't provide any constraint for improving CTM MODELING that entails emissions, meteorology, different atmospheric processes, and data assimilation. It is recommended to add 'outputs' after 'modeling' in the tittle to avoid confusion, or change the title to emphasize the data fusion part. This paper didn't improve any components in CTM modeling; instead, it belongs to research of "model output statistics" (MOS) to postprocess model outputs.

2) P2, L3. not sure what 'a systematic and practical approach' means here. As pointed by the first reviewer, there have been much work that combine satellite and ground-based observations already. Please see the summary paper by Hoff and Christopher (2010) prior to 2010 and many other works afterwards. Indeed, the study here is demonstrated for the days and locations that have field campaign data and fewer clouds (compared to many other regions that studied). So, further discussion of the application of the method here in other places is needed.

3) Overall, in what percentage spatially, the AOD values are filled based on MAIA AOD (and scaling factor based on MISR/MODIS AOD ratio)?

Specific concerns/comments:

4) P1, L25. This is a bit confusing. AOD is at 2 km resolution, while aerosol mass type can be retrieved at 275 m resolution? why not AOD at 275 m?

5) P1, L30. R2 is only one of the measures for agreement. How about mean bias and RMSE?

6) P2, L26. Also emissions and parametrization schemes, especially for CTM. See Ge et al., JGR, 2017.

7) P3, L4, it is worth mentioning that early studies, while neglecting these factors (speciation and vertical profile), indeed acknowledge the importance of these factors such as in Wang and Christopher (2003). The current writing gives readers an impression that these early studies didn't recognize the importance of these factors, which in not true. These factors have been recognized since the beginning (Wang and Christopher, 2003).

8) P3, L10. It is worth mentioning that all the work cited here has inconsistence of aerosol optical properties between models and satellite retrieval algorithms. Work has been done that uses CTMs to inform aerosol types for the retrieval from satellites, which in turn improve the estimate of surface PM2.5 from CTM. References include Drury et al. (2010, JGR), Wang et al. (2010, RSE), and van Donkelaar et al., 2013.

9) P5, L5. How long is the DISCOVR-AQ time period? In average, what are the percentage of days that MISR AOD has good spatial converge and AOD is higher than 0.15?

10) P6, L10-20. How many layers in the vertical and in the boundary layer? What is fire emission inventory used? Is CTM outputs data saved at every hour?

11) P7, section 2.5.1. MISR-RA. How does MISR-RA AOD compare with MISR operational AOD? Does MSIR operational product offer the aerosol type retrievals? Using MISR operational product would seem more practical. It will be nice to have some justification here.

12) P11, equation 1. Does CMAQ offer concentration of Al, Si, Ca, Ti, etc? if not, please give the exact equation used in reconstructing CMAQ PM2.5 in this research, so readers don't have to refer to the supplement often.

13) P11, equation 2. How are the values for negative and positive terms in right-hand side of equation obtained in this study?

14) P12, equation 2. fRH (upper case) in equation 3, but frh (lower case) in L15

15) P12, L24. This is not correct. The extinction per unit length is called extinction coefficient, and it is inversely proportional to visibility; see details in Kessner et al., Atmospheric Environment, 2013.

16) P13, and P14; AOD gap filling using MODIS. How to scale MAIA AOD exactly? In cases where both Terra and Aqua MODIS have AOD, is it only Terra MODIS AOD used? Some details are needed here, including when the method works best and when may not work well (such as with large cloud cover).

17) P14, L20-25. it will be good to show a scatter plot that summarizes the comparison for all days in one plot? Also, a plot showing the comparison for data filling only (e.g., in places/times that has no MISR AOD, but filled with MODIS AOD and through scaling/interpolation) can be good to show the improvement by combining both MODIS and MISR.

18) P15, L12. What happens in hours that have cloud? Daily AOD from AERONET has a clear-sky bias.

19) P15, L31 . not sure what 'sufficient' mean here?

20) P15, L11. There are papers talking about diurnal variation of AOD. for example Kaufman et al. in GRL. Are the results here consistent with previous findings?

21) equation 4. This equation is not correct. equation 3 won't give equation 4 as beta, fRH all depends on Z, and C(z) varies with Z.

22) for the results. It will be good to show the summary as several scatter plots respectively for PM2.5 and speciation in all days and sites in the main manuscript. Having summary statistics (such as R, RMSE, and mean bias) in figure. Are the results or improvement by MISR statistically significant?

23) P24, L5. Worthy mentioning recent studies that used VIIRS DNB to derive surface PM2.5 at night. see Wang et al., AE, 2016; Fu et al., 2018.

Again, overall, this is a nice work. it is hoped that the manuscript be further improved by considering the comments above.

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