**Reply to Reviewer 1**

**This study evaluates the uncertainties associated with geophysical approaches to derive surface $PM_{2.5}$, based on satellite AOD and modeled $PM_{2.5}$/AOD. The authors go through a very detailed evaluation of all the potential factors, using ground-based observations of $PM_{2.5}$, AOD, aircraft observations of aerosol extinctions/composition, and atmospheric soundings of RH over the Northeast United States. The analysis is very comprehensive, the paper is well written and I commend the authors for presenting the results in a succinct way on the figures.**

Reply: We would like to thank the reviewers for their time and effort to review our manuscript. We have revised the manuscript following the reviewers' suggestions.

**One suggestion that I have for the authors is to present a figure with time series of the daily variations in $PM_{2.5}$, AOD, and $PM_{2.5}$/AOD. The manuscript only contains barplots of the biases and Pearson correlation coefficients, and there would be value for the reader to see the actual timeseries. I found Figure 1 very interesting in terms of displaying the contributions of different factors to spatial variability in satellite-derived $PM_{2.5}$. Something similar to illustrate the controlling factors for the daily variability would be valuable.**

Reply:
That is a great point. We added a figure showing the temporal variability of regional average $AOD_{MAIAC}$, $PM_{2.5\_CMAQ}/AOD_{CMAQ}$, and $PM_{2.5\_MAIAC}$ (Figure 2). Similar to Figure 1, we show that the temporal variability of $PM_{2.5\_MAIAC}$ is mainly driven by the variability in $PM_{2.5\_CMAQ}/AOD_{CMAQ}$.

We have added the following discussions in the revised manuscript:

The temporal variability in $PM_{2.5\_MAIAC}$ is also mainly driven by variability in $PM_{2.5\_CMAQ}/AOD_{CMAQ}$ (R = 0.61), with little temporal correlation between regional average $AOD_{MAIAC}$ and $PM_{2.5\_MAIAC}$ (R = 0.05, Fig. 2). At short time scales, the daily variability in regional average $PM_{2.5\_MAIAC}$ shows stronger correlation with $PM_{2.5\_CMAQ}/AOD_{CMAQ}$ in all seasons except for JJA, when $PM_{2.5\_MAIAC}$ are driven by variability in both $AOD_{MAIAC}$ (R = 0.5) and $PM_{2.5\_CMAQ}/AOD_{CMAQ}$ (R = 0.4, Fig. 2). Summertime $AOD_{MAIAC}$ is higher than wintertime AOD by 50%, while summertime $PM_{2.5\_MAIAC}$ is lower than in winter by 46%. Previous studies also found inconsistent seasonal cycles in AOD and $PM_{2.5}$ (Ford et al., 2013; Kim et al., 2015). We attribute the opposite seasonal cycle in $PM_{2.5\_MAIAC}$ and $AOD_{MAIAC}$ to three factors: 1) weak boundary layer ventilation in winter that leads to sharp vertical gradients of aerosol distribution (Kim et al., 2015); 2) higher RH in summer that leads to larger hygroscopic growth; 3) model overestimates of $PM_{2.5}$ (especially OC) in wintertime and underestimates of $PM_{2.5}$ in summertime, leading to an overestimate of the winter-to-summer decrease in $PM_{2.5\_CMAQ}/AOD_{CMAQ}$ (see section 3.3).

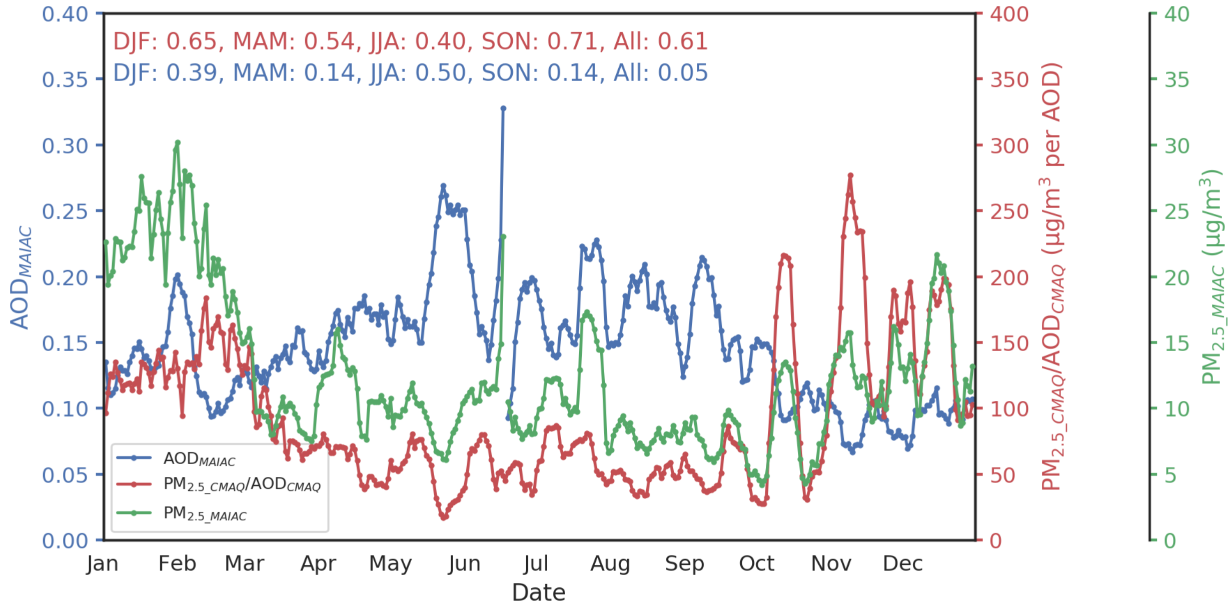


Figure 2 Regional 10-day running average of (a) MAIAC AOD ($AOD_{MAIAC}$, blue); (b) CMAQ modeled $PM_{2.5}$/AOD relationship ($PM_{2.5\_CMAQ}/AOD_{CMAQ}$, red); and (c) satellite derived $PM_{2.5}$ ($PM_{2.5\_MAIAC}$, green). The numbers on the upper left corner show the Pearson correlation coefficients (R) of $PM_{2.5\_MAIAC}$ with $PM_{2.5\_CMAQ}/AOD_{CMAQ}$ (red) and $AOD_{MAIAC}$ (blue).

**References:**


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