**Reply to Reviewer 2**

**This is a very well written paper that explores sources of random and systematic bias on estimates of ground-level $PM_{2.5}$ derived from satellite based AOD measurements and the ratio of AOD and $PM_{2.5}$ from a regional air quality model.**

**The paper provides a review of the literature in this area, and then uses MODIS MAIAC data and the CMAQ model to make $PM_{2.5}$ estimates. Comparisons are made to Aeronet ground based measurements, and field measurements from the DISCOVER- AQ campaign. They carefully evaluate errors that originate from satellite AOD errors and from the modeled $PM_{2.5}$/AOD relationship.**

**The methodology, analysis, and data sources are all clearly described. The figures are well formulated and clear. I found the conclusions to be very clearly written and supported by the details in the manuscript.**

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.

**There is one area where the authors should consider revisions. I think the hygroscopicity is an important element, and perhaps does not come across that way given that the details of the models for RH dependent particle growth are in supplementary material, and the statistics for RH are calculated like all the others. I would argue that factors like MEE and mass can be shown in box and whisker plots, but not the RH. The change of mass and extinction is very non-linear in RH. If the model says the RH is 90% and the field measurements say it is 60%, the situation is very different then if the model says RH is 60% and the observations say it is 30%. Can the analysis focus on the error due to RH errors that lead to substantial errors in the estimated aerosol growth - separate out high RH cases? This error source will be very seasonal and regional. Figure 8 hints at this, but the discussion still treats RH as if it is a factor that can be aggregated and treated like other linear factors, and I disagree.**

Reply: That's a good point. We agree that RH errors should lead to larger uncertainties to satellite derived $PM_{2.5}$ at high RH. To address the reviewer's concern, we have added a figure showing the impacts of model bias of RH on the derived $PM_{2.5\_MAIAC}$ ($\Delta PM_{2.5\_RH}$) as a function of observed near-surface RH (Figure 9d). However, we'd like to argue that it is not possible to entirely separate out high RH cases because RH varies vertically, and the impacts of model biases of RH on the $PM_{2.5\_MAIAC}$ reflect the biases of RH integrated across all vertical layers. In Figure 9d, we use near surface radiosonde observations of RH (averaged over the first vertical layer in the model) to categorize the environment as humid or dry, with the limitation that it may not represent the conditions at higher altitudes.

We've added the following discussion in the revised manuscript:

The hygroscopic growth factor is nonlinearly correlated with RH, which increases more rapidly at high RH (> 80%) than at low to median RH (<80%, Fig. S1). Compared with median RH conditions, model RH errors lead to more than double $\Delta PM_{2.5\_RH}$ (-6.4 $\mu g/m^3$ versus 3 $\mu g/m^3$) when observed near-surface RH > 80% (Fig. 9d). At RH > 95%, we find that the $\Delta PM_{2.5\_RH}$ can be as large as -20 $\mu g/m^3$ (Fig. 9d).

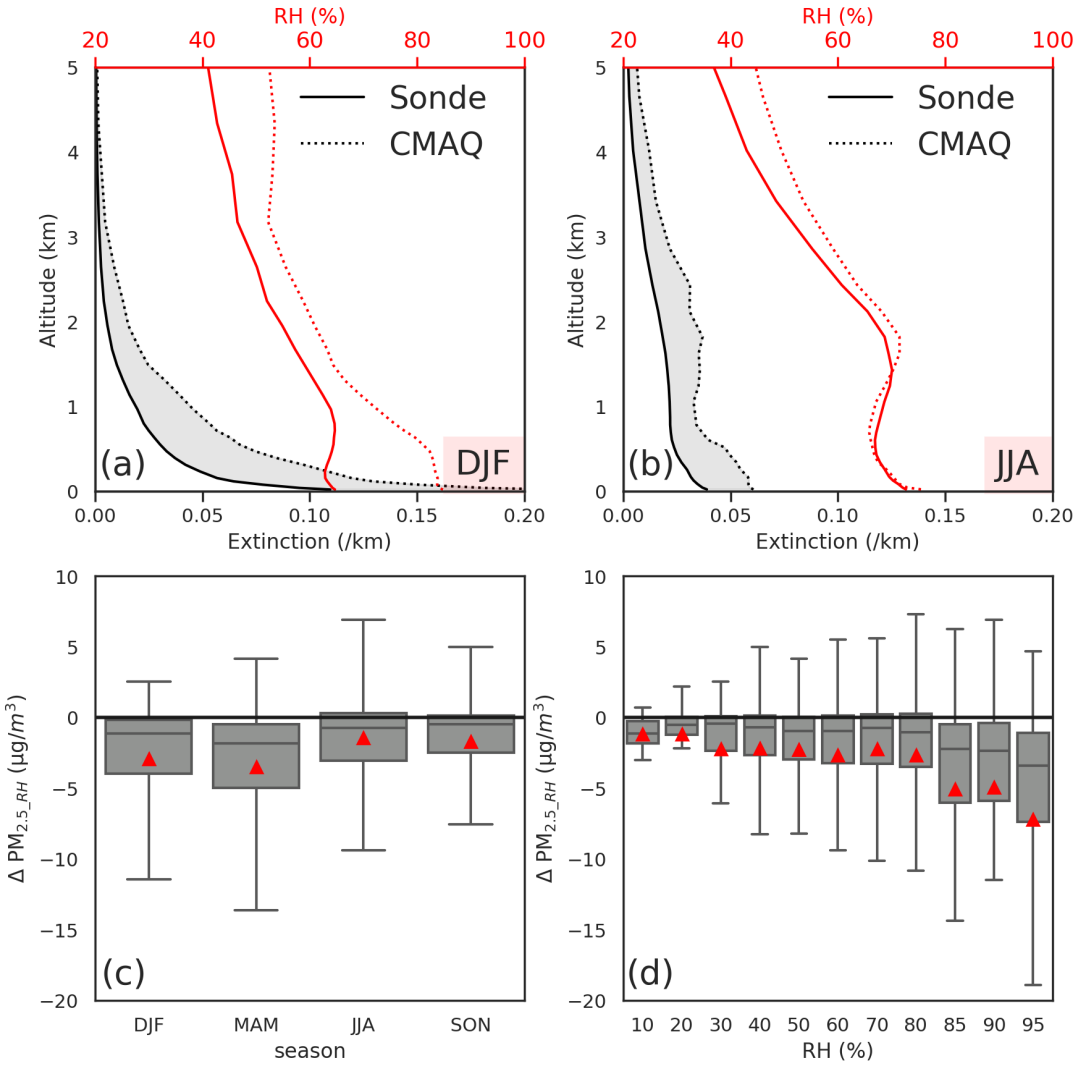


Figure 9 (a) DJF and (b) JJA average vertical profiles of the CMAQ modeled vs. observed RH at 6 atmospheric soundings over the Northeast USA, and the modeled extinction vs. that calculated by replacing modeled RH with observed values. The gray area shows the difference in extinction two profiles, with the total area being the difference in AOD. (c) Box plots showing the impacts of model bias of RH on the derived $PM_{2.5\_MAIAC}$ ($\Delta PM_{2.5\_RH}$) in four seasons of 2011, which are calculated by comparing the $PM_{2.5\_MAIAC}$ minus the one calculated using observed RH. (d) Box plots show the influence of model RH biases on the derived $PM_{2.5\_MAIAC}$ ($\Delta PM_{2.5\_RH}$) as a function of observed near-surface RH.