Response to Reviewer Comments on **"Aerosol loading in the Southeastern United States: Reconciling surface and satellite observations"**

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We would like to thank the anonymous reviewers for their feedback and overall positive response to this article. Responses to each comment are noted below the original comments which are given in bold italics. We will also submit a version of the article with all the changes marked to the editor.

Response to Anonymous Referee #1

1. ***P9926, L26-27 – It seems to me that GEOS-Chem shows far less seasonal change in the diurnal and seasonal variation as compared to observation. It would be helpful to have a more quantitative metric to support the statement that GEOS-Chem "captures the observed spatial, seasonal, and diurnal variation in PM2.5".***
   We have softened the statement and have included more quantitative comparisons in other sections.

2. ***P9928, L15 – Please quantify the variability in PM2.5.***
   The relative standard deviation in the diurnal variation averaged across sites and across months is ~10%. This has been added to the text.

3. ***P9928, L16-18 – It seems inconsistent with the premise of this paper that little diurnal variability in surface PM2.5 can be used to infer little diurnal variability in AOD. If a significant aloft source of aerosol is missing, I see no reason to assume it follows the same diurnal variability as near-surface PM2.5, especially when the authors find that adjustments to surface sources are insufficient to reproduce this discrepancy.***
   Our point here is not that there is no diurnal variability in AOD (although AERONET sites suggest little variability in AOD throughout the day), but that there is little diurnal variability in $PM_{2.5}$ and therefore using a 24-hour average $PM_{2.5}$ concentration rather than a one-hour average $PM_{2.5}$ concentration sampled to the overpass time, does not bias our comparison and cannot be a significant source of the mismatch between the surface concentration seasonality and column AOD. We have added specific discussion of the diurnal variability of the AERONET observations to clarify this point in the text.

4. ***P9928, L19-24 –Where is the contradiction between this and previous studies in the correlation of satellite-observed column AOD and surface concentrations? Figure 1 clearly shows enhanced AOD and PM2.5 in summertime compared to wintertime. While this study suggests that a greater fraction of organic AOD may be apportioned aloft during the summer, this does not negate a correlation between total column and surface values due to surface sources of sulphate and other aerosol. Please clarify your statement and quantitatively demonstrate that a good correlation is not found between AOD and PM2.5.***

We do not claim that this "contradicts other studies," but that these results contrast other regions where $PM_{2.5}$ is often strongly correlated with AOD. AOD and $PM_{2.5}$ are still correlated in the Southeastern US, but the correlation is weaker in the summertime and when compared to other regions. We have attempted to clarify this in the text and have quantified the correlation in the SEUS vs. other regions.

5. ***Figure 6 – CALIOP's extinction decreases rapidly near the surface, whereas modeled values increase sharply, yet modeled surface PM2.5 is shown to be underestimated in Figure 3. Some explanation needs to be made about these diverging features and tied to the agreement found with PM2.5.***
   This is a good point. We discuss the biases with the CALIOP retrieval near the surface in section 3.3 with regards to Figure 5. We have added to the discussion for further clarification.

6. ***P9927, L11 – I am unclear as to the meaning of "(~55% in the mean)". Does this mean that modeled summertime PM2.5 are _55% of the observed mean?***
   We meant that the summertime mean $PM_{2.5}$ is 55% greater than the mean wintertime $PM_{2.5}$ concentration. We have clarified this in the text.

7. ***P9927, L17 – "captures" should be "capture"***
   This has been corrected.

8. ***P9928, L3 – suggest remove "even"***
   We removed "even."

9. ***P9931, L25 – should "twice" be "half"?***
   This has been corrected in the text.

Response to Anonymous Referee #2

1. ***This is an excellent, very well presented, paper. My only significant concern is that the paper rules out a number of potential hypotheses, and concludes that there must be a "missing source of aerosol above the surface". This should be somewhat expanded. What kind of "source" can that be (aerosol are not generated out of blue sky)? What flux is needed to explain the aerosol load? I strongly suggest that the authors add one or two paragraphs in the discussion detailing the kind of process that may explain their observations and that they plan to validate/invalidate during the field experiment.***
   With regards to your major concern, we have added to our discussion section several other potential hypotheses. We would like to point out that we are not personally taking part in the SOAS field campaign and are therefore unable to design a specific plan to validate these hypotheses directly. We have also added in a rough estimate of the amount of mass needed to make up the difference in the profiles (roughly a tripling of the current sulfate mass above the surface level).

2. ***Other comments I do not like Figure 5. The scatter plots use a huge number of points. Over plot area with a large density of points, the information on the number of points is***

fully lost. On the other hand, the outliers are still visible. As a consequence, the figure gives a false impression of large mean: Sea the upper left figures in Fig 5. From these scatter plots, it seems that the typical extinction in the lower atmospheric layers is 0.2 to 0.4. et, the average (lower right) shows that it is 0.1 or less. I suggest to reduce (sample) the number of points used in the scatter plots.

This is a good point and motivated us to consider how we could present the data more clearly. As a result, we have changed Figure 5 from a scatter plot to a density plot so that it better shows the number of points. We would also like to note that this plot only shows the extinction values for the aerosol types shown and does not include every observation.

3. ***P9920 l15-16: Not clear. What are the level 2 data with a standard deviation "of greater than 2.5"?***

   Level three is a gridded product that combines level 2 observations. If the standard deviation from those combined level 2 observations is large in a specific grid box, we do not include it. We have edited the text to provide more details.

4. ***P9921 l12: CALIOP measures scattering, not extinction. Extinction may be estimated but is not directly measured.***

   This has been corrected in the text.

5. ***P9926 l14: Diurnal cycle. Aeronet makes measurement every 15 minutes. Why not use these observations, and rely on measurements from different sources (satellite, surface) acquired at different times, to study the diurnal cycle.***

   We have added this point about the variation in daytime AOD measured at AERONET sites into the text. Thank you for the suggestion.

6. ***P9931 l20. Biased => bias***

   This has been corrected in the text.

7. ***P9932 l6: Several studies indicate that the aerosol type from Calipso shall not be trusted***

   We agree that the aerosol type from CALIOP has limited application and do mention issues with the classification algorithm in the text. However, because we compare extinction profiles which rely on a lidar ratio for an assumed aerosol type to estimate extinction from backscatter, we believe it is important to include this discussion as an important caveat and potential source of error in our profile comparisons.

8. ***P9932 l22 : This is likely BE due to…Correct***

   This has been corrected in the text.

9. ***At several places in the paper, it is referred to "aerosols above the surface". Aerosols are ALWAYS above the surface so that this does not provide any relevant information. It should be rather referred to the "lowest atmospheric layers" and even better if some height could be defined.***

   This is an excellent point! We have corrected this to "aerosols above the surface layer." We understand that this is not precise but are unable to give a defined height without in situ profiles that specifically measure this.