Interactive review of 'Factors that influence surface PM2.5 values inferred from satellite observations: perspective gained for the Baltimore-Washington Area during DISCOVER-AQ' by S. Crumeyrolle

We thank the referee for the constructive comments on our manuscript, which are summarized with our italicized responses below.

1. Be consistent while using PM2.5 without sub-script or with subscript. I see problem through out the paper.

This has been corrected throughout the paper

2. Abstract needs to more informative or complete. For example Page 1, Line 26-27, 'The results indicate . . ...assumed to be negligible.' Predicted using what? Or how? Be more specific here. Also, include major findings of the study in the abstract.

The abstract has been revised per the suggestions of both Reviewers 1 and 2.

"During the NASA DISCOVER-AQ campaign over the Washington D.C., - Baltimore, MD, metropolitan region in July 2011, the NASA P-3B aircraft performed extensive profiling of aerosol optical, chemical, and microphysical properties. These in-situ profiles were coincident with ground based remote sensing (AERONET) and in-situ ($PM_{2.5}$) measurements. Here, we use this data set to study the correlation between the $PM_{2.5}$ observations at the surface and the column integrated measurements. Aerosol optical depth (AOD_{550nm}) calculated with the extinction (550nm) measured during the in-situ profiles was found to be strongly correlated with the volume of aerosols present in the boundary layer (BL). Despite the strong correlation, some variability remains, and we find that the presence of aerosol layers above the BL (in the buffer layer - BuL) introduces a significant uncertainties in $PM_{2.5}$ estimates based on column-integrated measurements (overestimation of $PM_{2,5}$ by a factor of 5). This suggests that the use of active remote sensing techniques would dramatically improve air quality retrievals. Indeed, the relationship between the AOD_{550nm} and the $PM_{2.5}$ is strongly improved by accounting for the aerosol present in and above the BL (i.e. integrating the aerosol loading from the surface to the top of the BuL). Since more than a quarter of the AOD values observed during DISCOVER-AQ are dominated by aerosol water uptake, the $f(RH)_{amb}$ (ratio of scattering coefficient at ambient relative humidity (RH) to scattering coefficient at low RH, see section Equation 2) is used to study the impact of the aerosol hygroscopicity on the $PM_{2,5}$ retrievals. The results indicate that

$PM_{2.5}$ can be predicted within a factor of 1.6 even when the vertical variability of the $f(RH)_{amb}$ is assumed to be negligible. Moreover, f(RH) and RH measurements performed at the ground may be used to estimate the $f(RH)_{amb}$ during dry conditions (RH_{BL} < 55%). "

3. Page 2, Line 7 – 'total mass concentration 'NEAR SURFACE' of the particle. . .'

Done.

4. Page 2, Line 8-10, Be specific, which part of the world you are talking about? Also, need a reference here. Even in US there are many rural PM monitoring stations exists.

The air-quality monitoring network is getting denser and denser since the last decade. Some air quality stations are located in remote areas all over the world and in US. Yet, ground-based observations have insufficient coverage at the global scale to allow assessment of long-term human exposure to PM2.5 and to evaluate air quality models. Moreover, some people, located in remote area, don't have access to air quality information in their region. For example, in the San Joaquin Valley (CA) the air quality monitoring network consists of 6 stations that measure continuously and 10 stations that measure in a non-continuous fashion (Sorek-Hamer, 2013). Accurate $PM_{2,5}$ retrievals from satellite measurements offer thus a great opportunity to fill in missing surface measurements. This has been clarified in the manuscript.

Sorek-Hamer M., A.W. Strawa, R.B. Chatfield, R. Esswein, A. Cohen, D.M. Broday, Improved retrieval of $PM_{2.5}$ from satellite data products using non-linear methods, Environmental Pollution, Volume 182, November 2013, Pages 417–423, 2013

5. Page 2, Line 25-29, these four points are not always true for eastern US. You must provide reference for each of those points. For example 3) uniform topography – what about Appalachian? 2) Uniform vertical distribution of aerosols? how do we know?

All these points are discussed in Engel Cox et al. (2006), which is cited in the text. Point #3 has been removed from the manuscript. We also clarified this was a comparison of the western and eastern part of the United States.

6. Page 2, Line 31 – both temporal and spatial scales/matching is important for AOD- PM relationships.

This has been clarified.

7. Page 3, Line 3 – AOD retrieval not measurement. Satellite does not make direct measurements of AODs.

This has been clarified.

8. Page 3, Line 5, Satellite does not retrieve AODs over Snow covered regions.

This point is questionable and so we removed 'over desert regions or snow covered areas' and corrected it into 'bright surfaces'. AOD retrievals over a bright surface, like snow-covered surface, is problematic at wavelengths that rely on dark surfaces for detection of extinction contrast. OMI AAOD retrievals are similarly unaffected by snow or low clouds because the effective scattering height for these UV wavelengths is 2–3 km or more (Hoff and Christopher, 2009). In the visible spectral range, a recent paper describes an algorithm that could be use to retrieve AOD over snow-covered surface based on a synergetic approach using data from both Moderate Resolution Imaging Spectroradiometer (MODIS) instruments flying on the TERRA and AQUA satellites (Mei et al., 2013).

Mei L., Y. Xue, G. de Leeuw, W. von Hoyningen-Huene, A. A. Kokhanovsky, L. Istomina, J. Guang, J. P. Burrows. Aerosol optical depth retrieval in the Arctic region using MODIS data over snow, Remote Sensing of Environment 128, 234–245, 2013.

9. Page 3, Line 13-16, not sure if extinction are decoupled, may be mass measurements are decoupled?

The aerosol extinction is linked to the aerosol mass in the same volume. Thus the extinction decoupling is a consequence of an aerosol mass decoupling. As the sentence was not clear we corrected it into : "Several studies reported the importance of an aerosol layer above the BL since elevated aerosol layers increase the AOD but are decoupled from the aerosol surface based measurements"

10. Page 3, Line 16-17, 'He et al., . . .' vague sentence ,not clear, does not fit there.

The sentence has been clarified. He et al. (2008) prove in his paper that the monthly averaged AOD are not only linked to the aerosol present in the BL. Indeed, 36% of the time the high AOD values are not a consequence of an increase of the aerosol concentration within the BL but mostly due to aerosol present above the BL (i.e. elevated layer). This study show then the importance of knowing the vertical profile of aerosol throughout the column to assess the $PM_{2,5}$ *concentrations at the surface.*

11. Page 11, Line 29 – Typo? Is it 51 or 5.1?

There is no typo in this sentence. All the DISCOVER-AQ profiles were performed from 300m to 4km except over Beltsville where the profiles were limited to 1,5 km. The presence of flight path frequently used over Beltsville forced us to shorten the profiles. This has been clarified in the manuscript.

12. Page 12, Line 18-19, How do you get that threshold value of angstrom coefficient? Provide more information and reference it.

This comment is similar to one raised by the referee 1. The scattering Angström exponent is related to the size distribution of the aerosol particles sampled in the atmosphere, but is somewhat qualitative as other factors confound a direct size-AE parameterization (e.g., chemical composition, aerosol mixing state). Most importantly, interpretations of scattering angstrom exponent when the particle size distribution is dominated by sub-100nm particles is not valid as illustrated in Figure 1.

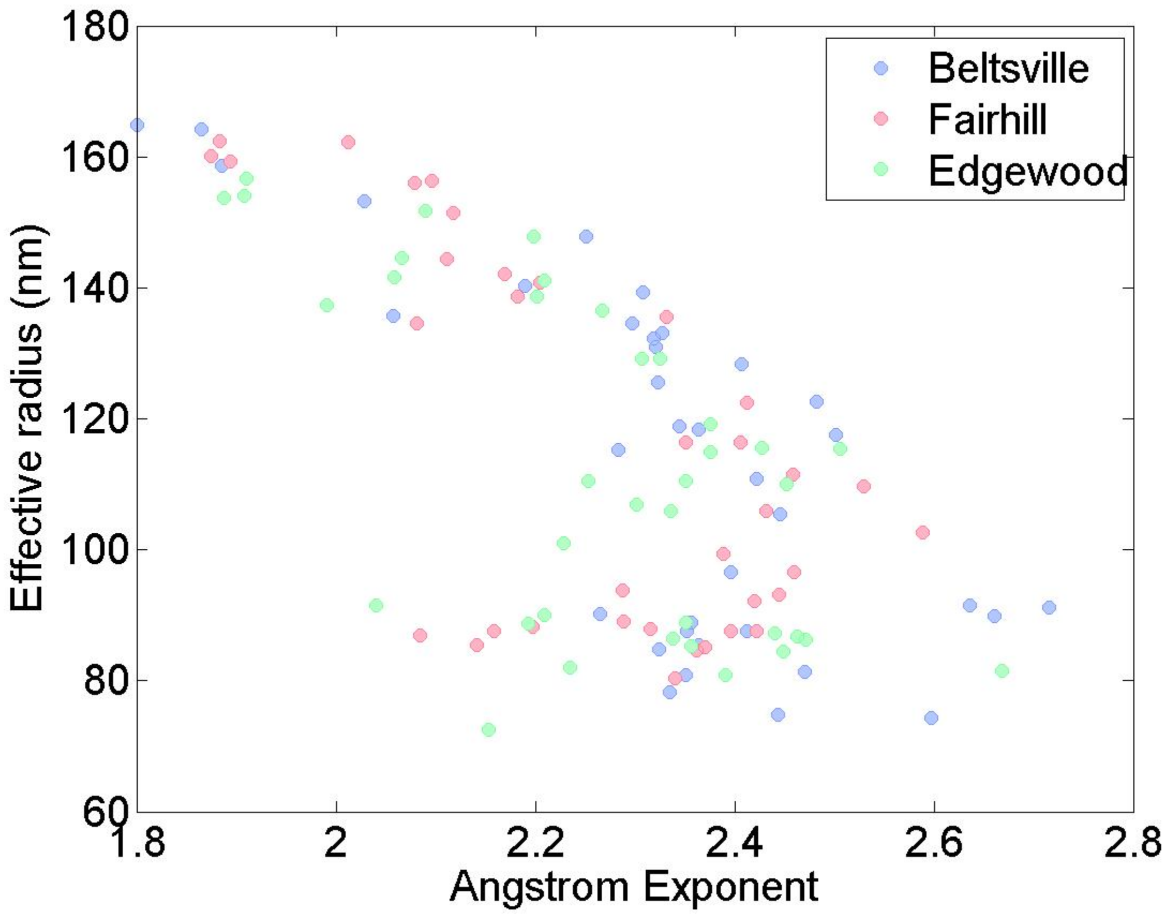

Figure 1 : Effective radius (nm) as a function of the Angstrom exponent (450-700nm) measured aboard the P3-B over Beltsville, Fairhill and Edgewood during the entire campaign.

We added part of this discussion in the manuscript : "The effective radius and the Ångström exponent measured aboard the P3-B are found to be directly related. The lower values of the Ångström Exponent are associated to the larger particles while the larger values (> 2.3) are related tot he presence of small particles (<100nm). Thus, the non-linearities, duing this campaign, can be avoided using a threshold value for the Ångström exponent (less than 2.3)." The figure 1 will be added as supplementary material.

13. Page 24, Table 1 – I don't see Figure 3 a, b, c – Are your referring to Figure 4?

The referee is right and it has been corrected.

14. Page 27, Figure 3, Must provide statistics for this comparison. Also, if there is any averaging performed over AERONET data, then it should be mentioned here. Also, the standard deviations should be plotted as vertical bar instead of fix value of 0.02.

In this figure, the AERONET data are not averaged. Each dot represents one measurement of $PM_{2,5}$ and one measurement of AOD (within an hour window compare to the $PM_{2,5}$ observation). The best linear fit equations as well as the correlation coefficient (R^2) are included in Figure 3 for each wavelength.

15. In all the figures, you reported R or Rˆ2 value? Please check it again. It looks like R value whereas you have written it as Rˆ2 value?

We reported R^2 values in all figures except in Figure 6 where it was R values. This has been corrected in the revised version of the manuscript.