Responses to Anonymous Referee #3

We would like to thank the reviewer for his/her time, thoughtful insights and helpful comments. A point-by-point response to each of the reviewers concerns is listed below. The reviewers comments are shown in bold italics, while the authors' responses are indented and displayed in regular type.

1. As seen from Fig. 6, PCA provides very good separation of dust from other aerosol types which obviously due to difference in forward scattering between coarse and fine aerosol. However, separation between fine mode aerosol types is much less distinct especially between BB and Biogenic. My guess is that the main difference between these aerosols is the different absorption level. What is the potential of PIN measurements in separating aerosols with similar particle sizes but different absorption? And if the potential is high what is the physical reason for that (PIN measures only scattering)?

The distance, within the PCA score space, between coarse mode dominated dust and other types is very significant but, as shown in Section 5.2 and 5.3 other types can be very reliably distinguished as well. For example, the "BB vs Fine" row of Table 4 shows that the biomass burning classification can be predicted from only the fine mode dominated types successfully in over 90% of the cases. In order to further address the reviewer's question, the separating plane technique was used to isolate the BB cases from only the biogenic and BB samples using the three PCA scores plotted in Figure 6. In this test it was found that the ancillary data classification could be predicted with a true positive rate of 88.5% and a true negative rate of 91.9%.

The GRASP retrieval was applied to these fine mode dominated cases in accordance with the techniques of Espinosa et al. (2017) and used to explore potential differences in size and complex refractive index that may allow for the separation between BB and other fine mode dominated types. In the context of GRASP's aerosol model it was found that particle absorption and size distribution were almost identical among all of the fine mode types but real refractive index (RRI) was meaningfully elevated in the BB cases. The RRI differences alone were not sufficient to distinguish the BB particles with accuracies comparable to the PCA score based separating plane technique though so there may be other factors (ex. particle morphologies that aren't included in GRASP's aerosol model) playing a role as well.

While the GRASP/PI-Neph retrieval does not have high sensitivity to absorption some sensitivity does exist due to unique changes in the angular dependence of the scattering intensities that are associated with changes in the imaginary part of the refractive index. The results of the GRASP/PI-Neph retrieval have been compared with absorption measurements made in parallel during DC3 by a Particle Soot/Absorption Photometer (PSAP). When GRASP is applied to PI-Neph light scattering measurements alone a correlation (R$\approx$0.4) is found between the measured and retrieved absorption coefficients but the retrieved values are biased high by more than a factor of two. This comparison is part of an on going effort by the authors to better understand absorption's impact on the parameters retrieved using the methods of Espinosa et al. (2017).

2. On page 7 nm units are used along with microns. I think it is better to use the same units throughout the manuscript.

All references to particle size have been converted to μm.

3. On Fig. 3 degree of linear polarization for SEACRS dust is much noisier than for other aerosol types. What do you think is the reason for that?

The noise in the dust measurements is primarily driven by the high dynamic range of the corresponding phase functions. Please see the brief discussion of this effect around line 10 of page 10 of the original discussion paper.

4. I am wandering if analysis in Section 4 can be supplemented with Mie or T-matrix calculations of scattering phase function and degree of linear polarization for typical (maybe AERONET based) size distributions.

The GRASP retrieval (Dubovik et al., 2011; Espinosa et al., 2017), which includes a spheroid model, as well as a separate Mie code (Mishchenko et al., 2002) was used to explore the relationships between size and refractive index of the particles and the scattering properties that are discussed in Section 4. Multiple changes have been made to the text to clarify this point.

The sentence beginning on line 32 of page 9 of the original discussion paper has been expanded to:
"Mie computations (Mishchenko et al., 2002) were performed in order to identify the size, shape and complex refractive index changes that are potentially driving this progression. In size distribution and refractive index regimes typical of ambient, fine mode aerosol ($r_v \approx$150 μm; σ =0.38; m =1.5+0.01i) the backscattering region of the phase function is very sensitive to the diameter of the particles, suggesting significantly smaller fine mode particles in the CO inflow than in the AL inflow."

Additionally, the sentence beginning on line 5 of page 10 of the original discussion paper has been changed to:
"Mie simulations and inversions of the angular scattering measurements (Dubovik et al., 2011, 2014; Espinosa et al., 2017) suggest that the reduced $-F_{12}/F_{11}$ maximum observed in this fine mode dominated data is likely driven primarily by fine mode particles with slightly larger diameters than those found in the three DC3 categories."

Lastly, a reference discussing the relationship between the forward scattering peak and fraction of coarse mode particles (Russell et al., 2004) has been added to Section 4.

References

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