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Interactive comment on "Retrieval of microphysical dust particle properties from SALTRACE lidar observations: Case studies" *by* Stefanos Samaras et al.

Anonymous Referee #3

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The manuscript presents the characterization of two dust events during the SALTRACE campaign, using the SphInX retrieval algorithm. The manuscript should go under major revisions, based on the suggestions in my initial manuscript evaluation, which are explained in more detail herein (the initial manuscript evaluation is provided at the end for completeness). Based on these suggestions, this work is scientifically significant not for the characterization of dust during SALTRACE (which is unsuccessful in my opinion), but for showing that SphInX retrieval algorithm is quite limited in characterizing dust particles, at least in its current version. Future versions may facilitate its usage for dust particles, since the authors mention the extension of the algorithm to larger sizes and different aspect ratios, which is vital for the proper retrieval of dust, as discussed below. Another suggestion is that since this paper should present the limitations of SphInX in retrieving dust, it is a technical paper and it should be published in a more relevant journal (e.g. AMT). But this is up to the editor to decide.

The limitations are due to the aspect ratio range of the spheroids (0.7-1.4), in combination to the limited size range used in SphInX. As shown in Bi et al. (2018), the spheroids with aspect ratios of 0.7-1.4 present quite large particle depolarization values, larger than what is measured for dust particles (<0.3) (Fig. 1). These much larger values are decreased when considering smaller sizes for dust (as the ones considered in SphInX, with radius up to 2.2 μm), together with higher imaginary part for the refractive index, as the one retrieved with SphInX, with a value of 0.05. Figure 1 helps to explain the above, using the plots shown in Bi et al. (2018) for the particle depolarization ratio for two refractive indices with real part of 1.5 and imaginary parts of 0.01 and 0.1 (unfortunately, there is no plot in Bi et al. (2018) for the retrieved imaginary part of 0.05, but the values should be in between of what is shown in the plots in Fig. 1). As shown in the left plot in Fig. 1, the spheroids that are used in SphInX (red rectangular) will have particle depolarization ratio up to >0.8. The plot at the right shows that these values are greatly decreased for higher absorption (refractive index of 1.5+i0.1). In other words, forcing the retrieval to fit the depolarization measurements at 355, 532 and 1064nm at the certain aspect ratio range (which presents quite characteristic features for the particle depolarization ratio), in limited size range for dust (up to 2.2 μm), forces the imaginary part to values that do not indicate dust particles. The explanation provided in the manuscript of possible mixtures with smoke cannot stand under this light, without supporting measurements.

To conclude, the retrieved size distribution and refractive index of dust for the cases of SALTRACE campaign presented in the manuscript are most probably an artifact of the limited aspect ratio and size range used in SphInX retrieval algorithm. For this reason, there is no point in discussing these findings on a physical base, going further into characterizing the dust events during the SALTRACE campaign, but the paper should go under major revisions, shifting its focus on the limitations of the current version of the SphInX retrieval algorithm for dust characterization.

Note 1: It is not surprising that the specific range of aspect ratios is excluded in the AERONET retrieval for dust (brown rectangulars in Fig. 1 and Fig. 11 in Dubovik et al. (2006)). See more details on this in my initial manuscript evaluation provided below.

Note 2: The authors did not include the fitting of the backscatter and extinction coefficients and the depolarization ratios at all wavelengths for both case studies, as requested in my initial manuscript evaluation. They are strongly advised to do so in the revised manuscript.

References:

Bi, L., Lin, W., Liu, D., and Zhang, K.: Assessing the depolarization capabilities of nonspherical particles in a super-ellipsoidal shape space, Opt. Express, 26, 1726–1742. https://doi.org/10.1364/OE.26.001726, 2018. Dubovik, O., Sinyuk, A., Lapyonok, T., Holben, B. N., Mishchenko, M., Yang, P., Eck, T. F., Voltne, H., Munoz, O., Veihelmann, B., Van der Zande, W. J., Leon, J.-F., Sorokin, M., and Slutsker, I.: Application of spheroid models to account for aerosol particle nonsphericity in remote sensing of desert dust, J. Geophys. Res., 111, D11208, doi:10.1029/2005JD006619, 2006.

THE INITIAL MANUSCRIPT EVALUATION

The retrieved aspect ratio distribution of the spheroidal particles presented in the manuscript is very different than the one presented in Dubovik et al. (2006) for dust particles (see Fig. 11 in Dubovik et al. (2006)). The backscattering is not included in the analysis of Dubovik et al. (2006), but this aspect ratio distribution has been shown to reproduce the backscatter measurements in other studies (see e.g. Lopatin et al. (2013)). The aspect ratio distribution shown in Dubovik et al. (2006) excludes the aspect ratios of 0.7-1.4. It is surprising that these are the aspect ratios that are shown to reproduce the dust measurements in your work. This result requires a more thorough investigation. An explanation could be found in the work of Bi et al. (2018). There you can see that the particle depolarization for spheroids with aspect ratios of 0.7-1.4 presents much larger values than what is measured for dust particles (<0.3) (see Fig. 5a in Bi et al. (2018)). These much larger values are decreased when considering smaller sizes for dust (as the ones considered in your work, with radius up to 2.2 μm) and higher imaginary part for the refractive index, as the one you retrieve at $\sim$0.05 (see Fig. 5d in Bi et al. (2018)). Please go through the work of Bi et al. (2018) and provide a more thorough explanation for the retrieved aspect ratio distribution and imaginary part of the refractive index, considering the limited size range used in your work.

Moreover:

1. Use the same range for the x-axis in Fig. 5a and b and in Fig. 10a and b. 2. Provide plots with the fitting of the backscatter and extinction coefficients and the depolarization ratios at all wavelengths for both case studies.

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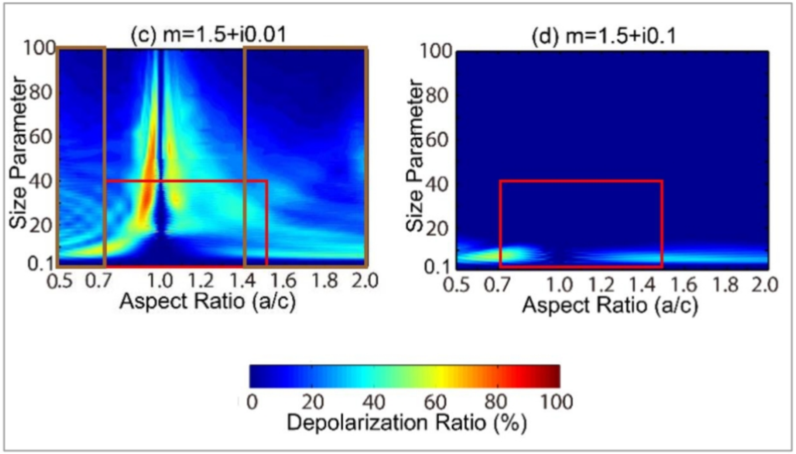

Figure 1: Depolarization ratio (%) as a function of the aspect ratio and the size parameter of randomly oriented spheroids at two different refractive indices with the same real part: (c) 1.5 + i0.01 and (d) 1.5 + i0.1 (source: Fig. 5 in Bi et al. (2018)). The red rectangulars indicate the size and aspect ratio range used in SphInX retrieval algorithm, whereas the brown rectangulars indicate the size and aspect ratio range used in AERONET retrieval algorithm (Dubovik et al., 2006).

Fig. 1.

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Discussion paper