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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Coarse mode mineral dust size distributions, composition and optical properties from AER-D aircraft measurements over the Tropical Eastern Atlantic" *by* Claire L. Ryder et al.

Anonymous Referee #3

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The study characterizes the dust properties during the beginning of trans-Atlantic transport of dust particles. It presents new airborne measurements of dust size distribution, composition, shape, and optical properties within the Saharan Air Layer (SAL) and the Marine Boundary Layer (MBL) taken during the AERosol Properties – Dust (AER-D) fieldwork campaign in August, 2015. In their 6 flights, the authors used wing-mounted optical particle counters and shadow probes to measure dust sizes between 0.1 and 100 μm diameter, a nephelometer and an absorption photometer to measure dust optical properties, and an in-cabin filter collection system to collect dust samples.

The focus of the study is to highlight the presence and contribution of coarse and giant mode dust particles to the dust size distribution, mass loading, shape, composition, refractive indices and optical properties. The authors found that within the SAL, dust particles with diameter (D) greater than 20μm are detected in 100% of the cases, and those with D>40μm are detected about 36% of the cases. Of the dust particles detected, 14% of the masses are for dust particles with size D<2.5μm, 60% for size D>5μm, and about 10% for D>20μm.

In addition, the authors also found the following: the shape of the measured particle size distribution does not vary significantly between dust layers; the modal aspect ratios are in between 1.2 to 1.4; the real part of dust refractive index in both SAL and MBL is within 1.47 to 1.49, but the imaginary part is between 0.0012 - 0.003i in the MBL and between 0.0004 - 0.0005i within the SAL. They also found that the single-scattering albedo (SSA) at 550nm decreases in the SAL when the measured coarse and giant dust particles are included in the calculation. However, they concluded that the variability of the SSA is not controlled by the dust size distribution, but by the variability in dust composition, contrary to previous studies.

Observational datasets for the coarse and giant dust particles, reported in this paper, are very important to better constrain dust properties in climate models. Current climate models over-estimate the fine-mode dust particles and under-estimate the coarse-mode particles, leading to uncertainties in the estimation of dust optical properties. This is largely due to inadequate observational constrains, and only few similar measurements of size-resolved dust properties are publicly available, with few obtained during the summer time period. Hence, high-quality measurements with a wider particle size range, like those reported in this study, are needed.

The paper is generally well written, and I believe it also meets the ACP standards. I recommend it for publication, if the authors can address the following comments:

1. Reading through the paper, some parts of it are rather confusing. This is primarily

because some of the sentences are too long, making the reading of the paper a bit tiring. The long sentences also sometimes obscure the point the author may want to pass across. I encourage the author to look more closely into each sentence, separating the long ones to multiple short sentences, where necessary. While few of these sentences are highlighted below, I cannot point to all the instances and I hope the author will do the due diligence in addressing this comment throughout the paper.

Pg 14 Lines 6-8, 14-16. Pg 15 Line 1-4. Pg 17 Line 1-4, 10-12. Pg 18 Line 22-26. Pg 20 Line 2-5. Pg 25 lines 16-19

2. Pg 6: The authors should provide a more objective assessment of the dust source areas. While HYSPLIT back-trajectory understandably are associated with uncertainty at the trajectory endpoints, it is still a reasonable method to determine the age of the dust particles, especially when the alternative is subjective. This is particularly useful for the dust particles in the SAL, where such trajectory can easily be estimated along a constant potential temperature surface, therefore avoiding possible influence of the convective events within the boundary layer. Doing it this way, may give a more close and objective approximation of the dust age, to which the SEVIRI images can eventually confirm. Free-tropospheric dust aerosols generally preserve their temperature for a considerable distance from the source region. Isentropic trajectories are therefore suitable above the boundary layer (e.g. Merrill et al., 1986).

From the HYSPLIT website (https://ready.arl.noaa.gov/HYSPLIT_traj.php), the figure below shows an example of the isentropic back-trajectory for flight #b932 starting on 20/Aug/2015 at 12Z for an arbitrary height of 2800 m above sea level. This height corresponds approximately to the highest extinction in your Fig. 4. The figure is a 3-day back-trajectory and it appears to suggest that the starting point after 3 days is approximately in the same area as suggested by SEVIRI in you Figure 1. This calculation can be repeated for different height within the SAL, and can also be combined with the SEVIRI images to give a more objective estimate of the dust sources, the age and the starting location.

In addition, the figure below uses the NCEP reanalysis dataset. It may be useful, however, to use a better quality meteorological dataset, like ERA-Interim with relatively higher resolution, to drive the HYSPLIT back-trajectories. ECMWF assimilates meteorological data from radiosondes that launch from few but important stations over north Africa. This may reduce the uncertainty even further, giving some more credence to the methodology.

3. The authors should either carefully justify the application of the Lorenz-Mie theory for dust particles larger than $\sim$20μm or use a more appropriate methodology for this size range. The manufacturer-provided size bin diameters were calibrated against polystyrene latex spheres, which the authors corrected to diameter of dust using Lorenz-Mie method (on PCASP and CDP). But Lorenz-Mie theory is only valid when the particle size is comparable to the wavelength (Bohren and Huffman, 1983). For coarse and giant dust particles with diameter larger than $\sim$20 μm, the application of Lorenz-Mie theory is no longer valid, and instead the geometric optics method may be useful (see Bi et al., 2009).

Specific Comments:

Pg 5, Line 7. Pg 7, Line 20. Pg 14, Line 4. Pg 16, line 25. Pg 18, line 2. Pg 21, line 15: The table numbers referenced here are wrong. Please check all other reference in the paper.

Pg 3, Line 9-10: Re-write for clarity.

Pg 9, Line 8-9: I wonder if this difference between the “all-in” and the “center-in” is actually quantified. This text referenced here appear to be an assumption as suggested by the use of word “considered”. If the latter is the case, I suggest this sentence should be re-written to clarify this point.

Pg 16, Line 24: There is no need for “6a”, there is just one figure. Please also correct this in other places of the manuscript.

Pg 18 line 14: Figure 8c is not provided.

There is no definition of some acronyms – an example is the “SLR” acronym in the text or in Fig. 4. I suggest the author look through the paper and make sure every acronym is defined before use.

References:

Bi, L., Yang, P., Kattawar, G. W. and Kahn, R.: Single-scattering properties of triaxial ellipsoidal particles for a size parameter range from the Rayleigh to geometric-optics regimes., Appl. Opt., 48(1), 114–126, doi:10.1364/AO.48.000114, 2009.

Bohren, C. F. and Huffman, D. R.: Absorption and scattering of light by small particles, 1st ed., Wiley-VCH., 1983.

Merrill JT, Bleck R, Boudra D. 1986. Techniques of Lagrangian trajectory analysis in isentropic coordinates. Mon. Weather Rev. 114: 571–581.

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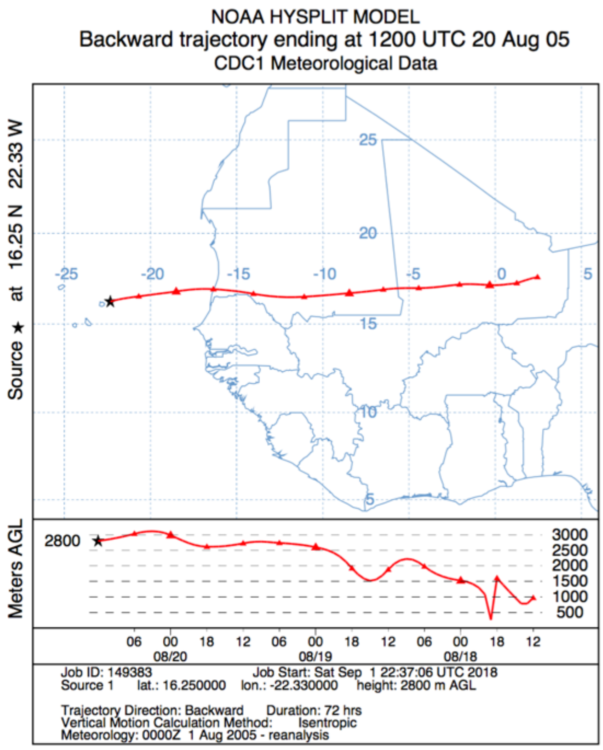

Fig. 1.