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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "A detailed characterization of the Saharan dust collected during the Fennec Campaign in 2011: *in situ* ground-based and laboratory measurements" *by* Adriana Rocha-Lima et al.

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This article characterizes Saharan dust collected during the FENNEC campaign in June 2011. Measurements at two sites (Algeria, Mauritania) are used to derive various optical properties of local aerosol samples. Filter samples were subsequently analyzed in a laboratory to provide additional information about particle size and elemental composition. The article contributes to the literature characterizing the physical and chemical properties of aerosols (mainly dust) within the Sahara. These studies are especially important for recent modeling work that attempts to characterize regional variations in

the mineral content of dust particles. My comments are mainly requests for clarification. I am recommending acceptance subject to minor revision. If the authors have any questions about my review, they can contact me at ron.l.miller@nasa.gov.

1) The 'mixed size' sample of particles collected by the filter captures a range of particle diameters, including smaller particles that overlap in size with that of the 'fine' sample (whose diameters are less than 5 um). This means that the mixed-size sample will differ from the actual size distribution of the ambient aerosols. In particular, the mixed-sized sample should have fewer fine particles than are in the air, because some of these passed through the filters into the fine sample. This means that aerosol properties that depend upon the distribution of particle diameter (like SSA), will differ from the actual ambient values that might be measured by AERONET (e.g.). This makes it difficult for modelers (or other measurement scientists whose size distribution will differ) to compare their SSA to the values reported in this study. I suggest that in the abstract and conclusions, the authors give emphasis to properties like index of refraction that are less dependent than SSA upon particle size, since the index can be more directly compared to values from other studies.

2) The description of the derivation of some of the optical properties (Section 4.3 and 5) is intricate. I occasionally had difficulty keeping track of what measurements were used to derive a particular optical property. The addition of a table relating a theoretical property (like SSA or absorption coefficient or index of refraction) to the specific measurements used, along with the temporal resolution of the property (that depends upon the measurement with the lowest temporal resolution) would be appreciated.

Minor Comments:

p.1 line 11, 13: The authors should give a specific diameter range for 'fine' amd 'mixed size'

p.2 line 7: 'acts to cool the planet'. The direct radiative forcing at TOA by dust is uncertain (as noted by the authors). Kok et al. note that the forcing could actually be positive (leading to warming of the planet). This possibility should be acknowledged.

Kok, J.F., D.A. Ridley, Q. Zhou, R.L. Miller, C. Zhao, C.L. Heald, D.S. Ward, S. Albani, and K. Haustein, 2017: Smaller desert dust cooling effect estimated from analysis of dust size and abundance. Nature Geosci., 10, no. 4, 274-278, doi:10.1038/ngeo2912.

line 8, 10: replace 'radiative forcing' with 'direct radiative forcing'?

p.4 line 15: define 'microphysical distribution' more specifically?

p.5 line 4: for the benefit of non-specialist readers, define the diameter range of the accumulation mode?

line 14: 'a technique applied' please provide some description of this technique

Table 1: could you clarify 'Sampling period'? Is each measurement a time-average over this period? Is this period the temporal resolution of each measurement?

p.8 line 20: 'These peaks are asociated with the sudden moistening convective events...' Allen et al (2013) attribute at least part of the event of June 18 to the breakdown of a low-level jet (see their Table 1 and their Figure 1c). The same comment applies to p.10 line 9: 'follows a moistening event'.

Allen, C. J. T., R. Washington, and S. Engelstaedter (2013), Dust emission and transport mechanisms in the central Sahara: Fennec ground-based observations from Bordj Badji Mokhtar, June 2011, J. Geophys. Res. Atmos., 118, 6212–6232, doi:10.1002/jgrd.50534

p.10 line 4: 'On June 22, the detection scale of the nephelometer was reconfigured...' Is this why Figure 4 looks slightly different from the nephelometer times series in Figure 1a of Allen et al. (2013). (It may be unreasonable to expect the authors to know the answer here, but if they do, it would be useful for readers familiar with the FENNEC literature.)

p.11 line 8: 'a large range of geometries' What does 'geometries' refer to? The interior

of the nephelometer?

line 12: 'the reflectance of the Nuclepore filter cannot be increased' Could you put this in plainer language? Do you mean that the filters only get dirtier and less reflective as the air flows through? (For a few events in Figure 5b, the reflectivity at 670 nm initially increases. Is this a measure of instrument error?)

line 19: what is delta t in this case? 45 seconds, corresponding to the sampling period of the reflectometer? In general, this page is very technical and difficult to read, although instrument scientists will have an easier time.

line 25: insert 'temporal' before 'subset'?

p.12 line 11: 'These results show variation along this period from 0.96 to close to 1, with a mean value around 0.995...' The low values near 0.96 in Figure 5d are short-lived. Are the values just noise or is there a physical cause?

line 12: 'systematically higher than the values for Saharan dust found in the literature at this wavelength' Please give examples of such studies.

Figure 5: Label each panel with a, b, c or d to correspond to the caption.

Figure 6: what do the different colored lines correspond to? Samples from different days?

p.14 line 11 'This strong spectral dependence is what causes the dust to appear brown to our eye.' This is an interesting comment. Could you elaborate by telling me what primary colors brown corresponds to? If I am interpreting the figure correctly, dust absorbs blue and some of green, allowing red to be scattered back to our eyes. (I will always regret not taking an optics class as an undergraduate :)

line 14: 'three groups of samples were identified' Were the Mauritania groups divided based on qualitative inspection or was an objective criterion used?

p.15 line 32: 'Other studies also show a decrease in coarse mode fraction as sampling moves towards aged dust and away from fresh dust near sources.' Please be specific and state which of the measurement sites is considered to be closer to the upwind sources.

p.16 line 3: 'A comparison between this geometrical distribution...' This sentence is unclear. How was the impactor efficiency taken into account in this study? Could the authors explain briefly why this matters? (This is probably obvious to an instrument scientist.)

p.18 line 5: 'Once the instruments arrived back at UMBC, dust deposited on the instrument surfaces was gently collected using a brush and sieved using a 45 μm mesh grid.' Does mechanical brushing break up larger aggregate particles, modifying the aerosol size distribution that was latter characterized using the SEM?

p.19 line 3: 'Figure 11 a) shows that the imaginary part of the complex refractive index of Saharan dust from Algeria has significant spectral differences between fine and mixed mode.' The authors should explain how the refractive index was calculated for the mixed mode, if the T-matrix code doesn't converge (p.18, line 20). (The answer appears to be in the caption of Figure 11, but this should be described in the text.) For samples from Mauritania, the use of Mie theory seems to introduce an uncertainty comparable to the measurement uncertainty, given the sensitivity of the fine sample index to this assumption. This should be discussed.

line 5: 'For longer wavelength the values diverge considerably...' Why is this? For pure materials, the index of refraction should be independent of particle size. Is this divergence evidence that the fine and mixed samples are comprised of different minerals?

Figure 12: I find it difficult to derive much quantitative information from this figure. Could the authors replot these four cases as four bar graphs, as in Figure 13?

Section 5.6: ('EDXRF analysis of Saharan dust') Are there any differences in elemental composition with respect to particle size? This is an important question for modelers

trying to reproduce the hematite composition in soil maps. (e.g. Scanza et al ACP 2015, Perlwitz et al ACP 2015). For example, Perez et al (2016) noted that Fe (from hematite) is mainly independent of particle size at Izana (just downwind of these sites), contrary to some soil mineral atlases that restrict it to larger particle sizes. A figure similar to Figure 13 showing the difference of elemental composition between the fine and mixed modes would be helpful to address this question.

Perez Garcia-Pando, C., R. L. Miller, J. P. Perlwitz, S. RodriÌĄguez, and J. M. Prospero (2016), Predicting the mineral composition of dust aerosols: Insights from elemental composition measured at the IzanÌČa Observatory, Geophys. Res. Lett., 43, doi:10.1002/ 2016GL069873.

Perlwitz, J. P., Perez Garcia-Pando, C., and Miller, R. L.: Predict- ing the mineral composition of dust aerosols – Part 1: Representing key processes, Atmos. Chem. Phys., 15, 11593–11627, doi:10.5194/acp-15-11593-2015, 2015.

Scanza, R. A., Mahowald, N., Ghan, S., Zender, C. S., Kok, J. F., Liu, X., Zhang, Y., and Albani, S.: Modeling dust as component minerals in the Community Atmosphere Model: development of framework and impact on radiative forcing, Atmos. Chem. Phys., 15, 537–561, doi:10.5194/acp-15-537-2015, 2015.

p.21 line 15: '...or do the AOT measurements follow the full magnitude of large events.' This could be because cold pools often arrive at night (Allen et al 2013), when the sun photometer is not measuring.

p.22 line 5: 'For example, it can be seen in Ryder et al. (2013a) that during fresh dust events...' This is interesting. Here, the authors seem to be arguing that discrepancies between AERONET and the nephelometer are due to departures of the height of the dust layer from the assumed value of 5 km. Can the authors estimate the frequency of this underestimate by AERONET compared to the frequency of missing retrievals because the dust concentration is so high that the aerosol layer is mistaken for a cloud?

p.24 line 12: "...follows expected variation associated with sources areas where the sites are located.' Do the authors mean specifically that the Mauritania site is more influenced by marine aerosols?

p.25 line 21: 'Ryder et al. (2013a) present results of dust optical properties measured and derived during Fennec from aircraft over northern Mauritania and North West of Mali. Differences between these airborne measurements and our ground-based results appear striking at first glance.' SSA depends upon the size distribution (as the authors note below). How much does this contribute to the different compared to possible differences in composition?

p.25 line 6: 'However, this bow-shape signature is seen in other previous work by Balkanski et al. (2007) and references therein.' I believe that a bow shape is also implicitly present in some models (e.g. GISS: c.f. Tegen and Lacis 1996; Miller et al JGR 2006) that interpolate the index of refraction between measurements in the visible (Patterson et al 1977 or Sinyuk et al 2003) and IR (Volz 1973). The imaginary part of the index is small within the visible (Sinyuk et al 2003), but rises as a result of interpolation to meet higher values in the IR around 3 um (Volz 1977).

Miller, R. L., et al. (2006), Mineral dust aerosols in the NASA Goddard Institute for Space Sciences ModelE atmospheric general circulation model, J. Geophys. Res., 111, D06208, doi:10.1029/2005JD005796.

Patterson, E. M., D. A. Gillette, and B. H. Stockton (1977), Complex index of refraction between 300 and 700 nm for Saharan aerosols, J. Geophys. Res., 82, 3153–3160.

Sinyuk, A., O. Torres, and O. Dubovik, Combined use of satellite and surface observations to infer the imaginary part of refractive index of Saharan dust, Geophys. Res. Lett., 30(2), 1081, doi:10.1029/ 2002GL016189, 2003.

Tegen, I., and A. A. Lacis (1996), Modeling of particle influence on the radiative properties of mineral dust aerosol, J. Geophys. Res., 101, 19,237 – 19,244.

Volz, F. E. (1973), Infrared optical constants of ammonium sulfate, Sahara dust, volcanic pumice and flyash, Appl. Opt., 12, 564–568.

p.26 line 13: 'may correspond to other size-dependent characteristics such as aspect ratio' Or mineral composition? For example, MoosmuÌĹller et al (2012) show that for aerodynamic diameters less than 2.5 um, SSA from African dust particles is linearly related to the elemental fraction of iron (which they attribute to hematite).

Moosmuller, H., J. P. Engelbrecht, M. Skiba, G. Frey, R. K. Chakrabarty, and W. P. Arnott (2012), Single scattering albedo of fine mineral dust aerosols controlled by iron concentration, J. Geophys. Res., 117, D11210, doi:10.1029/2011JD016909.

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