Interactive comment on “Dust optical properties over North Africa and Arabian Peninsula derived from the AERONET dataset” by D. Kim et al.

Response to the comment of Referee #1

The authors describe optical properties of mineral dust over North Africa and the Arabian Peninsula as derived from AERONET observations. The presented results may well contribute to the understanding of variability in dust optical properties from samples, observations and remote sensing. It gives clear evidence that there is a lot of variability e.g. in absorption also within dust observed at one station with the same method. The paper is well written and easy to follow. Besides the minor comments listed below, I have two major comments regarding the manuscript and the analyses and interpretations presented.

Major comments:
The major concern is that the authors seem to underestimate or neglect the influence of variable iron oxide (like hematite) contents on optical properties of dust – especially absorption. Although they introduce iron oxides as the main responsible component for absorption (in solar wavelengths), they do not pay much attention to the possibility of dust transport from different sources and the resulting impact on absorption (by means of single-scattering albedo) in the analysis and the discussion. More attention should be paid to this point in the final paper (I added a few comments where I missed some words about variable hematite content below). The second concern is related to the filtering of the two data subsets. It does not really get clear from the text a) What assumption the Angstrom exponent threshold is based on and why this value has been chosen and b) If the ALL dataset is also filtered by the AOD440 threshold (which I assume as otherwise no optical properties are retrieved). Especially the latter should be really a part of your interpretation, as the results are only valid for high AOD cases then. It can be questioned, if they are also representative for the more common cases with lower AOD (like e.g. fine layers of transported dust). The discussion of the results should be a little more elaborated in the light of these two major concerns, which regard mainly the interpretation, not the data analysis itself.

We thank the referee #1 for these comments. To answer the first major comment, we revised the manuscript as the following and added the discussion on iron oxides.

“The strength of dust absorption, or the imaginary part (k) of complex refractive indices (n+ik) is determined mainly by the iron oxides contents in soil such as hematite and geothite (Patterson et al., 1977; Claquin et al., 1999; Sokolik and Toon, 1999; Alfaro et al., 2004; Lafon et al., 2004, 2006; Forment et al., 2008; Derimian et al., 2008). Their absorption is highly variable due to the heterogeneous mineralogical contents in soil.”

“Back trajectory analysis showed that most of air mass is from East or North-East during the season. This shows that dust is the most dominant source of absorption and the variability of imaginary refractive index indicates different iron-oxide contents in each dust event.”

As for the second major comment, Angstrom exponent threshold of 0.2 in this study is more strict than using the typical Angstrom exponent values of 0.2-0.6 found in desert region (Todd et al., 2007; Eck et al., 2008 and 2010) in order to select nearly “pure dust”. We only use AOD data that are greater than 0.4 for both DU and ALL. We specifically show that $\tau(\mathrm{ALL}) \geq 0.4$ in the text.

Minor comments:
P20183, L 5ff.: This is only true in the solar wavelengths (which are considered here). In other wavelength bands like TIR also other constituents, e.g. Si-O are strongly absorbing. Generally I am missing a few words about the highly variable hematite (iron oxide) content, which might explain the differences in absorption between this study and previous ones.

The impact of iron oxide in light absorption is added manuscript.

P20184, first paragraph: What about fine mode portions of dust? The authors should at least mention, that dust particles also include (a minor fraction of) fine mode particles, but that for practical reasons only cases with low Angstrom exponent are used.

Because we think it is RIGHT that mineral dust is mainly in coarse mode, we select AERONET data with Angstrom Exponent less than 0.2 (coarse mode dominated) as representative of dust. Using higher value of threshold Angstrom Exponent would allow more fine mode aerosols, which may not be dust, to be included in the “dust” data.

P20184, L12: better use “observations” instead of “measurements” (the measured quantity is radiance, also by sun-photometer)

Fixed.

P20184: It would be worth adding the quality and validation status of the AERONET derived optical properties (as they are retrieved from the AERONET observations and thus subject to different kinds of retrieval uncertainties). The evaluation status and potential limitations of the method should also be part of the discussion of the results presented in this manuscript.

We added a sentence in the text that AOERONET and field measurement are comparable.

P20185, L1ff: What is your definition of “coarse mode” here? What is the effective or mode radius the selected Angstrom exponent relates to (with some assumption about aerosol composition and size distributions)?

Fixed. Coarse mode aerosol is defined as radii ≥ 1 μm.

P20185, L10ff.:When Angstrom exponent is typically between 0.24 and 0.6 at desert sites, where does your threshold of 0.2 come from? What does the selection of such low threshold mean for the filtering? What about dust events with Angstrom exponent of, let’s say 0.4? Do they consequently contribute to the ALL dataset? You should provide evidence that your selected threshold fits your requirements and does not filter out too many dust events with higher A_ext.

Lower threshold means more rigorous filtering of other fine mode aerosols leaving more pure dust. Even so, the sensitivity test showed that the intermediate threshold does not affect to our conclusion i.e., DU and ALL are close each other in dust active season while the departure between the two is greater in winter.

P20185, L14f.: I assume that the ALL dataset is also compiled with the AOD440>0.4 threshold. This should be mentioned here.

Yes and it is fixed.

P20186, L20f.: This is related to the comment above. If the ALL dataset is only with AOD440>0.4, it should be said explicitly, that the dust frequency relates to large AOD cases only.

It is stated in section 2.

“...under conditions of relatively high aerosol optical depth (AOD ≥ 0.4 at 440 nm) and large solar zenith angle (> 50°)”

P20187, L16.: What exactly do you mean by “shorter measurement period than other sites”?

Revised as “The number of days for ALL is only about 20 to 30 days in each month during the measurement period (Table 1)”

P20187, L22ff.: Variable absorption in the DUST subset throughout the year could be linked to dust transport from different sources with different hematite contents (e.g. from the Sahel with the summer monsoon flow). It would be worth to discuss the potentially included information of iron oxide content related to dust sources in more detail.

Back trajectory analysis indicates that the mean air mass is from the East or North-East. Therefore Iron oxides is a probable reason to the variability. We added it in the text.

P20188, L1.: closer to what? (I assume to each other?)

Yes and it is fixed.

P20188, L14f.: This kind of speculation (you do not really know, if fine mode aerosol is mostly biomass burning aerosols) belongs to the discussion, not to the results.

This sentence is moved to the discussions section.

P20189, L1f.: Is there something missing in the sentence? Otherwise remove “that” after “Sect. 1”.

Fixed.

P20198, L17.: You should add “and large particles” after “almost pure dust”. I wonder what will happen to your filter in the case of pure clay outbreaks with finer particles.

There is no doubt that dust in source region is dominated by large particles. We revised the text as “We have used a critical $Å_{ext,crit}$ of 0.2 in this study to select “almost pure” dust in source region.”

P20189, L29: What about Asian states other than China (there are AERONET stations in e.g. India, Mongolia, Iran, Korea, Pakistan, : : :)? May there be enough data at other stations?

We could not find a AERONET site in Asia where the data could pass our DU filter, because aerosols are often exist with mixed aerosol type in Asia that makes the selection of “pure dust” difficult.

P20190, L14ff.: You should also mention the variable hematite content as possible explanation. I would assume that this one is the strongest in the selected DUST cases.

Fixed.