

Interactive comment on “Complex refractive indices and single scattering albedo of global dust aerosols in the shortwave spectrum and relationship to iron content and size” by Claudia Di Biagio et al.

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The paper by Di Biagio et al. presents a new dataset of complex refractive indices and single scattering albedo (SSA) at 7 wavelengths in the shortwave range for dust aerosols generated from 19 soil samples collected from the 8 more prominent dust emission regions on Earth. The dataset was derived after resuspending dust into a smog chamber and measuring its spectral scattering and absorption coefficients and size distribution. The complex refractive index was estimated by Mie calculations combining the optical and size data, and the SSA was derived directly from the scattering

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and absorption coefficients. In addition, bulk composition was measured for each sample to better understand the influence of mineralogy upon absorption.

A main result is that the retrieved imaginary part (k) is in the lower range of values currently found in the literature. The study also provides wavelength-dependent (strong) linear relationships between k and SSA, and the content of iron oxides that may help simplifying the implementation of the effect of dust mineralogy upon absorption in climate models.

This well-written paper provides a new and unprecedented dataset along with new insights on the dependencies of the absorption on the content of iron oxides. Therefore, I strongly recommend its publication after addressing some minor general and specific comments that can be found below.

General Comment

The authors make several assumptions in the optical calculations in order to retrieve k from the measured data. These assumptions are clearly summarized in section 3.3. First, the size distribution from the OPC and the scattering coefficient depend upon the refractive index; the approach was to set fixed values. Second, the OPC optical-to-geometrical diameter conversion and the nephelometer truncation correction (in addition to the retrieval algorithm in section 3.2) assume homogeneous spherical particles and therefore use Mie theory.

In the first case the authors calculate the sensitivity of the results to the assumption and demonstrate the robustness of their approach. However, the potentially large impact of the second assumption (shape) is not quantified. It is argued that shape was not measured and that improper assumptions on the particle shape or morphology may induce even larger errors. I find this last argument a little weak: 1) There are estimates of shape in the literature and recent studies (e.g. Kok et al., 2017) highlighting the potential importance of shape upon extinction (using triaxial spheroids); 2) the influence of shape upon the conversion from optical to geometrical diameter seems also quite

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important (increasing the amount of fine particles compared to coarse ones; Huang and Kok, 2018); 3) The nephelometer truncation error should also be quite sensitive to shape; 4) The authors compare their results with other estimates in the literature; in page 15 they argue that the strong differences with Wagner et al. (2012) may be due to the choice of the optical theory (T-Matrix vs Mie), which somehow admits that assuming spherical particles may be a strong source uncertainty.

While I understand that accounting for shape is a complex issue beyond the scope of this paper, I nevertheless ask the authors to more clearly acknowledge this (potentially strong) uncertainty both in the abstract, discussion (section 3.3) and conclusions. I would also invite the authors to explore and report on this uncertainty in future studies.

Specific comments

Title: The current form of the title may induce to confusion (it is not clear whether size relates to iron size or dust size). I suggest two possibilities:

“Complex refractive indices and single scattering albedo of global dust aerosols in the shortwave spectrum and relationship to size and iron content”

or

“Complex refractive indices and single scattering albedo of global dust aerosols in the shortwave spectrum and relationship to iron content and dust size”

Abstract: Please emphasize that the linear relationship is stronger with iron oxides than with total iron. Also, indicate that your estimates are in the lower range of the literature values.

L197 to L217.: Please elaborate a bit on the assumption of spheres for the truncation correction and please connect it to an improved discussion in section 3.3 as suggested above.

L241: “varied between. . . nm and. . .”

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L268: 10 microns?

L301: what about shape?

L542: what do you mean by “our” population average of 1.8 % . . . ?

L557: Please develop more. This is quite important in my opinion as I highlighted above. Can you further discuss the differences with Wagner?

L600: k is an intrinsic property of matter by definition. Perhaps rephrase this sentence. k is independent of size if mineral composition does not change with size.

L642: I would rephrase this sentence. The variability is controlled by the iron oxide content. Using total iron partly reflects this because oxides are a large fraction of it but the linear relationship is obviously not as strong.

L650: This sentence is a little confusing. k is independent of size by definition. However, an “effective” k of a size distribution may change if mineralogy changes with size and size evolves with transport. In fact in L667 you further propose to investigate this potential dependence.

L657: the variability within regions can be very large though, please highlight that.

L675: you may mention and cite EMIT (Green et al., 2018) as a potential near-future source of high resolution surface mineralogy data for arid and semi-arid regions

Figures: Figure 1 is not readable, please increase the font size in the flowchart

References:

Green, R. O.; Mahowald, N. M.; Clark, R. N.; Ehlmann, B. L.; Ginoux, P. A.; Kalashnikova, O. V.; Miller, R. L.; Okin, G.; Painter, T. H.; Pérez García-Pando, C.; Realmuto, V. J.; Swayze, G. A.; Thompson, D. R.; Middleton, E.; Guanter, L.; Ben Dor, E.; Phillips, B. R. (2018) NASA's Earth Surface Mineral Dust Source Investigation. American Geophysical Union, Fall Meeting 2018, abstract #A24D-01

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Huang, Y.; Kok, J. F. (2018) Harmonization of size distributions of dust at emission. American Geophysical Union, Fall Meeting 2018, abstract #A21I-2821

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.

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