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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Using aircraft measurements to determine the refractive index of Saharan dust during the DODO experiments" *by* C. L. McConnell et al.

Anonymous Referee #2

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General comments

This is a high quality paper that uses two methods for refractive index determination, and couples this with a radiative closure study for the two different refractive index determination methods and compares with the measured radiation. It is particularly timely as much discussion exists as to what the correct imaginary refractive index for Saharan dust and possible source dependence.

This paper derives the imaginary part of the refractive index by:

1) Derives refractive index at 550nm by measuring scatting absorption and particle size distribution and then fits a Mie theory model for imaginary part of the refractive index

keeping the real part fixed at 1.53. This is only applies for aerosols smaller than 5 microns as this was the limit of the sampling inlet. To obtain refractive indexes over a wider wavelength range (0.1 to 10microns) the spectrally dependent imaginary part of the refractive index from WMO 1986 is scaled with the value found at 550nm.

2) Calculating the spectral dependent refractive index from published mineral refractive index using mixing rules and measured mineral composition from filter samples (these are thought to be biased to large particles). Four different mineral combinations are used (these calculations were only possible for one flight).

3) Comparisons are made to AERONET derived refractive indexes where possible.

This paper then uses a radiative model to enable a closure study; the assumption that refractive indexes are independent of size (as the size range of the inlet is different between 1 and 2 above). The full size distribution (0.01 to 60microns) is used in this case.

The calculated upward and downward short radiation is compared to aircraft pyranometer measurements for the 0.3-3micron wavelength range.

In addition it is found directly from the aircraft measurements that the single scattering albedo is dependent on the imaginary part of the refractive index in derived in 1) and not on the measured aerosol size for the aerosols sampled.

They find that the best mineral combination was GK (Bruggeman mixing rule was used for a mix of Goethite-kaolinite) and mie theory (scaled imaginary refractive index from WMO assuming only the accumulation mode) provided the best radiative closure for the aircraft measurements.

Specific comments

Section 2.3: Modeling refractive index from filter composition measurements.

More information required on how the chemically derived refractive index was arrived at:

It is not clear how the refractive index were calculated for the “limiting cases given” from the elemental composition of the samples. It is clear that the authors have attempted to do the best that could be achieved with the methods available to determine the chemical composition of the samples. The authors were able to identify the speciation of the minerals present namely; clays of the form illite and kaolinite, traces of chlorite and smecitite, quartz, feildspar and calcite. The authors then used external and internal mixture of the minerals (using a mixing rule approximation) to combine the refractive indexes from the minerals found.

From FormentiP2008 the flight B238 filter samples were similar to the one quoted in the paper with the X-ray diffraction signals of 50-60% Clays (kaolinite and illite) and about 30-40% for quartz, K-feldspar and plagioclase (feldspar containing Na and Ca) for about 5%, and carbonate (calcite, dolomite and gypsum) for the remaining 10–15%. These signals may not be directly related to the mass fractions but clearly indicate the importance of the other minerals present. FormentiP2008 also discuses how the hematite to goethite ratio was derived from diffuse reflectance measurements of the filter samples (giving 30% and 70% respectively of the clays present).

To overcome the calibration issues of the X-ray diffraction signals elemental concentrations (from X-ray fluorescence) were then used to infer the relative proportions of the minerals that were identified. No details are given of the inferred mineral proportions from this elemental data. To justify the mixtures used a list of the proportions used should be included as a function of run (from Fig. 1 it is clear that these proportions are a function of aircraft run as the imaginary part of the refractive index changes).

To represent the aerosol external mixtures of quartz, calcite and iron oxide-clay aggregates were used. The iron-clay aggregates where represented as an internal mixture using the Bruggeman approximation (a two component mixing rule). Four different mixtures where used; Hemiatite-Illite (HI), Hemiatite-Kalointe (HK), Goethoite-Illite (GI)

and Geothoite-Kaolinte (GK).

This begs the question what is the refractive index plotted for HI, HK, GI and GK in Fig. 1? Is it the imaginary part of the refractive index derived from the two component internal mixture? Is it some average imaginary refractive index involving the three component external mixture, (if so how was this done?)?

The chemically derived imaginary refractive index value is compared to the measured values (using the mie theory model). The Mie theory derived refractive index is the complete aerosol mixture, are we really comparing like for like in Fig. 1?

Section 2.2: Calculation of refractive indices using Mie code.

The real part of the refractive index was assumed to be 1.53, the paper reports that values ranged from 1.51 to 1.56. No indication is given to the sensitivity of the Mie results to this range of refractive indexes; this sensitivity is probably small but should be justified.

Section 2.3: Radiative transfer model.

It is well known that the radiative transfer is highly dependent on the chosen surface albedo. The authors have calculated this from upward and downward flight pyranometer measurements taken at the lowest possible altitude of 300m, giving a value of 0.44. Was an assumption of dust free atmosphere made for the lower 300m? Was this measured at one wavelength, or was it spectrally resolved in someway? Only a single value is given, what was the uncertainty in this surface abledo? How sensitive are the results to this?

Section 4.1: Spectral refractive indices.

No physical justification is given to the validity of scaling the imaginary parts of the refractive index across all wavelengths to match with the ones derived via Mie theory. Why is this physically realistic scaling? Justification should be given, or a statement of why this is necessary, with the caveat that this is probably not physically realistic. This is in-effect a spectral extrapolation, assuming the same spectral response as the WMO data, clearly if the mineral composition is different to the WMO data (as supported by the paper) this is going to be a very poor representation of the real optical properties at wavelengths far from 550nm.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 23505, 2009.