Global scale variability of the mineral dust longwave refractive index from new in situ chamber measurements

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Modeling the interaction of mineral dust aerosols with longwave (LW) radiation is still a challenge due to the poor knowledge on their complex refractive index. In particular little is known on the variability of the dust refractive index with particle mineralogy, which changes with the source region of emission, and size distribution, which modifies during transport due to gravitational settling.

In this study we explore the variability of the mineral dust LW refractive index as a function of its mineralogical composition and size distribution by in situ measurements in the CESAM chamber (Experimental Multiphasic Atmospheric Simulation Chamber) (Di Biagio et al., 2014). Mineral dust aerosols were generated from nineteen natural soils and sediments from Northern Africa, Sahel, Middle East, Eastern Asia, North and South America, Southern Africa, and Australia. These were selected to represent major dust sources worldwide and to account for the heterogeneity of the soil composition at the global scale. The generated aerosols were re-suspended in the chamber, and their LW extinction spectra (2-16 µm), size distribution, and mineralogical composition were measured. The generated dust aerosol exhibits a realistic size distribution and mineralogy, including both the sub- and super-micron fractions, and representing in realistic proportions the main LW-active minerals (clays, quartz, calcite). The complex refractive index of dust is obtained by optical inversion based on extinction and size data.

Results from the present study show that the LW refractive index of dust strongly varies both in magnitude and spectral shape from sample to sample, following the variability of the particle composition. For instance, the strength of the absorption at ~7 and 11.4 µm depends on the amount of calcite within the samples, while the absorption at 8-14 µm is determined by the abundance of quartz and clays. The available literature data (Volz, 1972, 1973; Fouquart et al., 1987) used nowadays in climate models and remote sensing retrievals, do not adequately represent either the magnitude, or the spectral features and the variability of the dust LW refractive index as observed in our dataset.

Our data also show that the spectral shape of the dust extinction spectrum does not modify with time due to the loss of coarse particles by gravitational settling. In consequence, the retrieved LW refractive index does not change, so it can be used to represent short-to-medium range transport conditions.

The unique dataset presented in this study is of great relevance for both climate modelling and remote sensing applications. First, our results permit taking into account the geographical variability of the dust LW refractive index, which at present is not accounted for in climate models and satellite/ground based retrievals. Our findings also support the common practice to treat the dust LW refractive index as static during transport, which would strongly simplify its representation.

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