The mineralogy of coarse dust aerosols retrieved from its mid−infrared extinction spectra: a laboratory testbed study on dust from worldwide sources

C. Di Biagio[a], J. F. Doussin[a], M. Cazaunau[a], E. Pangui[a], J. Cuesta[b], P. Sellitto[b,c], M. Rodenas[d] and P. Formenti[a]

[a] *Université Paris Cité and Univ Paris Est Creteil, CNRS, LISA, F-75013 Paris, France*

[b] *Univ Paris Est Creteil and Université Paris Cité, CNRS, LISA, F-94010 Créteil, France*

[c] *Istituto Nazionale di Geofisica e Vulcanologia, Osservartorio Etneo, Catania, Italy*

[d] *EUPHORE Laboratories, Fundación Centro de Estudios Ambientales del Mediterráneo (CEAM), Avda. Charles R. Darwin, 14, Parque Tecnológico, 46980 Paterna, Spain*

***Corresponding author e-mail**: claudia.dibiagio@lisa.ipsl.fr

The mineralogy of dust aerosols (i.e. the abundance, relative proportions and state of mixing of the different minerals composing the aerosols, including mainly silicates in the form of clays, quartz, and feldspars, carbonates, sulfates, and iron and titanium oxides) is of key relevance in driving its climatic and environmental effects. Ground–based and airborne observations support the evidence that the dust mineralogy is heterogeneous in the atmosphere, varying from local to global scale due to changes in the mineralogical composition of the emitting source soils and atmospheric processing. However, the capability to get regional and global mapping of airborne dust mineralogy is still missing to date. This gap represents a fundamental limitation for properly developing and validating the representation of dust in Earth System Models and constraining its regional and global climate forcing.

Because the different minerals composing the fine and coarse fractions of dust show different spectral absorption signatures, remote sensing spectral and hyperspectral observations can be used to fill this gap by detecting the presence of diverse minerals and reconstructing their relative proportions in the dust aerosols. Based on this idea, recent efforts move into this direction, including the EMIT mission (Earth Surface Mineral Dust Source Investigation) started in 2022.

In this study we demonstrate, starting from exemplary data acquired in the CESAM simulation chamber on dust aerosols from global sources [1], that the extinction signature of suspended dust aerosols in the 740−1250 cm^{-1} infrared spectral range (8−13.5 μm) can be used to derive dust mineralogy in terms of its infrared−active and coarse−sized minerals: quartz, clays, feldspars and calcite. We show that diverse spectral infrared signatures allow to distinguish dust aerosols from different sources worldwide with variable composition, and that following the changes of the dust extinction spectra with time informs on particles size−selective mineralogy changes during atmospheric transport. Results from the present study confirm the major advance that hyperspectral infrared remote sensing observations, as those by IASI (Infrared Atmospheric Sounding Interferometer) and the IASI−NG (Next Generation) instruments, can provide to dust science.

Keywords: mineral dust, mineralogy, climate, infrared remote sensing

References

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