Geophysical Research Abstracts
Vol. 17, EGU2015-2083, 2015
EGU General Assembly 2015

Local geological dust in the area of Rome (Italy): linking mineral composition, size distribution and optical properties to radiative transfer modelling

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Airborne mineral dust plays a key role in the energy balance of the Earth – atmosphere coupled system.
The microphysical and optical properties of dust drive the direct radiative effects and are in turn influenced by the dust mineralogical composition. The latter varies largely, depending on the geology of the source region. Knowledge gaps still exist about relationships between the scattering and absorption of solar and terrestrial radiation by mineral dust and its mineralogical, size distribution and particle morphology features; this also affects the reliability of radiative transfer (RT) modelling estimates (Hansell et al., 2011).
In this study, these relationships were investigated focusing on the crustal suspended PM10 dust, sourced from outcropping rocks of the local geological domains around Rome (Latium, Italy).
The mineral composition variability of the Latium rocks ranges from the silicate-dominated (volcanics domain) to the calcite-dominated (travertine), through lithological materials composed in different proportions by silicates, silica and calcite, mainly (limestone series, siliciclastic series) (Cosentino et al., 2009).
This peculiarity of the Latium region was thus exploited to investigate the behavior of the size distribution, optical properties and radiative transfer at BOA (Bottom Of Atmosphere) of the suspended dust PM10 fraction with the variability of mineral composition. Elemental source profiles of the same dust samples were previously determined (Pietrodangelo et al., 2013).
A multi-faceted analysis was performed, and outcomes from the following approaches were merged: individual-particle scanning electron microscopy combined with X-ray energy-dispersive microanalysis (SEM XEDS), bulk mineralogical analysis by X-ray diffraction (XRD), size distribution fit of the individual-particle data set and modelling of the dust optical and radiative properties. To this aim, the 6SV atmospheric radiative transfer code (Kotchenova et al., 2008; Vermote et al., 1997) was employed, which computes aerosol optical properties (single-scattering albedo, asymmetry parameter, extinction coefficient, scattering coefficient, phase function) by the Mie Theory, and simulates the downward flux at BOA (FdBOA) by solving the radiative transfer equation. Conditions of dryness and of spherical particle shape were applied to all parts of this work.
The size distribution fitting to the log-normal function appears unimodal, both for the volcanics and travertine domains, the first showing coarser mode than the latter. Volume distributions of quartz, feldspar, kaolinite and calcite fall in the coarse fraction, showing maximum around 5μm (aerodynamic diameter); differences in the curve height suggest particle density variety among mineral species.
The single-scattering albedo highlights the weak absorption of travertine, with respect to volcanics, along the visible and Near-InfraRed (NIR) spectral domain. The asymmetry parameter indicates that the volcanics dust appears composed by particles with highly forward scattering, mainly in the Near-InfraRed (NIR) spectral domain, while the travertine shows more isotropic particles.
Finally, both volcanics and travertine dusts leave the direct component of FdBOA unchanged, while the diffuse component depends strongly on the mineral composition.

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