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The intense Saharan dust event of 25–26 March 2010 in the Mediterranean: shortwave and longwave radiative effects

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Mineral dust is one of the most abundant aerosol species in the atmosphere and strongly contributes to the aerosol content both at the regional and at the global scale. The Sahara Desert is the largest source of dust worldwide, and the Mediterranean basin is largely affected by dust transport.

Due to its characteristic mineralogical composition and particle size distribution, mineral dust can affect both the shortwave (SW) and the longwave (LW) radiation fields. However, while a very large number of studies have been dedicated in recent years to the analysis of the dust shortwave radiative effect, direct determinations of the LW effect are scarce and a great uncertainty still exists in evaluating its contribution.

In most cases the aerosol direct LW radiative forcing is small and, given the concurrent effects due to mainly atmospheric humidity and temperature, its estimation is difficult. Instead, a more evident LW dust signature emerges in case of high optical depth cases.

Measurements of the aerosol optical and chemical properties as well as radiative fluxes are continuously performed at the island of Lampedusa (35.5°N, 12.6°E), in the central Mediterranean, at the Station for Climate Observations. Measurements of the aerosol optical properties have been available since 1999, while downward irradiances have been measured since 2003.

In March 2010 several dust events occurred at Lampedusa, with the most intense occurring on March 25 and 26. The aerosol optical depth at 500 nm, τ, reached a peak value of 1.88 on 25 March, which is the highest value measured since 1999.

Aerosol optical properties, and shortwave and longwave irradiances, measured at the island of Lampedusa during this dust event, and co-located simultaneous observations of the outgoing radiative fluxes at the top of the atmosphere (TOA) obtained from the Clouds and the Earth's Radiant Energy System (CERES) are used in this study. The SW and LW radiative forcings (RFs) over the sea were derived by combining surface ad TOA irradiances measured during the dust event and on a pristine day, and radiative transfer model calculations.

At the satellite overpass (solar zenith angle of about 35°) the SW instantaneous RF was -209 W m^{-2} at the surface, -116 W m^{-2} at TOA, and +93 W m^{-2} in the atmosphere; the diffuse SW downward irradiance increased by up to 376 W m^{-2} with respect to the dust-free case. The LW RF was as large as +41.5 W m^{-2} at the surface, +20 W m^{-2} at TOA, and -22 W m^{-2} in the atmosphere. The LW forcing offsets about 20% of the SW instantaneous forcing at the surface, about 17% at TOA, and 24% in the atmosphere. It is estimated that on a daily basis the LW radiative forcing offsets 49% of the SW effect at the surface, 35% at TOA, and about 77% in the atmosphere, thus compensating for a large fraction of the SW heating.