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Seasonal transport patterns and radiative forcing of Saharan dust at the Mediterranean island of Lampedusa

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Measurements of atmospheric aerosol optical properties were started in 1999 on the island of Lampedusa (35.52° N, 12.63° E) with a Multi Filter Rotating Shadowband Radiometer (MFRSR). Additional instruments for a better characterization of the aerosols and of their effects on the radiative budget were successively added. In this study measurements of aerosol optical depth at 500 nm, τ, and the Ångström exponent, α, derived from the MFRSR observations in the period 1999-2006 are used together with geopotential height maps to identify the main patterns leading to transport of Saharan dust to the central Mediterranean. The aerosol optical properties are also used together with downward shortwave and longwave irradiances, measured with a CM-11 and a PSP pyranometer and a PIR pyrgeometer, to calculate the Saharan dust forcing efficiency.

Episodes dominated by Saharan dust (SD) have been shown to occur in 26% of the cloud-free days at Lampedusa. We have selected the most significant events of SD, characterized by very large τ values, or long periods of consecutive days, or episodes of short but intense SD. The Saharan Dust Event Index (SDEI) is defined as the sum of daily τ measured in each period of consecutive SD days, and provides an indication of the intensity of the SD event. The index seasonal behaviour shows a minimum (with

values below 1) in winter and a maximum (with values larger than 2) in summer. The peak values (up to 7.48) are usually reached in July and August. The cases characterized by the largest SDEI index values in each season have been analyzed in relation to the NCEP-based 700 mbar level geopotential height. The common meteorological features leading to the intense spring and summer SD cases is the simultaneous existence of a high pressure system in Northern Africa, generally over Tunisia and Algeria, and a trough extending near the Atlantic coast of Europe. At the surface level the presence of a thermal low indicates the occurrence of surface heating and uplift of warm air. In winter dust transport is driven by a cyclonic circulation generated by depressions centered over Portugal, Central/ Northern Europe, or Western Mediterranean, typical of the winter meteorology of the region. In autumn SD outbreaks are less frequent than in spring. The high pressure present over the Sahara is the driving mechanism for the SW–NE transport of dust.The surface aerosol shortwave radiative forcing has been estimated using τ from the MFRSR and irradiance measurements in the period May-November of 2003 and 2004. The forcing efficiency (FE) has been calculated for SD as a function of the solar zenith angle, and estimates of the daily average forcing efficiency at the summer solstice and at the equinox have been derived. The daily average FE for SD is -86.4 W/m^2 at the summer solstice, and -68.8 W/m^2 at the equinox. The FE of the SD is larger than that of industrial and biomass burning aerosols, mainly because of the large aerosol optical depth values of SD throughout the whole shortwave spectral range. The daily aerosol forcing of SD is much larger than for other aerosol classes due to the combination of larger forcing efficiency and largest optical depths. The estimated average daily forcing at the summer solstice and equinox for DD is –30 and –24 W/m^2, respectively. An estimate of the surface longwave radiative forcing of SD has been performed using pyrgeometer measurements and a radiative transfer model for some days of large SDEI index.