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Evaluations of shortwave direct aerosol forcing in the Mediterranean Sea region through a procedure using MISR data

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It is well known that aerosols exert important effects on climate, both directly through scattering and absorption of solar radiation, and indirectly by changing the cloud microphysical properties and influencing their formation. In fact, aerosol scattering and absorption change the incoming flux of shortwave radiation, modifying also the net outgoing flux at the top of the atmosphere (TOA). Different approaches were followed to estimate the global values of these aerosol-induced radiative effects. Since an increasing number of satellites is presently employed to measure the radiative properties of airborne aerosols, more and more reliable remote sensing data became available over the last years. One of the most useful satellites is the NASA's Terra, carrying aboard the Multiangle Imaging SpectroRadiometer (MISR) and the Clouds and the Earths Radiant Energy System (CERES).

In the present study, a procedure was developed to estimate the instantaneous direct shortwave radiative forcing ΔF induced by aerosols in the Mediterranean region (30˚ N to 50˚ N, 15˚ W to 45˚ E), through the combined use of MISR data and modeled evaluations obtained by means of codes based on the well-known 6S Radiative Transfer Code.

The instantaneous cloud-free shortwave direct radiative forcing induced by aerosols at TOA is conventionally defined as the difference,

$\Delta F = F_0 - F$, (1)

between the upwelling shortwave TOA fluxes F_0 and F, determined in the pristine aerosol-free atmosphere and in the same atmosphere including aerosols, respectively. The calculations of flux F were tested through comparison with the irradiance measurements performed by the CERES sensor for clear-sky conditions. Daily and monthly maps of forcing ΔF and forcing efficiency Φ (evaluated as the ratio between ΔF and aerosol optical depth *AOD(558 nm)*) were then determined, together with their average values, over the whole Mediterranean region.

The geographical distribution of the monthly average forcing ΔF over the Mediterranean show that ΔF assumes in general negative values over the sea and the European land regions, and positive values in some limited areas of North Africa and Middle East only, where intense warming effects are observed, due to the relatively high surface albedo characteristics associated with marked aerosol loadings. The evaluations of ΔF were then examined as a function of *AOD(558 nm)* measured by the MISR sensor, separately for land and sea surfaces. The results over land are widely scattered, presumably as a result of the large changes in the surface reflectance characteristics, combined with significant variations in the aerosol single scattering albedo. The forcing efficiency Φ was found to present monthly mean values varying between -11 Wm^{-2} in October and -35 Wm^{-2} in March. Conversely, the results obtained over sea are poorly scattered, the monthly mean values ranging between -36 Wm^{-2} (June) and -59 Wm^{-2} (January).

The present analysis provided monthly mean values of instantaneous ΔF varying between:

(i) -7.4 and -0.1 Wm^{-2}over land, with an average yearly value of -3.7 Wm^{-2},

(ii) -11.2 and -6.4 Wm^{-2} over sea, with an average yearly value of -8.7 Wm^{-2}, and

(iii) -8.1 and -3.6 Wm^{-2} for the overall data-set, with an average yearly value of -5.6 Wm^{-2}m.

Compared with recent estimates of ΔF derived from satellite data, these evaluations result to be fully reliable.