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Vertical profiles of shortwave and longwave aerosol direct radiative forcing during GAMARF campaign at Lampedusa island

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The Ground-based and Airborne Measurements of Aerosol Radiative Forcing (GAMARF) campaign was held at Lampedusa island, in the Central Mediterranean, in April-May 2008 with the aim of measuring the shortwave (SW) and longwave (LW) direct aerosol radiative forcing (ARF) using a large dataset from instruments deployed at the surface and on airborne platform. The campaign was supported by the EUFAR project and took advantage of the measurements performed by the ultralight ENDURO-KIT, instrumented for airborne aerosol and radiation research. Ground-based measurements were performed at the ENEA Station for Climate Observations (35.5° N, 12.6° E, 40 m asl), where long time series of atmospheric composition, aerosol optical properties, and radiative fluxes from well-maintained and calibrated instruments are available.

Measurements of longwave aerosol radiative forcing are absent in the Mediterranean, while the shortwave aerosol radiative forcing has been widely studied. Aerosol particles exert a warming effect in the LW range, partially offsetting the cooling effect at solar wavelengths. The LW ARF is smaller (about one order of magnitude) than the SW ARF. Among aerosol types, desert dust presents the most intense effects in term of radiative forcing. Lampedusa island is largely affected by dust intrusions from the Sahara desert, particularly in late spring and early summer, with large aerosol optical depths and particles extending in the vertical up to 6-8 km.

Vertical profiles of upward and downward shortwave and longwave irradiance, aerosol size distribution, and meteorological variables were available during six flights, when the aircraft reached the altitude of 4 km. The aerosol backscattering, temperature, and humidity vertical distribution above the aircraft top altitude were measured by lidar and radiosonde, respectively. Column aerosol properties and water vapour were measured with a Multi Filter Rotating Shadowband Radiometer (MFRSR), a Cimel and a Microtops Sunphotometer; total ozone was obtained from Brewer and Microtops observations. SW and LW surface irradiances, meteorological parameters, aerosol size distribution, and soil temperature were continuously monitored at the ENEA Station.

The ARF is computed using observations and the MODTRAN 4 radiative transfer model, which is used to simulate SW and LW fluxes in aerosol free conditions. The model is initialized with all the available measurements.

During the campaign, dust was present in three of the six flights, and aerosol optical depth at 500 nm as large as 0.6 was measured on 3 May, with aerosol layer top altitude of 5.5 km.

For the flight on 3 May the downward LW irradiances decreases from 337.4 Wm^{-2} at the surface level to 184.7 Wm^{-2} at the aircraft top altitude of 4015 m. The LW ARF was positive throughout the flight altitude, being nearly zero at the top of the dust cloud and increasing with decreasing altitudes to a value of 13.2 Wm^{-2} at the surface.