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Atmospheric African mineral dust monitoring with Raman lidar over Napoli.

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Abstract

During the systematic lidar measurements in the framework of EARLINET projectSaharan dust optical properties have been carried out in the urban area of Naples (Southern Italy, 40˚50'18"N, 14˚10'59"E, and 118 m above sea level). Because of its geographic position Naples's lidar station is the closest EARLINET stations to Africa, allowing a full monitoring of desert dust plume without any mixing with continental aerosol. Climatological and optical properties of dust layer have been measured with an elastic-backscatter Raman lidar with special care to seasonal variation of integrated backscatter, optical dept and extinction to backscatter ratio.

Introduction

Because of increasing of aerosol emitted by anthropogenic activities in the last years there have been many studies on possible alteration of Earth/atmosphere radiative balance. From that studies appear that tropospheric aerosol play a relevant role in Earth radiative budget [1, 2]. Wide amount of such an aerosol (about 1000Mt/yr) [3, 4] is formed by mineral dust particles produced by wind erosion in desert areas. Long range transport events (up to 10000 Km) carry mineral aerosol far from source regions following the dominant wind directions mainly towards the Atlantic Oceans (because of trade winds) but also towards Mediterranean Sea (because of low pressure system coming from Nord West direction).

Methodology

Following the EARLINET [5] protocol, lidar measurements have been performed twice a week providing information about aerosol optical properties, with a final spatial resolution of 60m and a temporal resolution between 1 and 30 min.

The lidar system was based on a XeF Excimer laser working at typical repetition rate of 50 Hz with pulse energy of 50 mJ. Newtonian telescope collected the backscattered radiation. The detection and data analysis system included two acquisition channels corresponding to the elastic backscattered radiation and to the Raman shifted echoes from N_2 molecules. A new Nd:YAG laser source is operating for May 2003 at 355 nm and 532 nm wavelength allowing backscatter at 532 nm and water vapour mixing ratio measurements as well. To extend the sounded range up to 20 km, data acquisition has been performed through a double system, which includes both analog digitising and photon counting techniques. Ancillary observations with ground-based meteorological station and 96-hours air masses backtrajectories are used.

Statistical analysis

Desert dust layers have been observed in the troposphere region by means of Raman lidar located in the western part of Naples urban area, on the top of a hill, few kilometres far from the Tirrenic Sea. This location is so that the main part of the air trajectories coming from North Africa passes over the lidar station directly.

From May 2000 to August 2003 about 50 long range transport event from Sahara have occurred with a average time length of these events of 4 ± 3 days. This means that mineral dust was present in 180 days over a total of about 1200 days. So, at least in Italy, the atmospheric aerosol load is strongly influenced by Saharan dust during about 15% of the time. During regular measurements, 37 different Saharan dust transport events have been observed on total number occurred.

Statistical analysis shows that the vertical extension of the range Saharan dust clouds is quite large: dust has been revealed up to 8000 m, nevertheless in 70% of the observed events dust layer was confined below 5000 m of height. We also observed a seasonal dependence of mean thickness of dust plumes that appear thicker in summer. Furthermore, from the number of measured cases for any season it is clear that dust transport events from Sahara occur more frequently in spring than in the other seasons.

Measured mean optical properties of total Saharan dust layer show that extinction to backscatter ratio (LR) is 57 ± 12 sr, integrated backscattering (IB) and optical dept (OD) are $(6.8\pm0.5)\cdot10^{-3}$ sr^{-1} $(3.3\pm0.1)\cdot10^{-1}$, respectively. Nevertheless the same quantities measured for mineral dust cloud from the top of planetary boundary layer are 42 ± 6 sr, $(4.2\pm0.3)\cdot10^{-3}$ sr^{-1}, $(1.4\pm0.2)\cdot10^{-1}$, respectively. Seasonal behaviour of optical parameters in two atmospheric layers (1-2 km and 2-5 km) have been select to allow a comparison with same parameters retrieved from regular measurements [6]. In the first layer lidar ratio, OD and IB for Saharan dust events are quite similar to those corresponding to regular measurements, while there is a sensitive change of these parameters in the second layer. In particular, during Saharan dust outbreaks we have observed a reduction for LR and a rise for both OD and IB.

Finally, from preliminary analysis on backtrajectories (from German Weather Service) five main trajectories have been found for incoming air masses from Sahara, and some correlative differences in optical properties have been found as well. In particular, for Sud to Nord air masses back-trajectories mean lidar ratio was 38 sr, smaller than for other cases (variable between 46 sr and 57 sr).

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