Origin, size distribution and chemical composition of the Saharan dust particles collected in the North Atlantic free troposphere at Izaña Atmospheric Observatory

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Keywords: Saharan dust, size distribution, chemical composition, GAW, Izaña.

The Sahara is the most important source of soil dust in the world, with estimated emissions within the range 150-700 millions of tonnes / year (Goudie and Middleton, 2001). Saharan dust is mostly westward transported to the North Atlantic Ocean, where it interacts with atmospheric, oceanic and biogeochemical processes, with implications on climate and ecosystems. Moreover, dust produces air quality impairment and it has been associated with health effects on human health (Perez et al., 2008). Impact of dust may be influenced by the degree and type of mixing of the mineral compounds with other (anthropogenic or not) aerosol species. For a proper understanding and quantification of the impact of the Saharan emissions on the Earth system, a detailed knowledge on the dust physical and chemical properties is required. In this study, a physicochemical characterization of the Saharan dust particles transported to the subtropical North Atlantic free troposphere is exhibited.

We present the data base of aerosol chemical composition and size distribution produced at Izaña Observatory within the framework of the Global Atmospheric Watch (GAW) program. This site is located at 2367 m.a.s.l. (metres above sea level) in Tenerife (Canary Islands) and is representative of the free troposphere. The site is placed in the North Atlantic, at about 400km distant to the Western Sahara. The data set includes:

(1) mass concentrations and chemical composition of TSP, PM_{10} and $PM_{2.5}$ (PM_x), including major and trace elements (organic matter, elemental carbon, $SO_4^{=}$, NO_3^{-}, NH_4^{+}, Cl^{-}, Al, Ca, K, Na, Mg, Fe, P, Li, Be, Sc, Ti, V, Cr, Mn, Co, Ni, Cu, Zn, Sr, Cs, Ba, La, Ce and Pb), obtained by sampling on filter and laboratory analysis,
(2) water solubility of mineral dust components, obtained by sampling on filter and laboratory analysis,
(3) number size distribution from 10 nanometre to 20 microns measured with an Scanning Mobility Particle Sizer (SMPS) and an Aerodynamic Particle Sizer (APS).

These data cover the period from 2002 to 2009.

The following results are presented:

- chemical characterization, mass closure and compound contribution to total dust mass and to total aerosol mass,
- degree of mixing of dust with other non-soil compounds,
- number and mass size distribution of dust particles,
- origin region of the dust and aerosol compounds transported from Sahara,
- origin of the observed seasonal evolution,

Concentrations of PM_x at Izaña may experience large variations in short time periods. Under the prevailing NW free troposphere conditions, hourly PM_x concentrations are regularly lower than 5 $\mu g/m^3$ (~70^{th} percentile for PM_{10}). Abrupt increases in PM_x concentrations are observed when air from North Africa reaches the observatory. In these cases, daily mean concentrations as high as 680 $\mu g/m^3$ of TSP, 340 $\mu g/m^3$ of PM_{10} and of 120 $\mu g/m^3$ of $PM_{2.5}$ has been recorded.

As average, the chemical determinations in the presented data base accounts for 95-99% (mass closure) of the TSP, PM_{10} and $PM_{2.5}$ concentrations determined by gravimetry (via filter sampling). Similarly, mineral dust accounts for 85-98% of TSP, PM_{10} and $PM_{2.5}$ as average. The proportion (%) of mineral dust increases when PM_x levels increase.

As an example, Figure 1 shows the monthly average values of TSP, PM_{10} and $PM_{2.5}$ at Izaña during the study period (2002-2009). The July-August maximum observed every year is strongly related to the seasonal shift of the meteorological conditions, and to dust production and exportation regions. The source region of dust is studied by using back-trajectories and by comparing the chemical profile of the dust samples collected at Izaña with the chemical profile of size segregated soil samples collected in different regions of the Sahara.

Data on chemical composition are consistent with size distribution data obtained with the APS and SMPS. It is observed that the $PM_{2.5}/PM_{10}$ dust ratio is less variable than the PM_{10}/TSP dust ratio. Moreover, the APS data shows that very high dust concentrations events are associated with extraordinary increases in the >10 µm particle concentrations. This suggests that >10 µm particles may be significantly involved in very extremely high dust concentrations episodes.

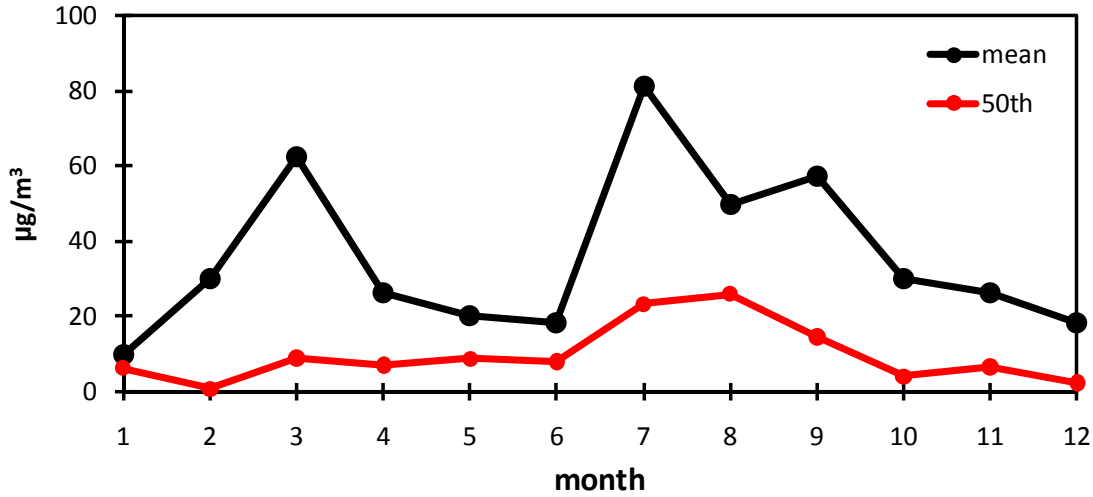

Figure 1. Monthly mean and 50^{th} percentiles of TSP concentrations at Izaña (2002-2009).

This study has been performed within the framework of the project GRACCIE (CSD2007-00067) and the GAW program financed by AEMET.

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