



Boundary layer aerosol size distribution, mass concentration and mineralogical composition in Morocco and at Cape Verde Islands during SAMUM I-II

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The Saharan Mineral Dust Experiment (SAMUM) is dedicated to the understanding of the radiative effects of mineral dust. Two major field experiments were performed: A first joint field campaign took place at Ouarzazate and near Zagora, southern Morocco, from May 13 to June 7, 2006. Aircraft and ground based measurements of aerosol physical and chemical properties were carried out to collect a data set of surface and atmospheric columnar information within a major dust source. This data set combined with satellite data provides the base of the first thorough columnar radiative closure tests in Saharan dust. A second field experiment was conducted during January–February 2008, in the Cape Verde Islands region, where about 300 Tg of mineral dust are transported annually from Western Africa across the Atlantic towards the Caribbean Sea and the Amazon basin. Along its transport path, the mineral dust is expected to influence significantly the radiation budget – by direct and indirect effects – of the subtropical North Atlantic. We are lacking a radiative closure in the Saharan air plume. One focus of the investigation within the trade wind region is the spatial distribution of mixed dust/biomass/sea salt aerosol and their physical and chemical properties, especially with regard to radiative effects.

We report on measurements of size distributions, mass concentrations and mineralogical composition conducted at the Zagora (Morocco) and Praia (Cape Verde islands) ground stations. The aerosol size distribution was measured from 20 nm to 500 μm . The size range of 20 nm < d < 10 μm was investigated by a DMPS/APS combination, whereas particles with 3 μm < d < 500 μm were measured by impactor collection on coated glass substrates and automated microscopic image analysis of the individual particles. The DMPS/APS combination was measuring quasi-continuously; the large and giant particle range was investigated once to twice a day. Mass concentrations were measured by filter gravimetry. For total suspended particles (TSP) an isoaxial, quasi-isokinetic sampler was used. For PM₁₀ and PM_{2.5} equivalents an omni-directional sampler with a pre-separator was used. The mineralogical composition was determined by X-ray diffraction from the filter samples.

The measurements in Morocco showed that large variations due to local and regional mineral dust emissions could be observed. Mainly local production of dust contributed to the giant particles and significant portions originating from advection contributed to the concentration of the smaller ones. The size distributions show signatures of anthropogenic influence in the submicron range for particles less than 500 nm. Under high dust concentrations, giant particles with d > 10 μm account for more than 90 % of the total airborne aerosol mass. The largest variations were found in the giant particles range above 100 μm during dust storm conditions. The measurements on the Cape Verde Islands show moderately enhanced concentration levels during the course of Saharan dust outbreaks. Ultra-giant particles are extremely reduced due to the long-range transport of more than thousand kilometers compared to the source-near distributions.

In the Saharan desert, mass concentrations ranging from 30 $\mu\text{g}/\text{m}^3$ to 1000 $\mu\text{g}/\text{m}^3$ for PM_{2.5} and from 90 $\mu\text{g}/\text{m}^3$ to 230,000 $\mu\text{g}/\text{m}^3$ for TSP were measured, representing a range from desert background conditions to moderate a dust storm. At Cape Verde islands, PM_{2.5} values between 5 and 180 $\mu\text{g}/\text{m}^3$ and TSP between 30 and 540 $\mu\text{g}/\text{m}^3$ have been found, representing a range from clean maritime situations to significant dust advection. In the desert, TSP dust concentrations are correlated with the local wind speed, whereas PM₁₀ and PM_{2.5} concentrations are determined by advection from distant sources. At Cape Verde, a weak anticorrelation of dust concentration and wind speed exists, indicating during dust events a decoupling of the boundary layer from the free troposphere by

decreased radiative heating and, thus, reduction of convection. In Morocco, the relation between TSP and PM10 had a geometric mean of 5.7, showing the presence of many large particles, whereas the value of 1.5 at Cape Verde indicates the sedimentation of these particles during transport. For PM10/PM2.5, values of 3.7 in the desert and 2.6 at Cape Verde were measured.

Major mineralogical constituents of the dust at Tinfou are quartz, potassium feldspar, plagioclase, calcite, hematite, and the clay minerals illite, kaolinite, and chlorite. During dust storms, the quartz content is elevated, showing the presence of many large particles carried by the wind. Except from this effect, only a small temporal variability of the bulk mineralogical composition was encountered. On Cape Verde, quartz, potassium feldspar, plagioclase, calcite, gypsum, and clay minerals (their detailed composition still has to be determined) are found.