Size distribution, mineralogical and chemical composition of Saharan mineral dust at Tinfou, Morocco (SAMUM, 2006)

K. Kandler[1], C. Deutscher[2], M. Ebert[1], H. Hofmann[1], S. Jäckel[1], P. Knippertz[2], A. Maßling[3], A. Schladitz[3], L. Schütz[2], S. Weinbruch[1]

Introduction

The Saharan Mineral Dust Experiment (SAMUM) is dedicated to the understanding of the radiative effects of mineral dust. A joint field campaign focused on the source-near investigation of Saharan dust was carried out in southern Morocco. Ground based measurements were a performed near Tinfou and at the Ouarzazate airport; airborne measurements were carried out onboard a Falcon and a Partenvia aircraft. Together with Satellite observations, these measurements ranged from May 11th to June 7th, 2006.

This presentation gives a summary on physical and chemical parameters of the boundary layer aerosol, which are important part of the columnar determination of the desert dust radiative effects. Measurements of aerosol size distribution, mass concentration, and mineral composition are presented as well as an example of detailed analyses for a selected single day (May 19th, 2006).

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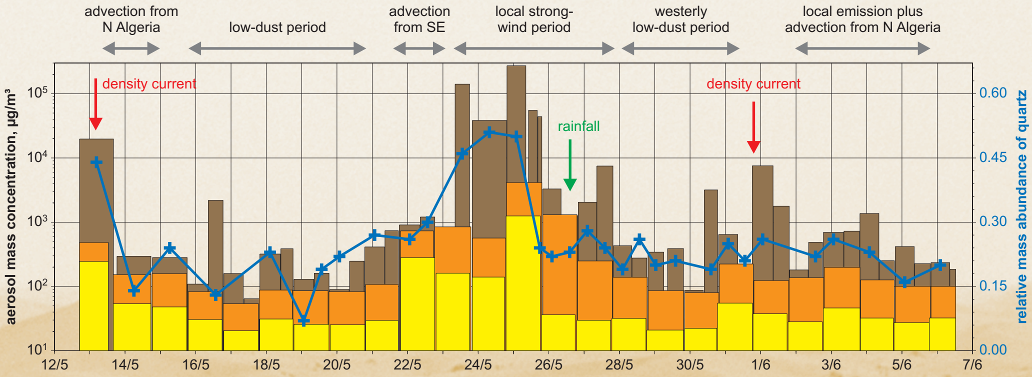
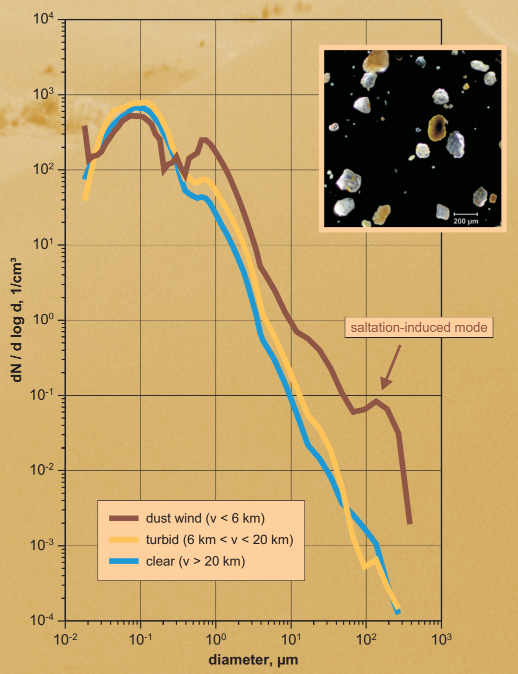


Time-series of aerosol mass concentrations at Tinfou

The bars show the aerosol mass concentrations (yellow "$PM_{2.5}$", orange "PM_{10}", and brown total suspended matter). The blue line reflects the relative mass abundance of quartz derived from x-ray diffractometry. In addition, the dominant weather situations are shown.

Various atmospheric conditions were encountered during the measurement period: For clear atmospheric conditions, mass concentrations of approximately 100 µg m^{-3} for total, 80 µg m^{-3} for "PM_{10}" and 30 µg m^{-3} for the "$PM_{2.5}$" were found. During moderate dust storms, concentrations of up to 300000 µg m^{-3}, 3000 µg m^{-3} and 1000 µg m^{-3}, respectively, were found. The largest concentration variations were observed for the total suspended matter. Under higher dust concentrations the "PM_{10}" and "$PM_{2.5}$" fraction is only of minor importance. The particle fraction with d > 100 µm can account for more than 95 % of total aerosol mass under high concentrations. The relative quartz content of the aerosol shows similar tendencies like the total suspended matter indicating the dominance of quartz grains within the giant particle fraction.
The maximum of May 25th/26th is caused by a large convective system with high local wind speeds up to 16 m/s.

On May 13th and 31st high concentrations were caused by local and regional high wind speeds stimulated by density currents which emerged from the Atlas mountains. The dust front on May 31st, caused by a density current passing directly the measurement location, was observed in detail. Repeated density currents occurred to the NE between June 2nd and 5th. Advection from North Algerian sources caused higher concentrations around May 16th. Various large scale SE sources contribute to elevated concentrations on May 22nd. A more detailed analysis on meteorology and the density currents in particular is given by Knippertz et al. (2007).



Aerosol size distributions at Tinfou

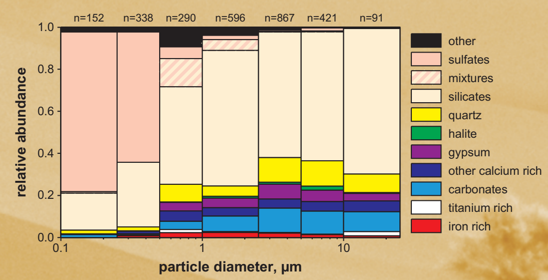
The size distributions were averaged according to measured visibility (v) in three categories: clear, turbid, and dust wind conditions.

The aerosol size distribution was measured with a combined scanning mobility particles sizer/aerodynamic particle sizer system in the sub micron range beginning at 20 nm particle diameter, and with a nozzle impactor/free-wing impactor system followed by automated optical microscopy in the super micron range up to 500 µm. The sample image gives an impression of the giant particles encountered.

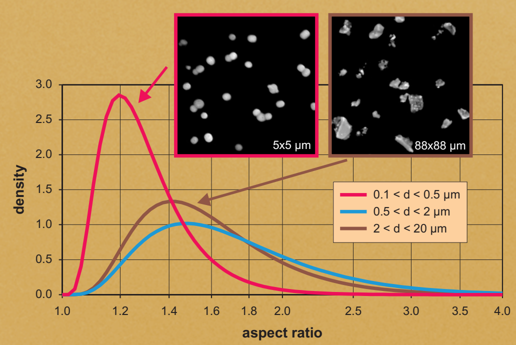
Independently of the atmospheric conditions a maximum is found around 80 nm particle diameter. Below 300 nm the size distributions follow a rather similar pattern. Major sulfur components within this range indicate anthropogenic origin. For clear and turbid conditions the size distributions are quite close. However, during dust wind greatly enhanced concentrations are observed above particle sizes of 300 nm. A relative maximum is found at approximately 150 µm, which is probably related to to saltation generated particles under strong-wind conditions.

Relative chemical composition of atmospheric aerosol at Tinfou for May 19th, 2006

The relative abundance of the chemical particle classes is determined in the scanning electron microscope. Chemical information (analysis of the characteristic X-ray spectrum) and morphological information leads to the shown particle classes.



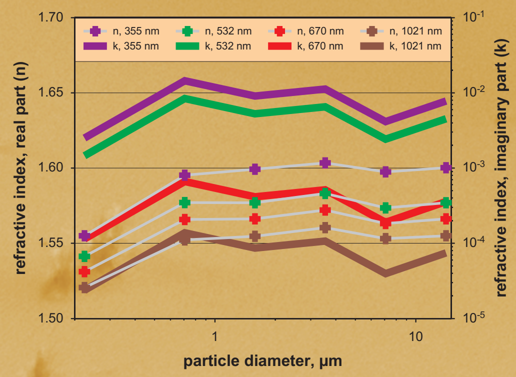
Below 500 nm particle diameter the aerosol is dominated by sulfate particles. The relative abundance of the mineral dust increases towards larger particles. At 2.5 µm and above mineral dust is nearly the sole aerosol component. Within the mineral dust, three major particle type are identified: the silicate fraction, quartz and calcium-dominated matter. Whereas below 10 µm particle diameter the quartz/silicates ratio is more or less constant, the ratio of the calcium-dominated particles to the silicates varies around nearly one order of magnitude, depending on the source region of the dust. The relative abundance of the iron-rich particle shows a smaller variation for this aspect.



Aspect ratio density distribution for three size ranges at Tinfou on May 19th, 2006

Aspect ratios for all individual particles were determined in the scanning electron microscope by fitting an ellipse to the particle shapes. The two images illustrate the particle morphology in the submicron (left) and supermicron range (right).

The aspect ratios of the particles can be parametrized very well with a log-normal distributon function. In the submicron range the particles are dominated by sulphate, according to their morphology evaporated droplets. Accordingly, the aspect ratio distribution is rather narrow with a median around 1.3. In the supermicron range the mineral dust leads to a broader aspect ratio distribution with a median around 1.6. The transition range in between shows a very broad aspect ratio distribution reflecting a complex aerosol composition.



Particle refractive index as function of particle diameter for several wavelengths

Crosses represent the real part (left axis), colored lines the imaginary (right axis).

The refractive index of the particles was derived by re-modeling the measured particle chemical composition by a simplified composition, consisting of an "average" silicate, quartz, calcite and hematite. Using refractive indices of these materials found in literature as well as measured within the SAMUM project and applying a volume mixture rule, the refractive index was calculated.

Low values of both real and imaginary part are caused by the sulfate-dominated chemical composition in the submicron range. The increase towards larger particle sizes reflects the chemical composition changing to mineral dust dominance. For this calculation, all absorption is assumed to be caused by hematite, titanium-bearing and other particles are neglected. Thus, the uncertainty of these values has to be assumed rather high.

Affiliations
1 Applied Geosciences, Darmstadt University of Technology, Darmstadt, Germany
2 Physics of the Atmosphere, Johannes Gutenberg University, Mainz, Germany
3 Institute for Tropospheric Research, Leipzig, Germany

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Reference
P. Knippertz, D. Althausen, A. Ansmann, T. Dinter, W. von Hoyningen-Huene, D. Müller, M. Tesche (2007): Synoptic Aspects of Dust Emission and Transport during the Saharan Mineral Dust Experiment SAMUM 2006. Poster at IUGG 2007, MS004, 7598.