Chemical and mineralogical composition of Saharan dust over southeast Morocco

K. Kandler[1], C. Deutscher[2], M. Ebert[1], H. Hofmann[1], S. Jäckel[1], A. Petzold[3], L. Schütz[2], S. Weinbruch[1], B. Weinzierl[3], S. Zorn[2]

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 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 were performed from May 13th to June 7th, 2006.

Airborne as well as ground based samples were collected with a miniature impactor system on carbon coated substrates and carbon foils; additionally, filter samples for determination of the aerosol mass concentration were collected. The size-resolved particle aspect ratio and chemical composition is determined by means of electron-microscopical single particle analysis.

This map gives an overview of four situations encountered during the SAMUM 2006 field campaign:

- In yellow color: May 18th, 2007: outbreak of dust reaching the Iberian peninsula.
- Blue: June 3rd/4th, 2007: Mediterranean cold air masses flowing southwest parallel to the Atlas mountain range; dust from the Chott El Djerid arrives in the measurement region.
- Red: June 22nd, 2007: Dust advection from southeast with high dust concentrations
- Green: May 19th, 2007: Desert background situation.

The chemical composition graphs shown for different altitudes are based on particles between 1 and 2.5 µm in diameter. However, the chemical composition changes significantly for particles smaller than 1 µm.

Legend

Sample location of Falcon aircraft

Sample location of Partenavia aircraft

Tinfou ground station

May 18th, 2007

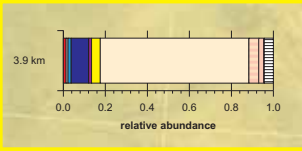
May 19th, 2007

May 22nd, 2007

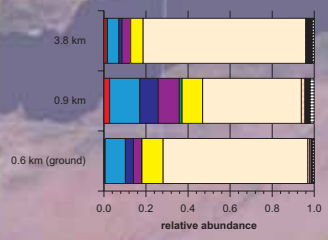
June 3rd, 2007

chemical particle classes

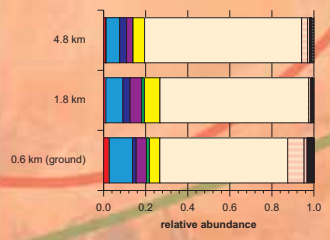
- other
- carbonaceous
- mascagnite
- sulfates
- mixtures
- silicates
- quartz
- halite
- gypsum
- other calcium rich
- carbonates
- titanium rich
- iron rich



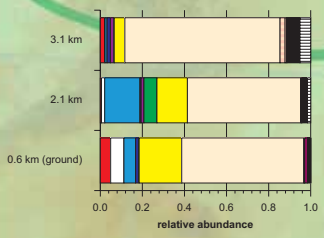
On May 19th, 2007 the Falcon captured an outbreak of Saharan mineral dust reaching the Portuguese coast. The chemical composition shows an average calcium content and rather low values for quartz. In spite of the transport over sea, no halite can be detected indicating that the air masses investigated were decoupled from the marine boundary layer during the whole transport.



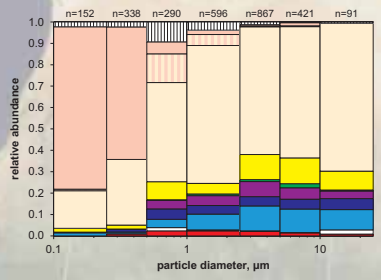
On June 3rd and 4th, 2007, dust from the Chott El Djerid arrives over Tinfou. High concentrations of gypsum and calcite as well as the presence of halite give evidence of this source.
On June 3rd, the concentration of the calcium-rich particles are elevated mainly in altitudes of a few hundred meters above ground. On June 4th (not shown), the calcium content is elevated all over the mineral dust layer up to 4 km.



On May 22nd, 2007 air masses from southeast and east arrive in the measurement region. The chemical composition during this phase of the experiment is close to the average composition encountered in south east Morocco.



May 19th, 2007 shows quite low total dust concentrations and high visibility, so it can be considered as a "desert background" situation without any strong prevailing dust source. Note the high halite concentrations found at 2.1 km above sea level, which indicate an influence of marine air masses. This example also demonstrates, that the horizontal variability in aerosol composition over the Sahara is high, as it was taken approximately 100 km west of the 3.1 km sample.



Tinfou ground station: Size-resolved chemical composition for May 19th, 2007. The mineral dust is the dominant species for particles with sizes above 500 nm. Below 500 nm, however, the sulfates - mainly ammonium sulfate - and a variable, but small fraction of nitrates are prevalent.

Conclusions

Different source regions produce different aerosols, which can easily distinguished by chemical measurements. Even within the well mixed mineral dust layer above the Sahara, simultaneous aircraft measurements at locations 100 km apart can exhibit significant differences in chemical composition.

The electron-microscopical analysis shows, that the most important mineral dust component in terms of radiation interaction - the iron components like hematite, goethite, etc. - occurs in two ways: as small single particles with very high iron and - with a varying fraction - titanium contents and attached to or incorporated into large silicate particles. Both kinds of occurrence could have different radiative impacts.

Outlook

From the measured chemical data, a simplified model mineralogy will be derived. From this model mineralogy, the refractive index - resolved in terms of particle size and sampling location/time - will be calculated. These values will be incorporated in the radiation transfer models within the SAMUM research group.

Affiliations
1 Applied Geosciences, Darmstadt University of Technology, Darmstadt, Germany
2 Physics of the Atmosphere, Johannes Gutenberg University, Mainz, Germany
3 Institute of Atmospheric Physics, German Aerospace Center, Wessling, Germany

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The map is based on the "Blue marble" true-color satellite image mosaic, which is available from NASA Earth observatory (http://earthobservatory.nasa.gov/Newsroom/BlueMarble/).