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Lidar Observations During the Saharan Mineral Dust Experiments 1 and 2

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Polarization Raman lidar measurements at various wavelengths were performed during the Saharan Mineral Dust Experiment (SAMUM) 1 and 2 to study the optical properties of desert dust aerosol. SAMUM 1 at the airport of Ouarzazate (30.9° N, 6.9° W, 1133 m height above sea level, asl) in southern Morocco was devoted to the investigation fresh desert dust. SAMUM 2 at the airport of Praia (15.0° N, 23.5° W, 75 m height asl), Cape Verde focussed on the characterization of a mixture of aged dust from North Africa and biomass burning aerosol from Central Africa. A large dataset of optical, microphysical, and radiative properties of the respective aerosol types has been collected.

From the BERTHA measurements at Ouarzazare during May–June 2006 multiwavelengths information of backscatter and extinction coefficients, and the resulting lidar ratio were derived. The statistical analysis of the SAMUM 1 dataset reveals that the dust layer depth typically reaches 4–6 km height asl, sometimes even 7 km asl. A vertically inhomogeneous dust plume with internal dust layers was usually observed in the morning before the evolution of the boundary layer starts. The Saharan dust layer was well–mixed in the early evening. AERONET observations of these layers showed an optical thickness ranging from 0.2–0.8 (at 500 nm, mean value 0.32). Ångström exponents derived from photometer and multiwavelengths lidar data were between 0–0.4. The volume extinction coefficients (355 nm, 532 nm) varied from 30–300 Mm^{-1} with a mean value of 100 Mm^{-1} in the lowest 4 km asl. On average, extinction–to–backscatter ratios of 53–55 sr ($\pm$ 7–13 sr) were obtained at 355 nm, 532 nm, and also at 1064 nm. The latter value was derived by combining Sun photometer observations of the particle optical depth at 1020 nm and the lidar–derived backscatter coefficient at 1064 nm. Dust particle depolarization ratios were as high as 30–35% at 532 nm. Mean profiles as well as profiles of the respective standard deviations and of extreme values of the lidar ratio at 355, 532, and 1064 nm and of extinction–related and backscatter–related Ångström exponents were obtained.

During January–February and May–June 2008 measurements were performed at Cape Verde, about 500 km west of the African mainland. Before arriving at the SAMUM 2 site Praia airport the observed aerosol layers were transported over more than 1500 km from their source regions. SAMUM 2 winter (Jan/Feb) lidar measurements show a typical aerosol stratification that can be observed by means of intensive parameters like lidar ratio, depolarization ratio or the Ångstöm exponent. We observed marine aerosol in the lowermost 500 m topped by deep layers dominated by dust (from North Africa) and by biomass burning aerosol (from Central Africa), respectively. Depending on the flow pattern we also observed a constellation of marine and biomass burning aerosol only. Soundings performed at the measurement site show that the relative humidity is rather low within the Saharan dust layer while it shows various values in the layer of biomass burning aerosols. Profiles of the 355/532 nm extinction related Ångstöm exponents show values of 0.5–1.0 (small submicron particles) within the layers that are dominated by biomass burning aerosols. Ångstöm exponents of pure desert dust during SAMUM 1 were found to be around zero. The particle depolarization ratio shows values around 30 % in the Saharan dust layer and about 12–18 % within the biomass burning plume. With the results obtained during SAMUM 1, this quantity can be used to clearly separate between the contribution of Saharan dust and biomass burning aerosols to the measured backscatter coefficient. For the number of cases we investigated so far, a fraction of 30–50 % of dust was found within the biomass burning

plume from Central Africa.
The summer (May/Jun) measurements show similar conditions than were observed during SAMUM 1 in Morocco. Now the marine boundary layer is topped by deep dust layers up to heights of 6 km asl that were advected from North Africa. Volume extinction coefficients varied from 50–300 Mm^{-1} with a mean value of 100 Mm^{-1}. Dust lidar ratios are in the range of the SAMUM 1 observations. Ångström exponents of the extinctions coefficients showed values around unity within the strongly depolarizing dust layers. However, a detailed analysis of the SAMUM 2 measurements will be performed in the next months.