Geophysical Research Abstracts
Vol. 12, EGU2010-**PREVIEW**, 2010
EGU General Assembly 2010

Atmospheric dust charging, vertical profiles and optical properties measured in the Arabian Peninsula during the DREAME campaign

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Polarimetric observations of atmospheric Saharan dust over the Canary Islands have provided strong evidence for the presence of vertically aligned particles. The alignment was thought to be due to the electric field present because of dust charging. It was concluded that the charging and consequent partial alignment could be a common feature of atmospheric mineral dust layers, influencing the optical properties of dust layers and possibly also dust transport (Ulanowski et al. Atmos. Chem. Phys. 7, 6161, 2007). We show preliminary results from the DREAME campaign, aimed at investigating these phenomena.

DREAME used simultaneous and collocated measurements from specially developed aerosol radiosondes, and ground-based sun photometers and electric field meters. The radiosondes provided vertical profiles of dust size distribution and electric charge density, in addition to standard meteorological parameters (Ulanowski et al. EGU 2010, AS3.16). The electric field was measured in Kuwait between late April and November 2009, and at Solar Village (Riyadh, Saudi Arabia) between May and June 2009. The measurements were supplemented by satellite retrievals of aerosol properties. Similar measurements but without electric field meters were carried out on Cape Verde Islands in August 2009 (Nicoll et al. EGU 2010, AS4.7).

The electric field measured on the ground in Kuwait showed strong variability, particularly in the presence of atmospheric dust, when polarity reversals from the normal positive potential gradient (PG) clear-sky pattern were frequently observed. In the absence of clouds the negative PG excursions were often down to -800 V/m and reached -1300 V/m. The PG was strongly correlated with the aerosol optical thickness (AOT) from the sun photometer: the correlation coefficient was about –0.51 at visible and near infra-red wavelengths and a few percent less in the UV. Slightly lower correlation was present for satellite AOT: -0.4 for MODIS AOT at 550 nm, and -0.3 for OMI AOT at 483.5 nm. On average, the PG decreased by 200 V/m for unit AOT increase. In contrast, the PG measured at Solar Village showed weaker correlation with AOT - about -0.3, with much fewer strong negative PG excursions but some positive ones instead.

There were three radiosonde launches in Kuwait, two of which were successful. The size distribution profiles showed dust present mainly in the boundary layer, although on the 1st June a second less dense layer was present between 2.2 and 5.2 km. The dust was accompanied by electric charges with densities up to about 100 pC per cubic metre. However, the charge sensor saturated in the lower, more dense layers, so it is likely that larger values were present. Negative space charge dominated, in agreement with the negative PG found from ground-based measurements. The measured size distributions showed good agreement with AERONET ones and good closure with AOT. Three soundings on Cape Verde Islands (Nicoll et al. EGU 2010, AS4.7) also showed dust predominantly in the boundary layer, and in one sounding dust just above the boundary layer dominated. In all four cases charging was present, with densities typically up to 15 pC per cubic metre.

It is concluded that atmospheric mineral dust was generally accompanied by electric charging, and the field may in some cases reach sufficiently high values for dust particle alignment to occur.