Effect of Charging on Radiative and Transport Properties of Atmospheric Mineral Dust

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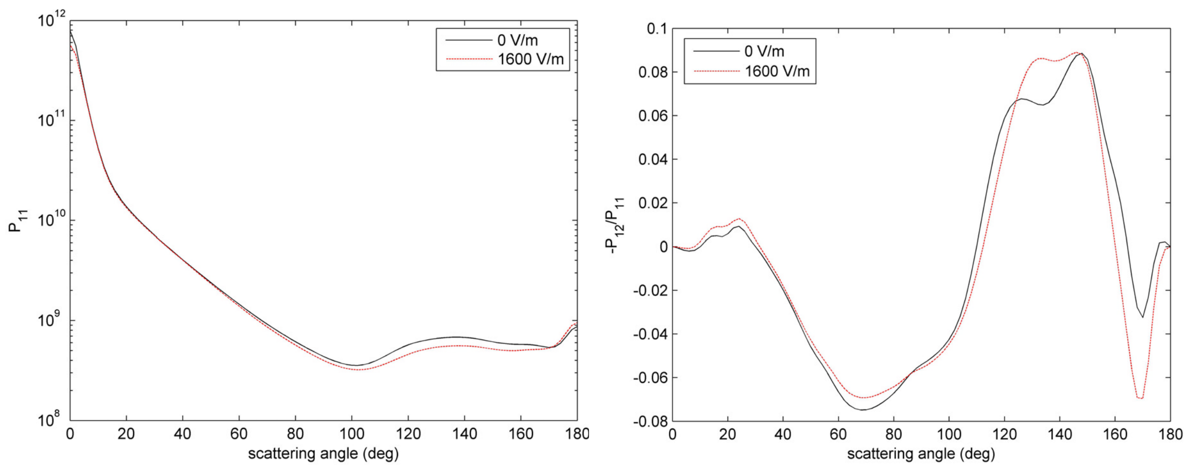
Recent polarimetric observations of atmospheric Saharan dust on La Palma, Canary Islands, have provided strong evidence for the presence of vertically aligned particles. The alignment was thought to be due to electric field present because of dust charging. It was concluded that partial alignment was likely to be a common feature of atmospheric mineral dust layers, and suggested that the alignment and the associated electric field could modify dust transport by altering particle fall speeds and aiding the retention of larger particles (*Atmos. Chem. Phys.* 7, pp.6161-6173, 2007).

We carry out a preliminary investigation of the influence of the alignment on the scattering properties of dust layers, including polarization. We use the T-matrix method (*Appl. Opt.* 39, pp. 1026-1031, 2000) for prolate spheroids of aspect ratio 1.5. Aerosol size distributions and refractive index for modelling are obtained from AERONET sun photometer in Santa Cruz. This data is combined with size-dependent orientation distributions calculated for predicted electric field strengths. The modelling indicates that the alignment can significantly alter the optical thickness of the dust layer, leading to a "Venetian blind effect" dependent on the strength of the electric field. For example, shortwave optical thickness in the vertical direction can change due to the alignment by about 7% for the observed Saharan dust layer case. The phase function is estimated to change by up to 27% in forward scattering and 20% at larger scattering angles. Changes in polarization due to alignment are also significant, particularly at larger angles; they are similar in magnitude to those caused by the removal of 33% of the size distribution by volume. These differences can have significant impact on remote sensing retrievals of dust properties, particularly from satellite platforms.



Unnormalized phase functions (left) and degree of linear polarization (right) for non-aligned (no electric field) and aligned dust (1600V/m field), modelled for the La Palma case. The wavelength is 780 nm.

We also investigate the influence of dust charging on dust transport using a coupled bin, one-dimensional dry deposition model including electrostatic effects. Charge densities typical of previous observations are used, and it is further assumed that large and small particles have opposite polarities. The model results can be summarised as follows. As postulated, a neutral dust layer gravitationally separates into a stable, small particle layer at top, and oppositely charged large particle layer below. Charge density in a mature layer locally reaches -10^{-9} C/m^3 (initially $-4 \cdot 10^{-12}$ C/m^3). The electric field reaches a peak value of about 20 kV/m at the boundary between the small and large particle layers. Most importantly, dry deposition of larger particles is found to be significantly retarded by the field. For example, mass loss after 4 days can be only 18%, in contrast to 50% without charging, for a layer at 1.3 km.