Geophysical Research Abstracts
Vol. 13, EGU2011-9167, 2011
EGU General Assembly 2011

Diagnosing the Electrical Structure of Dust Devils

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Convective vortices such as dust devils are a major contributor to atmospheric dust loads in the arid regions of Earth and Mars. Previous studies conducted at the Eldorado Valley Dry Lake Bed outside of Boulder City in Nevada and elsewhere have shown that saltating sand, dust devils, and dusty gust fronts are strongly electrified. Electrification may play a significant role in the ability of these atmospheric phenomena to lift dust into the air. The present study is concerned with the vertical electrical structure of the electric fields in dust devils, and ultimately with the physical mechanism that generates the electric fields. To resolve the vertical electric fields, we placed a 10-meter tower with electric field sensors at four levels (0.2 m, 2 m, 5 m, and 10 m above the surface), a sonic anemometer to measure 3-D wind speed, and a Prandtl probe to measure the static and stagnation pressures. To mitigate the shielding effects of the tower, the presence of a uniform electric field in undisturbed (fair weather) conditions is assumed. When a dust devil encounters the tower, the adjusted electrical field values are first-differenced to estimate space charge density versus height from Poisson's equation. The results show evidence for positive charge at the lowest height (< 2 m) and negative charge at higher levels. Various electrostatic models that could account for the observations will be discussed in this presentation.