Diagnosing the Electrical Structure of Dust Devils

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Dust Devils, columns of rotating dust caused by convective vortices, 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, NV 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 dust devil, and ultimately with the physical mechanism for their electrification. To resolve the vertical electric field, our team fitted a 10-meter tower with electric field mills at four levels (0.2, 2, 5, and 10 meters), a sonic anemometer to measure 3-D wind speed, and a Prandtl probe to record static and stagnation pressures. To eliminate shielding effects from the tower, the presence of a uniform electric field is assumed in undisturbed (fair weather) conditions. When a dust devil encounters the tower, the corrected electrical field magnitudes 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 meters) and negative charge at higher levels. Various electrostatic models are considered to account for the observations.

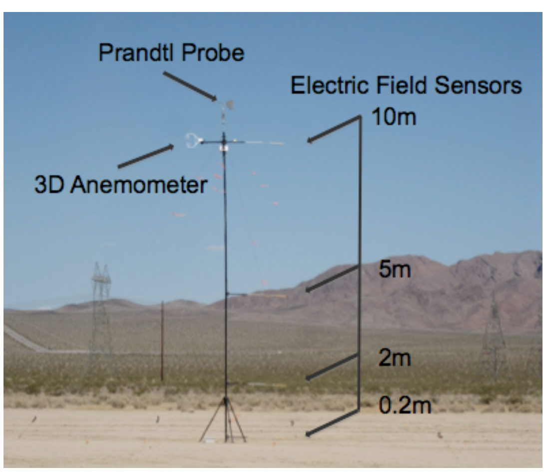

Figure 1. 10-meter tower with electric field mills, 3-D sonic anemometer, and Prandtl probe shown.

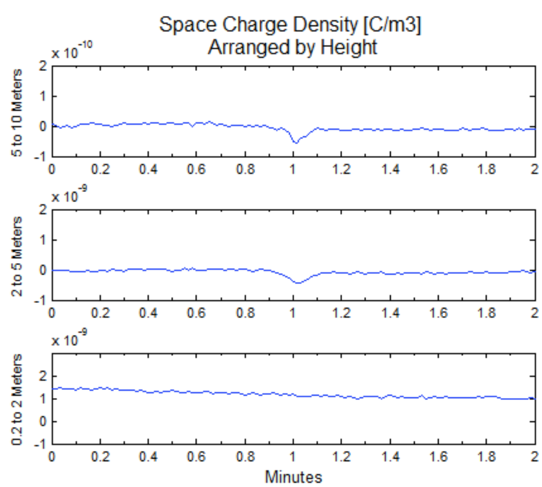

Figure 2. Space charge density of a dust devil encounter in Eldorado Valley, NV on July 1, 2010