MODELING ELECTRIC FIELD GENERATION IN MARTIAN DUST DEVILS. E. L. Barth[1], W. M. Farrell[2] and S.C.R. Rafkin[1], [1]Southwest Research Institute, 1050 Walnut St. Suite 300, Boulder, CO 80302, ebarth@boulder.swri.edu, [2] NASA Goddard Spaceflight Center, Greenbelt, MD.

Introduction: Dust charging studies with Mars soil simulant [1,2] suggest triboelectric charging of dust is very possible on Mars. A typical terrestrial dust devil has been found to generate macroscopic electric field perturbations in excess of 100 kV/m [3]. Once charged, some of these grains are injected further into the air where they are transported upward by atmospheric currents. Differential transport and gravitational sedimentation sorts the dust devil aerosols so that the lighter and predominantly negatively charged particles populate the higher portion of the disturbance while the heavier, positively charged particles fall to the ground or remain in the lower portion of the vortex.

We have added triboelectric dust charging physics via the Macroscopic Triboelectric Simulation (MTS) code to the Mars Regional Atmospheric Modeling System (MRAMS) in order to simulate the electrodynamics of dust devils and dust disturbances on Mars. Using the model, we explore how macroscopic electric fields are generated within storms and attempt to quantify the time evolution of the electrodynamical system.

Modeling: MRAMS is a nonhydrostatic model which permits the simulation of atmospheric flows of large vertical accelerations, such as dust devils. Dust particles are represented by discrete mass bins; each bin is carried in the model as a scalar species that can be advected and diffused. The dust lifting scheme includes multi-size dust transport capability. The dust surface source is parameterized based on the work of [4,5]. Laminar wind and dust devil lifting are implicitly included in this single scheme. Dust devils occupy the tail end of theWeibull distribution in unstable (Ri<0) conditions. MTS quantifies charging associated with swirling, mixing dust grains. Grains of predefined sizes and compositions are placed in a simulation box and allowed to move under the influence of winds and gravity. The model tracks the movement of grains in prevailing winds and charge exchange upon grain-grain collision. The composition of the grains is also a predefined variable and we impose a compositional mix to maximize the triboelectric surface potential difference between larger and smaller grains. Specifically, we apply the grain/grain contact electrification algorithm presented in [6]. Information describing each MTS dust particle (i.e., charge, radius, and mass) are fed into the MRAMS dust lifting scheme for each MRAMS model grid-point (Fig. 1). The coupled model enables the ability to simulate charging with a fully dynamic model in a manner that allows the wind field, dust distribution, and charging to be physically consistent.

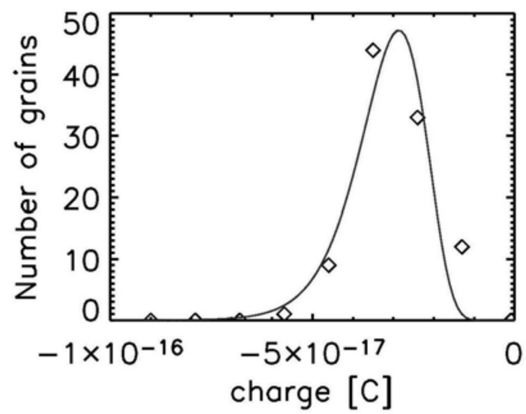

Figure 1: Each of the MTS dust grains are sorted into the microphysics mass bins, and a log-normal function is fit to the charge data. The first and second moments of the charge distribution are sent as tracers to MRAMS so that as the dust grains move around in the MRAMS domain, the charge distribution across a particle size bin can be reconstructed at any point.

Simulation Results: The coupled model is run over a 15 km x 15 km domain up to a height of about 8 km. The MTS dust particles are classified as either metals or silicates based on their charge sign (negative or positive, respectively). The metals range from 0.5 – 2m in radius, with most particles having a radius of 1m; the silicates are 2 – 100m in radius, with the peak of the size distribution at 4m. Because the silicates are much less dense than the metals, the smaller silicate particles fall at speeds comparable to the metal particles. A number of neutral particles are also present. The charge on individual particles ranges from about 10^{-18} to 10^{-15} C. There are about 3 times as many metal grains as silicates, but the entire population of the surface dust reservoir is net neutral. The atmosphere is initialized using temperature and wind profiles from a Viking 1 landing site LES model at approximately 10:00 LMST.

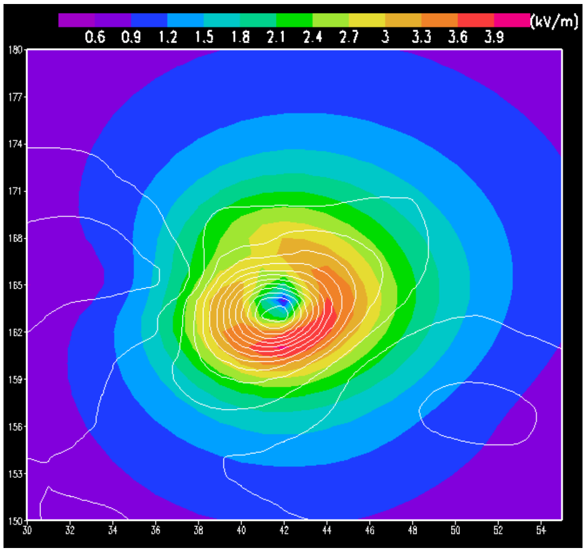

Figure 2. Electric field (colored contours) generated by a dust devil, shown in a plane near the surface (~ 1km x 1km area shown). Pressure contours are overplot in white to show the center of the dust devil.

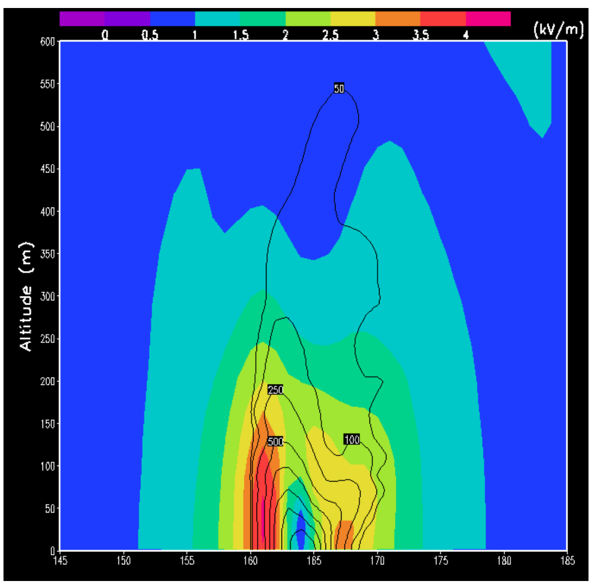

Figure 3. Vertical slice through the dust devil in Fig. 2 at x=42 (approximate location of the peak and trough in the electric field). A non-zero e-field is seen up to ~3 km. Also shown (black contours) is the dust particle number density (cm^{-3}).

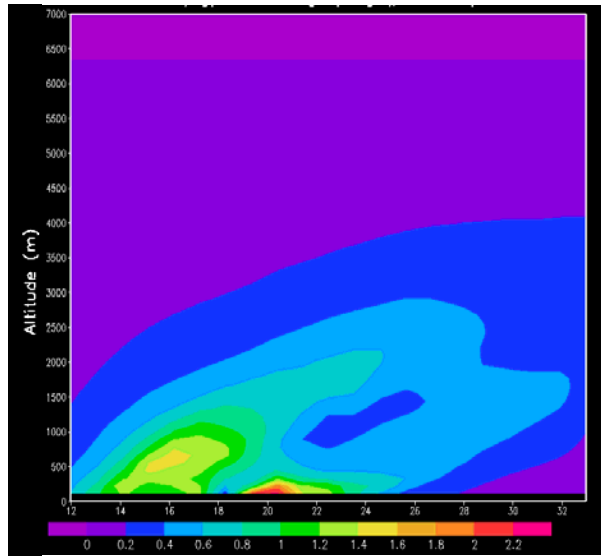

Figure 4. Time (and vertical) variation of the electric field within the dust devil shown in Fig. 2. The e-field values shown are what an observer moving with the dust devil at the minimum pressure point would see over the lifetime of the dust devil. The x-axis indicates time at 30 second output frequency (10.5 minutes shown).

A number of simulations have been run varying the dust particle properties. Electric field strength is shown to be a function of composition, relative size of the two particle populations, and efficiency of the dust lifting (number of dust particles present). Most of the dust devil e-fields generated in the current scenarios remain below the breakdown strength. Disturbances other than dust devils also generate electric fields.

References: [1] Krauss, C.E., Horanyi, M. and Robertson, S. (2003) *New J. Phy*, 5, 70.1-70.9. [2] Sternovsky, Z. and Robertson, S. (2002) *JGR*, 107, 5105. [3] Jackson, T.L. and Farrell W.M. (2006) *IEEE Transaction on Geosciece and Remote Sensing*, 44, 2942-2949. [4] Michaels, T.I. (2006) *GRL*, 33, L19S08. [5] Armstrong, J.C. and Leovy C.B. (2005) *Icarus*, 176, 57-74. [6] Desch, S.J. and Cuzzi, J.N. (2000) *Icarus*, 143, 87-105.