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The role of moisture on controlling dust emissions from crusted supply-limited surfaces

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Dust emissions from crusted surfaces are both highly variable and difficult to measure directly. Seasonal changes in surface soil moisture, temperature, evaporation, surface roughness, and sediment supply result in a highly complex surface condition that remains to be fully described in the context of wind erosion potential. A highly intensive project on Makgadikgadi Pan, Botswana using the PI-SWERL (portable wind tunnel) combined with surface measurements of crust and soil properties has led to a new understanding of the time sensitive controls on wind erosion from these surfaces.
The PI-SWERL is a highly portable wind tunnel that applies a shear stress to the surface using a motor-controlled rotating annular blade and measures resulting dust emissions with a PM10 monitor (DustTrak TSI Inc.). We undertook a sequence of tests with the PI-SWERL to obtain both the wind erosion threshold (using a slowly increasing shear velocity) and a dust emission flux (using a constant shear velocity) across a 12 km by 12 km grid across the pan surface. A total of just over 1500 wind tunnel tests and 3000 correlated measurements of a variety of surface properties including crust thickness, surface and subsurface soil moisture, shearing strength (shear vane), normal stress resistance (penetrometer), and surface roughness were conducted in August 2011 and August through October 2012. Two sets of results are presented providing discussion on: 1) Spatial variations in surface characteristics 2) Temporal variation in the control of surface characteristics and climatic conditions on potential dust emissions. These results show that wind erosion potential is best described by measurements of normal stress resistance rather than shearing strength at low dust emission fluxes, but despite their frequent use in wind erosion studies of crusted surfaces neither metric provided a good explanation of higher dust emission fluxes. Surface soil moisture explained the most variation in both dust emissions and wind erosion threshold although much variation remains unexplained. As pan surfaces can exhibit a range of aerodynamic roughness lengths over three orders of magnitude the small-scale partition of wind stress could be considered. Surface soil moisture also had a very large range and due to the fine texture of salt pans produced a crucial threshold for potential emissions equal to or even greater in importance than surface crusting. Although the role of surface moisture in dust emissions is understood it remains a very difficult (yet critical) parameter to measure and a call for more precise estimations of this metric is highly encouraged.