Supplemental Information

PI-SWERL Methods

Dust emission potential was measured using the Portable in situ Wind Erosion Laboratory (PI-SWERL), a circular wind erosion device that measures particulate matter <10 µm (PM10) in diameter (Etyemezian et al., 2007). Testing at White Sands and the Monahans dunes occurred primarily in May 2018. Tests from Lake Lucero at White Sands were included from March and June 2021. GPS locations of all PI-SWERL sites are listed in Table S1.

Dust emissions under the PI-SWERL are initiated by a spinning annular blade that simulates a range of friction velocities (Etyemezian et al., 2007) which can be converted to a wind speed using the 'law of the wall' if surface roughness is known. At each testing site, friction velocity was increased from naught to above the entrainment threshold and held constant for 60 s in a series of steps from 2000, 3000, 4000, and 5000 RPM or from 4000, 5000, and 6000 RPM. Surface roughness is assessed on-site by assigning an alpha value (0.98 being very smooth playa, vs. 0.86 being very rough botryoidal salt crust, for example) from a look-up table in Etyemezian et al. (2014). The alpha values are used to convert RPMs to corrected friction velocities. The RPMs in this study equate to corrected surface friction velocities of 0.4 m/s to 1.0 m/s, which roughly equate to 10-m wind speeds of 9.4 to 23.6 m/s, respectively, using a surface roughness length for dunes of 0.0008 m (Eastwood et al., 2008).

PM10 dust was measured using a DustTrak II Model 8530, which measures concentrations up to 400 mg/m^3. PI-SWERL tests were suspended if concentrations reached 400 mg/m^3, which usually only occurs at the highest RPMs (5000-6000) on soils lacking crusts. This occurred for two tests only, located at Lake Lucero in March 2021. The PI-SWERL therefore measures a minimum of dust emission potential considering the particle size and concentration limitations of the DustTrak.

Dust flux in mg/m^2/s at a given RPM are calculated using the equation (Sweeney et al., 2008):

$$E_i = \frac{\sum_{begin,i}^{end,i}(C_i \times F \times t_o)}{\left(t_{end,i} - t_{begin,i}\right) \cdot A_{eff}}$$

where E_i is the flux emitted at a given RPM, i, C is the dust concentration, F is the rate of clean air entering the PI-SWERL chamber (m^3/s), t_o is the frequency at which dust concentration data are measured (1 s), A_{eff} is the effective test area of the PI-SWERL annular ring (0.035 m^2; see Etyemezian et al., 2014), and t_{end} and t_{begin} are the time at the beginning and end of the RPM step (the duration of the test). A summary of PI-SWERL fluxes is listed in Table S2. Optical sensors inside the PI-SWERL chamber record sand movement after saltation begins, allowing observations of the role of saltation in dust production, but horizontal saltation flux cannot be calculated (Etyemezian et al., 2017).

The Dust Trak II Model 8530 is calibrated to the Arizona Test Dust standard composed of quartz. Due to the composition of dust at White Sands being primarily gypsum with a lower density and different optical properties compared to quartz, dust concentrations reported from White Sands are likely underestimated, but to what degree they are underestimated is currently not well known based on the lack of literature that documents the use of Dust Trak II Model 8530 in environments with unique dust compositions.

To calculate dust emitted from 1 km^2 parcels of landform units in this study, we used wind speed and distribution data from White Sands National Park. At White Sands, Pederson et al. (2015) found the threshold friction velocity for sand was 8.34 m/s at 10-m height, and that winds exceeded that threshold approximately 381 hours per year. The 10-m wind speeds of 9.4 to 23.6 m/s occur about 50% of the time in the White Sands area (Pedersen et al., 2015). This distribution of wind speeds at White Sands were used to estimate the PM10 dust emission in metric tons (t) per year from 1 km^2 parcels of landform units (e.g., active dunes, playa, sand sheets). This wind distribution was also used to estimate emissions from Monahans, since no comprehensive wind information was available for that dune field. The geometric mean and maximum PM10 fluxes and associated dust loads in t/km^2/yr are listed in Table S3.

Particle Size Methods

A sediment sample was collected at each PI-SWERL testing site. Particle size distribution was determined by laser diffraction in a Malvern Mastersizer 3000 using the Hydro LV unit for dispersion of samples in water, and the Aero S unit for dispersion of samples in air. Pretreatment and dispersion in water is the standard protocol for measuring particle size distributions with laser diffraction because the pretreatment breaks down aggregates and gives a percentage of sand, silt, and clay (Mason et al., 2003). However, particle size distributions measured this way may give an inaccurate view when sediments contain soluble minerals, or if sand sized aggregates of silt and clay are important in sedimentary transport. Considering the solubility of gypsum and other evaporite minerals potentially present in the White Sands playa and dunes, we used the Aero S unit to determine particle size distributions. White Sands playa sediments were also analyzed in water dispersion using the Hydro LV unit for comparison, in order to assess the relative proportion of sand-sized aggregates in the samples. All Monahans samples were analyzed in water dispersion.

First, samples were oven dried and sieved to remove the >2 mm fraction. For samples dispersed in water, they were mixed with 10% surfactant of sodium hexametaphosphate, shaken overnight, and analyzed in the Hydro LV unit with ultrasonication and a continuous 3000 RPM stirrer speed.

For samples dispersed in air, no pretreatments were given and they were analyzed by the Aero S unit with 2.0 bar pressure.

References

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