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Changes in the Saltation Flux Following a Step-Change in Macro-Roughness

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Recent research has documented the change in the mass flux of particles in saltation as the saltation cloud moves from relatively flat, unobstructed flow conditions to one in which the flow encounters and is perturbed by the presence of large roughness elements (≈0.3 m in height, ≈0.8 m in length). Measurements of the saltation flux exterior and interior to a change of roughness show clearly that the mass flux decreases exponentially with increasing distance into the roughness, reaching a new equilibrium flux at >100 roughness element heights. The rate of change of the mass flux with distance and the resultant equilibrium saltation flux scale with the roughness density (λ). It is now generally acknowledged that the horizontal mass flux of wind-driven particles in saltation decreases exponentially with elevation above the surface. The effect of roughness on the mass saltation flux in the vertical dimension has not been examined to determine if the reduction in the total mass flux upon is due to a reduction in the entire grain size distribution in saltation or if there is a change in the particle size distribution as particles are transported by the wind through the roughness elements.

A new set of time-integrated, particle size distribution- and height-resolved mass saltation flux profiles, collected at the full scale in the atmospheric inertial sublayer through an array of large roughness elements are used to examine how the saltation flux profile is changed upon encountering a step-change in roughness. Measurements of the saltation flux through the vertical dimension at increasing distance into the array show that the sand in saltation tends to a lesser rate of change with height while diminishing substantially in its magnitude. In addition, the geometric mean diameter (GMD) of particles in transport decreases with increasing distance into the array and with height above the surface. The decrease in total saltation flux due to the presence of the roughness has been observed previously, and the observed reduction of 90% for λ=0.046 corroborates with a previously published relationship between λ and predicted sand flux reduction. The reduction in total mass flux is due to shear stress partitioning effects that reduce the shear stress at the surface among the roughness elements as well as through interaction with the elements. The decrease in the GMD with increasing distance into the array is due to preferential loss of particle sizes with increasing height above the surface. Over the travel distance inside the array of 50 m, the greatest loss of particles for the measurement heights of 0.2 m, 0.5 m, 0.8 m and 1.3 m are, respectively, >204 μm, >246 μm, >298 μm, and >404 μm, which shows that the distribution of particle size diameters becomes increasingly restricted as the range of transportable particle diameters diminishes with increasing distance, and the mass is more evenly distributed with height deeper into the roughness array.