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Aeolian saltation layer

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Saltation — the motion of sand grains in a sequence of ballistic trajectories close to the ground — is the primary mode of sand transport, and is responsible for sand encroachment, dune motion and formation of coastal and desert landscapes. Although saltation has been matter of research for decades, it has not been possible to provide accurate measurements of particle trajectories in fully developed turbulent flow. Indeed, many uncertainties remain about the distortion of the wind velocity field in the presence of saltating particles, which strongly affects the motion of the grains. Here we calculate the motion of saltating grains by directly solving the turbulent wind field and its interaction with the particles. We obtain an expression for the velocity profile of the wind distorted by the particle motion and propose an equation for the dependence of the height of the saltation layer as function of the wind velocity. We determine the saturated flux $q_{\rm s}$, show that its behaviour is consistent with classical relations obtained from wind tunnel measurements, and propose a new relation valid for small fluxes, namely $q_{\rm s} = (u_* - u_{*{\rm t}})^\alpha$, where u_* and $u_{*{\rm t}}$ are the shear and threshold velocities of the wind, respectively, and the scaling exponent is $\alpha \approx 2$. Saltation is also calculated using atmospheric conditions of Mars. Mars grains saltate in 100 times higher and longer trajectories and reach $5 - 10$ times higher velocities than Earth grains do. On the basis of our results, we arrive at general expressions which can be applied to calculate the length and height of saltation trajectories and the flux of grains in saltation under different physical conditions.