Geophysical Research Abstracts
Vol. 21, EGU2019-4655-1, 2019
EGU General Assembly 2019

Unification of Aeolian and Fluvial Continuous Transport of Nonsuspended Sediment

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Aeolian transport of sand and fluvial transport of coarse sand and gravel are usually considered fundamentally different. In aeolian transport, particles move in large ballistic hops and strike the ground often so violently that they eject bed particles into the transport layer. In contrast, in fluvial transport, particle hops are comparably tiny, many particles role and slide along the surface, and particle-bed interactions are much less violent. In particular, the different nature of particle-bed interactions is thought to be the ultimate cause for why the sediment transport rate scales linearly with the bed fluid shear stress (in excess of the transport threshold) in aeolian transport and nonlinearly in fluvial transport and why the threshold Shields number is so much smaller in aeolian transport than in fluvial transport. I will present recent published [1-3] and unpublished results, based on numerical DEM/RANS simulations, that, if put together, are constituting a theory of nonsuspended sediment transport that unifies aeolian and fluvial conditions. At the core of the theory are a general Shields-like threshold diagram and a simple transport rate formula that is applicable to continuous transport conditions (but not to intermittent transport close to the transport threshold). Both threshold and transport rate predictions simultaneously agree with measurements for aeolian and fluvial conditions despite not containing fit parameters.

[1] T. Pähtz & O. Durán, Fluid forces or impacts: What governs the entrainment of soil particles in sediment transport mediated by a Newtonian fluid?, Physical Review Fluids 2, 074303 (2017).
[2] T. Pähtz & O. Durán, The Cessation Threshold of Nonsuspended Sediment Transport Across Aeolian and Fluvial Environments, Journal of Geophysical Research: Earth Surface 2, 123, 1638-1666 (2018).
[3] T. Pähtz & O. Durán, Universal friction law at granular solid-gas transition explains scaling of sediment transport load with excess fluid shear stress, Physical Review Fluids 3, 104302 (2018).