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Aeolian Sediment Transport Initiation Threshold: The Role of Boundary Layer Thickness

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Turbulent boundary layers of natural atmospheres can be several orders of magnitude thicker than those of wind tunnels. Yet, it is quite common to assume that initiation threshold friction velocities derived from wind tunnel experiments also describe transport initiation in the field because the standard viewpoint is that mainly the mean flow field matters. However, observations seem to challenge this viewpoint. For example, according to wind tunnel measurements, sand transport on Mars should be very rare in the present climate on Mars, but observations suggest widespread and persistent sediment activity [1]. Or, in developing boundary layer wind tunnels, aeolian transport is first initiated at the downwind end of the test section, where friction velocities are smallest and the boundary layer thickest [2]. Here, based on a theoretical analysis and a reanalysis of wind tunnel experiments from the literature, we show that the nondimensionalized threshold friction velocity (Bagnold's threshold parameter) is a function of the particle Reynolds number and the ratio between boundary layer thickness and particle diameter (but not of the density ratio) for cohesionless conditions [3]. One of the most important conclusions is that aeolian transport in the field may be much more readily initiated than in wind tunnels because of a much thicker boundary layer.

[1] Sullivan & Kok (2017), https://doi.org/10.1002/2017JE005275
[2] Williams et al. (1994), https://doi.org/10.1111/j.1365-3091.1994.tb01408.x
[3] Pähtz et al. (2018), https://doi.org/10.3390/geosciences8090314