WIND TUNNEL ANALOG FOR AEOLIAN SEDIMENT MOTION UNDER PLANETARY CONDITIONS.

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Introduction: Many worlds, with a wide range of atmospheric properties and sediment types, are known to experience wind-driven (aeolian) sediment motion. From the dense atmosphere and basaltic sands of Venus, to organic sediments of Titan, to the tenuous atmosphere and ice grains on Pluto, to even smaller bodies such as Comet 67P/Churyymov-Gerasimenko, aeolian sediment transport is an important process shaping the surfaces of bodies throughout our solar system.

Recent work by [1] has highlighted the discrepancies between current models for sediment motion initiation and observed behaviors on Mars. The current expressions for the fluid thresholds (velocities at which particles will be entrained into a flow) were formulated based on experiments under terrestrial conditions [i. e. 2, 3, 4]. Additional studies have been conducted in the Titan and Mars Wind Tunnels [5, 6], which operate at a desired atmospheric pressure or composition and use lightweight grains (i.e. crushed walnut shells) to simulate boundary conditions on the target planetary body.

Given the differences between predicted and observed behaviors on Mars, we seek to generalize the expressions for sediment motion initiation and cessation to be applicable under a wide range of boundary conditions. This has implications for mission planning and safety, as ongoing missions on Mars and the upcoming mission to Titan are likely to be impacted by airborne sediment particles. Using novel analog materials, namely low-density spherical plastics, we simulate boundary conditions on planetary bodies across the solar system to create a better fit to particle behaviors beyond Earth.

Methods: This study uses the UCLA Gale Labs wind tunnel, which is an 'open' tunnel operating at ambient conditions measuring 7m x 2m x 1m. The experiments are designed to identify the threshold velocities at which particle motion begins (fluid threshold), is continuous across the bed (general threshold), and when motion ceases (impact threshold). As shown in Figure 1, experimental runs consist of increasing the fluid velocity (wind speed) in the tunnel until grain saltation is initiated. The velocity is further increased until saltation is continuous across the test bed. At this point, the velocity is decreased until motion ceases.

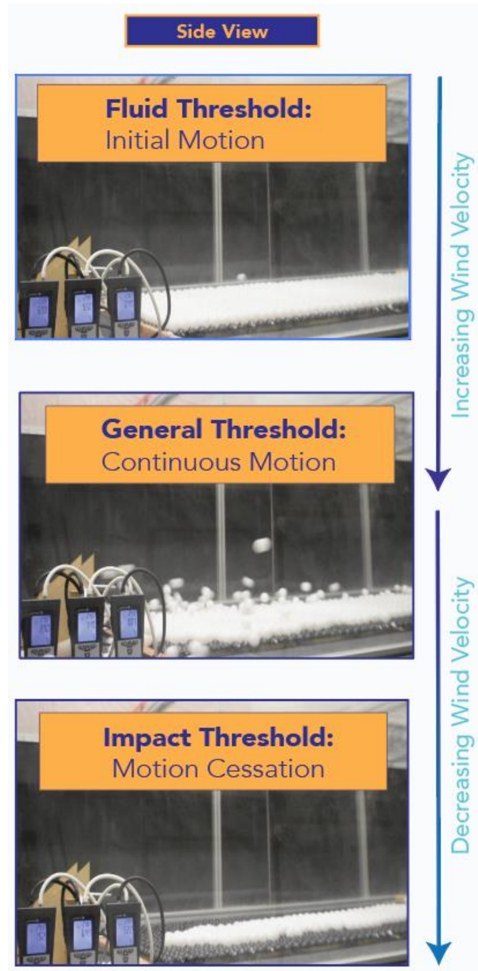

Figure 1. Experimental run showing the different phases of particle motion. This is an example from a trial simulating conditions on nitrogen ices on Pluto and/or organics on Titan using table tennis balls.

Materials: Given that the atmospheric pressure and composition, as well as gravitational acceleration, are all fixed to terrestrial conditions, the "sediments" being used have been chosen to simulate the overall forces experienced by grains in the natural systems we are replicating. Using scaling parameters from [6], we have identified pre-fabricated spherical materials that serve as analogs for conditions on Pluto and Titan (namely, table tennis balls and ball pit balls). Additionally, we are 3D-printing grains of specific densities to match conditions on Mars, and to create a series of intermediate conditions such that the results are widely applicable.

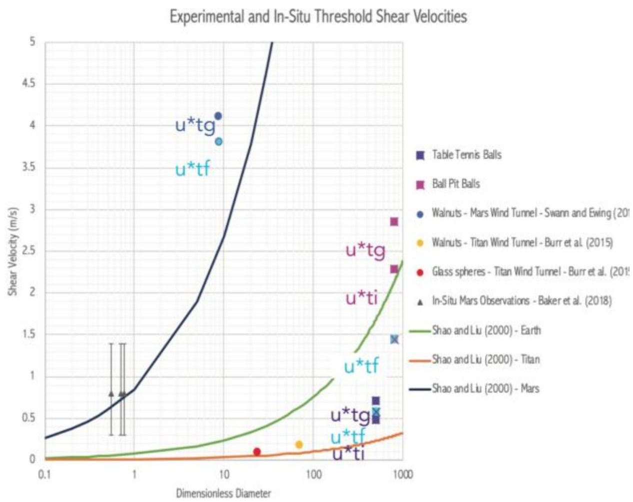

Figure 2. Comparison of threshold shear velocities versus dimensionless diameter. The dimensionless diameter is a scaling parameter from [6] that enables comparison of grains across a wide range of sizes and conditions. Values from this study are plotted as squares, previous work as circles and observations from Mars as triangles. Lines are model values based on the expression from [2] extrapolated to planetary conditions.

Initial Results: As with real sediments, the observed fluid threshold is higher than the impact threshold for the table tennis balls studied. The ball pit balls did not exhibit this behavior, like because they are larger and heavier, and were only mobilized at the extreme end of the wind velocity capabilities of the tunnel. Shown in Figure 2, these results have been compared to previous work in other wind tunnels [5, 6], as well as observations from Mars [1], and recent models [2].

Future Work: This project is ongoing and additional sediments are being produced in order to expand the range of measured conditions. The next step will be updating the expressions for the threshold velocities to capture a wider range of conditions beyond Earth.

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References:

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