

DUST DEVILS ON EARTH AND MARS: EXTENSION OF PARTICLE THRESHOLD LABORATORY SIMULATIONS

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Introduction. Dust devils are proposed as effective mechanisms for lofting large quantities of dust into the martian atmosphere. Previous work [1] showed that vortices entrain dust more easily than simple boundary layer winds. However, these previous lab studies that used the *Arizona State University Vortex Generator* (ASUVG) were limited to vortices of 0.01 to 0.10 m in diameter. Utilizing a newer facility at Iowa State University, the *Tornado/Microburst Simulator* (ISUTMS)[2], allowed larger vortex sizes (0.60 to 1.20 m in diameter) to be studied. Natural dust devils on Earth are generally a few meters to 10s of meters in diameter and occasionally reach upwards of 100 m in size [3]. On Mars, however, dust devils expand to much larger sizes from <10 m to 500 m in diameter [4,5]. The goal of this study was to examine vortex particle threshold in the laboratory using the ISUTMS to study vortices with a range of diameters larger than was possible with the ASUVG and then apply the results to scaling aspects of terrestrial and martian dust devils.

The two vortex systems used in this study are designed differently yet provide similar Rankine-like vortices. The main observational difference is that the ASUVG vortex 'wanders' within an ~60cm-radius zone because the system is not confined as in the ISU case. The ISUTMS employs a recirculatory system resembling a Ward-model vortex generator [2] to produce an incredibly stable with almost no wander. This allows the system to be accelerated to tornadic conditions (i.e., $v > 27$ m/s).

Approach and Methods. Building on previous work [1], we investigated how dust devils lift sand at laboratory scales. We employed similar techniques outlined in [1] for determining threshold using the ASUVG and the ISUTMS. Threshold was designated as the point at which sediment begins to move under wind action. Movement can be designated as rolling, saltating, or suspended in the flow. Vortex action is different from boundary layer winds as small particles are more easily entrained, probably because of an added lift provided by the low pressure in the core of the vortex, which overcomes interparticle forces (e.g. cohesion, statics, etc.)[1].

For both systems, threshold values were determined by slowly ramping up the velocities until particles began to move on the test surface. Particle layers were thick (> 5mm) for each experiment to reduce testbed surface effects. The two mechanical systems behave differently because of differences in design. Therefore, threshold appears different in both cases, which could have an effect on the comparison of the data.

Results and Implications. The preliminary data show better-constrained values of threshold for the ISUTMS system (less scatter). The lower scatter is probably due to higher vortex stability in the ISUTMS experiments. Threshold values for the ISUTMS also display values that are lower than those published in [1]. This also might be due to the instability (wander) of the ASU vortices. Greeley et al. [1] noted that threshold is attained at two distinct points: "continuous threshold" where entrainment is approximately constant over time and a lower value deemed "intermittent" in which bursts of entrainment occur. Intermittent threshold coincides more with initial movement of particles on the test surface, which makes it a more likely analog to threshold determined with the ISUTMS. Due to the wander instability, "continuous" threshold is prohibited until higher velocities are attained potentially skewing the determination of the true threshold velocities.

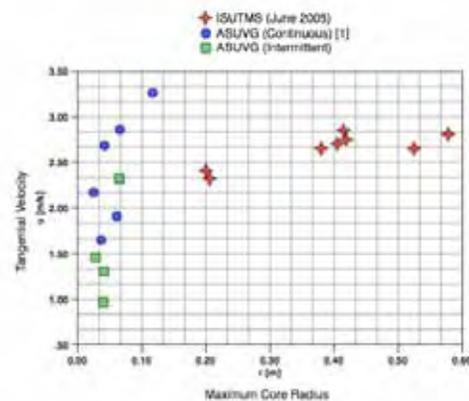


Figure 1. A plot showing the extension of threshold data for 125 μ m silica sand using the ASUVG "continuous" data (blue), the ASUVG "intermittent" data (green), and the ISUTMS data (red) collected last summer.

