THE TITAN WIND TUNNEL: ILLUSTRATING THE IMPORTANCE OF PLANETARY WIND TUNNELS FOR UNDERSTANDING AEOLIAN PROCESSES. D. M. Burr[1] (dburr1@utk.edu),. N. T. Bridges (Nathan.bridges@jhuapl.edu) [2], J. K. Smith (James.K.Smith@nasa.gov)[3,4], J. R. Marshall (jmarshall@seti.org) [5], [1]University of Tennessee Knoxville, [2] Applied Physics Laboratory, Laurel, MD, [3]Arizona State University, Tempe, AZ, [4]NASA Ames Research Center Planetary Aeolian Laboratory, Mountain View, CA, [5]. SETI Institute, Mountain View, CA.

Introduction: The Titan Wind Tunnel (TWT, Fig 1; [1]) is a recently available facility in NASA's Planetary Aeolian Laboratory [2]. A refurbishment of the Venus Wind Tunnel, this facility provides for the measurement of controlled air flow under high-presusre conditions. It thereby enables the simulation and characterization of select aspects of aeolian processes on the surface of Titan [1]. Descriptions of the Titan Wind Tunnel are available in [1,2] and important components of the facility are shown in Figure 1, although see section 'Current Titan Wind Tunnel configuration' below for some recent updates. A review of past work using this high-pressure facilitiy, in conjunction with results from recent and on-going experiments [e.g., 3,4], illustrates the importance of accurately reproducing the relevant boundary conditions for correctly simulating the aeolian processes under investigation [1].

Review of past wind tunnel work: Beginning with the ground-breaking work of Bagnold [5], wind tunnel experiments have a long history of providing critical data for describing aeolian sediment transport. A fundamental descriptor is the threshold wind speed, or the minimum wind speed needed to entrain sediment [e.g., 6]. Threshold wind speeds have been derived from planetary wind tunnels at a range of atmospheric pressures, and these data have been used as the basis for subsequent numerical models.

Initial predictions for Mars threshold wind speeds were derived using ambient wind tunnels [7]. Subsequent experimental data derived from Mars analog conditions showed the need for correcting these predictions with model fits to the new wind tunnel data [8]. Later, these terrestrial and martian data were used as the foundation for threshold models for Venusian conditions [9]. However, these models were also subsequently shown to underestimate the experimental data, in this case from Venus analog conditions [10, 11]. Predictions were Titan were made using these models [6], and the discovery of extensive dunes on Titan motivated the refurbishment of the Venus Wind Tunnel to test these predictions [1]. Comparison of these model predictions with data from the Titan Wind Tunnel showed that these models also underestimate the experimental data for Titan analog [3]. Inclusion of a densitiy-ratio term, derived from the Venus analog studies in order to cause the model to match the experimental data, also shifted the Titan model curves to match the Titan model predictions. However, the theoretical basis for the use of the density-ratio term is unclear [3], although it may be related to "the relative speed with which particles first moved by fluid friction impact upon other particles" [11].

On-going Titan Wind Tunnel work: Current projects in the Titan Wind Tunnel include investigations to understand grain-scale entrainment processes as well as the effects of global-scale changes.

Entrainment process: One on-going series of investigations addresses the origin of the density ratio. This term was originally derived for higher atmospheric density conditions under the presumption of increased impact entrainment [11]. However, recent numerical models suggest that entrainment is a greater function of grain impact under thinner atmospheres [12,13]. And the physical cause for the density ratio term is not clearly substantiated by the available experimental results for which it was derived [11].

Understanding the physical mechanisms associated with entrainment of grains at different pressures will eludicate the applicability of the density ratio term. On-going work in the Titan Wind Tunnel is investigating the effects of higher and lower pressures on entrainment mechanisms, in order to infer how entrainment varies with pressure [4].

Global climate change: The study into grain-scale interaction as various pressure is relevant to paleoclimate studies for Titan. Titan is inferred to have experience global climate change over the past few billion years [14]. These episodically less dense environments would have changed aeolian processes.

On-going studies are investigating processes at modeled paleoclimate pressures for Titan [from 14]. The results from this work will be fed into sand transport models [15] and global atmospheric model [16] to assess the effects on saltation trajectory and global sediment flux.

Current Titan Wind Tunnel configuration: Users of the Titan Wind Tunnel benefit from continuous improvements to the facility by the Planetar Aeolian Laboratory engineer (JKS). Recent examples include: 1) the installation of a single pitot tube on the test plate, eliminating the need to correlate between multiple pitot tubes and thereby reducing uncertainty in the data [see 3]; and 2) a reconfiguration that enables collecting data simultaneously from two different transducers with different operating ranges and sensivities. As a result of such improvements, the configurations shown in previous publications [1, 3] may be out of date in some aspects. Figure 1 shows the current configuration.

Use of the Titan Wind Tunnel: A variety of data and other support is available from PAL for scientists using with the Titan Wind Tunnel. The data that may be provided to the user includes files of transducer voltages for conversion to dynamic pressures [e.g., 3], calibration data for boundary layer profiles for a range of roughness sizes and pressures [e.g., 3], low-speed video documentation of the bed during experiments, and imaging documentation of the resultant bedforms. For other data-collection methods, such as high-speed video documentation [e.g., 4], scientists may bring their own equipment. The authors of this abstract welcome any questions as to equipment availability in the PAL or 'lessons learned' for conducting experiments in this facility.

Conclusions: The history of discoveries made through planetary wind tunnels illustrates the importance of conducting experiments under analog conditions for deriving accurate data [1]. Planetary boundary-layer wind tunnels, including the Titan Wind Tunnel, enable those analog experiments. The resultant data reveal uexpected processes that continue to advance our understanding of planetary aeolian processes throughout the Solar System.

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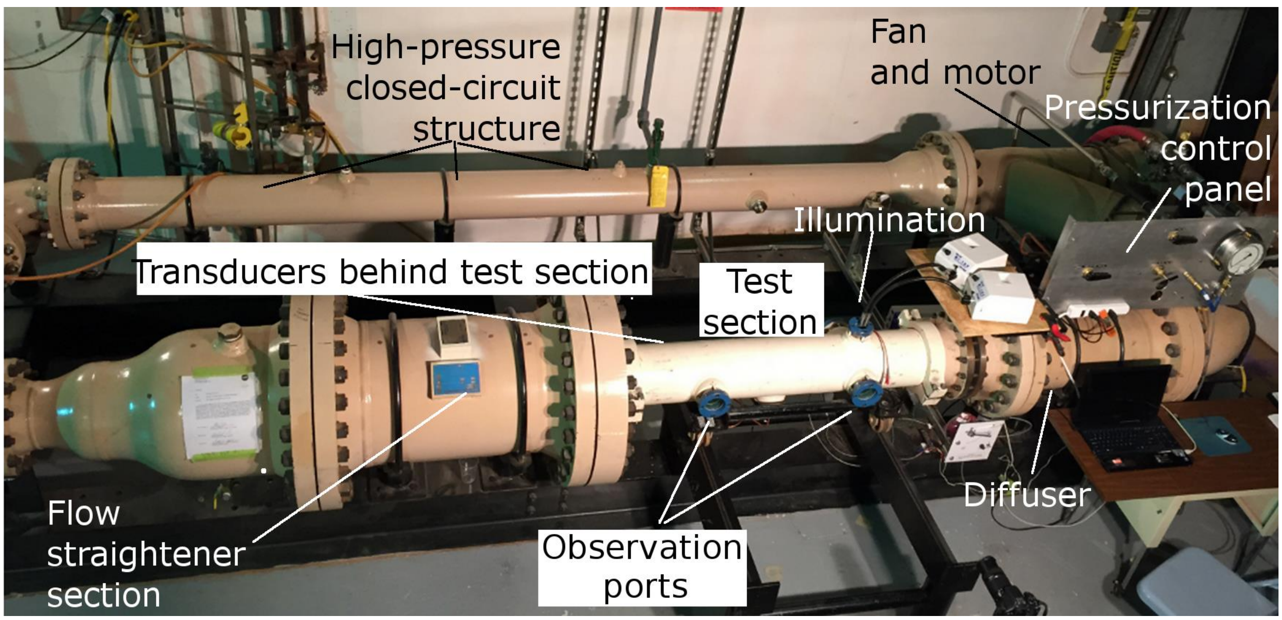

Figure 1: The current configuration of the Titan Wind Tunnel with some important components labeled.