
# THE TITAN WIND TUNNEL:
## ILLUSTRATING THE IMPORTANCE OF PLANETARY WIND TUNNELS FOR UNDERSTANDING AEOLIAN PROCESSES

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**Abstract 2356**

Data from the Titan Wind Tunnel -- a unique resource in the NASA Ames Research Planetary Aeolian Laboratory -- are improving our understanding of aeolian processes, while illustrating the general importance of wind tunnel facilities for community use.

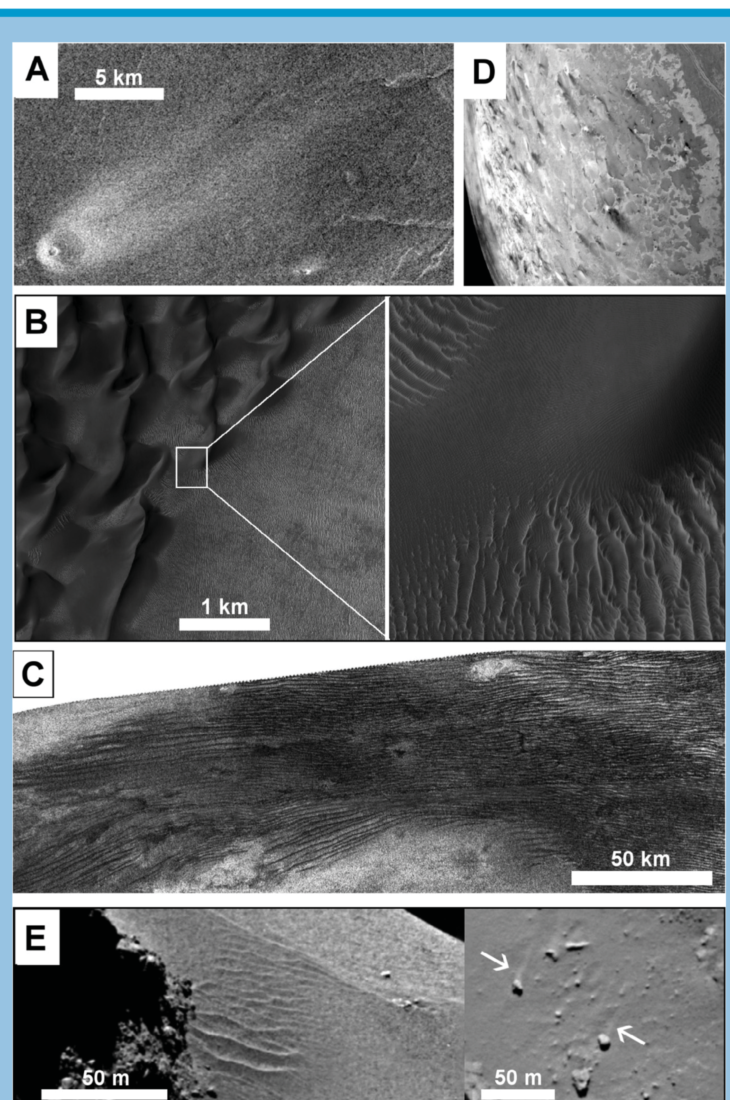


*Fig. 1: (A) Venus wind streaks. (B) Martian dark dunes. (C) Titan radar-dark linear dunes. (D) Triton wind streaks. (E) Comet 67P dune-like forms (left), possible wind streaks (right).*

### 1. INTRODUCTION

* Aeolian processes are common on Solar System bodies [1] including (Fig. 1):
--> inner terrestrial planets with atmospheres
--> outer icy moons with atmospheres (Titan) or jets (Triton)
--> Kuiper Belt Objects with seasonal atmopsheres (e.g., Pluto)
--> comets with episodic jetting (e.g., 67P/Churyumov-Gerasimenko.

* Wind tunnel simulation of planetary atmospheric surface flows has been used for decades to better understand wind-driven particle motion [e.g., 1,2,3].

* The Titan Wind Tunnel (Fig. 2) enables the simulation of atmospheric surface flows and associated aeolian processes under high-pressure conditions [1,2].

***A review of past wind tunnel work illustrates the importance of reproducing the relevant boundary conditions for correct simulation of aeolian processes [1].***

### 2. REVIEW OF PAST WIND TUNNEL WORK:

* Bagnold [4] --> Description of threshold, or minimum, wind speed needed to entrain sediment. From this groundbreaking example, threshold wind speeds have been derived from planetary wind tunnels at a range of atmospheric pressures [3], and these data have been used as the basis for subsequent numerical models.

* Iversen et al. [5] --> Ambient wind tunnels used to predictions for martian threshold wind speeds. *Subsequent experimental data from Mars Surface Wind Tunnel showed these model predictions UNDERESTIMATED the experimental values. [6].*

* Iversen and White [7] --> Ambient + martian data used to predict Venus threshold wind speeds. *Subsequent experimental data from the Venus Wind Tunnel shows that these model predictions ALSO UNDERESTIMATED the experimental data [8,9].*

* Greeley and Iversen [3] --> Ambient + martian data used to predict Titan threshold wind speed. The discovery of extensive dunes on Titan [10] motivated the refurbishment of the Venus Wind Tunnel to test these predictions [1]. *These subsequent experimental data from the Titan Wind Tunnel showed that these model predictions ALSO UNDERESTIMATED the experimental data* [1].

***Model predictions of threshold wind speeds were consistently incorrect. Implications: Analog condition wind tunnel experiments are necessary to correctly constrain this basic parameter.***

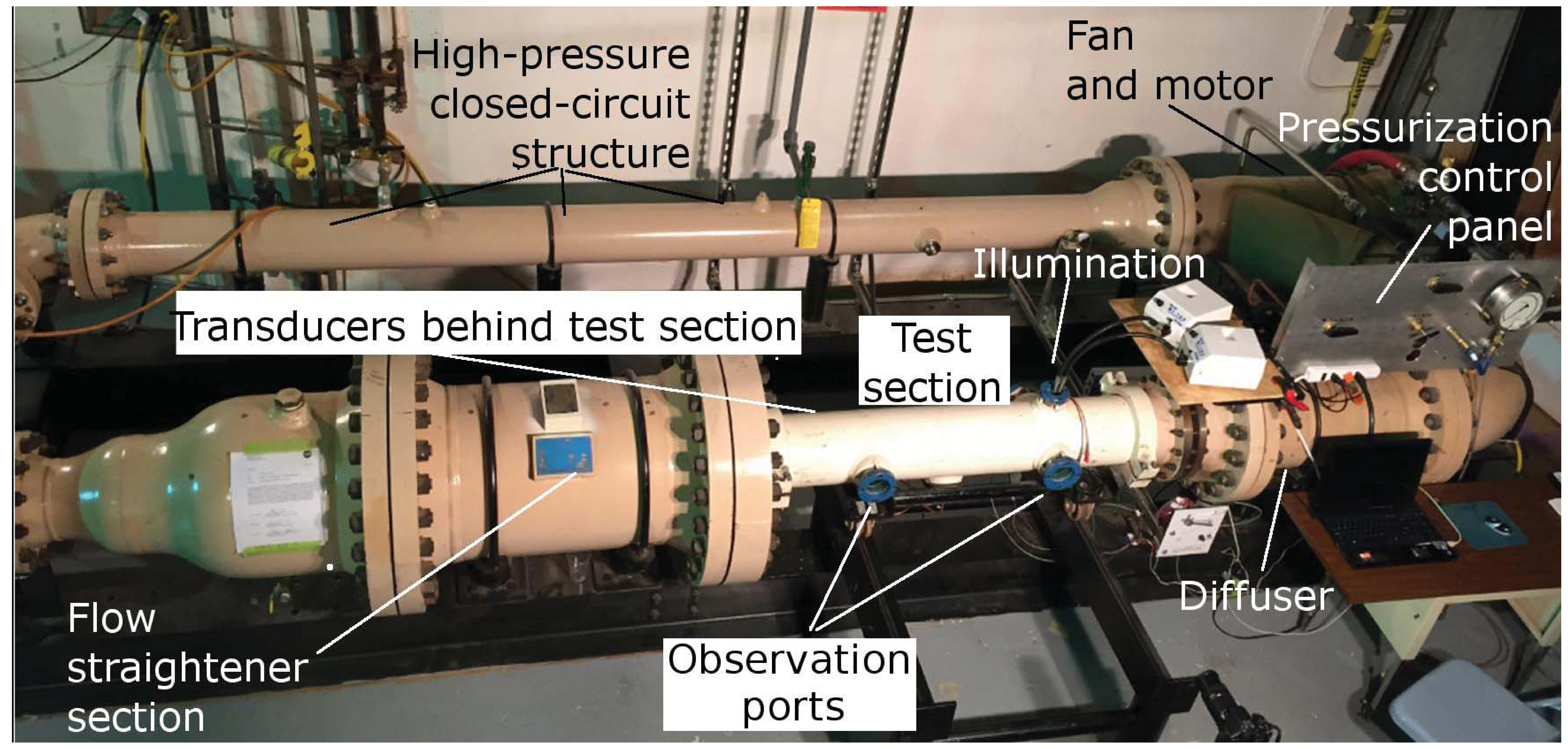


*Figure 2: The Titan Wind Tunnel (TWT) in the Planetary Aeolian Laboratory, NASA Ames Research Center, Mountain View, CA, USA. This image shows the current configuration, upgraded even since the initial (i.e., 2015) publications [1, 2]. These ongoing upgrades by the PAL engineer (JKS) are designed to improve data reliability and facilitate use by the community.*

### 3. SUMMARY OF ON-GOING TITAN WIND TUNNEL WORK:

*(1) Entrainment process*: One on-going series of investigations addresses the origin of the density ratio. This term was originally derived from the mismatch that occurred under higher atmospheric density conditions under the theoretical mass balance associated with impact entrainment [9], but the data collected under higher atmospheric density conditions in the Titan Wind Tunnel do not fall along the density-ratio curved derived from these Venusian analog data.

Recent numerical models suggest that entrainment is a greater function of grain impact under thinner atmospheres [11,12]. Understanding the physical mechanisms associated with entrainment of grains at different pressures will elucidate 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 en-trainment mechanisms, in order to infer how entrainment varies with pressure [4].

*(2) Global climate change*: The study into grain-scale interaction as various pressure is relevant to paleoclimate studies for Titan. Titan is inferred to have experienced global climate change over the past few billion years [13], which would have changed aeolian processes.

On-going studies are investigating processes at modeled paleoclimate pressures for Titan [from 13]. The results from this work will be fed into sand transport models [14] and global atmospheric model [15] to assess the effects on saltation trajectory and global sediment flux.

**4. USE OF THE TITAN WIND TUNNEL:** For scientists using the Titan Wind Tunnel, a variety of data and other support is available from PAL. These data include files of transducer voltages [e.g., 1], data for boundary layer profiles [e.g., 1], low-speed video documentation of the bed during experiments, and imaging of any resultant bedforms. For other data-collection methods, such as high-speed video documentation, scientists may bring their own equipment. The authors of this abstract welcome questions as to equipment availability in the PAL or 'lessons learned' for conducting experiments in this facility.

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