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## The winds of Mars: Why InSight wind data are so valuable and what they tell us

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Measurements of near-surface winds on Mars are vital to understand momentum, heat, and gas exchange (e.g. water vapor, methane) at the surface; to interpret surface aeolian features, from wind streaks to dunes; to understand the conditions required for raising dust from the surface; to combine with other observations of atmospheric phenomena such as baroclinic waves, convective vortices, and clouds; to test and improve atmospheric models, which may then be used with greater confidence for other locations and epochs; to provide ground truth for Entry-Descent-Landing, the Mars2020 helicopter, and Ascent Vehicles; and finally, to help quantify the conditions that will be faced by future human explorers of Mars.

Despite this, however, good wind datasets are very rare for Mars. The Viking Landers provided valuable information on seasonal and diurnal variations in wind speed and direction, including the impact of dust storms, but recorded high frequency winds only a small portion of the time. Mars Pathfinder lasted only a few months on the surface and recorded wind directions but could not produce calibrated wind speeds. Phoenix similarly had a short lifetime and only measured intermittently at low temporal resolution and accuracy, although provided both wind speed and direction. Spirit and Opportunity carried no wind sensors at all. The ongoing Mars Science Laboratory mission's Curiosity Rover carried the first wind sensor to operate in a region of strong topography (Gale Crater); however, electronic noise and damage upon landing resulted in many data gaps and biases in the wind dataset, and the wind sensor was permanently lost after fewer than three Mars years due to further damage.

InSight carries the TWINS wind sensor, consisting of two booms facing in opposite directions. The wind speed and direction at any time is obtained by selecting the boom with the least interference by lander components or heating. By the time of this presentation, InSight should have measured wind continuously at ~1.2m above the surface for over 500 Mars sols (nearly three-quarters of a Mars year), with the majority of this dataset available at a frequency of 1Hz.

We will present the InSight wind dataset and describe how it has already helped Mars scientists to make progress in a range of fields. These include understanding the origins of aeolian features and inferring thresholds for sand motion or dust lifting, as well as quantifying the impact of topography and dust loading on modifying the regional circulation. Comparison with the winds predicted by atmospheric models has shown areas of disagreement, pointing to places where a

different model setup or boundary condition (e.g. resolution, roughness map) may be needed, or where the model's parameterizations of sub-grid scale physical processes (e.g. vertical mixing) need to be improved. Finally, given InSight's proximity to the Curiosity Rover, we will show how winds in some seasons provide information on the regional flow before it reaches Gale Crater, and hence aid in interpreting Curiosity's more complex wind dataset.

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