ATMOSPHERIC OBSERVATIONS FROM THE MARS INSIGHT MISSION

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Introduction:

The NASA Discovery Program mission InSight is principally aimed at understanding the seismicity of Mars and its interior structure. However, to understand the potentially confounding effects of atmospheric perturbations on the seismic signals, InSight also will carry a complement of meteorological sensors that can add to the record of atmospheric observations at the surface of Mars. We will discuss the capabilities of InSight for atmospheric observations, and present the current plans for how its sensors will be used in operations.

InSight Goals:

The InSight mission's highest level goal is to understand the processes of formation and differentiation that have occurred on Mars, and thus the structure of the interior of the planet. Additionally, InSight will also study tectonic activity and meteorite impacts on Mars. To achieve these goals, InSight carries a set of seismometers, a heat flux probe and Doppler receiver/transponder to detect rotation variations. Supporting these primary instruments are cameras to ensure safe and proper placement of the seismometer and heat flow sensors on the ground, as well as a meteorology package to characterize the effects the atmosphere may have on the primary sensors.

Meteorological Support of Seismology:

The Viking seismology experiments demonstrated that winds can have a significant effect on seismometry (e.g., Nakamura and Anderson, 1979). InSight will mitigate this effect to a much larger degree than did Viking by placing its seismometers directly in contact with the ground, isolating them from the lander via a tether, and covering the seismometers with a wind and thermal shield. Nevertheless, it is expected that local wind and pressure perturbations will influence the observed seismic signals. For this reason, InSight carries basic wind and air temperature sensors (a variant of the wind and air temperature sensors from MSL REMS), as well as a highly sensitive pressure sensor (a Tavis pressure sensor, an improved version of those used on the Viking and Pathfinder missions). The pressure sensor is also equipped with a quad-disk inlet, adapted from those used in terrestrial infrasound detectors, to isolate atmospheric pressure changes from wind-induced dynamic pressure fluctuations. Because InSight will be monitoring for Martian seismicity essentially continuously, the operational plans also call for it to monitor the meteorology on a continuous basis.

Because the InSight mission is solar powered, and thus power availability is dependent on intensity of the sunlight received on its solar panels, InSight will use its arm-mounted camera to determine the atmospheric opacity.

Meteorological Sensor Performance:

The meteorological instrumentation on InSight was not chosen to be optimized for addressing MEPAG atmospheric goals. Rather it was selected to enable the key science goals for InSight, the seismic investigation of the planet. As such, there are superior instruments available, but these were not consistent with the InSight budget. Consequently, InSight's meteorological investigation will be incremental rather than transformational, but there will be avenues in which it will make scientific contributions. In particular, the continuous nature of the observations will provide a more complete catalog of atmospheric phenomena on Mars than has previously been obtained.

Pressure sensor performance. The pressure sensor will be sampled at 20Hz with a response time of at least several Hz, and have a noise level on the order of 5 mPa. This is roughly two orders of magnitude more sensitive than its predecessors, and will be sampled about 1 order of magnitude higher than its predecessors as well. We expect that this may open up possibilities to detect infrasound events from bolide impacts or other events as-yet unforeseen.

Wind sensor performance. The wind sensor is a repackaged version of the MSL REMS wind sensors. In the specific implementation for InSight, the two wind sensor booms will be separated and mounted independently on the lander deck, facing outward on roughly opposite sides of the lander. This placement allows one boom to sense least perturbed wind flows in nearly any azimuth wind. Operational plans for the wind sensors for InSight will switch between these two booms based on the experience of previous Sols and the expected regular variation of the wind with local time. If energy allows, both booms may be operated continuously.

The wind sensor will be sampled at 1 Hz matching its physical response time. The wind sensor accuracy is about +/-40% for winds <3.5m/s, decreasing to +/-15% for stronger winds.

The air temperature sensor will be sampled at 1 Hz, but its physical response time is 30-90s. The sensor accuracy is 5K but measurements are recorded with a resolution of 0.1K.

Meteorological Goals:

With a nearly continuous data set of pressure, air temperature and wind speed and direction, InSight will be the most complete record of meteorological conditions at a Mars landing site. The possibility of identifying anomalous events (e.g., dust devils, bolides) is better with InSight than its predecessors due to its continuous observation capability and the sensitivity of its pressure sensor.

In addition to the standard meteorological observations, InSight will also be able to use its arm-mounted camera to characterize the aerosol properties in the vicinity of the lander, including possible dust devil searches that may be correlated with the winds and the very sensitive pressure measurements. The arm-mounted camera will also be used to search for clouds to characterize the seasonality and time of day behavior of the clouds at the landing site.

Surface changes induced by Aeolian processes will be detectable using the arm-mounted camera, and can be correlated to the continuously observed winds to yield a good understanding of the wind environment during the time when the Aeolian changes may occur.

We cannot fully anticipate what the meteorological investigations on InSight will reveal. The continuous data set may turn up new (rare) phenomena, or characterize expected ones in greater detail. The much greater sensitivity of the pressure sensor may reveal a wealth of infrasound sources, for which we aren't fully prepared to analyze. The observational strategy for meteorological data taking on InSight is designed with the possibility of serendipity and the unexpected in mind.

Summary:

InSight carries a suite of meteorological sensors that is similar to those that have flown before, except in its pressure sensitivity and the fact that it will record data nearly continuously. InSight's meteorological capabilities will allow it to make a contribution to our understanding of the atmospheric boundary layer on Mars. We recognize that we don't know all that we should expect to see from InSight's meteorological sensors, and welcome input and ideas for how best to conduct the InSight meteorological investigations.