
Introduction: The InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) mission landed in western Elysium Planitia on November 26, 2018. In this work, we present the most significant changes from aeolian activity detected by the InSight lander during its first 400 sols of operations. We will show that particle entrainment by wind activity around InSight is a subtle process and report measurements observed across multiple instruments, to support and constrain the times and atmospheric conditions when changes occurred.

Our observations show that all aeolian movements are consistent with the passage of deep convective vortices between noon to 3 pm local time. These vortices may be the primary initiators for aeolian transportation at InSight, inducing episodic particulate motion of grains up to 3 mm in diameter.

Background: Aeolian change is the result of wind detaching or setting particles in motion along a surface. Orbital and surface campaigns for change detection were previously employed to constrain atmospheric conditions for wind-induced particle transportation on Mars [1]. Because of its stationary position and a multi-instrument package, InSight offers the unique opportunity of detecting aeolian changes and constraining the atmospheric conditions responsible for particle motion. Coordination of multi-instrument data allows synergistic approaches to infer the conditions (e.g. free stream vs vortex parameters) which set particles in motion.

InSight so far has demonstrated a paucity of aeolian changes consistent with orbital observations of weakly active bedforms. Despite recording the highest vortex activity on Mars [2], no direct observations of dust devils were made and only a few aeolian changes have been observed so far. These are episodic and cluster towards the first and last two months of the 400-sol investigation, correlated to high levels of wind activity.

Data and Methods: Air pressure, wind speed and direction, temperature and magnetic field measurements are recorded by the Auxiliary Payload Sensor Suite (APSS) [3]. The lander is equipped with an Instrument Context Camera (ICC) and Instrument Deployment Camera (IDC) [4]. The ICC is mounted on the lander and provides an overview of the surface to the south, while the IDC is mounted on the robotic arm providing close-up images of near-lander surfaces of interest.

Observed Aeolian Changes:
1) Coarse sediment motion and dust-lifting on the surface: Images from sols 364 and 385 show coarse sediment motion along the surface (Fig. 1). Grains ≤ 2 mm in diameter are seen displaced on sol 364, whereas...
sol 385 sees motion of $\leq 3$ mm grains. IDC image subtraction suggests widespread, but subtle changes across the field of view (Fig. 1). Sol 385 exhibits additional scattered dark spots on rocks, indicative of a dust coating removal. ICC image subtraction shows coarse localized changes and a wide track at the south of the lander, with a trajectory consistent to the dominant wind direction (Fig. 1). The corresponding wind speed time-series while the robotic arm was looking at the HP3 mole is shown in Fig. 1. Preliminary wind-speed estimates show the maximum peak observed so far at InSight occurred on Sol 364 at 31.6 m/s, associated with a ~3.5 Pa pressure drop, while a 30.5 m/s peak associated to a ~6 Pa pressure drop was captured on Sol 385.

2) Dust motion on the west footpad: During landing, the lander west footpad was partially covered with regolith, which included a patch of dust on its east-most side. This patch was confirmed with an IDC image taken on Sol 10, but a size-range was not resolvable (Fig 2.). Between sol 18 and 65, this patch was episodically removed. Three distinct aeolian changes were observed from daily ICC images: between image pairs taken on sols 18-20, sol 26, and sols 65-66 (Fig. 2). Between each pair of images, high wind speeds up to 28.2 m/s and large pressure drops up to 9.2 Pa, associated with the passage of vortices, were observed.

3) Dust and particle motion on the deck and solar arrays: One aeolian change was detected between IDC images taken on sol 65 at 13:25 and 14:30 LMST. The latter was acquired six minutes after the occurrence of the deepest pressure drop ever recorded on Mars at 9.2 Pa [2]. Two notable changes were observed: a streak of dust was removed in the lee of one of the ribs of the solar panels [5] and particle motion on the Wind and Thermal Shield is evident. These changes are illustrated in Fig. 3, together with simultaneous measurements by other instruments. Fig. 3 also shows the corresponding magnetometer time-series, where a signature in the horizontal components correlates to the aeolian event. Similar signatures on 20% of the pressure drops larger than 1 Pa over the first 200 sols are observed by [6]. In all cases of aeolian changes with an evident dust lift-off component, correlated magnetic signatures are observed. Further analysis is required to identify whether the magnetic field changes are related to dust dynamics or simply to solar array current fluctuations.

Summary: Although InSight’s landing site has proven to be a relatively quiescent area for aeolian changes, dust-lifting and coarse sediment motion are systematically associated with the passage of deep convective vortices during months of high wind-activity levels. Aeolian changes are also seen correlated with excursions in both seismic and magnetic signals as might be expected from vortex-induced ground movement and charged-particle motion. Further analysis should provide a deeper insight into the atmospheric coupling with the regolith, and the induced aeolian transport on Mars.

Figure 2 (Top): IDC images of the west lander footpad taken on Sol 10 and 106 with the wind-speed time-series in between. (Bottom) Aeolian change events on the footpad observed between sol 18-20, sol 26, and sol 65-66 (same candidate vortex from Fig. 3), color coded with candidate wind peaks on the top.

Figure 3 Sol 65 aeolian change event. (a) & (b) shows the before and after images, with the selected areas of changes differenced in (c). (d) Lander schematic with changes pointed (e) 1 Hz Wind speed and (f) Wind direction (g) Demeaned solar array current (h) & (i) Detrended magnetic data for X & Y components at 0.2, 2 and 20 Hz (j) Pressure data 20 Hz (k) Vertical component of VBB seismometer at 20 Hz.