Geophysical Research Abstracts
Vol. 21, EGU2019-11231-1, 2019
EGU General Assembly 2019

Predicting The Meteorological And Seismic Signals Of Martian Dust-Devil Vortices As Observed On The Insight Lander

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In November 2018 the InSight mission landed on Mars. Over the next two years this mission will perform the first comprehensive surface-based geophysical investigation of Mars [1]. Prior to landing, there were extensive efforts to understand the atmospheric contributions to the seismic signal on Mars [2-6]. Pressure fluctuations in the atmosphere induce an elastic response in the ground that can be detected as a ground tilt by seismic stations installed on, or close to, the surface. This effect has been known for a long time [7-9], and is one of the reasons that terrestrial seismic stations are typically installed deep underground vaults. However, given the absence of microseism-producing oceans on Mars, the atmosphere directly dominates the background seismic noise [10].

One atmospheric signal that is predicted to be visible on the InSight seismometers is caused by convective vortices (named dust devils when the vortex transport dust particles). The negative load of a dust-devil vortex pulls up the ground as it passes, causing the ground and seismometer to tilt away from the dust-devil vortex. This first identification of the isolated seismic signature of a dust-devil vortex on Earth [11] demonstrated that a seismometer appears to be capable of tracking close encounters with dust-devil vortices and, in addition, that seismometers may be more effective than in-situ meteorological instruments at detecting dust-devil vortices at long-range.

We present modelling results that predict how dust-devil vortices may be observed by the meteorological (pressure and wind) and seismic instruments (the Short Period sensors [12]) on the InSight lander deck, before the deployment of SEIS onto the surface of Mars. This model takes into account both the ground deformation due to the dust-devil vortex passage, and the lift and drag forces acting on the lander (Fig. 3). We find that the aerodynamic forces can lead to signals similar in amplitude to the ground deformation at close (i.e. within one dust-devil vortex diameter) approaches (Fig. 4). Using techniques similar to those applied in [11,13], it will be possible to use this model, in combination with observed meteorological (pressure, wind speed, wind direction acquired by InSight APSS) and seismic data (acquired by InSight SEIS) to place constraints on convective vortex parameters (size, core pressure drop, advection speed) and their trajectories.

References: [1] Lognonné et al., 2018; [2] Murdoch et al., 2017a; [3] Murdoch et al., 2017b; [4] Mimoun et al., 2017; [5] Kenda et al., 2017, [6] Spiga et al., 2018; [7] Crary and Ewing, 1952; [8] Sorrels, 1971; [9] Sorrels et al, 1971; [10] Lognonné and Mosser, 1993; [11] Lorenz et al., 2015; [12] Warren et al., LPSC, 2019 [13] Lorenz et al., 2016.