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Seismometer Signature of Dust Devils : Implication for InSight

Ralph D. Lorenz[1*], Sharon Kedar[2], Naomi Murdoch[3] ,Philippe Lognonné[4], Taichi Kawamura[4], David Mimoun[3], W. Bruce Banerdt[2] [1]Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel, MD 20723, USA. (ralph.lorenz@jhuapl.edu / Fax: +1 443 778 8939) [2]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, USA [3]Institut Supérieur de l'Aéronautique et de l'Espace (ISAE-SUPAERO), Université de Toulouse, 31055 Toulouse, France [4] Institut de Physique du Globe de Paris/ University of Paris Diderot, 75205 Paris Cedex 13, France.

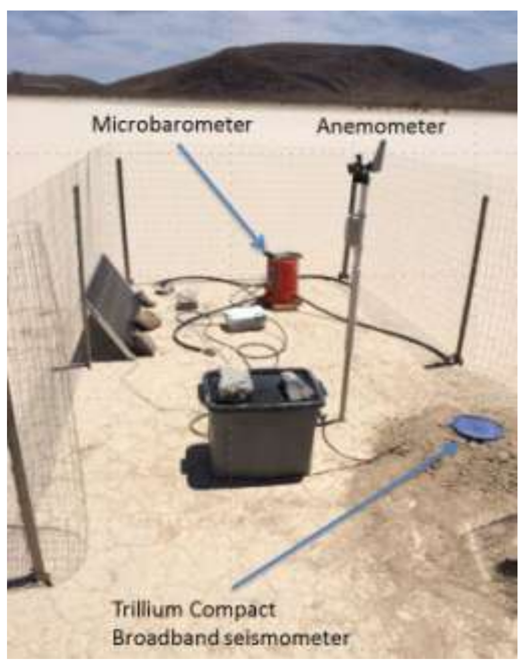
Abstract

As well as Marsquakes, the sensitive InSight SEIS instrument will detect ground deformations caused by atmospheric effects. In order to validate the models used to validate the models used to study the environment impact on a seismometer deployed on the field, a station with a configuration similar to the one deployed on Mars has been set-up at a playa near the Goldstone DSN station. Among the most locally-intense of these are dust devils, which act as a negative load on the surface. We have identified the tilt of the ground caused by dust devils in field measurements with a seismometer on a with the vortex encounters documented by an array of pressure loggers. One devil had a signature consistent with a simple point-load model, but the signature of a larger vortex had a more complicated structure requiring wind effects to be considered. There is evidence that dust devils may be detectable at longer ranges by seismic means than by in-situ meteorological measurements.

1. Introduction

Seismic stations for geological studies are typically installed in concrete vaults, ideally deep underground. While burial suppresses direct wind effects (a noted problem on the Viking seismometer) and reduces temperature fluctuations, shallow installations are somewhat susceptible to tilts caused by the elastic response of the ground to the atmospheric pressure and wind fields. While InSight's SEIS instrument has a wind and thermal shield (WTS) to improve its noise performance considerably over Viking, it is expected to measure atmospheric effects, which can be partly decorrelated from the signal by meteorology measurements.

In order to gain an understanding of seismometer response to field conditions and to explore atmospherically-excited seismic noise, a field experiment [1] was conducted in summer 2014 in Goldstone. This experiment (figure 1) featured a seismometer buried at very shallow depth in the soft playa sediment, together with meteorological instrumentation which included an array of pressure loggers (used previously in dust devil surveys [2]) dispersed around the seismic station. This configuration allowed to identify when atmospheric event. Dust devils encounters were therefore recorded, and the vortex size and trajectory could be derived from the measurement setup. In typical summer conditions, a few encounters a day may be seen.



2. Event

A pair of dust devils was identified, about 10 minutes apart (a typical interval, likely related to be advection of the planetary boundary layer convection pattern) which made it easy to recognize the event in all datasets (not all were recorded on the same time reference). A first vortex had an irregular maximum pressure drop of ~1mbar and a duration of about 1 minute, and appeared similar in all loggers (spanning a distance of ~120m, indicating a vortex at least this large). The second had a pressure dip of ~0.6 mbar and was somewhat shorter in duration : the pressure loggers suggest it moved in a ENE direction, passing about 45m to the south. Seismic signals are clearly seen (figure 2) for both events.

Conclusions

We have searched for and found a seismic signature of dust devils, and find the characteristics can be effectively modeled, in some cases by a simple point load on an elastic half-space, but in some cases demanding a more sophisticated approach. The migration of devils can in fact be tracked, the tilt azimuth indicating the direction to the dust devil, and it may be that dust devils can be detected better with seismic data than in-situ meteorological measurements. By acquiring both types of data, InSight should prove interesting for boundary layer convection studies. Dust devils may also serve as useful 'calibration' loads to assess the regolith elastic properties.

Acknowledgements

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References

[1] Lorenz, R. et al., Seismometer Detection of Dust Devil Vortices by Ground Tilt, Bull. Seismological Society of America, submitted [2] Sorrells, G. et al.,1971. Earth motion caused by local atmospheric pressure changes. Geophysics Journal 26, 83–98.

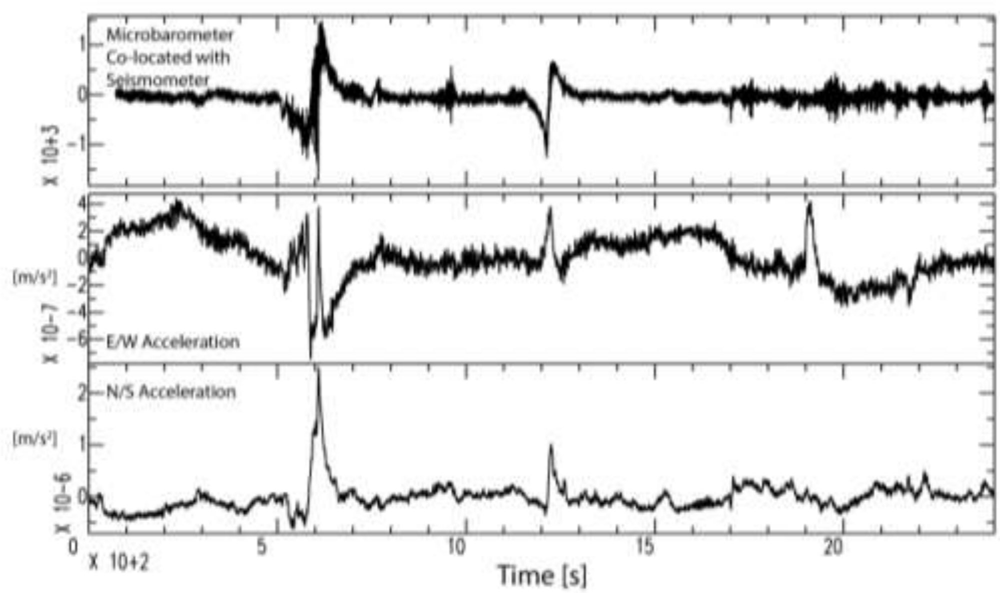

Figure 3. Record of the seismometer output showing tilts of tens to hundreds of nanoradians, coincident with pressure excursions (the microbarometer is co-located with the seismometer, but differentiates the pressure time series). Three events are seen – the first, largest has a somewhat complex structure (which can be largely reproduced using the theory of Sorrells [2]). The second event is smaller and simpler, and can be essentially reproduced with a point-load model, with the vortex moving eastwards to the south of the station. A third event, equispaced from the first two, is seen in the E/W data alone, suggesting an additional encounter that was not detectable in the pressure signal.