Geophysical Research Abstracts
Vol. 21, EGU2019-13030, 2019
EGU General Assembly 2019

Reconstructing the InSight HP^3 hammering seismic signals beyond the Nyquist frequency

David Sollberger (1), Cedric Schmelzbach (1), Fredrik Andersson (1), Johan Robertsson (1), Nienke Brinkman (1), Peter Zweifel (1), Jan ten Pierick (1), Thomas Haag (1), Martin van Driel (1), Simon Stähler (1), John Clinton (1), Domenico Giardini (1), Philippe Lognonné (2), Tom Pike (3), Raphael Garcia (4), Troy Hudson (5), and Sharon Kedar (5)

(1) ETH Zürich, Institute of Geophysics, Zürich, Switzerland (david.sollberger@erdw.ethz.ch), (2) Institut de Physique du Globe, Paris, France, (3) Imperial College, London, UK, (4) ISAE-SUPAERO / DEOS / SSPA, Toulouse, France, (5) Jet Propulsion Laboratory, California Institute of Technology, USA

The InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) mission is the first Mars mission to place an ultra-sensitive broadband seismometer on the surface of the planet. Placed next to the seismometer, a Heat Flow and Physical Properties Probe (HP^3) experiment will be conducted involving hammering a probe into the Martian subsurface to measure the heat coming from Mars' interior and to reveal the planet's thermal history. The hammering mechanism of the HP^3 probe will generate repeated seismic signals that will be recorded by the seismometer. These signals can be used to seismically characterize the shallow subsurface just below the lander. However, the expected high frequency content of the signal generated by the hammering will likely be beyond the Nyquist frequency dictated by the seismometer's highest-possible sampling rate of 100 Hz. The nominal anti-aliasing filter implemented in the SEIS electronics will remove the information contained in the hammering signal above 50 Hz. We thus propose to turn off the anti-aliasing filter during HP^3 hammering and reconstruct the full-bandwidth signal in post-processing.

We developed an algorithm to reconstruct the seismic signals at frequencies above those dictated by the sampling theorem. We exploit the structure in the data due to thousands of repeated, gradually varying hammering signals as the heat probe slowly propagates down to 5 meters depth. In addition, we make use of the randomized sampling of the repeated hammering signal due to the unsynchronized timing between the hammer strikes and the seismometer recordings. Based on these observations, we implement a compressed sensing technique enforcing a sparsity constraint on the signal in a modified Radon transform domain. Using synthetic data and field data collected in the California Mojave desert, we extensively tested the proposed algorithm and demonstrate that the high-frequency hammering signals can be successfully reconstructed.