MARSQUAKES' LOCATION AND 1-D SEISMIC MODELS FOR MARS FROM INSIGHT DATA. M. Drilleau[1], R.F. Garcia[1], H. Samuel[2], A. Rivoldini[3], M. Wieczorek[4], P. Lognonné[2], M. Panning[5,6], C. Perrin[2], S. Ceylan[7], N. Schmerr[8], A. Khan[7,9], S. C. Stähler[7], D. Giardini[7], D. Kim[8], Q. Huang[8], J. Clinton[7], T. Kawamura[2], J.-R. Scholz[10], P. Davis[11], B. Pinot[1], and W.B. Banerdt[5]. [1]Institut Supérieur de l'Aéronautique et de l'Espace ISAE-SUPAERO, 10 Avenue Edouard Belin, 31400 Toulouse, France (melanie.drilleau@isae-supaero.fr), [2]Institut de Physique du Globe de Paris, CNRS, Université de Paris, 1 rue Jussieu, 75005 Paris – France, [3]Royal Observatory of Belgium, Brussels, Belgium, [4]Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, Université Côte d'Azur, Nice, France, [5]Jet propulsion Laboratory, Pasadena, CA, USA, [6]California Institute of Technology, Pasadena, CA, USA, [7]Institute of Geophysics, ETH Zurich, Sonneggstrasse 5, Zurich, Switzerland, [9]Department of Geology, [8]University of Maryland, College Park, Maryland, USA, [9]Physik-Institut, University of Zurich, Zurich, Switzerland, [10]Max Planck Institute for Solar System Research, Göttingen, Germany, [11]Department of Earth, Planetary, and Space Sciences, University of California, Los Angeles, Los Angeles, CA, USA

Introduction: The InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) lander [1] successfully delivered a geophysical instrument package to the Martian surface on November 26, 2018, including a broadband seismometer called SEIS (Seismic Experiment for Interior Structure). After two years of recording, seismic body waves phases of a small number of high-quality marsquakes have been clearly identified. As part of the InSight cooperation, [2] proposed the first identification of multiple body waves and inverted them to map the structure of the mantle. Following this first work, we present and discuss the marsquakes' location and the interior structure, by inverting this unique dataset.

Dataset: The P and S arrival times are picked from SEIS records filtered in the 0.4-1 Hz range. An arrival is validated if the instantaneous phase coherence between vertical and horizontal components is high, and the incidence angle of the dominating polarization is approximately corresponding to one predicted for P and S waves. Perturbations induced by glitches are considered by tracking these signals on raw records, and the perturbations induced by wind signals are considered by comparing the azimuth of the dominant polarization to the one of the wind direction because wind related signals are expected along wind azimuth. Only the seismic events providing consistent estimates of quake back azimuth from P and S waveforms are kept. After this careful selection, only 6 events are selected. Because of the low signal to noise ratio, the determination of the arrival time of primary and multiple is very challenging and might be contaminated by wind noise. Clinton et al. [3] has proposed the use of filter bank, while vespagrams can also be used [4]. Here we estimate the differential travel times between direct P (respectively S) and multiples PP, PPP (respectively SS, SSS) by correlating the direct waveform along the vertical (respectively transverse) component with the rest of the record of that component. The times at which the correlation coefficient is maximum is providing the differential time of the multiple phase.

Methodology: The model parameterizations are described in detail in [5-10]. The inverse problem consists of a Bayesian inversion method [11], in order to investigate a large range of possible locations and models, and to provide a quantitative measure the uncertainties and non-uniqueness. As such, it is well suited to our problem given the still poorly known nature of the Martian interior, as well as the small number of identified phase arrivals recorded by SEIS at this time [12,13]. In the absence of surface waves, body waves arrival times inversions are complicated since accurate epicentral distance and origin time measurements are difficult to estimate with only one station. For this reason, the inversion scheme is divided into two steps. First, a range of possible epicentral distances is given by inverting the differential times t_S-t_P only. These ranges of epicentral distance for each quake are then used as a prior for the second step, where all the seismic phases are taken into account in the misfit function.

Results: Thanks to the InSight mission, we used body waves arrival times to constrain the locations of the marsquakes and the interior structure. The seismic modellings discussed here are based on spherically symmetric models. However, the crustal dichotomy between the Southern and Northern hemispheres deduced from gravity and topography measurements, indicates a crustal thickness varying from a few kilometers to more than 80 km [14], which undeniably will complexify the interpretation as a 1-D radial model considered here and could cause significant misinterpretations [15]. In order to account for the seismic lateral variations, we are currently modifying the forward problem to add arrival times corrections using crustal thickness maps obtained from gravity and topography data [16].

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