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Joint inversion of receiver functions and apparent incidence angles to investigate the crustal structure of Mars

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Since InSight (the Interior Exploration using Geodesy and Heat Transport) landed 26 months ago and deployed an ultra sensitive broadband seismometer(SEIS) on the surface of Mars, around 500 seismic events of diverse variety have been detected, making it possible to directly analyze the subsurface properties of Mars for the very first time. One of the primary goals of the mission is to retrieve the crustal structure below the landing site. Current estimates differ by more than 100% for the average crustal thickness. Since data from orbital gravity measurementsprovide information on relative variations of crustal thickness but not absolute values, this landing site measurement could serve as a tie point to retrieve global crustal structure models. To do so, we propose using a joint inversion of receiver functions and apparent incidence angles, which contain information on absolute S-wave velocities of the subsurface. Since receiver function inversions suffer from a velocity depth trade-off, we in addition exploit a simple relation which defines apparent S-wave velocity as a function of observed apparent P-wave incidence angles to constrain the parameter space. Finally we use the Neighbourhood Algorithm for the inversion of a suitable joint objective function. The resulting ensemble of models is then used to derive the full uncertainty estimates for each model parameter. Before its application on data from InSight mission, we successfully tested the method on Mars synthetics and terrestrial data from various geological settings using both single and multiple events. Using the same method, we have previously been able to constrain the S-wave velocity and depth for the first inter-crustal layer of Mars between 1.7 to 2.1 km/s and 8 to 11 km, respectively. Here we present the results of applying

this technique on our selected data set from the InSight mission. Results show that the data can be explained equally well by models with 2 or 3 crustal layers with constant velocities. Due to the limited data set it is difficult to resolve the ambiguity of this bi-modal solution. We therefore investigate information theoretic statistical tests as a model selection criteria and discuss their relevance and implications in seismological framework.