Geophysical Research Abstracts
Vol. 20, EGU2018-14952, 2018
EGU General Assembly 2018

Modeling low S-wave velocity in sedimentary basins through adaptive sampling of the parameter space, an application to receiver function inversion

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Low values of S-wave velocity characterize the shallow layers of the Earth's crust. This is particularly the case in basins filled with unconsolidated sediments of recent deposition. Such low-velocity materials trap seismic energy, and can lead to large ground accelerations. Therefore precise knowledge of those low shear-wave velocities in sedimentary basins is important for better understanding seismic hazard, e.g. for modeling seismic wave propagation and reconstruction of shake maps.

Noteworthy, high-frequency (2-4Hz) receiver functions (RF) contain a full-spectrum of information about the shallowest layers of the Earth's crust, in terms of both their S-wave velocity and thickness. In fact, teleseismic RFs computed for seismic stations located across sedimentary basin show peculiar features, which are diagnostic of very-low S-wave velocity at near-surface depths like, e.g., a very-low amplitude direct P-wave peak followed by pronounced multiples. Unfortunately, in most of these cases, the application of widely-used Monte Carlo algorithms to the RF inverse problem, based on fixed-length perturbations of a seismic model, is prone to fail in matching the weak direct-P peak, resulting in a wrong estimate of the shallow Vs and consequently of the whole velocity model.

Here we present a new method to estimate the sedimentary structure beneath a seismic station by testing an asymmetric sampling of the S-velocity model space. As a modification of the traditional trans-dimensional Markov Chain Monte Carlo (McMC) sampling algorithm, seismic models are perturbed following an adaptive scheme, which keeps at a constant level the resulting perturbation in P-to-S converted phase time-delay. This therefore allows a more regular sampling of the misfit surface. We demonstrate the technique for a station located on the Molasse Basin in the Eastern Alps, and compare our results with the borehole log data from nearby petroleum exploitation wells.