Travel-time Inversion in a Surface Consistent Scheme

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Abstract

Seismic exploration in complex environments relies on accurate velocity model building (VMB), including a detailed characterization of the shallow subsurface. A fully automatic and data-driven solution was recently developed to derive near-surface velocities through a surface-consistent analysis of refraction data, in particular, of first break travel-times (FB). A velocity model can be efficiently obtained through this method and used as a good starting model for advanced VMB techniques such as 3D Refraction Tomography (RT) or Full Waveform Inversion (FWI). FB travel-times and traces are organized in a multidimensional space consisting of a common-midpoint location and offset (XYO). Data quality is automatically controlled and the outliers rejected. FB travel-time statistical properties are extracted from the XYO hypercube and are used to derive velocity profiles through a travel-time vs. offset to velocity vs. depth conversion process. Such profiles are then used as starting models for a FB travel-time 1D inversion, based on Tarantola's Gauss-Newton minimization with an analytical forward calculation. The velocity profiles generated by the inversion are later used as input by more advanced VMB tools. We tested the method on the SEAM Arid model synthetic dataset, which is mimicking the complex features of the shallow geology of desert environments, such as karsts, wadis, sand dunes and other unconsolidated sediments, outcropping bedrock, and highly variable topography. The surface-consistent FB travel-times inversion is providing velocity profiles more accurate than the ones obtained with simple conversion. The inversion results are comparable with the ones obtained by 3D RT but they are produced via a simpler and more automatic workflow and in a much shorter amount of time. Tests on field data are currently ongoing. In order to improve the accuracy of the near-surface characterization in complex geology environments, we proposed a novel data-driven and fully automatic technique based on a surface consistent inversion of FB travel-times to derive accurate initial velocity models for 3D RT or FWI. Recent R&D efforts are in the direction of also extracting estimation uncertainties out of the inversion process.