Case Studies: Full-waveform Inversion and FWI Imaging for Land Data

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Abstract

Summary: Velocity model building and imaging for land surveys are particularly challenging due to the complexities of the near surface model and strong noise. We design a model building workflow for land seismic data that incorporates dynamic matching full-waveform inversion (DMFWI). DMFWI employs an objective function that uses multi-dimensional local cross correlations which minimize the impact of amplitudes and gives reliable results even in the presence of strong noise. The model building workflow is designed to achieve geologically and data-consistent results for data acquired with limited offsets. The workflow includes the following steps: a) Refraction tomography to build the near surface model. The near surface model is inserted into a smooth velocity model reaching maximum depth; b) Long-wavelength tomographic updates to build a global model as accurate as possible below the near surface model to use as the initial model input to DMFWI; c) DMFWI run from low to increasingly higher frequencies using early arrivals, including refractions and wide-angle reflections, to update the shallow portion of the model. This step targets the low to mid frequency components and has the most impact on migration kinematics; d) Tomography and wavepath DMFWI to resolve the long wavelength of the mid to deep portion of the model. This step is optional, but often necessary due to the limited offsets of the surveys in our study areas and could be eliminated if the acquisition is more suitable for FWII; e) Reflection DMFWI from low to increasingly higher frequencies with mainly reflection data to obtain fine details in the velocity model. The workflow is applied to onshore surveys in Mexico. Despite the challenges of land data and limitations of the acquisition parameters of the surveys in the study areas, we successfully incorporate DMFWI into a robust model building workflow for land data yielding a high-resolution velocity model and improved images.We also explore full-waveform inversion (FWI) for imaging and utilize the high-resolution FWI velocity model to estimate reflectivity. The FWI images show enhanced features and provide an alternative image for poor S/N land.