Surface-consistent transmission FWI

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Abstract

The near surface imprints distortions in the seismic data that we record for exploration purposes. These distortions occur in phase and amplitude and are either sub-resolution or related to complex physics that are difficult to be solved with a modeling/inversion approach such as full waveform inversion (FWI). Preprocessing and corrections are needed to deal with the near surface complexities to enable stable FWI. We have developed a novel transmission-based surface-consistent framework performing optimal data preconditioning for high resolution near surface FWI. This relies on the transmitted portion of the wavefield and allows derivation of phase and amplitude corrections including frequency-dependent operators for the deconvolution of the shallow near surface anomalous response from the seismic recordings. Additional signal-to-noise enhancement obtained through the generation of virtual super shot gathers reconstructed at the CMP positions. CMP-based FWI in the Laplace-Fourier domain is further developed and applied to field data to retrieve high resolution details of the near surface. It has been shown that surface-consistent refraction-based technologies, can approximate the near surface through a 1D framework with a midpoint-offset (XYO) sorting domain. Surface-consistent analysis can be applied directly on raw data to obtain good velocity estimates from travel times, residual phase corrections and deconvolution of the near surface anomalous amplitudes, using the transmitted portion of the wave field. A novel 1.5D Laplace-Fourier FWI methodology was developed and applied on an area characterized by sand dunes, sinkholes, and paleo-channels. This domain was chosen since its damping term acts as an extrapolator of lower frequencies not typically available in most of the seismic exploration data acquisition cases in the industry. Inversion starts from the lowest available frequency with high damping, and gradually utilizes higher frequencies while reducing the damping to increase the resolution of the model.