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Near-Surface Velocity Estimation Using Source-Domain Full Traveltime Inversion and Waveform Inversion

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ABSTRACT

Near-surface velocities are critical for subsurface seimic imaging. Conventionally, ray-based first-arrival tomography has been an efficient and robust tool to derive large-scale near-surface velocity models for decades (Zhang and Toksöz, 1998). Ray theory derived from the high-frequency approximation conflicts with the finite-frequency bandwidth of the seismic data and could lead to a poor velocity estimation (Sheng et al., 2006). Ray-based methods involve picking first arrivals. Although modern traveltime picking is very automated, manual intervention and quatlity control are always required (Keho and Zhu, 2009) and can be very time consuming. In addition, when subsurface low velocity zones exist, the first arrivals become shingled, resulting in jumps in the arrivals, which make the first arrival difficult to pick. To overcome the high-frequency limitaions of ray theory and avoid manual picking, we propose to use wave-equation-based source-domain full traveltime inversion (FTI). This method is capable of automatically generating the background velocity that can kinetically best match the reconstructed plane-wave sources of early arrivals with true sources in the source domain. This method does not require picking first arrivals for inversion, which is one of the most challenging aspects of ray-based first-arrival tomographic inversion. Compared with conventional Born-based methods, source-domain FTI can distinguish between slower or faster velocities via providing the correct sign. In addition, this method does not need source wavelet estimation, which is required for receiver-domain wave-equation velocity inversion. In this paper, early-arrival waveform inversion was applied to obtain the short-wavelength velocity component starting from the velocity generated by source-domain FTI. We have tested our method on synthetic and real field datasets. The results show source-domain FTI can generate good background velocities for the early-arrival waveform inversion, even when shingled first arrivals are present.