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Acoustic Full Waveform Inversion using the Pure Acoustic Wave Equation in VTI Media

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During the past several decades, full waveform inversion (FWI) has received considerable attention for the high resolution imaging of complex media in seismic exploration applications. After its introduction in the 1980s, several researchers endeavored to develop a more practical and robust FWI algorithm based on recent advancements in computer performance. However, the computational cost of FWI is extremely high in modern acquisitions with high-fold, dense sources and receivers and wide azimuthal coverage. Moreover, the intrinsic non-linearity, ill-posedness, and possibility of being trapped in local minima must be addressed to consider multiparameter FWI in an anisotropic media. In this study, a pure-acoustic wave modeling algorithm using a modified cell-based method was developed as a modeling engine for FWI, and the developed pure acoustic algorithm was used to simulate P-wave propagation in VTI media without generating any S-wave artifacts. For efficient anisotropic inversion, a FWI algorithm that uses the plane-wave approach and a multifrequency simultaneous inversion method were also developed. The computational cost of FWI can be effectively reduced by using the proposed FWI algorithm. To overcome the intrinsic problems of the multiparameter FWI, a hybrid inversion strategy consisting of monoparameter and multiparameter FWI was suggested based on the sensitivity analysis according to the ray parameter range. In the developed hybrid FWI, the vertical velocity, which has a major influence on the data, is first estimated using the monoparameter FWI scheme. In the second stage, joint updates of the vertical and horizontal wave speeds without a lower absolute value of the ray parameter are performed using the multiparameter FWI scheme. By applying the suggested FWI strategy, both the vertical and horizontal velocities were reconstructed properly for the complex model and fault model, and the root mean square (RMS) error curves converged steadily to lower values. In addition, the reconstructed vertical and horizontal velocities exhibited better agreement with the true model parameters than the conventional FWI results.