COOPERATIVE CROSS-HOLE ERT AND 2-D FULL-WAVEFORM GPR INVERSION

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Abstract

Recent advances in high-performance computing make full-waveform inversion (FWI) of cross-hole ground penetrating data feasible. FWI, where high-resolution imaging at half the propagated wavelength is expected, allows a better resolution in comparison to ray-based tomography. The inverse problem is generally solved using local optimization algorithms that can converge to local minimum depending on the selection of starting model, nonlinearity of the problem, lack of low frequencies, presence of noise, and approximate modeling of the wave-physics complexity. In this work, multiscale FWI strategy is combined cooperatively with electrical resistivity tomography (ERT) to mitigate the nonlinearity and ill-posedness of FWI and improve the ERT resolution. Different from taking advantage of low frequencies in the data, the proposed multiscale FWI reduces the number of model parameters and yields low frequencies in the model space using a regularization method that consists of imposing an L_1-norm penalty in the wavelet domain. The minimization of the L_1-norm penalty is carried out using an accelerated iterative soft-thresholding algorithm. The thresholds are used to control the frequency content in the model space. The initial velocity model for FWI is built from first-arrival traveltime tomography, whereas the ERT inversion result is used as FWI conductivity starting model. The conductivity model resulting from FWI is then introduced as reference model in ERT inverse problem using hierarchical Bayesian approach.

To validate our methodology and its implementation, two synthetic models were created. Experiments demonstrate that the proposed approach improves the spatial resolution and convergence properties in comparison to classical FWI. This work is an extension to full-waveform inversion of a previously published work (Bouchedda et al., 2012).