Waveform Energy Focusing Tomography for Passive Sources

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Full waveform inversion (FWI) is one of the most attractive geophysical inversion methods that reconstruct models with higher quality by exploiting the information of full wave-field. Despite its high resolution and successful practical applications, there still exist several obstacles to the successful application of FWI for passive earthquake sources, such as the high non-linearity for model convergence and demand for accurate source information, such as the moment tensor, the source time function, etc. To alleviate the requirement for a priori source information in waveform inversion, we propose a new method called Waveform Energy Focusing Tomography (WEFT), which backpropagates the observed wavefield from the receivers, not the data residuals like in conventional FWI, and tries to maximize the back-propagated wavefield energy around the source location over a short period around the origin time. Therefore, there is no need to provide the focal mechanism and source time function in advance. To better reconstruct the passive sources, the least-squares moment tensor migration approach is used, and the Hessian matrix is approximated using either analytic expression or raytracing. Since waveform fitting is superseded by simpler energy maximization, the nonlinearity of WEFT is weaker than that of FWI, and even less-accurate initial velocity model can be used. These advantages of WEFT make it more practical for challenging earthquake data, especially for local small magnitude earthquakes where both velocity model and earthquake source information are unknown.