

Robust Localization of Passive Sources with Cross-Coherence Migration

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Abstract

Objectives: Locating microseismic source positions utilizing seismic energy emitted from hydraulic fracturing is essential for choosing optimal fracking parameters and maximizing the fracturing effects in hydrocarbon exploitation. We introduce cross-coherence, which uses normalization by the spectral amplitude of each of the traces, to improve the source locating methods. The proposed method enhances the spatial resolution of source images and is particularly effective in the presence of highly variable and strong additive random noise.

Procedures: We propose cross-coherence migration method to improve the resolution of source locations. Unlike the cross-correlation, which is stable but needs estimation of the power spectrum of the noise source, and deconvolution, which is unstable and needs regularization, the cross-coherence method calculates the cross-correlation of traces normalized by their spectral amplitudes, and therefore does not require estimation of the source spectrum. The proposed methods generate the virtual shot gathers by applying the cross-coherence between the master trace and all the other traces. All the virtual shot gathers are then migrated and stacked together to generate the image of the source location.

Results: This abstract presents two alternative implementations of cross-coherence migration to improve the resolution of source locations. The first one is similar to the conventional cross-correlation migration method, except replacing the cross-correlation with cross-coherence for generating virtual shot gathers. The second approach applies frequency normalization to the input data and then generates the source image by zero-lag auto-correlation of the time-reversal wavefield reconstructed from the normalized data. We compared the proposed methods with conventional cross-correlation and deconvolution migration under different conditions including band-limited random noise, velocity perturbations, and multiple sources. Test results demonstrate that the proposed methods improve the spatial resolution of the source image, and are particularly effective and robust in the presence of highly variable and strong additive random noise.

Conclusions: This abstract presents an innovative method to improve the robustness of microseismic source localization. This method is demonstrated to be effective in the presence of highly variable and strong additive random noise. Thus, it has great potential in reducing the uncertainty of microseismic locating during the process of hydraulic fracturing, which will be beneficial for choosing optimal fracking parameters and maximizing the fracturing effects in hydrocarbon exploitation.