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Enhancement of High-Channel Count Land Seismic Data Using Nonlinear Beamforming for Unbiased Time Processing

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ABSTRACT

Land seismic data acquisition is moving from sparse grids of large source/receiver arrays to denser grids of smaller arrays, and, ultimately, to point-source, point-receiver systems. In the past, large arrays were designed to attenuate different kinds of noise with low apparent velocities and to increase overall signal-to-noise ratio (SNR) of the data. It is expected that high-channel-count seismic acquisition with dense sampling of the recorded wavefield should give benefits in terms of final seismic image quality and acquisition production rates in comparison to the old sparse surveys. In practice, processing of the huge amounts of low SNR data acquired in single-sensor, or small array, surveys is very challenging. After applying noise suppression techniques, pre-stack data still has low SNR. At the same time, conventional time processing techniques such as surface-consistent scaling and deconvolution, statics correction and velocity analysis require reliable pre-stack signal in the data. Their straightforward application to the data with low SNR leads to biased results, because the estimated operators and scalars are derived from heavily noise-contaminated signal. To overcome this challenge, prestack data-enhancement algorithms can be applied to boost the signal and to provide a reliable input to the conventional time-processing algorithms. We developed a nonlinear beamforming method for enhancing challenging pre-stack land seismic data with low signal-to-noise ratio caused by strong near-surface scattering. It searches for nonlinear local coherent events in the data and performs partial summation along the estimated trajectories. The approach is free from the classical hyperbolic assumptions and is based on a general local second-order travel-time approximation. Nonlinear beamforming shows excellent results when applied to synthetic as well as challenging land data acquired in a desert environment. The enhanced data should provide significant benefits for many stages of the processing flow. Specifically, it should allow more robust estimation of pre-stack parameters, such as surface-consistent scalars, deconvolution and filtering operators, statics estimation and velocity picking, as well as better imaging. We expect that nonlinear beamforming might lead to better processing of modern high-channel count and single-sensor data and should enable extracting the maximum usable information especially in the presence of a complex near surface or overburden.