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Advanced Noise Attenuation Techniques in Seismic Data Processing

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ABSTRACT

Seismic noise interferes with the signal or the useful part of recorded data, damaging or concealing the signal leading to image distortion and wrong interpretation. Separation of signal and noise is a challenging process in seismic processing workflows, particularly in a desert environment, where the near surface is very complex and the seismic data suffers from scattering and noise contamination. Signal and noise decomposition from seismic data is properly represented in a transform domain where the signal appears sparse. Classic transforms such as the Fourier or the wavelet transform, cannot properly represent complex seismic wavefields, because of the non-stationarity of seismic data as they operate on a one-dimensional scale. Advanced algorithms are needed to address these challenges. In recent years, multi-scale methods, such as seislet and curvelet transforms have started to be deployed by the industry to address the challenges mentioned above. The seislet transform is an effective sparse multi-scale wavelet-like transform specifically tailored for proper representation of seismic data. The transform computes multi-scale orthogonal basis functions, which are aligned along varying slopes or dips of seismic events in the input data. The curvelet transform, another higher order transform, is multi-directional sparse representation of data using basis functions with minimum overlap between signal and noise in the curvelet domain. It is a higher dimensional transform designed to represent images at different scales and different angles. The transform aims to find the contribution from each point of data in the t-x domain to isolated directional windows in the f-k domain. To effectively separate signal and noise from the input data, one needs to further estimate any signal component that has leaked into the noise estimate and restore it back to the separated signal. This is achieved by an innovative and recently developed signal-and-noise orthogonalization technique. In this approach, we first estimate the noise using one of the transforms. We then apply the orthogonalization scheme to retrieve the leaked signal energy and put it back to the initial signal estimate. These technologies are applied to several field data examples from the Arabian Peninsula. The main objective is improving the signal-to-noise ratio, increasing the frequency bandwidth of the data and enhancing the image quality for subsequent seismic data processing and interpretation.