Geophysical Research Abstracts
Vol. 13, EGU2011-8913, 2011
EGU General Assembly 2011

Matched Field Detection of Variable Seismic Sources

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The use of correlation detectors to detect repeating events from single sources is becoming common. The technique works well for highly repeatable sources that produce nearly identical waveforms at observing stations. Correlation detectors can fail to perform well when some aspect of the source, such as its time history, mechanism or location varies significantly. We are working on a somewhat different type of detector that attempts to suppress sensitivity to source time history variation. Such detectors potentially should allow sensitive detection of variable events from interesting classes of sources, such as open-pit mines. The detectors we are developing are based upon matched field processing (MFP), a technique developed for problems of source location in underwater sound. MFP was developed to track very narrowband sources (e.g. rotating machinery), and operates by matching the spatial amplitude and phase structure of a wavefield incident on an observing array or sensor network. In adapting the technique to operate on wideband seismic signals, we are breaking the observed seismic wavefield into many narrow frequency bands, a decomposition which, frequency-by-frequency, separates the spatial and temporal structures of the wavefield. This separation enables a detector which matches the spatial structure of the wavefield, but is insensitive to its time history.
The development of frequency-dependent spatial templates for this type of detector is labor intensive, if performed manually. Consequently, we are developing a system to perform this type of detector calibration automatically. The detection framework that we describe has a sufficiently general representation that it can implement a spectrum of detector types ranging from correlation detectors to matched field detectors. We are experimenting with a self-calibrating detector for a single discrete source that, with many observations of event waveforms, automatically configures as a correlator if the waveforms are highly repeatable or a matched field detector if they are not. We are developing the framework to operate on an array or a network of arrays operating coherently across a very large spatial aperture.