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CTBT Seismic Monitoring in Far East Asia using Coherent and Incoherent Array Processing

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The detection and location capability of the International Monitoring System for small seismic events in the continental and oceanic regions surrounding the Sea of Japan is determined mainly by three primary seismic arrays: USRK, KSRS, and MJAR. Body wave arrivals are coherent on USRK and KSRS up to frequencies of around 4 Hz and classical array processing methods can detect and extract features for most regional signals on these stations. We demonstrate how Empirical Matched Field Processing (EMFP), a generalization of f-k analysis, can provide calibrated direction estimates which mitigate bias resulting from near-station geological structure. It does this by comparing the narrowband phase shifts observed at a given time with those measured on signals from historical seismic events. The EMFP detection statistic is evaluated as a function of source location rather than slowness space and the size of the geographical footprint valid for EMFP templates is affected by array geometry, the available signal bandwidth, and Earth structure over the propagation path. The MJAR array has similar dimensions to KSRS but is sited in far more complex geology which results in poor parameter estimates with classical f-k analysis for all signals lacking energy at 1 Hz or below. EMFP mitigates the signal incoherence to some degree but the geographical footprint valid for a given matched field template on MJAR is very small. Spectrogram beamforming provides a robust detection algorithm for high frequency signals at MJAR. The array aperture is large enough that f-k analysis performed on continuous AR-AIC functions, calculated from optimally bandpass-filtered signals at the different sites, can provide robust slowness estimates for regional P-waves. Given a significantly higher SNR for regional S-phases on the horizontal components of the 3-component site of MJAR, we would expect incoherent detection and estimation of S-phases to improve with 3-component sensors at all sites.