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The Applicability of Incoherent Array Processing to IMS Seismic Array Stations

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The seismic arrays of the International Monitoring System for the CTBT differ greatly in size and geometry, with apertures ranging from below 1 km to over 60 km. Large and medium aperture arrays with large inter-site spacings complicate the detection and estimation of high frequency phases since signals are often incoherent between sensors. Many such phases, typically from events at regional distances, remain undetected since pipeline algorithms often consider only frequencies low enough to allow coherent array processing. High frequency phases that are detected are frequently attributed qualitatively incorrect backazimuth and slowness estimates and are consequently not associated with the correct event hypotheses. This can lead to missed events both due to a lack of contributing phase detections and by corruption of event hypotheses by spurious detections. Continuous spectral estimation can be used for phase detection and parameter estimation on the largest aperture arrays, with phase arrivals identified as local maxima on beams of transformed spectrograms. The estimation procedure in effect measures group velocity rather than phase velocity and the ability to estimate backazimuth and slowness requires that the spatial extent of the array is large enough to resolve time-delays between envelopes with a period of approximately 4 or 5 seconds. The NOA, AKASG, YKA, WRA, and KURK arrays have apertures in excess of 20 km and spectrogram beamforming on these stations provides high quality slowness estimates for regional phases without additional post-processing. Seven arrays with aperture between 10 and 20 km (MJAR, ESDC, ILAR, KSRS, CMAR, ASAR, and EKA) can provide robust parameter estimates subject to a smoothing of the resulting slowness grids, most effectively achieved by convolving the measured slowness grids with the array response function for a 4 or 5 second period signal. The MJAR array in Japan recorded high SNR Pn signals for both the 2006 and 2009 North Korea nuclear tests but, due to signal incoherence, failed to contribute to the automatic event detections. It is demonstrated that the smoothed incoherent slowness estimates for the MJAR Pn phases for both tests indicate unambiguously the correct type of phase and a backazimuth estimate within 5 degrees of the great-circle backazimuth. The detection part of the algorithm is applicable to all IMS arrays, and spectrogram-based processing may offer a reduction in the false alarm rate for high frequency signals. Significantly, the local maxima of the scalar functions derived from the transformed spectrogram beams provide good estimates of the signal onset time. High frequency energy is of greater significance for lower event magnitudes and in, for example, the cavity decoupling detection evasion scenario. There is a need to characterize propagation paths with low attenuation of high frequency energy and situations in which parameter estimation on array stations fails.