Geophysical Research Abstracts
Vol. 16, EGU2014-8630, 2014
EGU General Assembly 2014

A Filter Bank Approach to Earthquake Early Warning

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Earthquake Early Warning (EEW) is a race against time. The longer it takes to detect and characterize an ongoing event, the larger is the blind zone - the region where a warning arrives only after the most damaging ground motion has occurred. The problem is most acute during medium size earthquakes, where damaging ground motion is confined to a small zone around the epicenter. An ideal EEW algorithm which is fast enough to provide relevant alerts for such scenario events would have to produce reliable event characterization based on observations of very short snippets of data recorded at only very few stations. For such a scheme to work, without significant numbers of false alarms (which continue to hamper both single-station and network based approaches today), the real-time information that is available for an earthquake has to be exploited in a more optimal way than what is currently done.

Our approach is to fully mine the broadband frequency content of incoming waveforms that contains significant information on the size and epicentral distance of the ongoing event. We propose a filter bank approach with minimum phase delay filters which allows us to use frequency information from each frequency band at each triggered station at the earliest possible time. We have compiled and processed an extensive dataset of near-field earthquake waveforms. In an empirical maximum likelihood scheme, we use the filter bank output from the first seconds after the P-wave onset of each waveform to estimate the most likely magnitude and epicentral distance to have caused this waveform. We show how our single station approach can be integrated into an evolutionary and fully probabilistic network EEW system. We demonstrate that our method can allow sufficiently accurate characterization of an ongoing event with two stations, with consistent characterization of the evolving uncertainty of the location and magnitude.