# Abstract

The Virtual Seismologist method for earthquake early warning uses a Bayesian approach to find the most probable magnitude and location estimates given the incoming ground motions envelopes from a rupturing earthquake. Ground motion ratios and ground motion envelope attenuation relationships are used to estimate magnitude and epicentral location as early as 3 seconds after the initial P wave detection. The use of prior information distinguishes this method from other proposed methods for seismic early warning. The state of health of the seismic network, previously observed seismicity, fault locations, and the Gutenberg-Richter relationship are the types of prior information useful in resolving trade-offs in the initial source estimates which are unresolved by the limited data. Short-term earthquake forecasts are ideal priors for seismic early warning.

Having a high density of stations with real-time telemetry reduces the complexity involved in finding the most probable source estimates and communicating these estimates to early warning subscribers. The benefits of prior information are most evident for regions with low station density. Most early warning studies are focused exclusively on either the source estimation problem, or how subscribers use the warning information. The inclusion of prior information ultimately requires a level of coordination and communication between the network broadcasting the early warning information and the subscribers that is not consistent with this divide. The need for a more integrated approach to seismic early warning which considers the source estimation and user response as interacting and interrelated parts of a single problem is discussed.

A parameterization that decomposes observed ground motion envelopes into P-wave, S-wave, and ambient noise envelopes is developed and applied to a large suite of observed ground motion envelopes recorded within 200 km of $2 \leq M \leq 7.3$ Southern California earthquakes. Separate attenuation relationships are developed to describe

the magnitude, distance, and site dependence of various channels of P- and S-wave envelopes. The P-wave relationships allow the early warning source estimates to be obtained from observed P-wave amplitudes. Aside from early warning applications, these envelope attenuation relationships are used to investigate the average properties of ground motions recorded by the Southern California Seismic Network. Station-specific amplification factors for 150 Southern California Seismic Network stations were obtained for horizontal and vertical acceleration, velocity, and displacement amplitudes, and are included (Excel format) as external multimedia objects.