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Evaluating and comparing performance of earthquake early warning algorithms

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The earthquake early warning algorithm development project of the California Integrated Seismic Network (CISN) has two important parts: implementing early warning algorithms in a realtime environment and evaluating their performance under these conditions. Three early warning algorithms are being implemented as part of the CISN project. Two, Elarms (Allen and Kanamori) and Virtual Seismologist (Cua and Heaton), are network-based and estimate magnitude, location, and distribution of peak ground motions over a given region. The third, the Pd/TauC method (Wu and Kanamori), is a single-station approach that could be implemented at a station. It estimates magnitude and peak ground motion at that particular site.

An important goal of our efforts is to define performance measures that capture the gist of an algorithm's performance as quickly and succinctly as possible. Most network-based early warning algorithms continuously update their estimates as more data becomes available. Their performance can be assessed using, for example, the difference between the magnitude and location estimates for an event from the algorithm, and those found for the event in the earthquake catalogues. An algorithms' prediction of peak intensity measures (PGA, PGV, estimated shaking intensity) at various stations across the network can also be used to evaluate its performance. Available warning time is also an important criterion. An early warning algorithm's performance with respect to these measures is likely to be a function of magnitude, distance of the site(s) from the source region, and the amount of data available to constrain each estimate. Thus, it will be dependent on station density and telemetry. Along with accuracy and reliability, algorithm performance can also be evaluated by the time required to

produce a warning after P wave arrival. This depends on the duration of input data required by the algorithm and the processing time it requires. For early warning applications, algorithm accuracy and reliability may need to be traded for speed of warning production. Based on these measures, we will also develop criteria for comparing algorithm performance.

We illustrate these concepts with real and synthetic datasets. They will be implemented on the CISN early warning website, where the output from the various algorithms is collected. These concepts currently use deterministic information from the various algorithms; future work will take into account the probabilistic nature of these early warning estimates.