Updates on EEW Testing and Finite Fault Research at Caltech

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Within a feasibility study funded by the U.S. Geological Survey, we currently test different approaches for earthquake early warning (EEW) in California using the infrastructure of the California Integrated Seismic Network (CISN). The CISN operates 450 broadband and strong motion sensors deployed at 300 different locations across California. The real-time transmission of waveform data to the central processing facilities at UC Berkeley, the U.S. Geological Survey (USGS) Menlo Park, and Caltech/USGS Pasadena includes dedicated data communications (radio, frame relay, DSL, satellite, and cell phone services) and publicly available Internet services (world wide web). The data transmission latencies are in the order of a couple of seconds. Latencies also depend on the type of data logger (*Boese et al.*, 2009a).

We have implemented the Tau_c-Pd on-site warning algorithm (*Kanamori*, 2005; *Wu et al*., 2007) using the infrastructure of the CISN. We have tested the real-time performance of the algorithm during more than 60 small to moderate-sized earthquakes (3.0≤M≤5.4) that have occurred in California and Baja during the past two years. Combined with newly derived station corrections the algorithm allows for a rapid determination of moment magnitudes and Modified Mercalli Intensity (derived from the peak ground velocity) with uncertainties of ±0.5 and ±0.7 units, respectively (*Boese et al.,* 2009a). The majority of reporting delays ranged from 9 sec to 16 sec, but recently have been reduced to 4 sec to 11 sec with a new software implementation.

The largest event, the July 29 2008 M5.4 Chino Hills earthquake, triggered a total of 60 CISN stations at epicentral distances of up to 250 km. Magnitude predictions at these stations ranged from M4.4 to M6.5 with a median of M5.6 (*Boese et al.*, 2009a). The first estimate (M6.1) was available 10 sec after origin time, providing up to 6 sec notification time at Los Angeles City Hall, if the system would have been operational. Recent improvements of the algorithm led to a significant increase of the processing speed. In the case of another earthquake at the same site like the Chino Hills earthquake, notifications should be available within 5-6 sec after origin. The implementation of the Tau_c-Pd trigger criterion (*Boese et al.*, 2009b) reduced the number of false triggers significantly and stabilized the magnitude estimates for small to moderate-size earthquakes.

Large magnitude earthquakes ($M>7.0$) with ruptures up to hundreds of kilometers long cause damaging ground motions in much larger areas than moderate to strong earthquakes. Although their occurrence is rare, many more people could benefit from an EEW system during such large events. We have developed a probabilistic approach to EEW for large earthquakes based on the Bayesian theory, which allows us to quantify the uncertainties of magnitude and ground motion predictions. We find a strong dependency of slip amplitudes and rupture length on the characteristics of the underlying fault (slip heterogeneity). We conclude that EEW for large events requires a rapid recognition of the rupturing fault, e.g. from real-time GPS measurements, and consideration of the respective *a priori* statistics for the occurrence of earthquakes of different size along this fault.