RESEARCH OBJECTIVES

The goal of this research program is to assess the feasibility of providing ground shaking warnings for earthquakes underway in northern California. During the past year our focus has been to (1) test the ElarmS early warning methodology using the available northern California waveform dataset and develop the methodology as necessary, (2) implement the algorithms for automated, non-interactive processing of future events, and (3) begin the development of a real-time implementation as part of the existing real-time earthquake monitoring system.

APPROACH

The ElarmS methodology was developed using the earthquakes and networks available in southern California. The methodology therefore needed to be evaluated for use in northern California where the number and density of broadband velocity instruments is lower. As a result of this testing the methodology has been improved through the development of additional components including (1) the use of strong motion data, (2) the use of P-wave amplitude to estimate magnitude in addition to predominant period, (3) incorporation of signal-to-noise information to indicate waveform quality, and (4) the use of components of ShakeMap to provide output predictions of PGA, PGA and MMI.

Since February 2006 the ElarmS algorithms have been processing waveform data in an automated, non-interactive mode. Ten minutes after all M ≥ 3.0 earthquakes an email notification initiates processing of waveform data for a time window that includes the earthquake. This provides an assessment of algorithm performance based on all available data 10 mins after an event assuming no telemetry delays.

Figure. “AlertMap” output from the automated ElarmS processing for the August 2, 2006, Ml 4.7, earthquake near Santa Rosa. The AlertMap shows the predicted MMI output every second. The lower right figure is the event ShakeMap which is essentially identical to the AlertMap produced 3 sec after the first seismic station to detect the P-wave arrival.
August 2006 was the beginning of a new undertaking to test several early warning algorithms on California’s real-time seismic systems. This effort is a collaboration of UC Berkeley, Caltech, SCEC and the USGS. The difference between the automated, non-interactive processing and the real-time implementation is that the real-time implementation is (1) running on continuous waveforms rather than only for time windows which include earthquakes, and (2) the processing occurs in real-time as necessary if warnings are to be issued. The UC Berkeley contribution to date has been to implement the waveform processing components of ElarmS on the real-time platform. This processing sequence is now operational.

ACCOMPLISHMENTS

The methodological improvements have now been tested through the automated processing of almost 1 year of earthquakes in northern California. The example earthquake shown in the figure for the August 2, 2006, M_L 4.7, earthquake near Santa Rosa shows that the output prediction 3 sec after the first P-wave trigger is essentially identical to the ShakeMap for the event. One second after the trigger the first MMI prediction is high due to a high magnitude estimate based on just 1 sec of data from one station. One second later the magnitude estimate is improved, and one second after that the first peak ground shaking is observed at the closest station to the epicenter. The AlertMap is nearly identical to the ShakeMap at this point when there is still 12 sec warning until the peak ground shaking in Oakland and San Francisco. While this is only a small event, it is perhaps similar to a damaging scenario rupture propagating down the Hayward-Rodgers Creek Fault.

The median warning time for all processed events is 49 sec for Bay Area cities when 4 sec of data is available from 4 seismic stations. The average magnitude error at this time is 0.5 magnitude units and the average MMI error is 0.1.

Given the success of the automated, non-interactive processing we have now completed the first stage of the real-time implementation of ElarmS for evaluation purposes. The waveform derived parameters necessary for ElarmS including triggers, predominate periods, peak amplitudes and signal-to-noise ratios are now output ready for processing by the event monitor.

We have also initiated discussions with potential users of early warning information. BART is one example of an organization that would like to receive the information and is currently in the process of determining the most effective method of incorporating it into their operations.

SIGNIFICANCE OF FINDINGS

The results of these various studies are providing the information necessary to evaluate the potential utility of an early warning system in California. The testing with northern California data has demonstrated that the approach is effective given the existing distribution of seismic stations. The automated, non-interactive processing is providing insight into the difficulties of running an automated system and testing the algorithms on “new” events without human interaction. It has also provided estimates of the accuracy of warnings and demonstrated that both the accuracy and timeliness of warning information is as was predicted by the feasibility study conducted previously (and reported in last year’s NEHRP research summary). Finally, the real-time implementation is beginning to test the false trigger rate and the limitations of the existing telemetry system.
PUBLICATIONS (FY2006)

Papers

Papers in press

Papers in review

Abstracts

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