Toward real-time ground motion warning for earthquakes in southern California

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The deployment of an earthquake warning system was first discussed in the aftermath of the "great San Francisco earthquake" of 1868. However, such a system is only now being implemented in California as available technologies and analysis algorithms have previously not been capable of detecting, transmitting, processing and issuing warnings within the short time between the event onset and damage occurring.

Ground motion warning relies on detection of earthquake initiation close to the epicenter facilitating prediction of the ground motion across the earthquake region. In the case of an earthquake some distance from metropolitan areas, the peak ground motion may be observed close to the epicenter and a prediction of the peak ground motion made for locations further from the event. If a warning system is also to be useful for events located beneath metropolitan areas (such as Northridge), it must be capable of detecting an event, and predicting peak ground motion using the initial pulse of relatively minor ground motion which arrives at the surface a few seconds before the damaging pulse.

The deployment of the dense TriNet network across southern California provides the potential for real-time ground motion detection and warning. The algorithm currently under development uses both approaches to ground motion prediction. Firstly, for the worst case scenario of an event directly beneath a metropolitan area, we use the predominant period of the P-arrival. This parameter is relatively insensitive to epicentral distance allowing an estimate of magnitude from the arrival at a single station. Attenuation relationships then provide the predicted peak ground motions and approximate times. Depending on the depth of the event, much of this process is possible before the peak shear motion (responsible for most damage) reaches the surface. This system could provide ground motion warnings of zero to a few seconds in the region directly above an earthquake.

As time progresses and the system warnings update, the second approach using peak ground motion observations becomes possible. The best-fit attenuation relation is used to predict ground motion further from the epicenter. This technique may only be used after a number of stations have experienced their peak ground motion, but it provides more accurate predictions of ground motion than the predominant period method. We anticipate this approach will be of most use for the "great" earthquakes, which propagate along significant lengths of known and monitored faults. It could provide tens of seconds of warning.

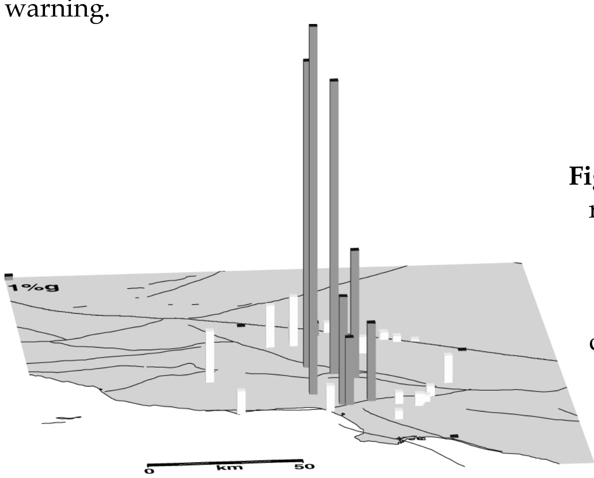

Figure: Perspective map of the Los Angeles area showing recorded peak acceleration (vertical bars) between 9 and 10 sec after the Northridge earthquake. Grey bars are predominantly horizontal motion, white are the predominantly vertical P-arrivals which arrive first but cause little damage. The sites above the fault plane start to experience their peak ground motion in this time window, 3 sec after a magnitude estimate can be made from the P-arrivals at the same stations.