Real-time ground motion prediction 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. The concept then, as now, is simple: Earthquakes occurring some distance from a metropolitan area could be detected near the epicenter and a warning signal transmitted ahead of the associated ground motion. Such a system has not yet been implemented in California as available technologies and analysis algorithms were not capable of detecting, transmitting, processing and issuing warnings within the short time between the event onset and damage occurring.

The deployment of the dense TriNet network across southern California provides the potential for truly real-time ground motion detection and warning. The algorithm currently under development uses two 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.

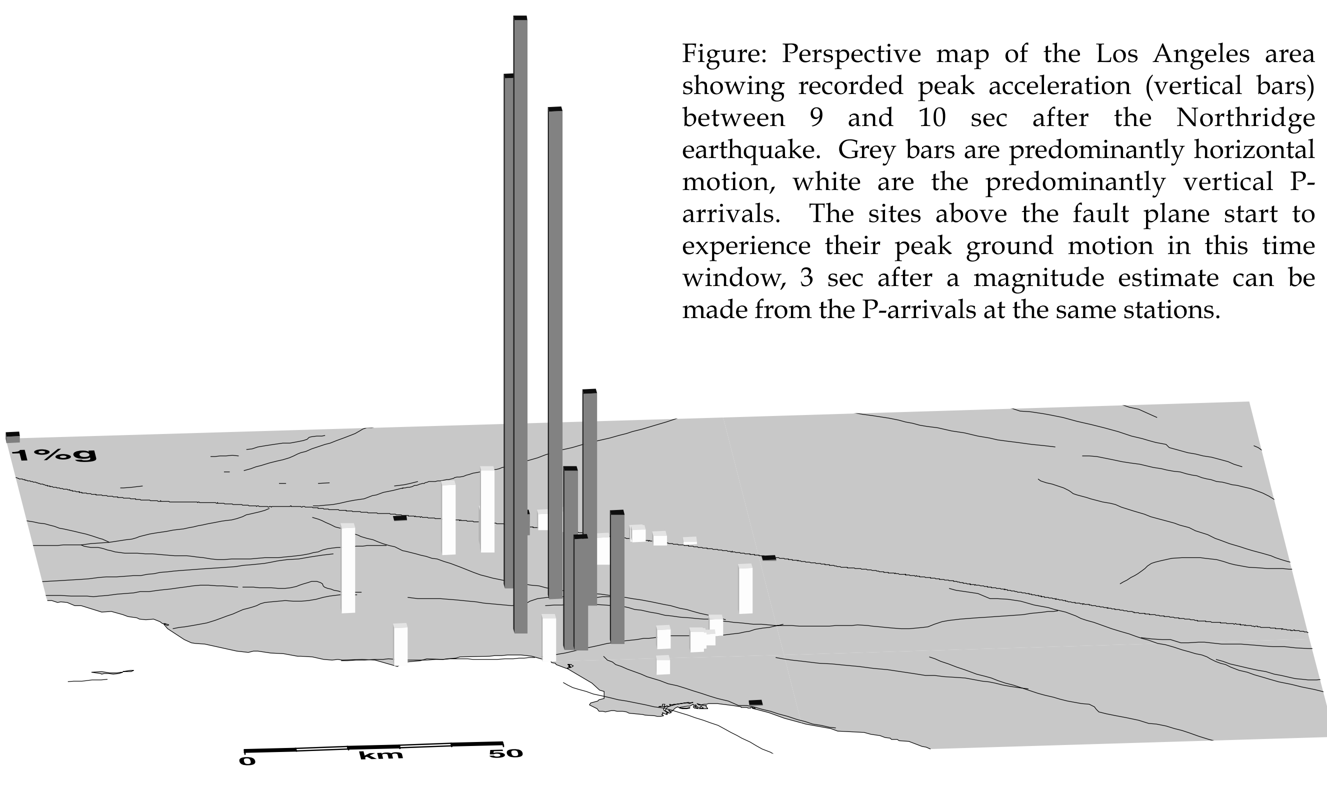

Figure: Perspective map of the Los Angeles area showing recorded peak acceleration (vertical bars) between 9 and 10 sec after the Northridge earthquake. Grey bars are predominantly horizontal motion, white are the predominantly vertical P-arrivals. The sites above the fault plane start to experience 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.