1-070

Characteristics of Ground Motion Attenuation during the M7.2 El Mayor Cucapah (Baja) Earthquake

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1. Summary

The magnitude 7.2 El Mayor Cucapah earthquake of April 4, 2010, occurred in northern Baja California, approximately 40 miles south of the US-Mexico border at shallow depth along the plate boundary between the North American and Pacific plates. Ground shaking was recorded by 408 free-field strong motion stations in US territory; these data were processed in order to calculate peak ground acceleration (PGA) and 5 percent damped spectral ordinates at 1, 3, 5, 7 and 10 s. Although ground motion showed faster attenuation from the source, typical for California due to low regional Q-factor, long-period motions were significantly amplified in San Fernando, San Bernardino and Los Angeles basins; all of them located more than 300 km away from the source. In this study, five recently developed ground-motion prediction equations (GMPEs) were examined for their relative performance in modeling attenuation of PGA and spectral acceleration at various periods inside and outside of basins. Ground motion prediction equations considered are those of Graizer and Kalkan (2007 and 2009), Abrahamson and Silva (2008), Boore and Atkinson (2008), Campbell and Bozorgnia (2008), and Chiou and Youngs (2008). All these models utilized the NGA database, which includes data from stations in southern California basins. Except for GMPE of Boore and Atkinson, rest of the models accounts for basin amplification. In computing the predictions, Vs30 and basin depth parameters (Z1.0 and Z2.5) specific to each station were considered. We used California site classification map (Kalkan et al. 2010) for Vs30 and the latest SCEC Community Velocity Model (CVM-H 6.2) for deriving the aforementioned basin parameters. Ranking of GMPEs is achieved by using an information-theoretic approach suggested by Scherbaum et al. (2009) and further applied by Delavaud et al. (2009) for the purpose of selecting GMPEs for seismic hazard analysis in California. The resulting data driven rankings show that performance of GMPEs is strongly dependent on both distance and frequency. All five models estimate ground motion in southern California fairly for PGA, 0.3s and 1s for distances up to 350 km from the source. At long periods (5 s and beyond), all models tend to underestimate the significantly amplified ground motions in Los Angeles basins. This underestimation is much less for the GMPE of Abrahamson and Silva.

2. Southern California Basins: Los Angeles, San Bernardino and San Fernando

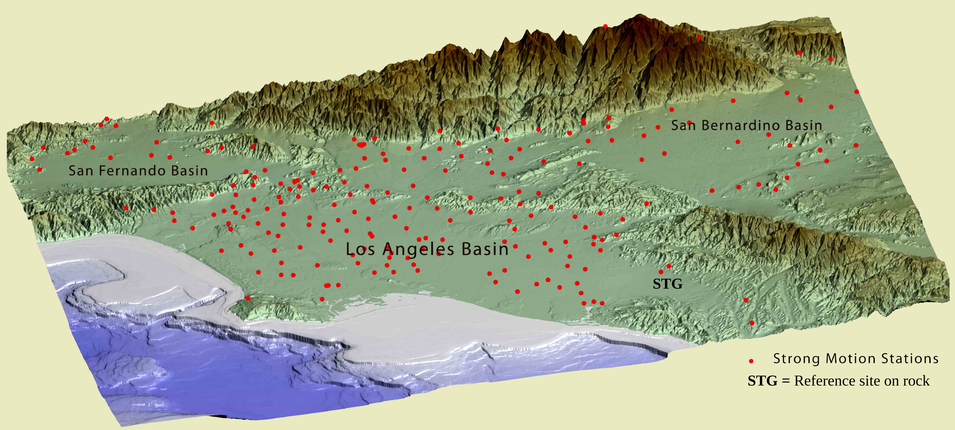

Figure 1. Three-dimensional topographic map of the Los Angeles, San Fernando and San Bernardino basins; strong motion free field stations are denoted by red circlues.

The observed peak ground velocity (PGV) values clearly shows that the LA basin significantly amplifies the long-period motions (see our poster #1-069). The largest PGV values observed within the LA basin range from 0.1 to 0.12 m/s, though the basin is around 350 km away from the epicenter. These largest PGV values were recorded at seven stations in the central part, and one station in the western part of the basin. The Fourier acceleration spectra of records from these eight stations are predominant at the periods of 6 to 8 s with the corresponding peak values of 1 to 1.4 m/s.

To understand how the long period spectral amplification due to basin underground structure, we plotted map of the amplification factors at 1, 3, 5, 7 and 10 s spectral periods with respect to the reference site (i.e. STG station of the Southern California Seismic Network, located on hard rock in the southeast edge of the LA basin). We utilized the latest SCEC Community Velocity Model (CVM-H 6.2) to define the basin underground structure.

3. Site Amplification at Different Spectral Periods (Period Range: 3 to 10 s)

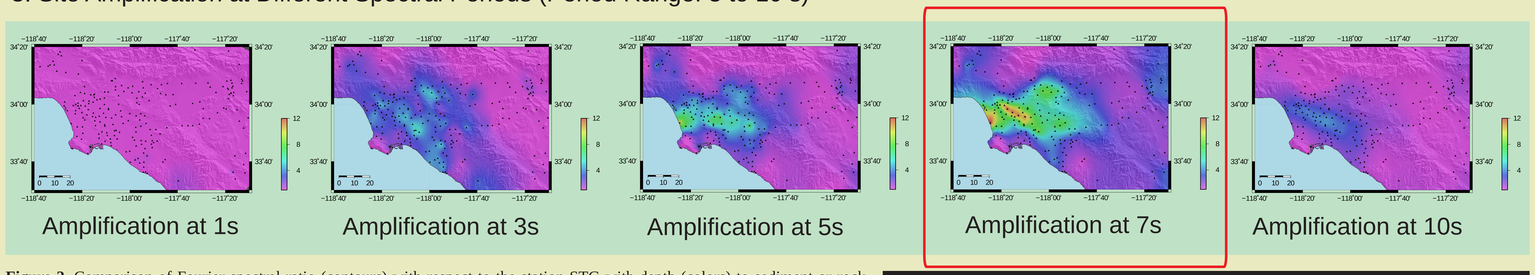

Figure 2. Comparison of Fourier spectral ratio (contours) with respect to the station STG with depth (colors) to sediment or rock different S-wave velocities. The Fourier spectral ratio are shown for the horizontal component. The depths are after the CVM-H 6.2.

Large amplification (as much as 12 times more at 7 s as compared to a site located on a bedrock) occurs in the central part of the LA basin where the depth to Vs = 3.2 km/s reaches to its maximum at a depth of 9.5 km.

4.Comparison of Predictions with Recorded Data (Period Range: PGA to 10 s)

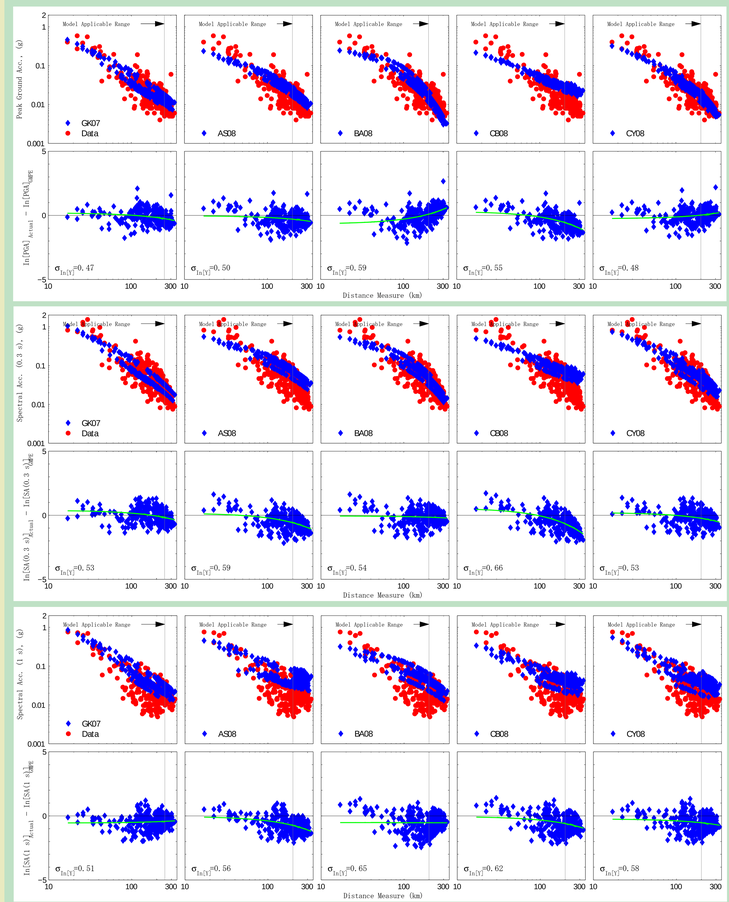

Figure 3. Comparison of recorded data at short periods (PGA, 0.3 s and 1 s) from the El Mayor-Cucapah earthquake with five different ground motion prediction equations. Also shown are the distribution of residuals and linear fit to identify trends in predicitons.

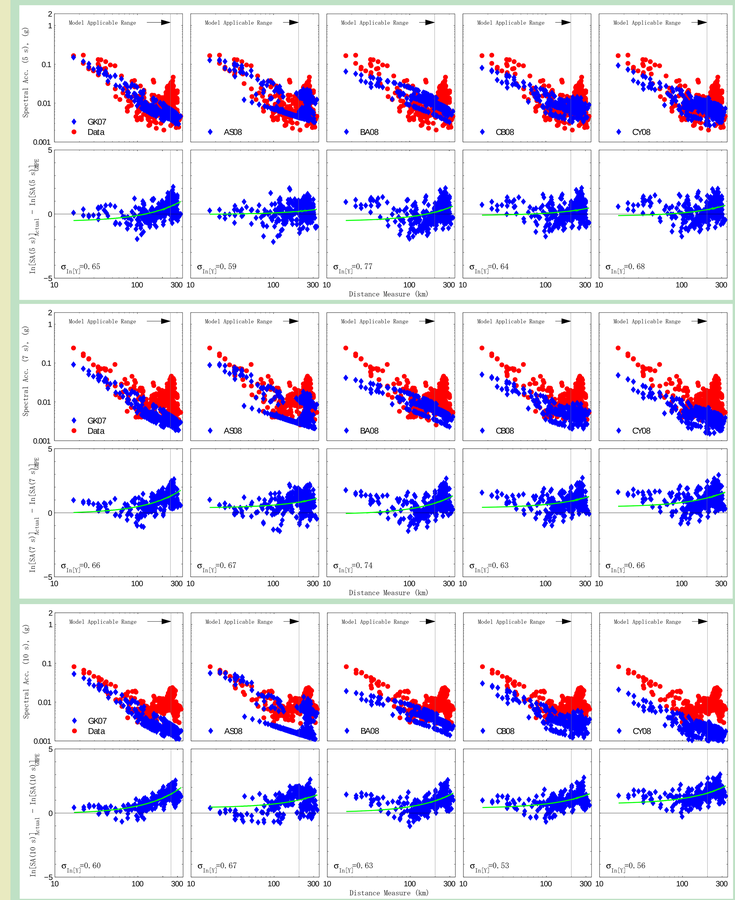

Figure 4. Comparison of recorded data at long periods (5 s, 7 s and 10 s) from the El Mayor-Cucapah earthquake with five different ground motion prediction equations. Also shown are the distribution of residuals and linear fit to identify trends in predicitons.

5.Ranking Ground Motion Prediciton Equations

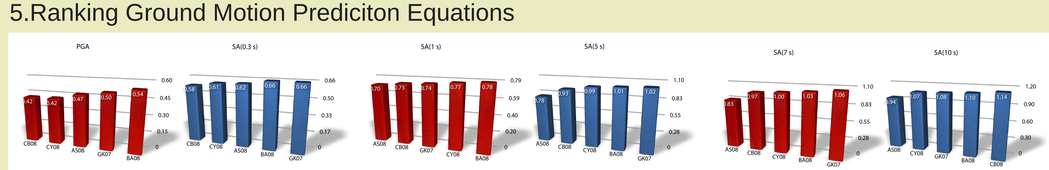

Figure 5. "Following the information theoretic approach suggested by Scherbaum et al. (2009) ground motion prediction equations have been ranked for their relative performance in estimating the ground motion of the El-Mayor Cucapah earthquake. The resulting rankings support a worse performance at longer periods (T>1s), indicated by the higher average-log likelihood values (see LLH values listed).

6.Conluding Remarks

Ground motion data show significant amplification at long periods (T>3 s) in LA basins, 250-300 km away from the source.

Ground motion prediction equations generally show equally good performance in their estimates at short periods (PGA, 0.3 s and 1 s), and they tend to underestimate the data at longer periods. This underestimation is lesser for the model of Abrahamson and Silva (2008).

Acknowledgment: We would like to thank Dave Boore for providing us the distance metrics for El-Mayor Cucapah Eq. (Rrub and Rjb) and also his Fortran code for the NGA relations.