Comparison of ground motions in earthquakes with SCEC CVM predictions

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Abstract

Southern California, and particularly the Los Angeles region, contains strongly heterogeneous crustal structures that have been carefully studied, mapped, and integrated into the SCEC Community Velocity Models (CVMs). Although the CVMs of Southern California are widely used for simulations of wave propagation and as a reference for many studies, their shortcomings in predicting ground motions are well recognized, especially in reproducing basin effects at high frequencies. The most recent SCEC model, CVM-S4.26, was inverted from waveform data at frequencies below 0.2 Hz. Our objective is to develop a model that can better predict higher frequency ground motions, which is a SCEC-stated priority in physics-based hazard assessment. Using the forward modeling of several moderate magnitude earthquakes that recently occurred in the Los Angeles region, we construct synthetic-data comparisons that characterize the inaccuracies in the CVM-S4.26 predictions up to about 0.5 Hz, focusing on features associated with the boundaries of the deep sedimentary basins. Our next step will be to use the 3D waveform modeling to identify coherent groups of seismic energy that can be accurately measured and have path-localized Fréchet kernels with good sensitivity to basin and near-surface structures. From these waveforms, we plan to extract phase and amplitude data up to 0.5 Hz or higher. Our goal is to invert these data using full-3D tomography and thereby improve the predictive power of SCEC's CyberShake ground-motion forecasts.

Station Maps

Stations used for Data v. Synthetic Comparison - La Habra 2014

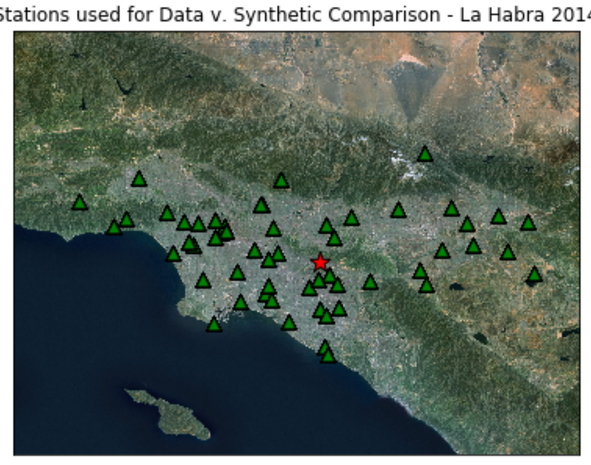

Figure 1: Green triangles represent all stations within or near the LA Basin that were used to compare data to synthetic calculation. Red star represents the epicenter of the 2014 La Habra event.

Stations used for Data v. Synthetic Comparison - Inglewood 2009

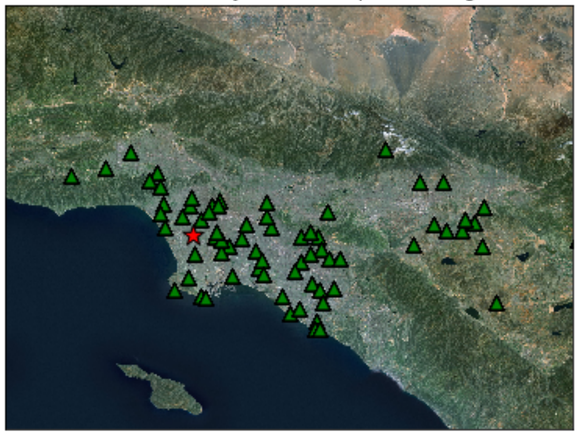

Figure 2: Green triangles represent all stations within or near the LA Basin that were used to compare data to synthetic calculation. Red star represents the epicenter of the 2009 Inglewood event.

Results

As an initial step, we compare simulations of moderate earthquakes with the data. The simulations were run by Rob Graves (pers. comm.) with CVM-S4.26, the data was processed by CESMD (CE network) and Ricardo Taborda (CI network). We present two examples here, the M4.7 2009 Inglewood and M5.0 2014 La Habra events. We show a comparison of data with synthetics for the transverse component, then show all the data for the larger set available.

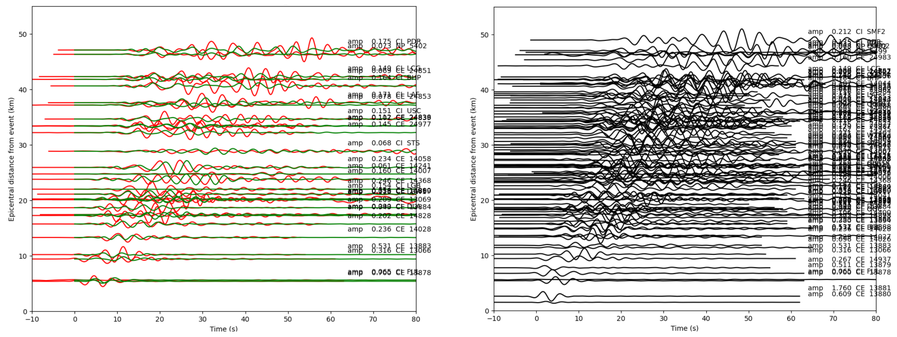

Figure 3: Left - Ground velocity (red) vs CVM-S4.26-223 prediction (green) for La Habra earthquake, vertical component, filtered 3 to 10 s period. Right –all available basin stations.

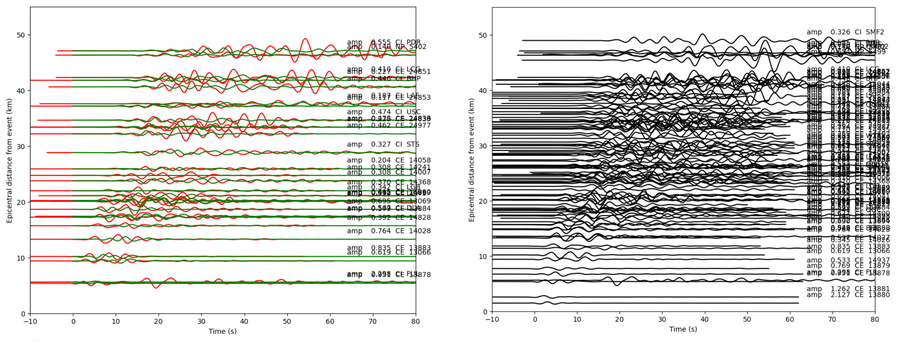

Figure 4: Left - Ground velocity (red) vs CVM-S4.26-223 prediction (green) for La Habra earthquake, transverse component, filtered 3 to 10 s period. Right –all available basin stations.

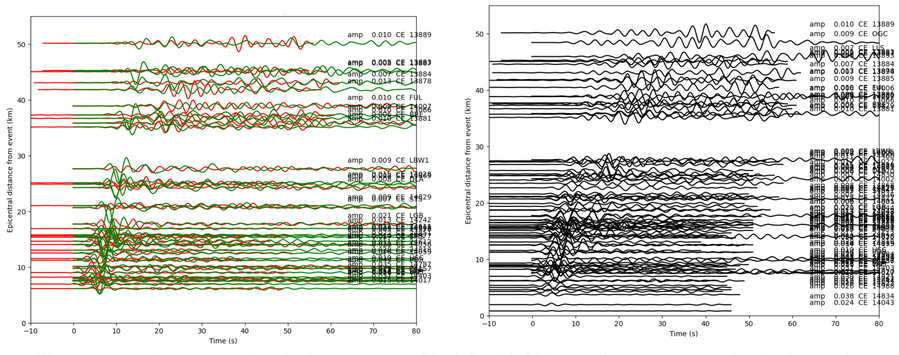

Figure 5: Left - Ground velocity (red) vs CVM-S4.26-223 prediction (green) for Inglewood earthquake, transverse component, filtered 3 to 10 s period. Right –all available basin stations.

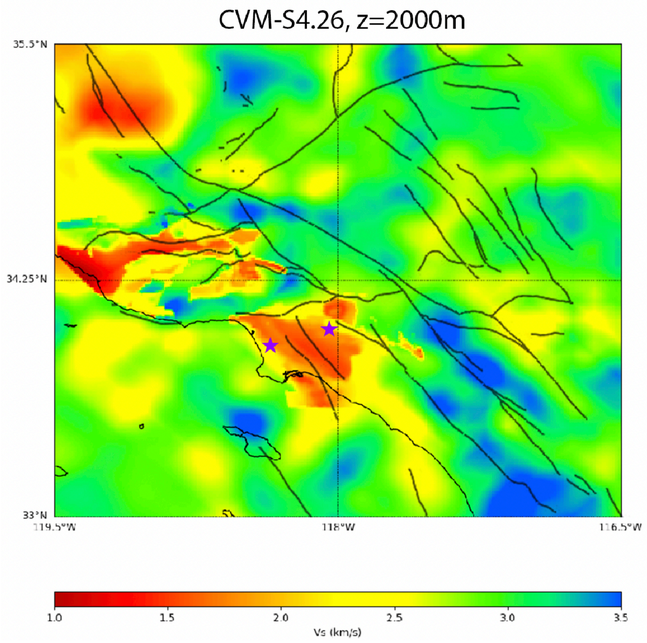

Figure 6: Purple stars are Inglewood and La Habra epicenters.

Summary

In the Los Angeles basin, even in the long-period passband from 3 to 10 sec period, it is clear that waveform fits from current SCEC models could be improved and motions for some paths are underestimated in amplitude and duration. This is seen both for Love energy on the transverse and Rayleigh energy on the vertical and radial components.

There is ample data to constrain refinements to the CVMs.

This work is still at an early stage due to a difficult year.

References

Lee E-J, P Chen, TH Jordan, PB Maechling, M DeNolle, GC Beroza, 2014. Full-3-D tomography for crustal structure in Southern California based on the scattering-integral and the adjoint-wavefield methods, JGR, 119, 6421-6451.

Nweke, C, R Graves, C Goulet, S Brandenberg, J Stewart, 2019. Forward Simulation of Earthquakes in Southern California with UCVMs, in *Southern California Earthquake Center (SCEC) Simulation Validation for Southern California Basins using Ground Motion Recordings*. DesignSafe-CI. https://doi.org/10.17603/ds2-762f-sg15.CVM-S4

Taborda, R, S Azizzadeh-Roodpish, N Khoshnevis, K Cheng, 2016. Evaluation of southern California seismic velocity models through simulation of recorded events, GJI, 205, 1342-1364.

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