Updates to the CyberShake PSHA Platform

Scott Callaghan[1], Philip J. Maechling[1], Fabio Silva[1], Christine A. Goulet[1], Kevin R. Milner[1], Bruce E. Shaw[2], Kim B. Olsen[3], Te-Yang Yeh[3], Robert W. Graves[4], Karan Vahi[5], Ewa Deelman[5], Albert R. Kottke[6], Thomas H. Jordan[1], Yehuda Ben-Zion[1]

(1) University of Southern California: {scottcal, maechlin, fsilva, cgoulet, kmilner, tjordan, benzion}@usc.edu; (2) Columbia University: shaw@ldeo.columbia.edu; (3) San Diego State University: kbolsen@mail.sdsu.edu, tyyeh316@gmail.com;
(4) U. S. Geological Survey: rwgraves@usgs.gov; (5) USC Information Sciences Institute: {vahi, deelman}@isi.edu; (6) Pacific Gas and Electric: ARKK@pge.com

Recent CyberShake updates include:

1) Study 21.12, performed using an earthquake rupture forecast derived from an RSQSim earthquake simulator catalog.
2) Validation using both the SCEC Broadband Platform and observations from the Northridge, Chino Hills, and Whittier events.
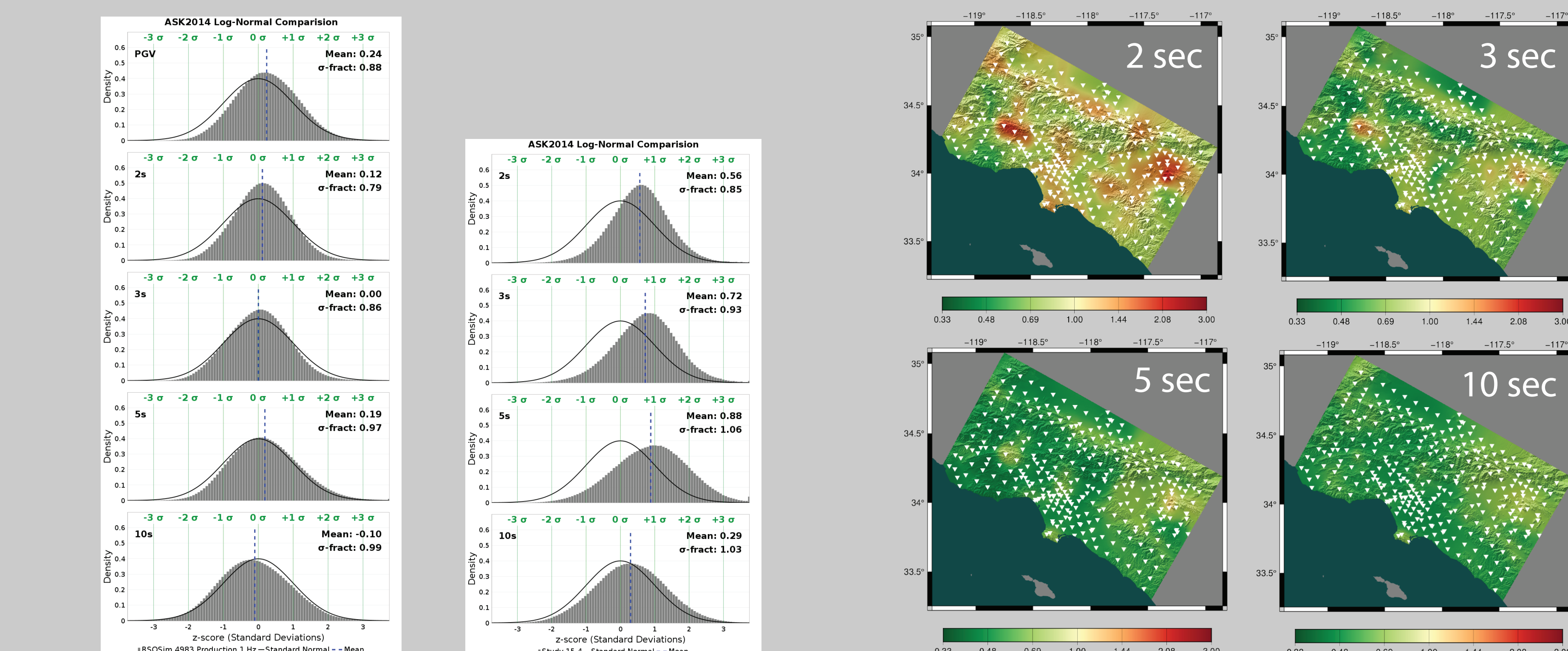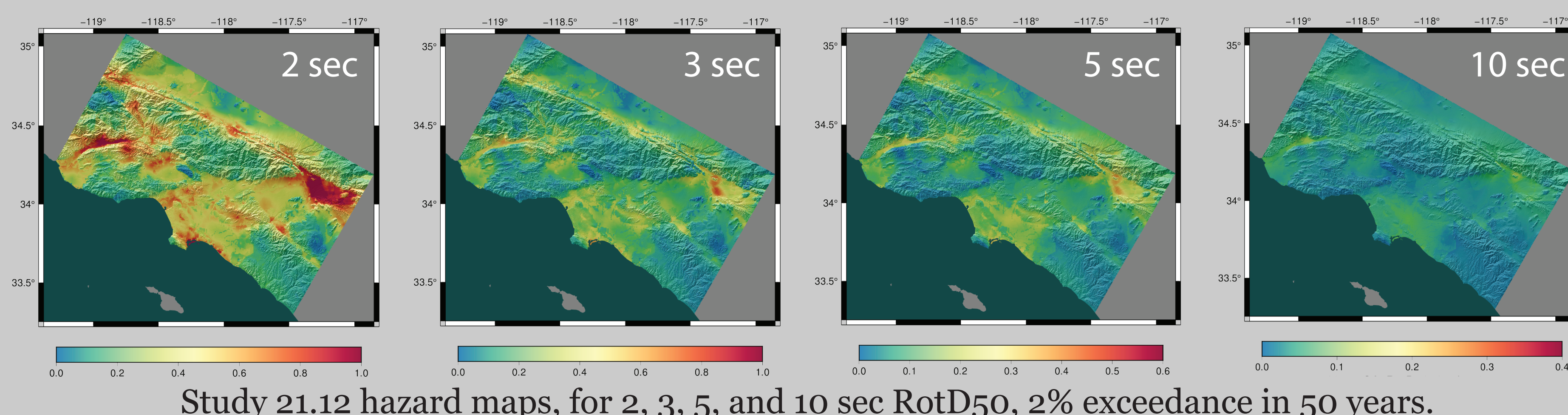
1) Study 21.12

For the first time, we performed a CyberShake study with an earthquake rupture forecast (ERF) derived using the RSQSim earthquake simulator. Previous CyberShake studies in this region (Study 15.4) used an ERF derived from UCERF2.

RSQSim ERF

Comparison of the magnitude distribution of the UCERF2 ERF used in Study 15.4 (left) with that of the RSQSim ERF used in Study 21.12 (right). The RSQSim ERF was derived from a 775kyr catalog with 221,000 events with M≤6.5.

Results

Study 21.12 hazard maps, for 2, 3, 5, and 10 sec RotD50, 2% exceedance in 50 years.
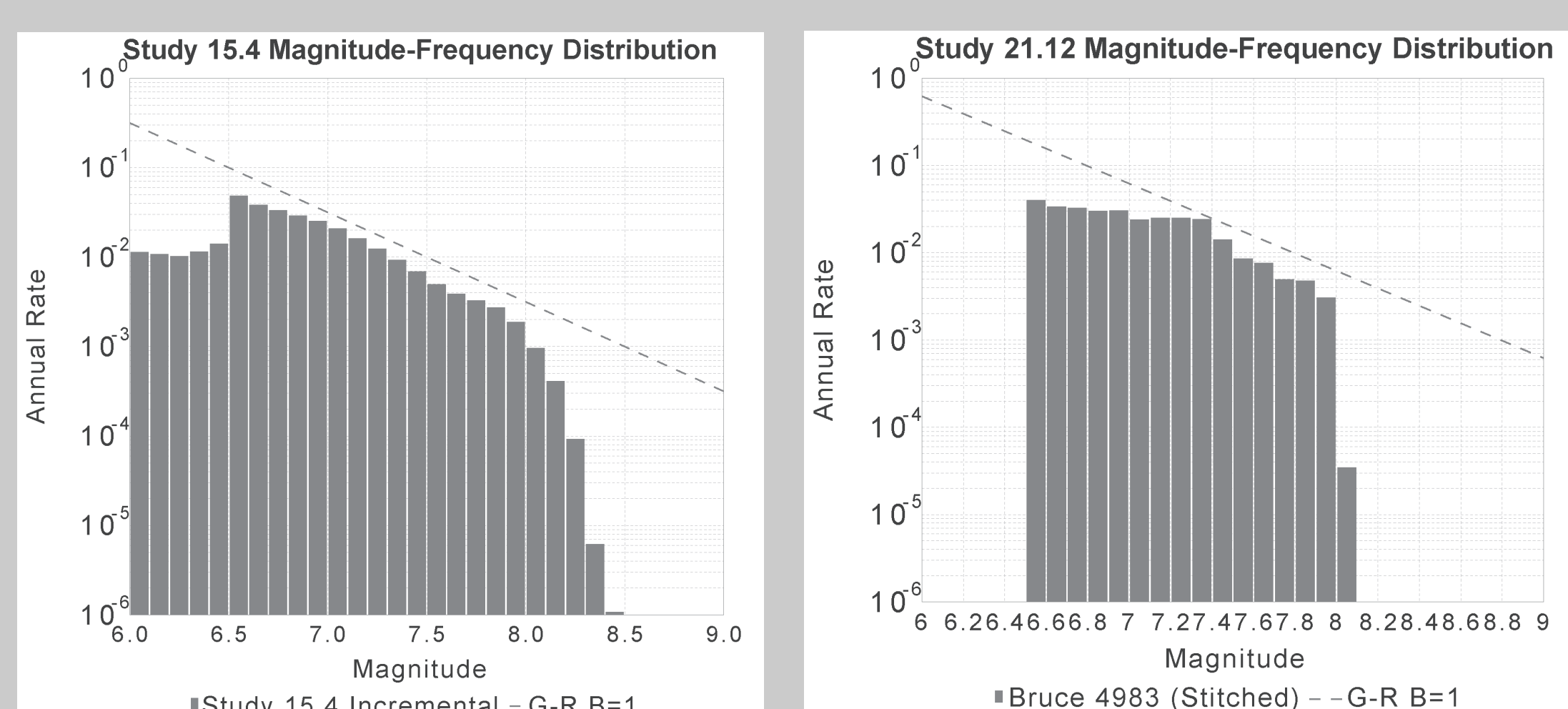
Ground motion comparisons between Study 21.12 and ASK2014 (left), and Study 15.4 and ASK 2014 (right)

Ratio of Study 21.12/Study 15.4 hazard models.

Study 21.12b

We investigated the impact of modifying the RSQSim rupture parameters to mimic a velocity strengthening layer in the top 3 km, reduce near-surface stress drops, and reduce near-fault ground motions. We generated a new RSQSim catalog and ran Study 21.12b with this new ERF.
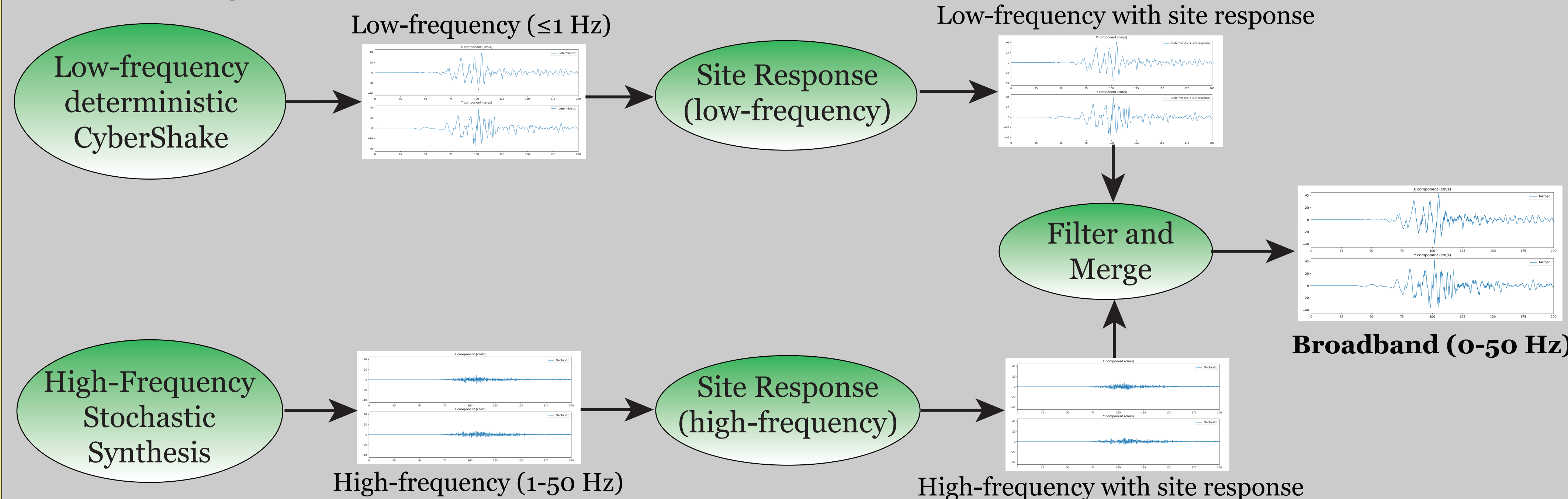
Study 21.12b hazard curves RotD50, 2% exceedance in 50 yrs.

Ratio of Study 21.12b/Study 15.4 hazard models.
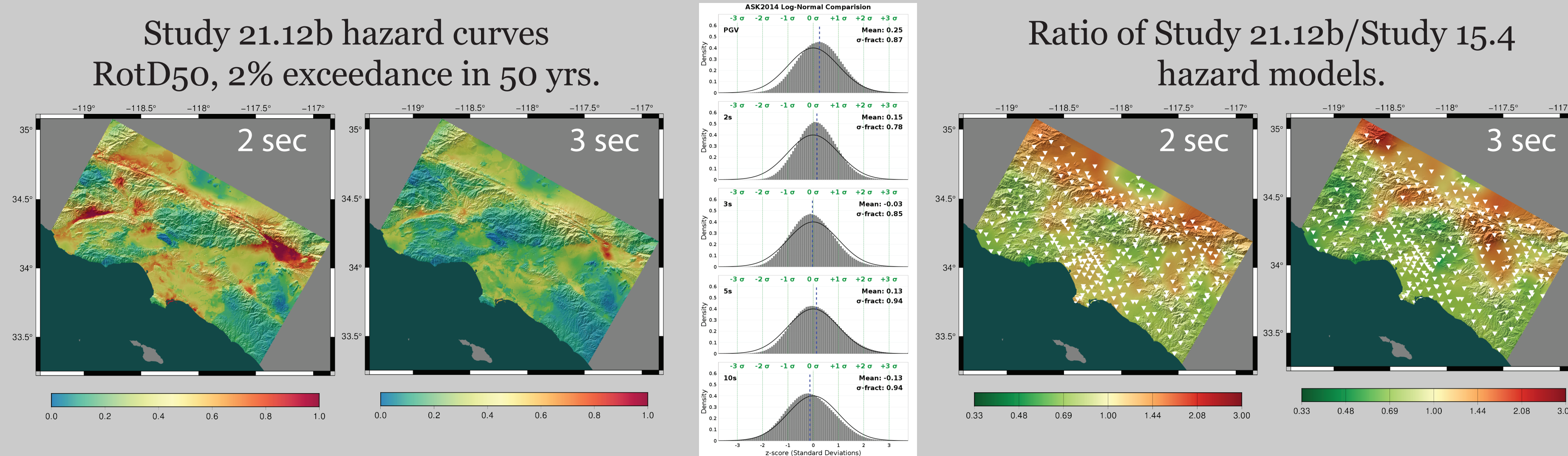
Ground motion comparisons between Study 21.12b and ASK2014.
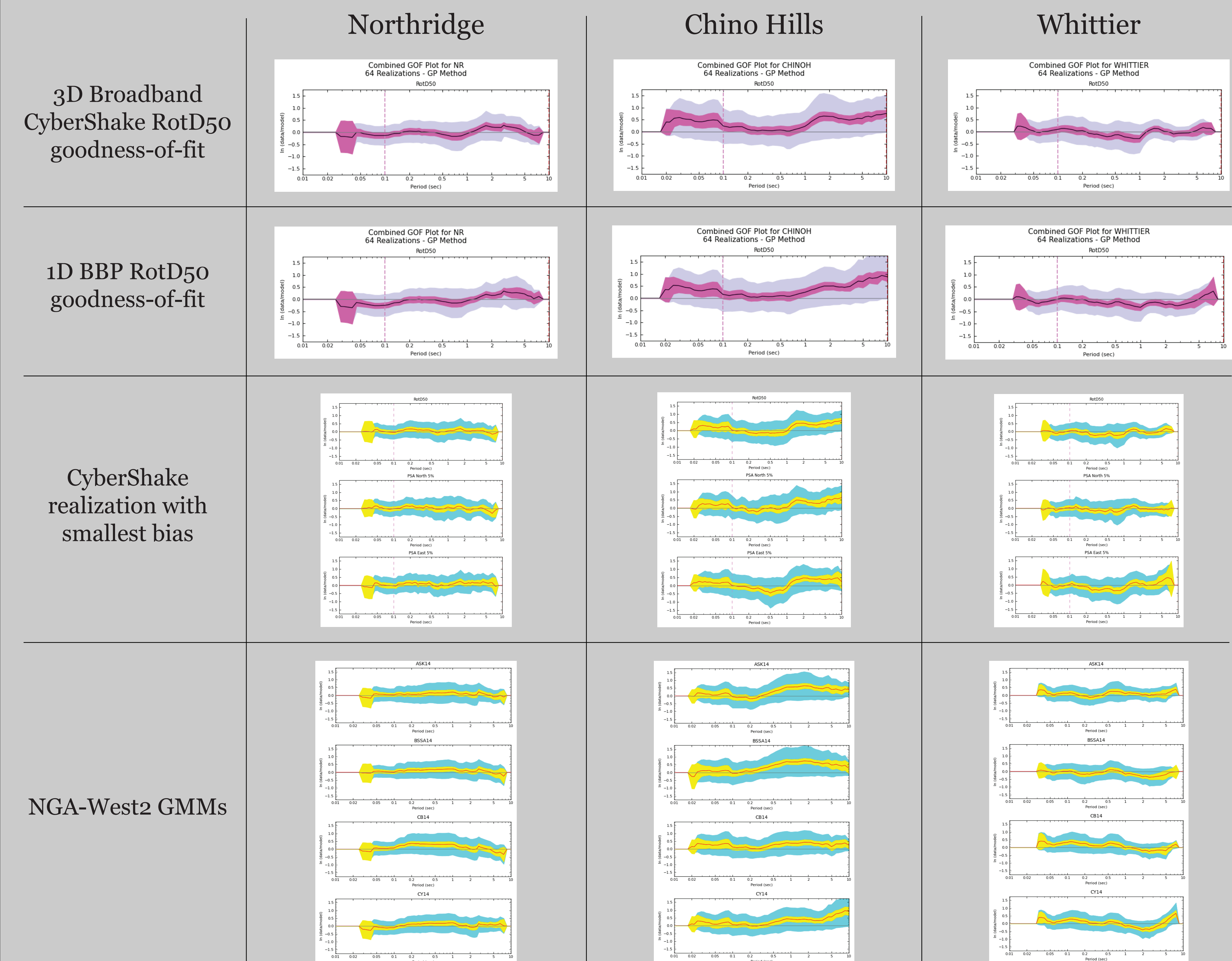
2) Validation Activities

To validate the Broadband CyberShake (BB CS) platform, we compared 3D BB CS results to the 1D SCEC Broadband Platform v22.4 (BBP) and observations of historical earthquakes.

Broadband CyberShake

Low-frequency deterministic CyberShake → Low-frequency (≤1 Hz) → Site Response (low-frequency) → Low-frequency with site response

High-Frequency Stochastic Synthesis → High-frequency (1-50 Hz) → Site Response (high-frequency) → High-frequency with site response

Filter and Merge → **Broadband (0-50 Hz)**

Validation Results

For each historic earthquake, we selected ~40 stations with recordings and simulated 64 realizations with the same magnitude and hypocenter, but varying slips. Below we show goodness-of-fit results aggregated across all stations and realizations. The goal is to show CyberShake generates reasonable results across realizations, not to exactly match the recordings.

	Northridge	Chino Hills	Whittier
3D Broadband CyberShake RotD50 goodness-of-fit			
1D BBP RotD50 goodness-of-fit			
CyberShake realization with smallest bias			
NGA-West2 GMMs			

The BB CS results show generally good agreement with observations, comparable or better than the BBP and GMM results. Differences in the Chino Hills results on both platforms are due to the large fault surface and low stress drop used in the simulations.