Electronic Supplement to

The SDSU Broadband Ground Motion Generation Module BBtoolbox Version 1.5

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This electronic supplement contains descriptions of the validation events and scenarios and fixed and region-dependent parameters, additional goodness-of-fit plots for GMPEs versus data, simulations versus GMPEs, and PSA bias versus distance, and comparison of rupture models with associated PSA bias and time histories for Landers.

Table S1. Description of Part A events. Z_{tor} is depth to the top of the fault.

Table S2. Description of Part B scenarios.

Table S3. Fixed parameters for BBtoolbox V1.5.

Table S4. Region-dependent parameters for BBtoolbox V1.5. Here, c_o is chosen as 2.1 for active regions, and as 1.1 for stable regions (Somerville et al., 2009).

Figure S1. PSA bias plots for the observed data versus the four GMPEs used in the validation for Alum Rock. AS08 is Abrahamson and Silva, 2008; BA08 is Boore and Atkinson, 2008; CB08 is Campbell and Bozorgnia, 2008; CY08 is Chiou and Youngs, 2008. Note that the GMPEs overpredict the data, similar to but more pronounced than the SDSU synthetics (see Figure 3), suggesting the presence of a relatively large event term for Alum Rock.

Figure S2. Part B of the validation comparing PSAs for 50-realization ensemble synthetics against leading GMPEs for M_w5.5, 6.2, and 6.6 scenarios, using the southern California 1D velocity model. The plots show the mean (square) and standard deviation (box), while error bars show extrema for all realizations.

Figure S3. PSA bias for selected periods versus distance for the Alum Rock scenario. The dots and error bars depict the median and range of values obtained for the 50 realizations.

Figure S4. Same as Figure S3, but for Chino Hills.

Figure S5. Same as Figure S3, but for Landers.

Figure S6. Same as Figure S3, but for Loma Prieta.

Figure S7. Same as Figure S3, but for North Palm Springs.

Figure S8. Same as Figure S3, but for Northridge.

Figure S9. Same as Figure S3, but for Whittier.

Figure S10. Same as Figure S3, but for Niigata.

Figure S11. Same as Figure S3, but for Tottori.

Figure S12. Same as Figure S3, but for Mineral.

Figure S13. Same as Figure S3, but for Riviere du Loup.

Figure S14. Same as Figure S3, but for Saguenay.

Figure S15. Best fit line (green) and 95% confidence regions (red-dashed) for period bins of 0.01-0.1s, 0.1-1s, 1-3s, and 3-5s including all 12 part A validation events. Y-axis is the mean bias in natural log units. Values are for each distance bin plotted with respect to the natural log of the central distance of each bin. Data are weighted by the number of stations and discrete periods in each distance bin. The ratio is the absolute value of the slope of the trend lines (green) divided by its standard error. Values less than 1 indicate that zero slope lies within the 95% confidence, and constitutes a passing criterion. All SDSU results met this criterion.

Figure S16. (left) Slip and rupture time contours and (right) GOF for the Landers realization with the (top) smallest and (bottom) largest bias. Notice that the rupture and slip pattern for the source generating the best fit appears in general better agreement with the kinematic inversion models obtained for Landers as compared to the source associated with the poorest fit.

Figure S17. (left) map of station locations (circles), fault (black line), and epicenter (star), and (right) Broadband velocity time histories and Arias Intensities for station YER (yellow circle in map) for the Landers realization with the smallest bias (data in black, synthetics in red).

References

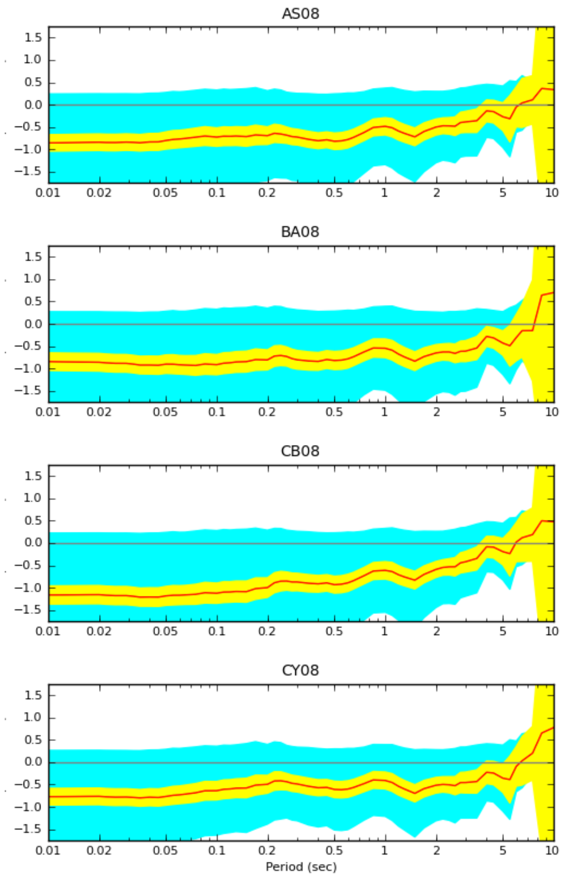
Abrahamson, N. A., and W. J. Silva (2008). Summary of the Abrahamson & Silva NGA Ground-Motion Relations, *Earthquake Spectra*, 24(1), 67-97.

Boore, D.M., and G.M. Atkinson (2008). Ground-motion prediction equations for the average horizontal component of PGA, PGV, and 5%-damped PSA at spectral periods between 0.01 and 10.0 s, *Earthquake Spectra* 24, No. 1, pages 99-138.

Campbell, K. W. and Y. Bozorgnia (2008). NGA ground motion model for the geometric mean horizontal component of PGA, PGV, PGD and 5% damped linear elastic response spectra for periods ranging from 0l01 to 10s, *Earthquake Spectra*, 24(1), 139-171.

Chiou, B. S.-J. and Youngs R. R. (2008). An NGA model for the average horizontal component of peak ground motion and response spectra, *Earthquake Spectra*, 24(1), 173-215.

Somerville, P., R. Graves, N. Collins, S.G. Song, S. Ni, and P. Cummins (2009). Source and Ground Motion Models for Australian Earthquakes, Proc. 2009 Annual Conference of the Australian Earthquake Engineering Society, Newcastle, 11-13.


AS08
BA08
CB08
CY08
1.5
1.0
0.5
0.0
−0.5
−1.0
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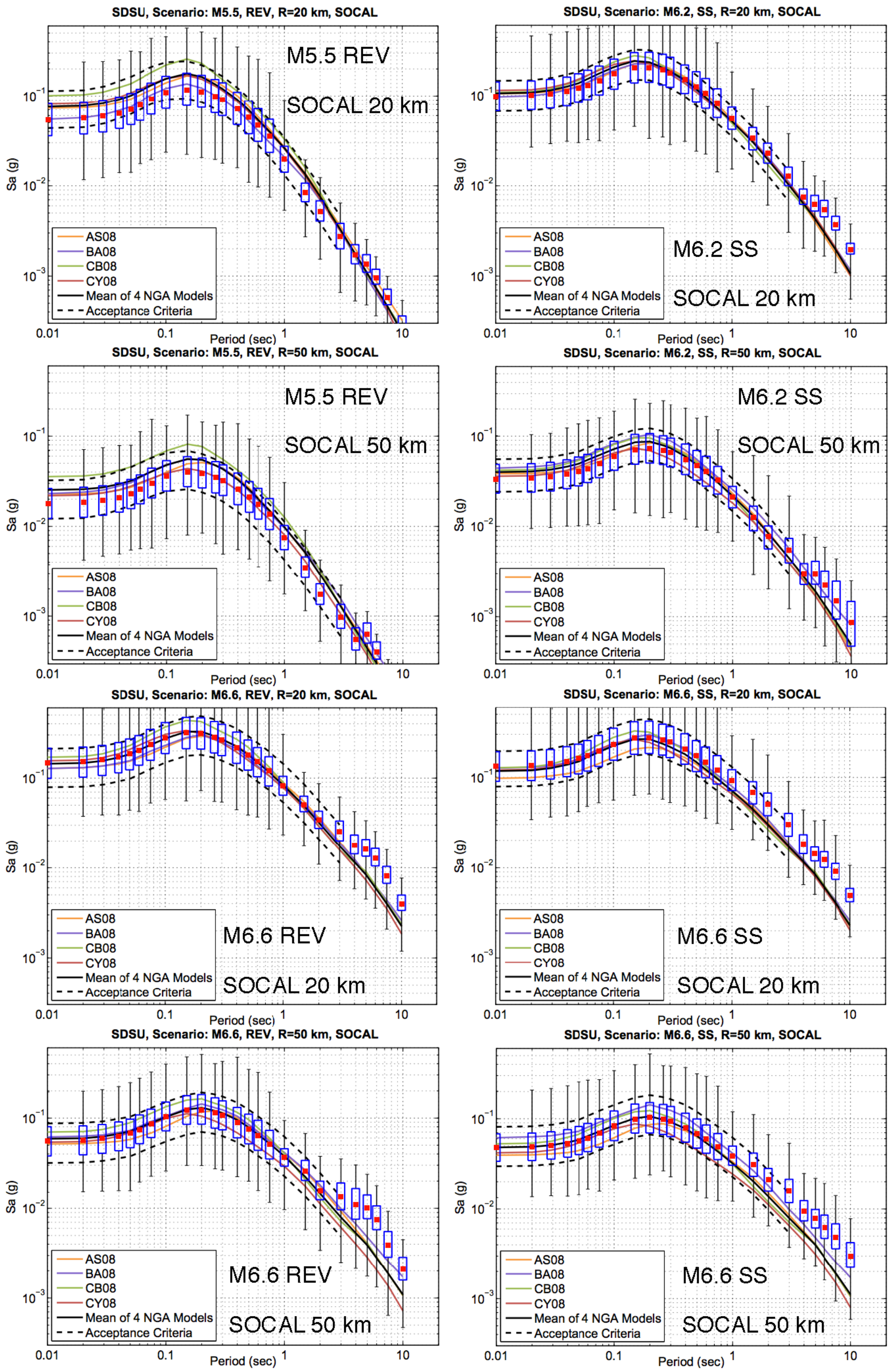
0.01
0.02
0.05
0.1
0.2
0.5
1
2
5
10
Period (sec)

Figure S1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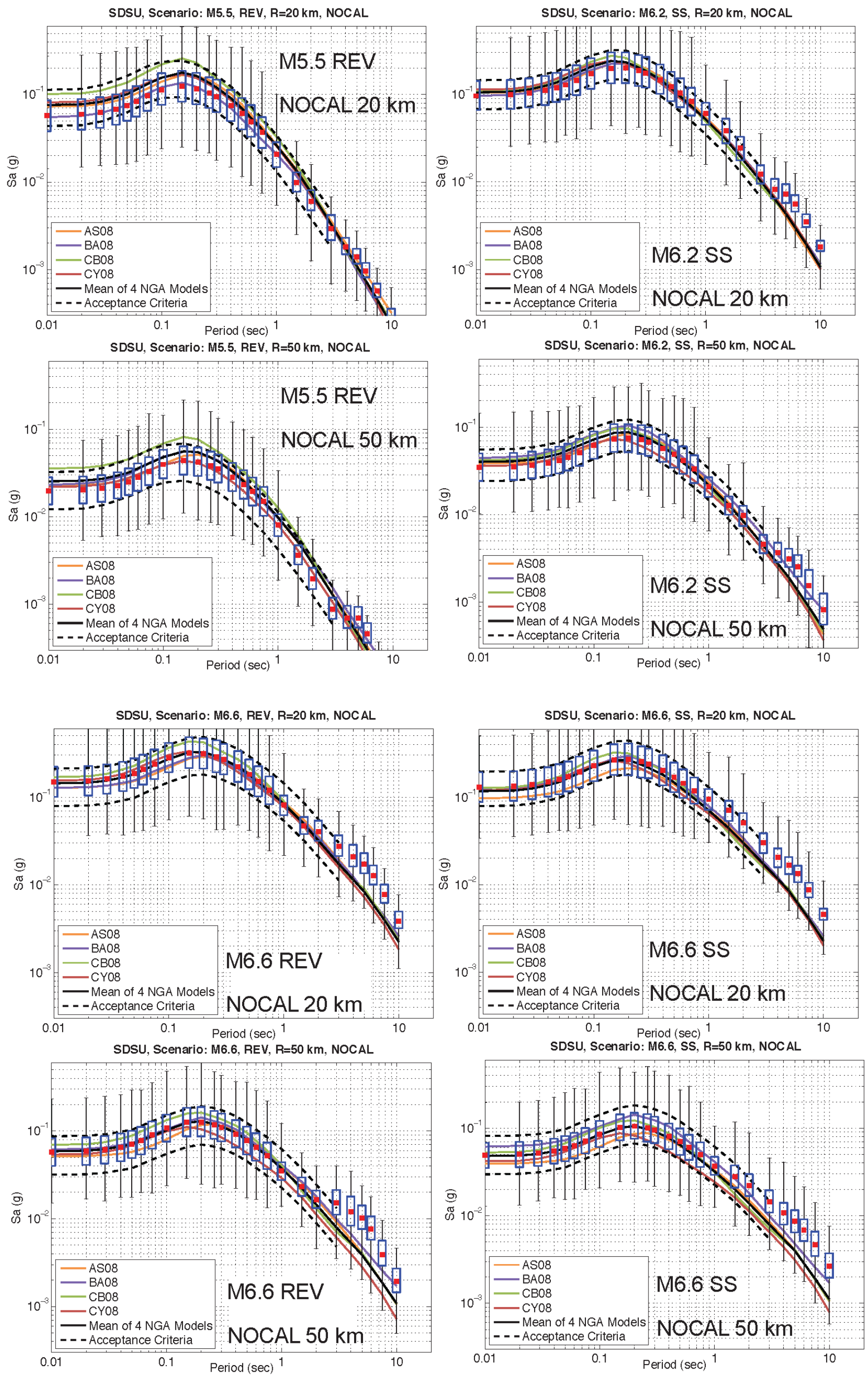
M5.5 REV
SOCAL 20 km
SDSU, Scenario: M6.2, SS, R=20 km, SOCAL
M6.2 SS
SOCAL 20 km
SDSU, Scenario: M5.5, REV, R=50 km, SOCAL
M5.5 REV
SOCAL 50 km
SDSU, Scenario: M6.2, SS, R=50 km, SOCAL
M6.2 SS
SOCAL 50 km
SDSU, Scenario: M6.6, REV, R=20 km, SOCAL
M6.6 REV
SOCAL 20 km
SDSU, Scenario: M6.6, SS, R=20 km, SOCAL
M6.6 SS
SOCAL 20 km
SDSU, Scenario: M6.6, REV, R=50 km, SOCAL
M6.6 REV
SOCAL 50 km
SDSU, Scenario: M6.6, SS, R=50 km, SOCAL
M6.6 SS
SOCAL 50 km
AS08
BA08
CB08
CY08
Mean of 4 NGA Models
Acceptance Criteria
Sa (g)
Period (sec)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NOCAL 20 km
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M6.2 SS
NOCAL 20 km
SDSU, Scenario: M5.5, REV, R=50 km, NOCAL
M5.5 REV
NOCAL 50 km
SDSU, Scenario: M6.2, SS, R=50 km, NOCAL
M6.2 SS
NOCAL 50 km
SDSU, Scenario: M6.6, REV, R=20 km, NOCAL
M6.6 REV
NOCAL 20 km
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M6.6 SS
NOCAL 20 km
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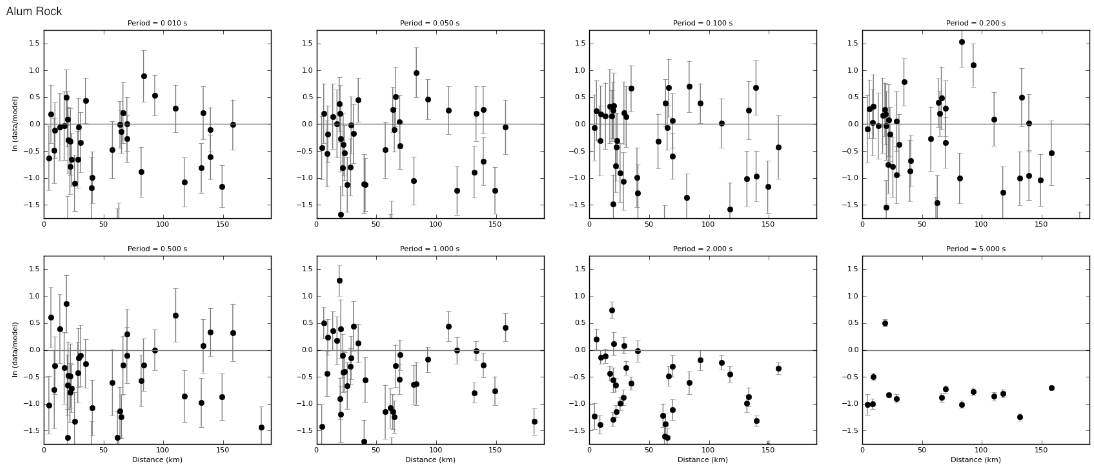
M6.6 REV
NOCAL 50 km
SDSU, Scenario: M6.6, SS, R=50 km, NOCAL
M6.6 SS
NOCAL 50 km
AS08
BA08
CB08
CY08
Mean of 4 NGA Models
Acceptance Criteria
Sa (g)
Period (sec)

Figure S2



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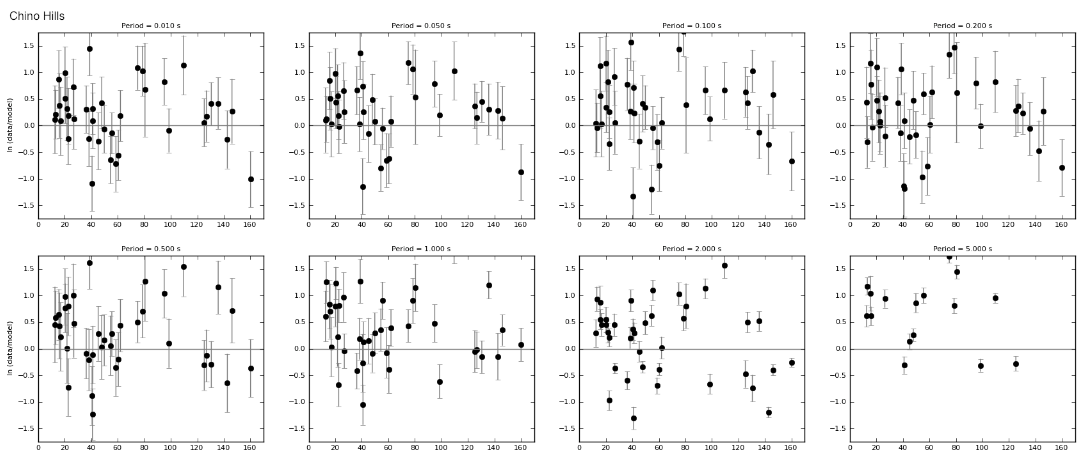

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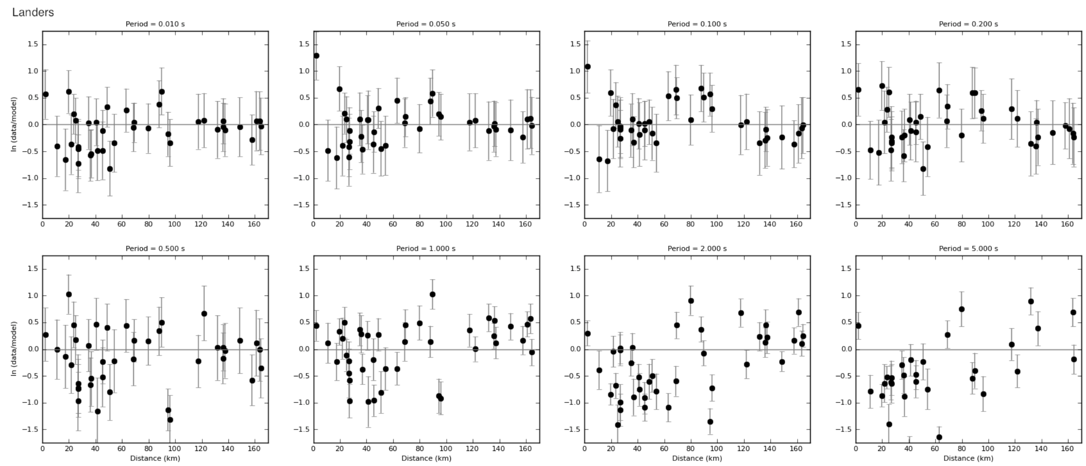

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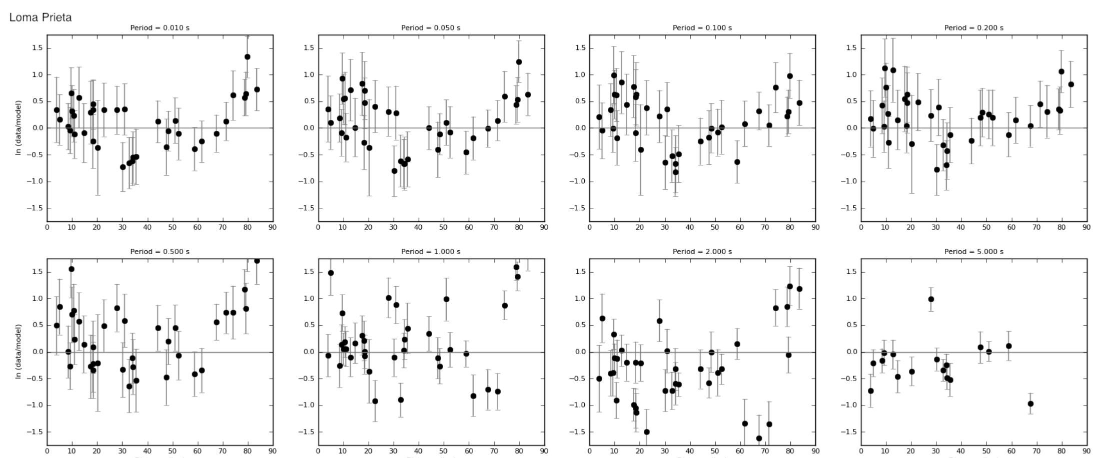

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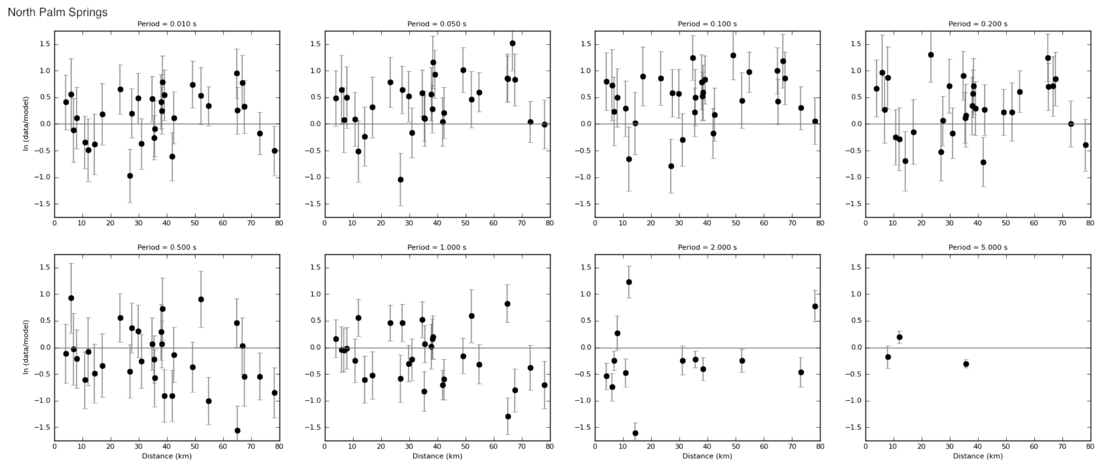

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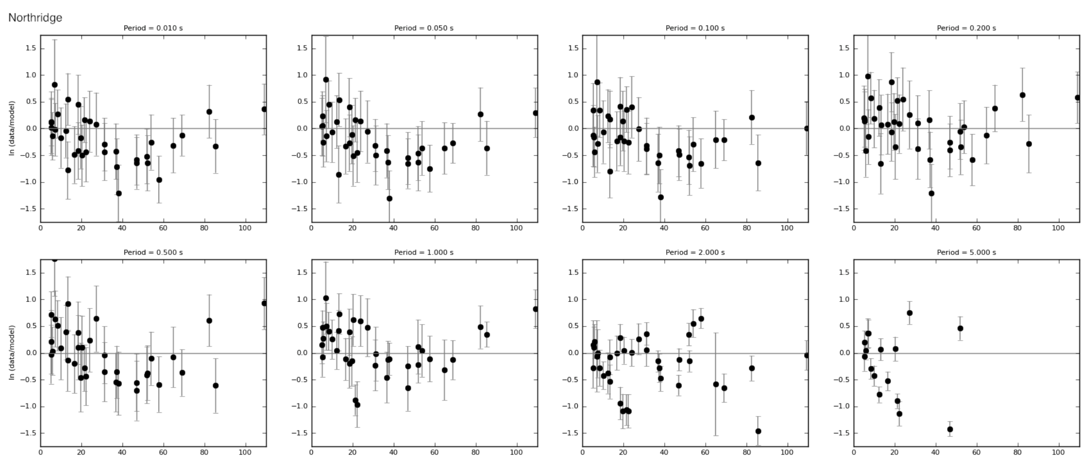

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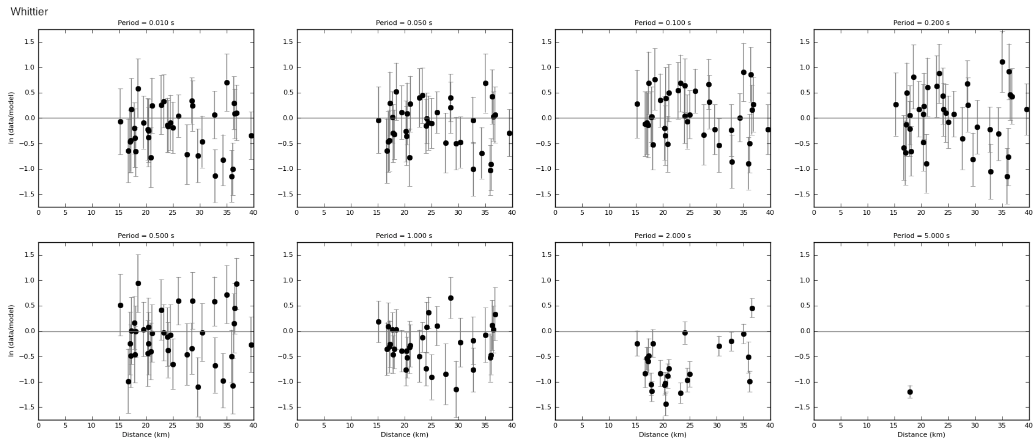

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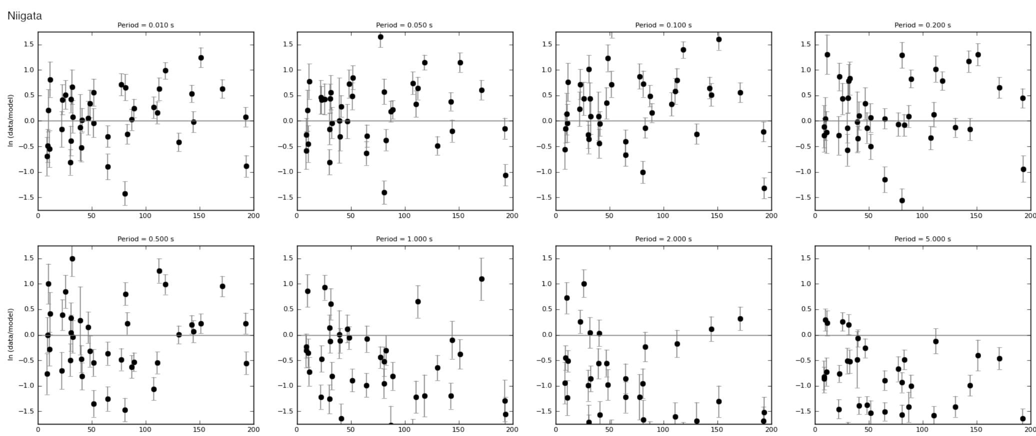

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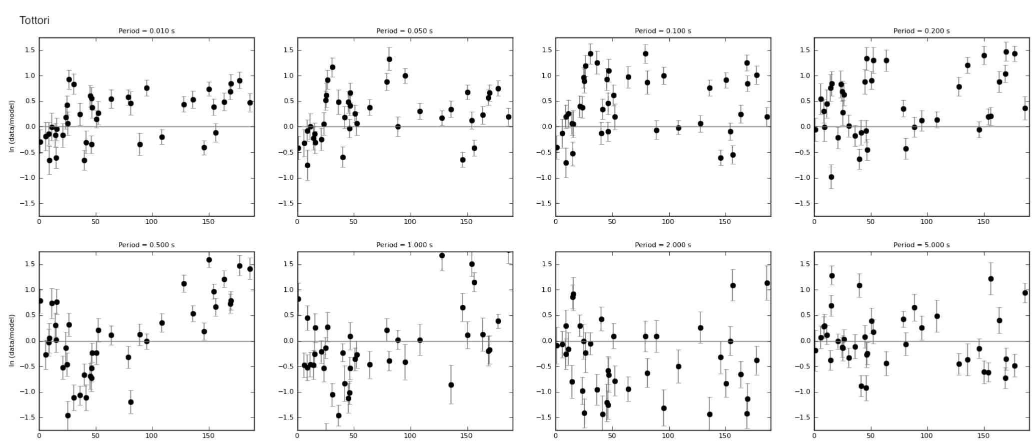

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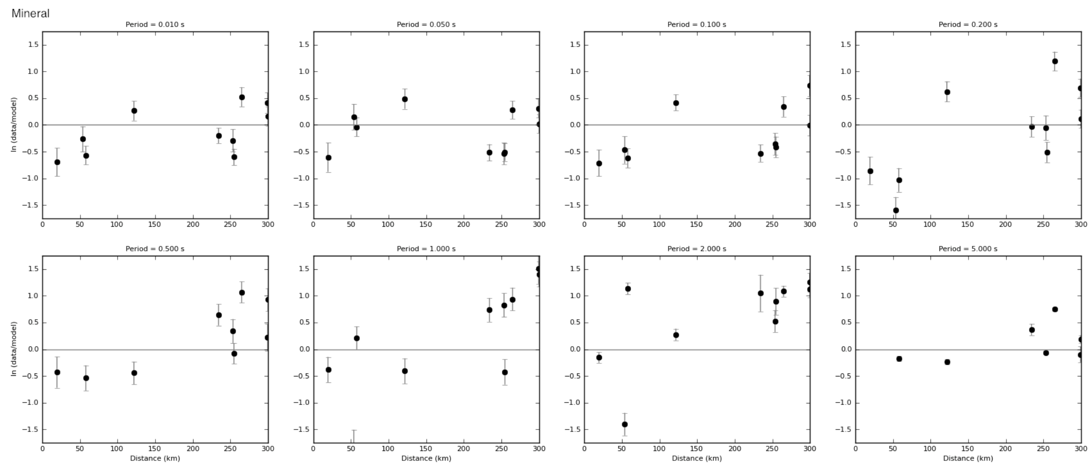

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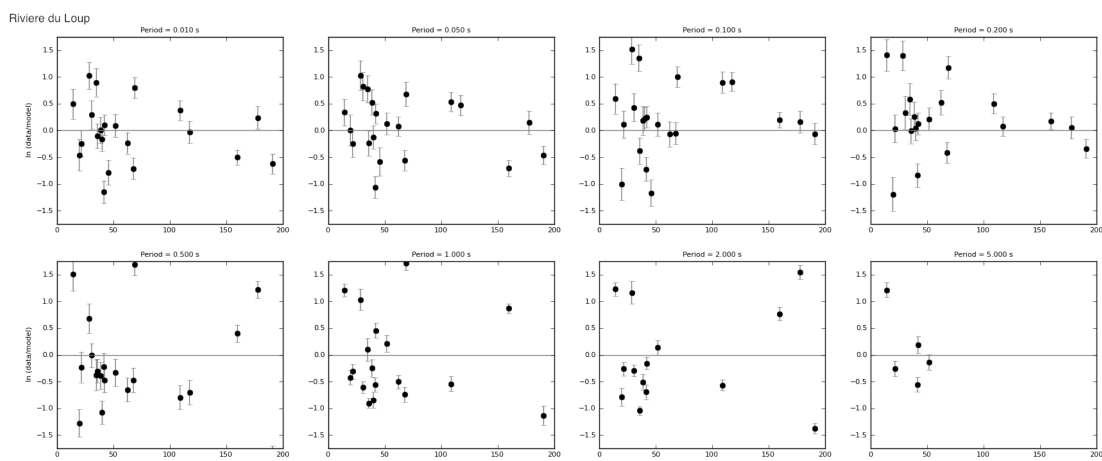

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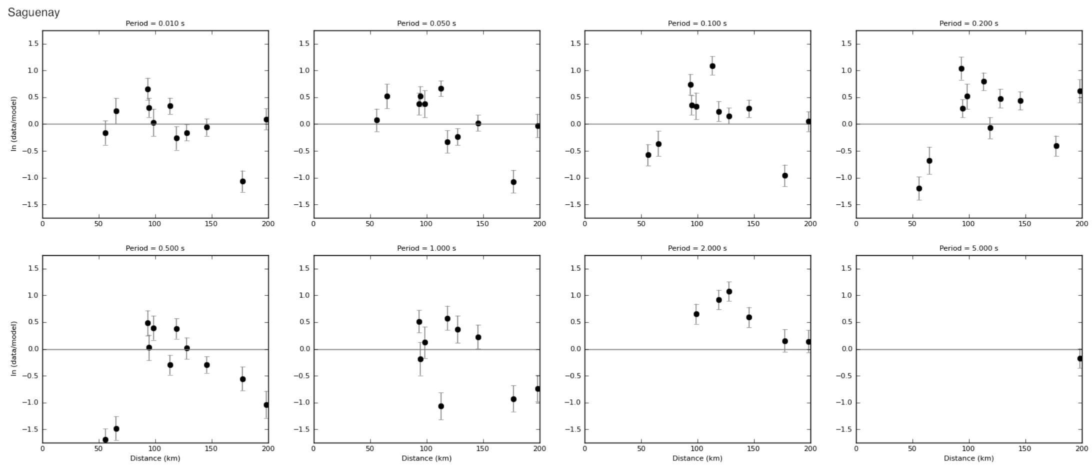

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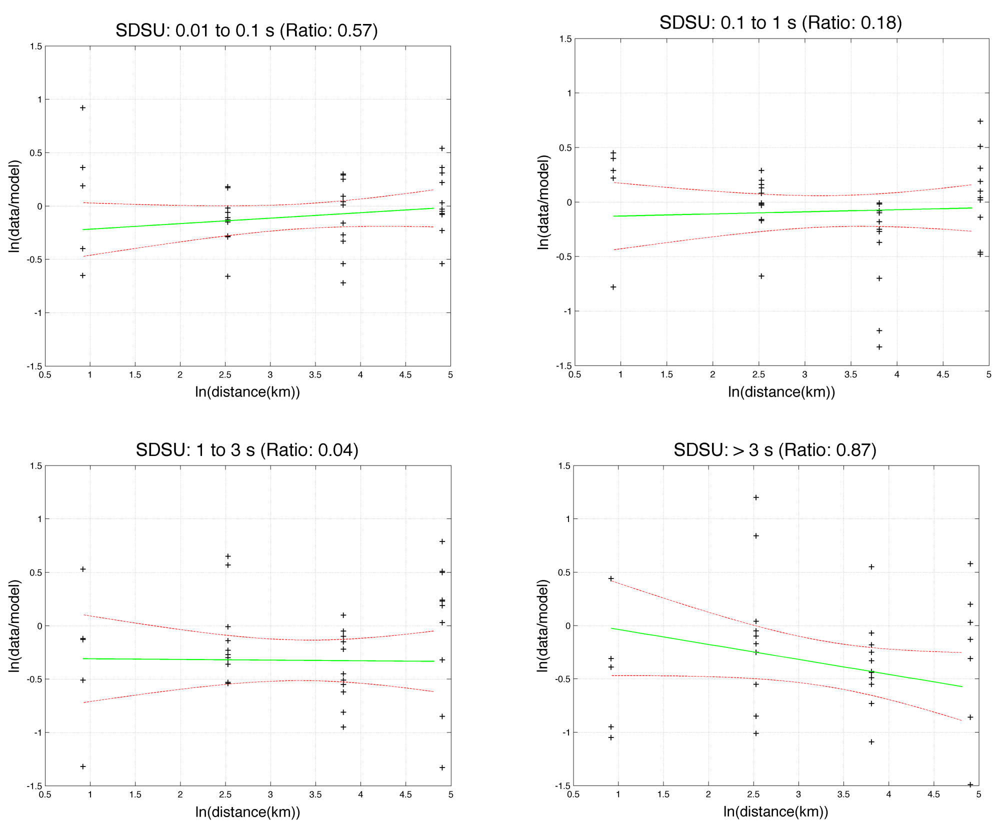

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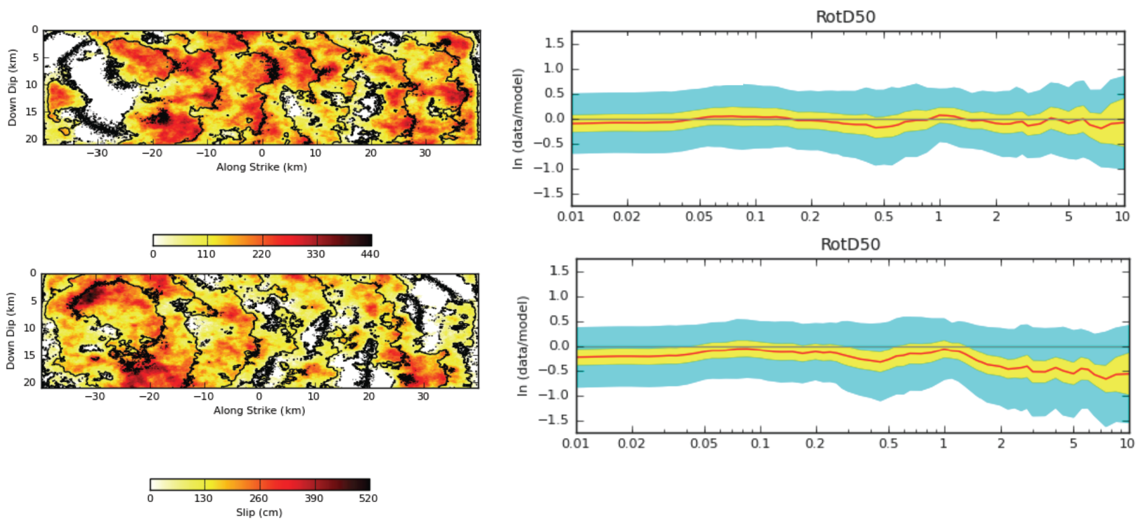

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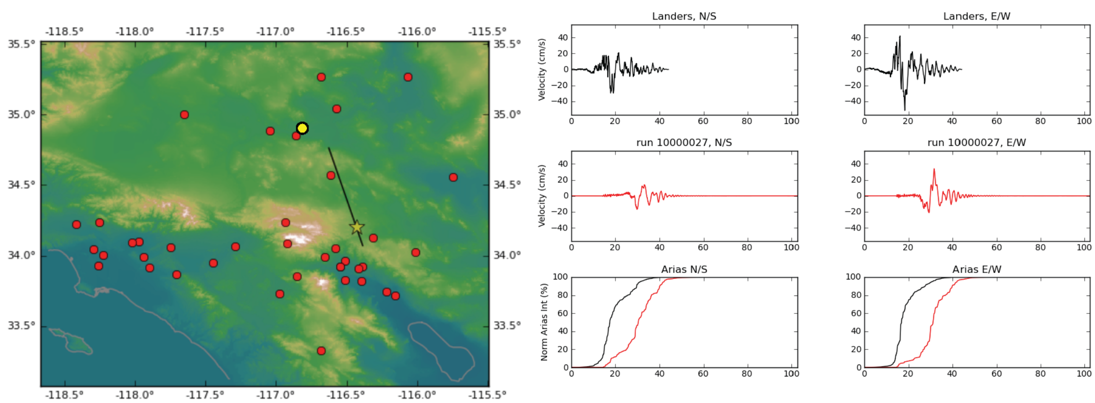

Figure S17

Table S1. Description of Part A events

Event	M_w	Mechanism	Dip (°)	Z_{tor} (km)	Largest R_{rup} (km)
Chino Hills	5.39	REV-OBL	66	12.79	160.1
Alum rock	5.45	SS	87	4.69	181.8
Whittier	5.89	REV	30	12.00	39.5
N Palm Springs	6.12	REV-OBL	46	6.40	78.1
Tottori	6.59	SS	90	0.10	186.3
Niigata	6.65	REV	47	1.09	193.1
Northridge	6.73	REV	40	5.00	109.1

Loma Prieta	6.94	REV-OBL	70	3.85	83.5
Landers	7.22	SS	89	0.00	164.4
Riviere du Loup	4.60	REV	60	12.30	190.7
Mineral	5.68	REV	51	5.84	299.9
Saguenay	5.81	REV	65	21.47	198.2

Table S2. Description of Part B scenarios

Event	Mechanism	Dip (^{o})	Z_{tor} (km)	R_{rup} (km)
M5.5 SoCal 1D Model	REV	45	6.00	20, 50
M5.5 NoCal 1D Model	REV	45	6.00	20, 50
M6.2 SoCal 1D Model	SS	90	4.00	20, 50
M6.2 NoCal 1D Model	SS	90	4.00	20, 50
M6.6 SoCal 1D Model	REV	45	3.00	20, 50
M6.6 NoCal 1D Model	REV	45	3.00	20, 50
M6.6 SoCal 1D Model	SS	90	0.00	20, 50
M6.6 NoCal 1D Model	SS	90	0.00	20, 50

Table S3. Fixed Parameters for BBtoolbox V1.5

Parameter	Explanation	All Regions
η_s	Scattering coefficient	0.01 km^{-1}
η_i	Absorption coefficient	0.01 km^{-1}
Nscat	Number of scattering wavelets	1500
Iseed	Seed for random number generator	3071
Target matching frequency	Target matching frequency	1-2 Hz (magnitude dependent)
Bandwidth for target matching frequency	Bandwidth for target matching frequency	0.05 Hz

Table S4. Region-dependent Parameters for BBtoolbox V1.5

Parameter	Explanation	Western Scenarios	Tottori	Niigata	Eastern US/Canada
afac	Q_k=afac+V_s*bfac	41	41	30	228
bfac	Q_k=afac+V_s*bfac	34	34	20	136
Q_o	$Q(f)=Q_o f^{fdec}$	150	150	95	500

fdec	$Q(f)=Q_o f^{fdec}$	0.8	1.14	1.14	0.6
κ	Kappa value	$0.04s^{-1}$	$0.02s^{-1}$	$0.035s^{-1}$	$0.02s^{-1}$
strfac	Brune stress parameter	50 bars	50 bars	50 bars	350 bars or M_w dependent
c_0	Subfault corner frequency scale parameter	2.1	2.1	2.1	1.1