

SDSU Module

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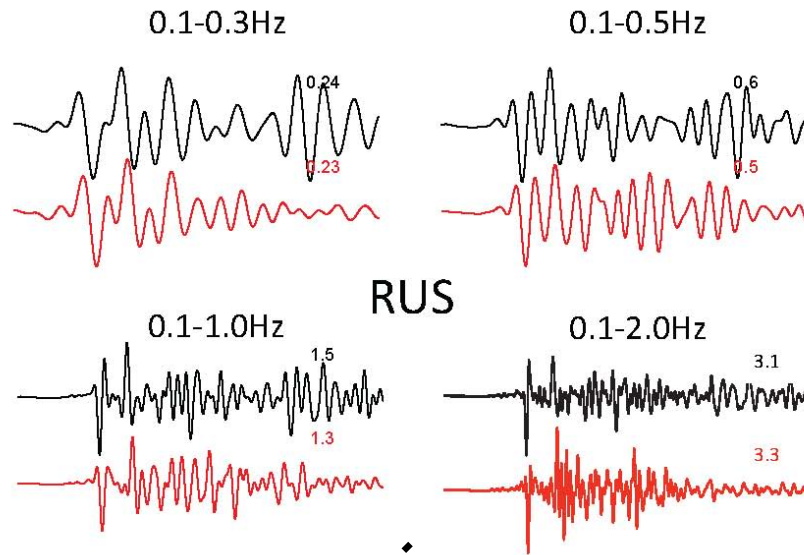
SCEC-ERI Summer School, Oxnard, CA Sept 30, 2014

Frank and Ernest

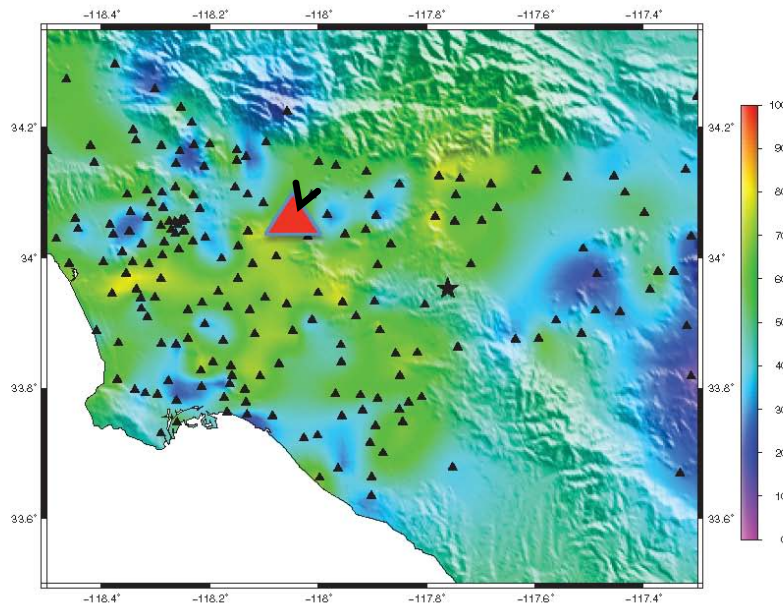


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Accuracy of Deterministic Long-period Ground Motion Prediction



Comparison of recorded data (black traces) and synthetics (red traces) for station RUS



Average goodness-of-fit (perfect fit = 100) at 0.1-0.5 Hz for synthetics relative to data.

Ground Motion Prediction

- Low-frequency ground motion prediction (<1 - 2 Hz) reasonably accurate
- But what about high-frequency signals > 1 - 2 Hz?

High-frequency ground motion Modeling

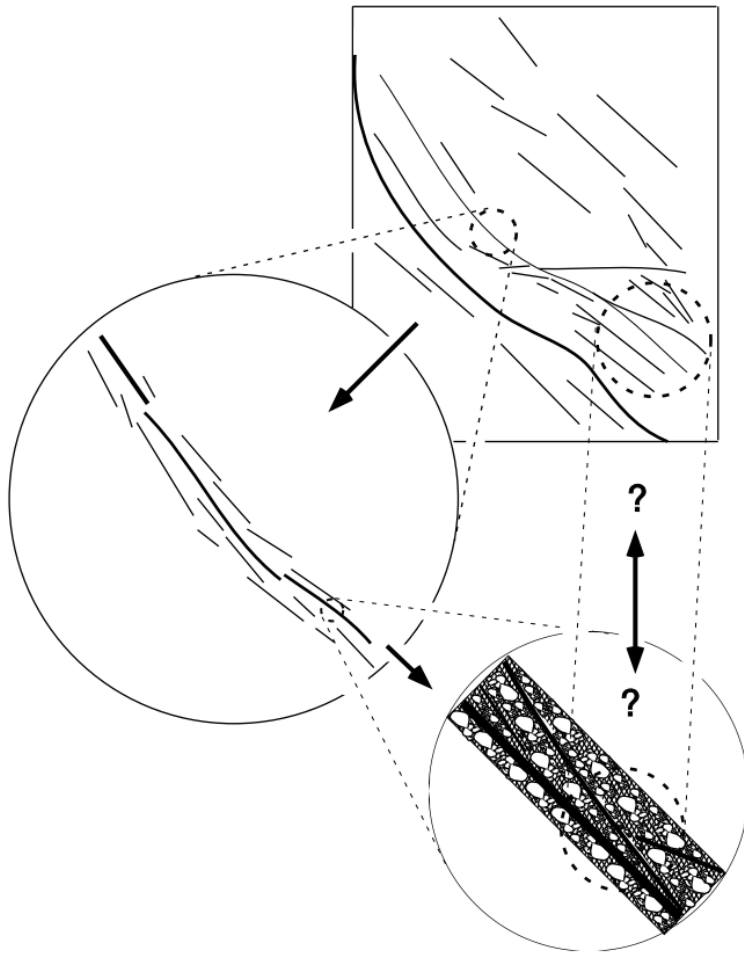
- Requires small-scale complexity

➤ Source

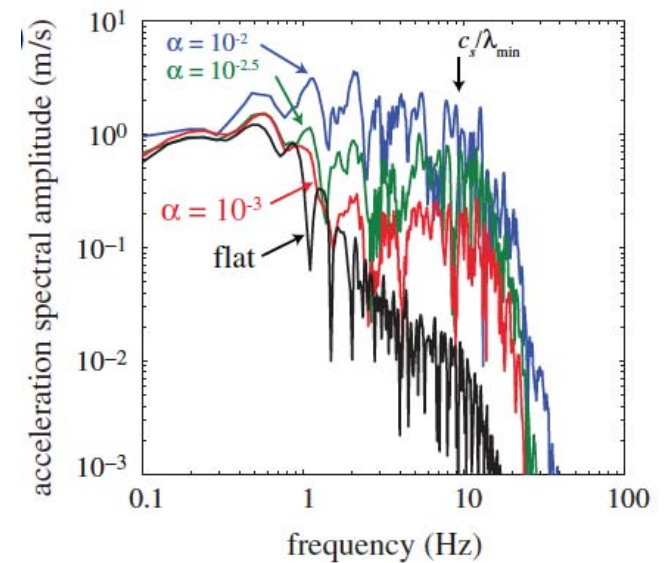
➤ Media

Source Complexity: Rough Faults

- Roughness is observed at all scales



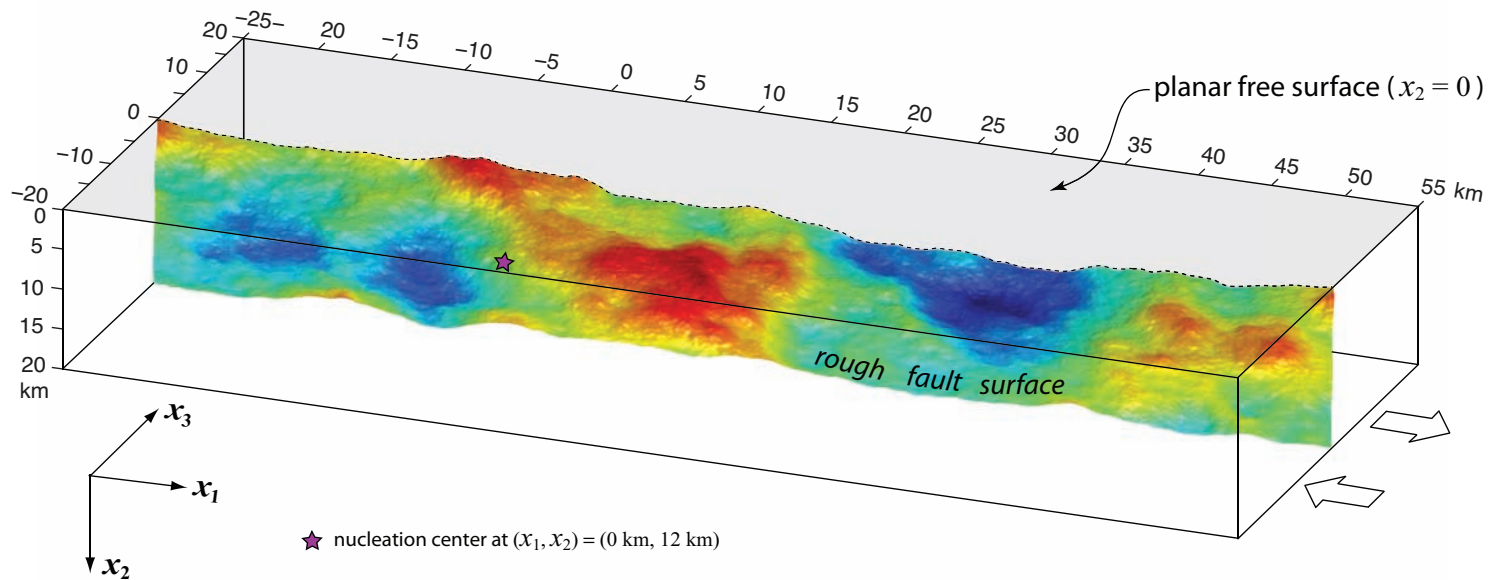
(Ben-Zion, 2003)



(Dunham, 2011)

Rough Faults

- Rough fault topography: subfaults follow self-similar fractal distribution for wavelengths from 80 m to length of fault

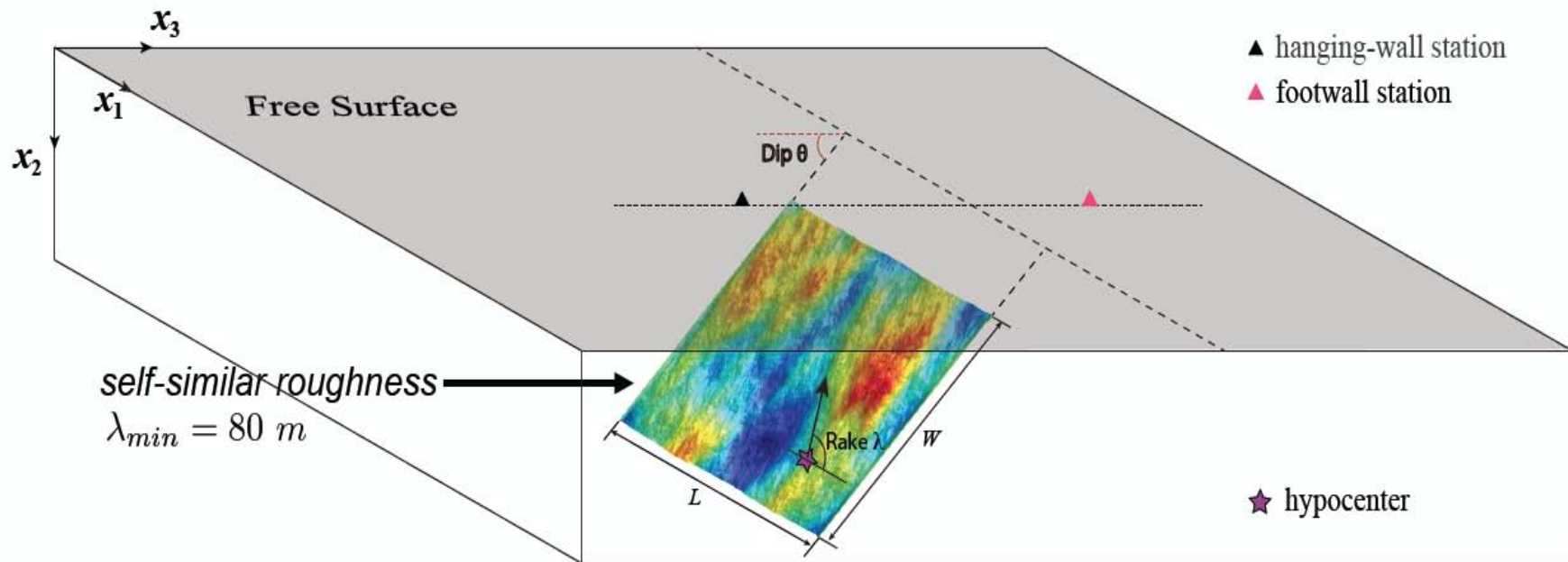


(Shi and Day, 2013)

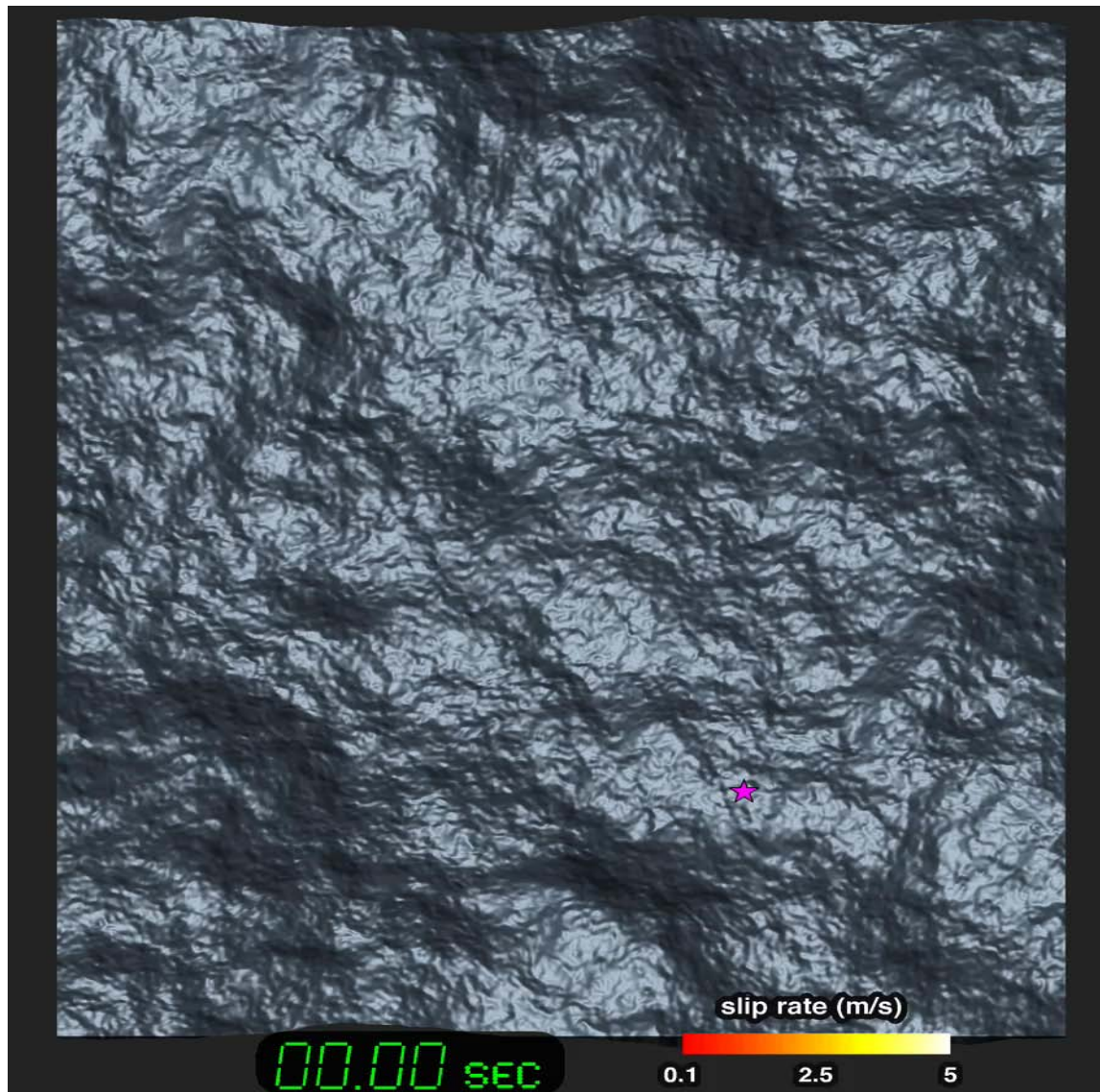
Rough Fault Radiation

**Visualization Of Deterministic High-Frequency
Ground Motions From Simulations Of Dynamic
Rupture Along Rough Faults Without
Medium Heterogeneity Using Petascale
Heterogeneous Supercomputers**

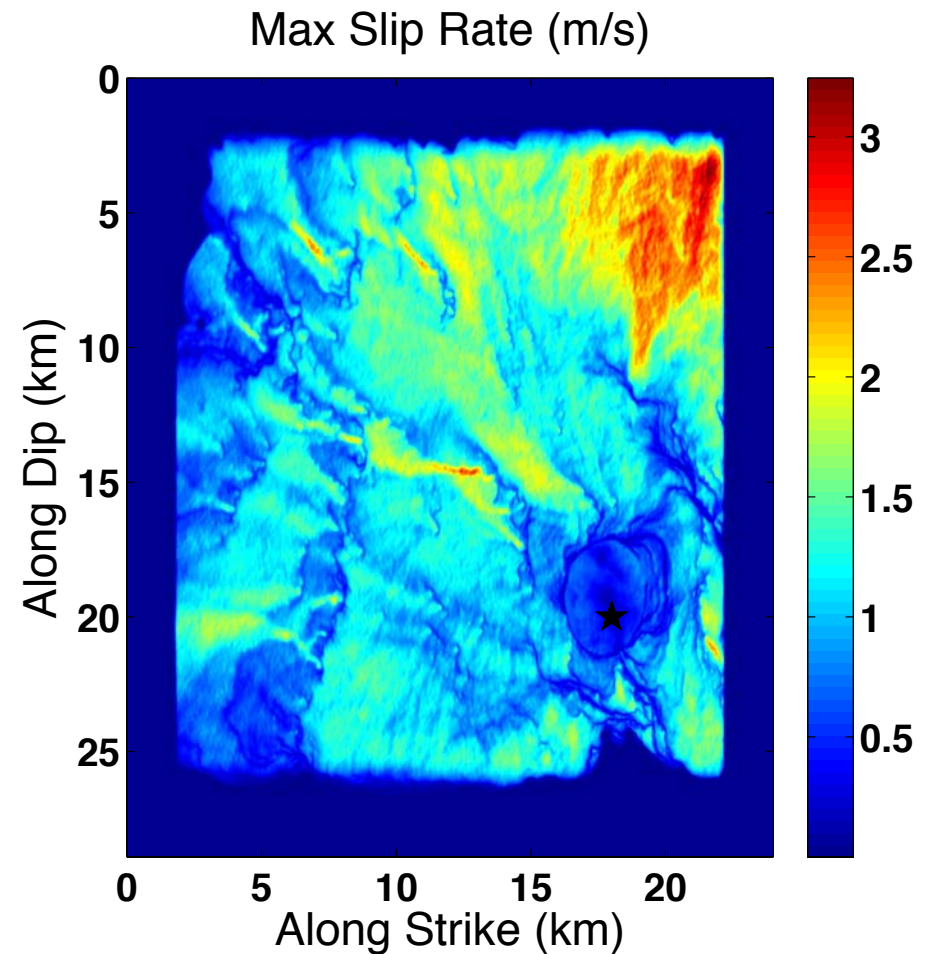
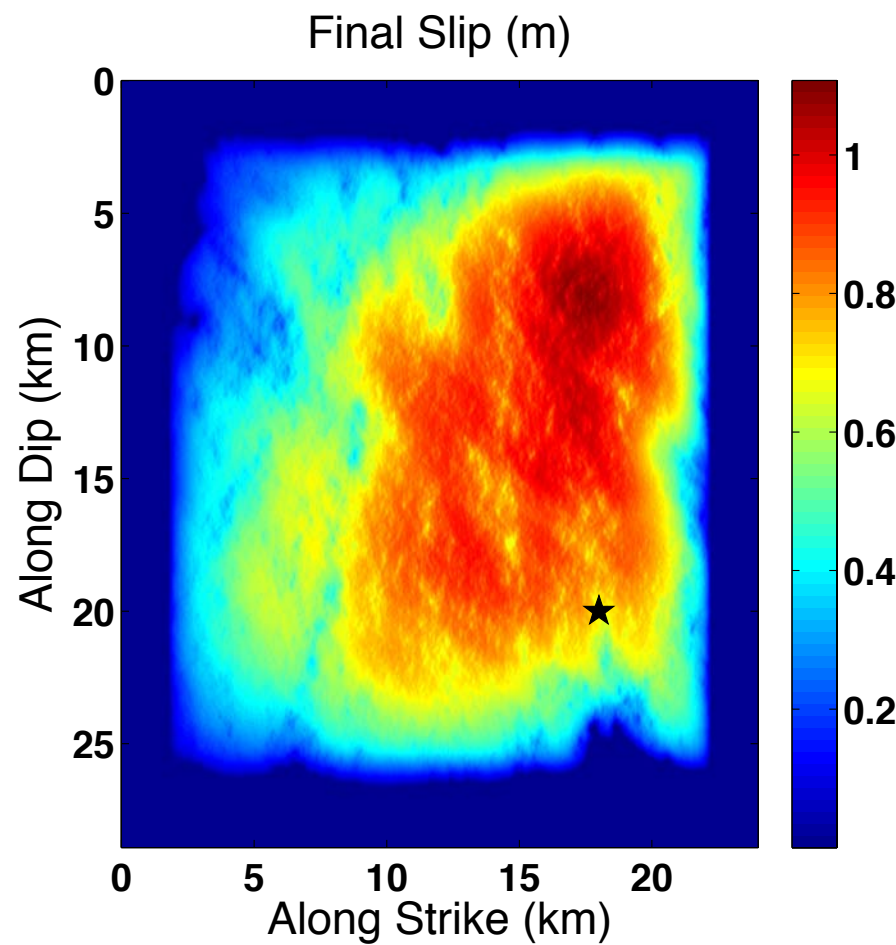
Northridge Mw 6.7 1994 Earthquake



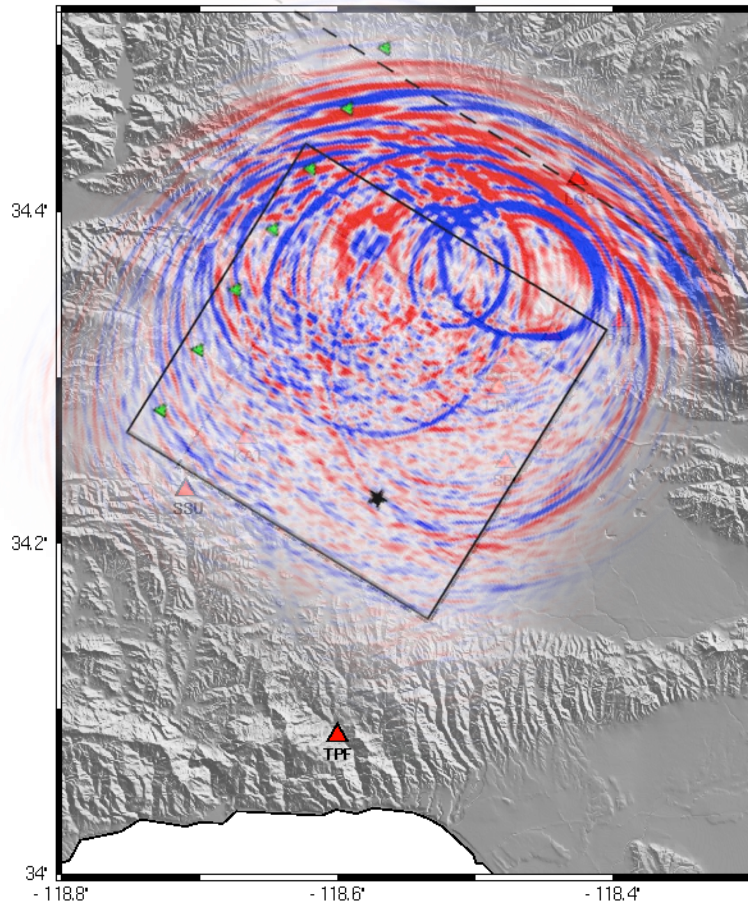
0-10Hz Northridge Rough Fault Rupture



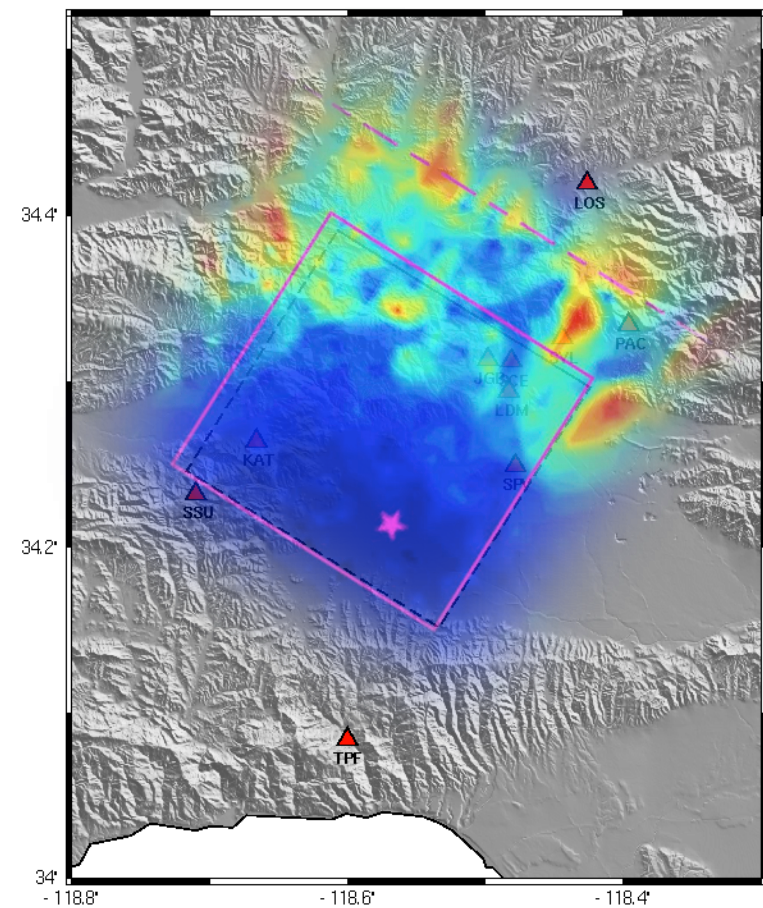
0-10Hz Northridge Rough Fault Rupture



0-10Hz Northridge Rough Fault Rupture



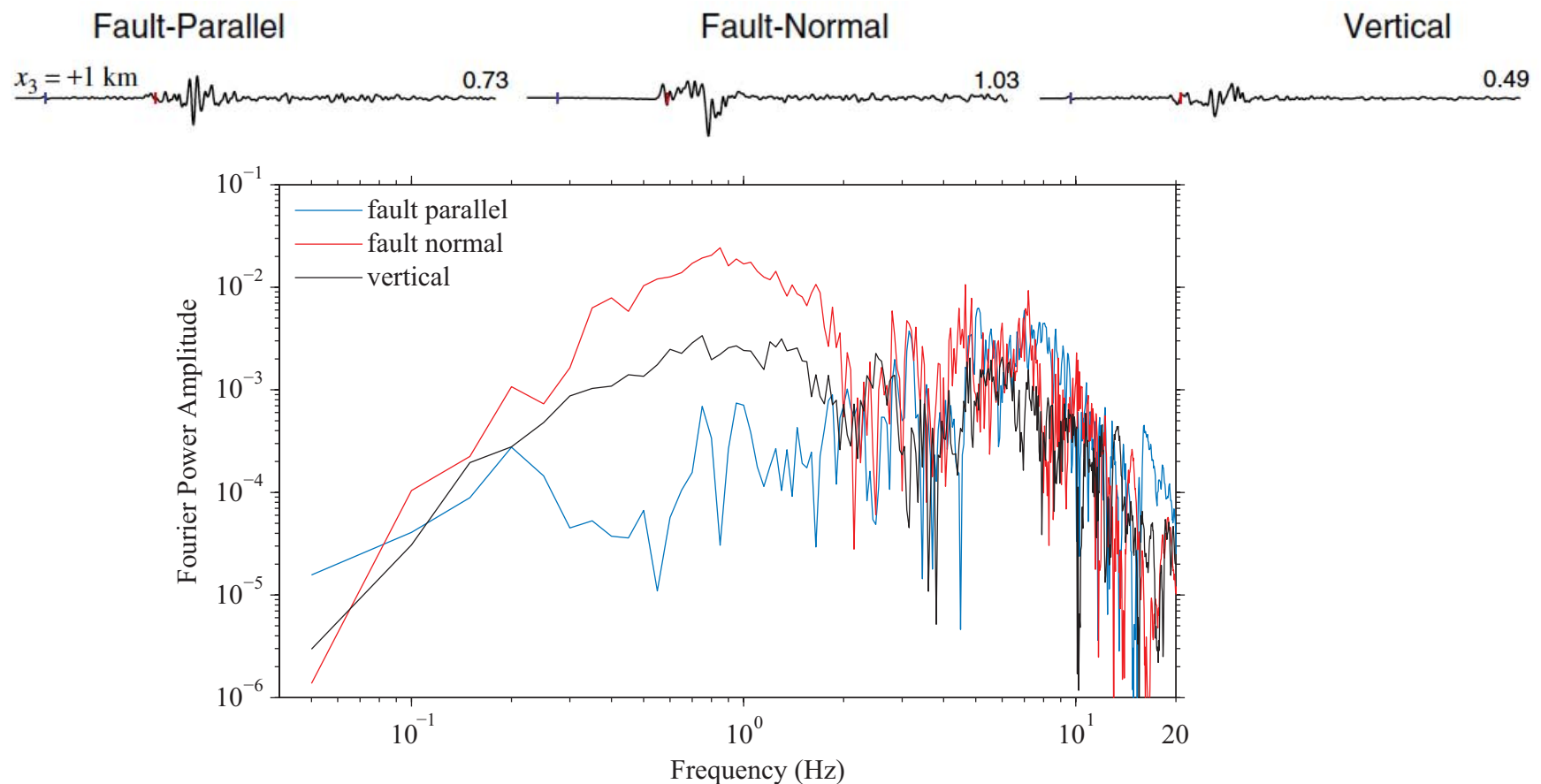
Snapshot of Acceleration



Strike-parallel PGA

Realistic Power Spectra

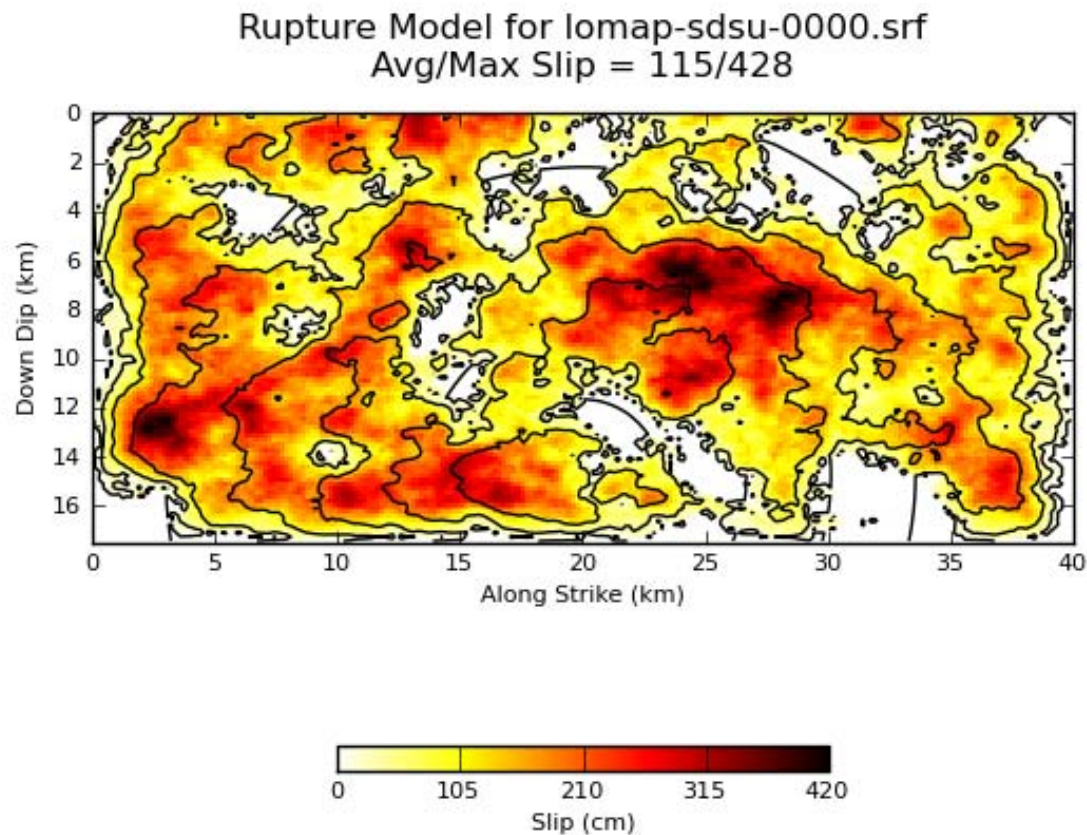
- Near-flat power spectra up to ~ 10 Hz



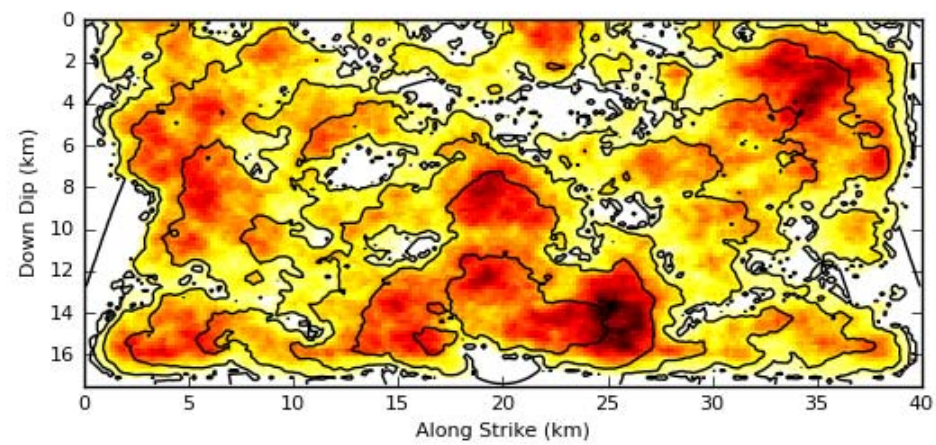
(Shi and Day, 2013)

GFs, Rupture Model

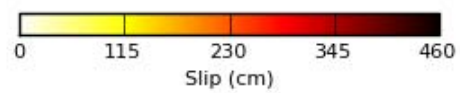
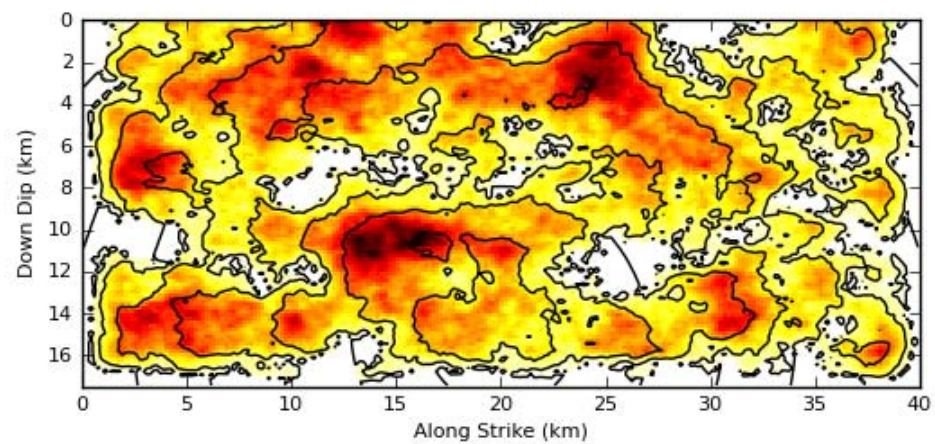
- SDSU module uses URS kinematic rupture generator



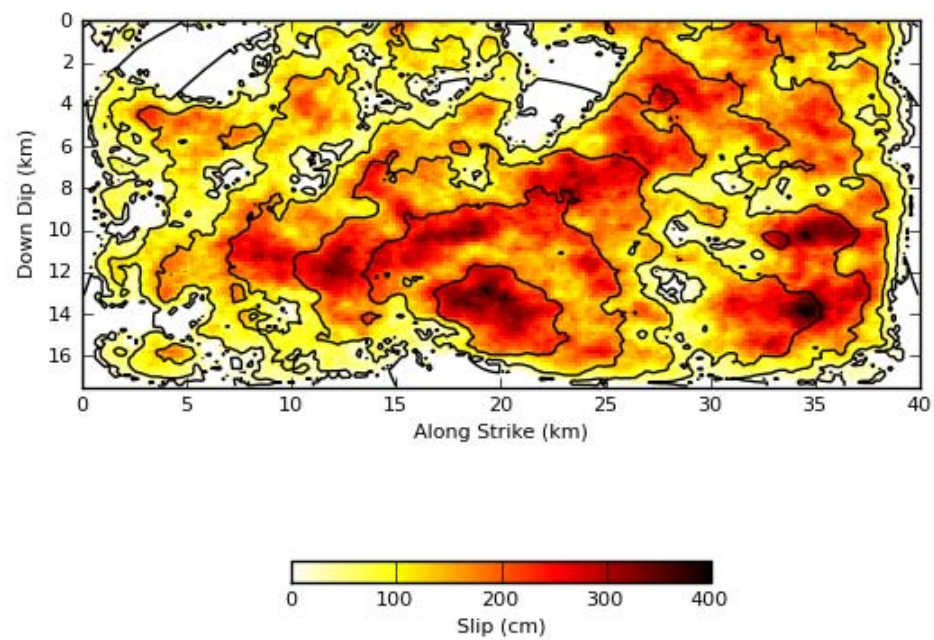
Rupture Model for lomap-sdsu-0007.srf
Avg/Max Slip = 114/453



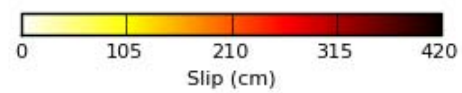
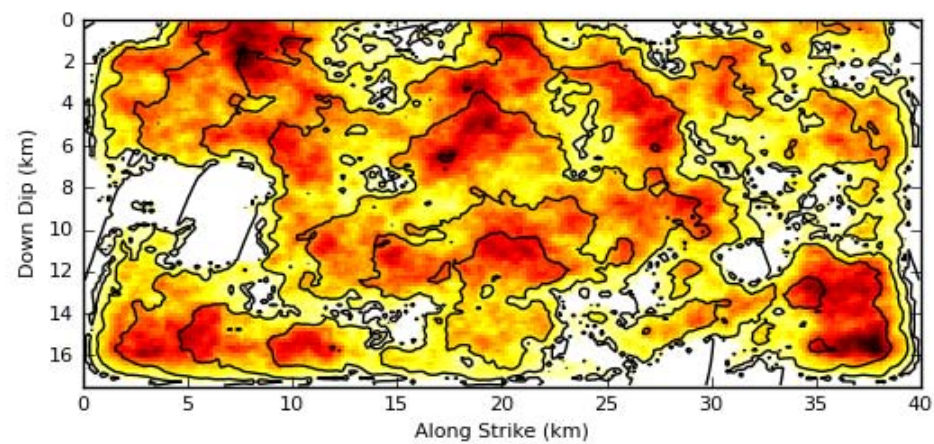
Rupture Model for lomap-sdsu-0008.srf
Avg/Max Slip = 118/468



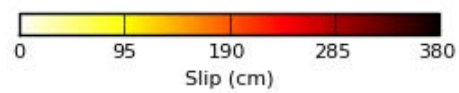
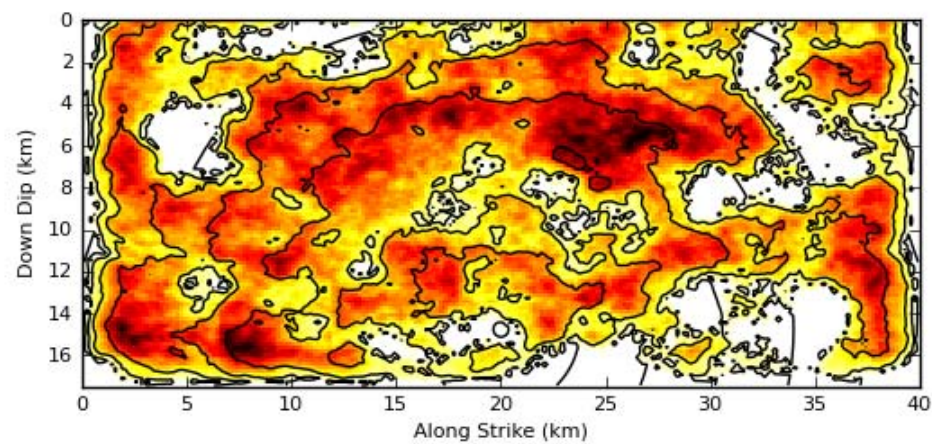
Rupture Model for lomap-sdsu-0009.srf
Avg/Max Slip = 115/410



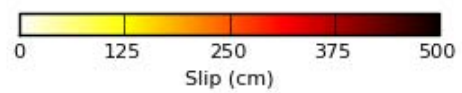
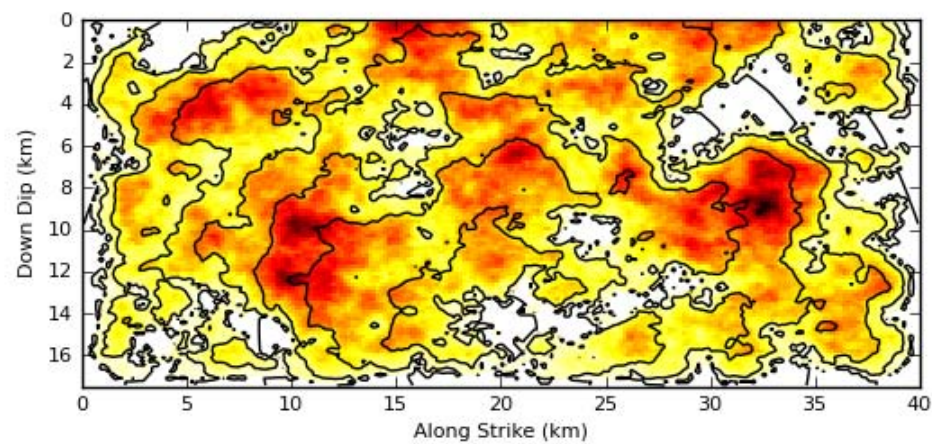
Rupture Model for lomap-sdsu-0010.srf
Avg/Max Slip = 117/427



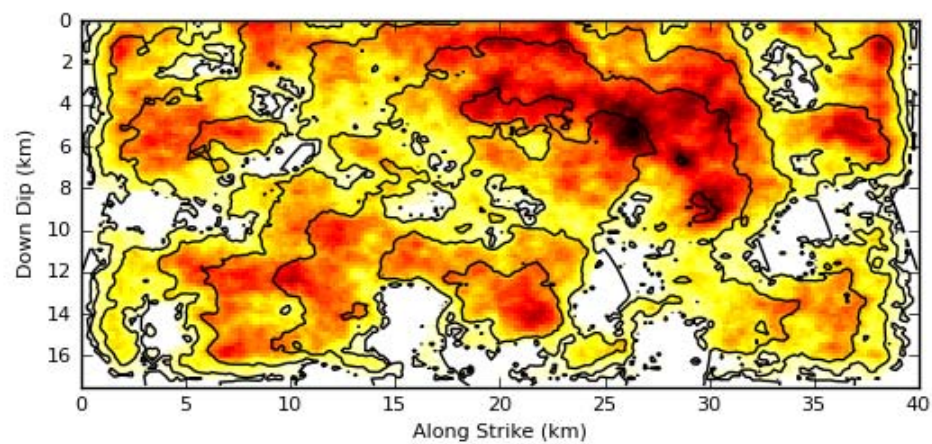
Rupture Model for lomap-sdsu-0011.srf
Avg/Max Slip = 117/399



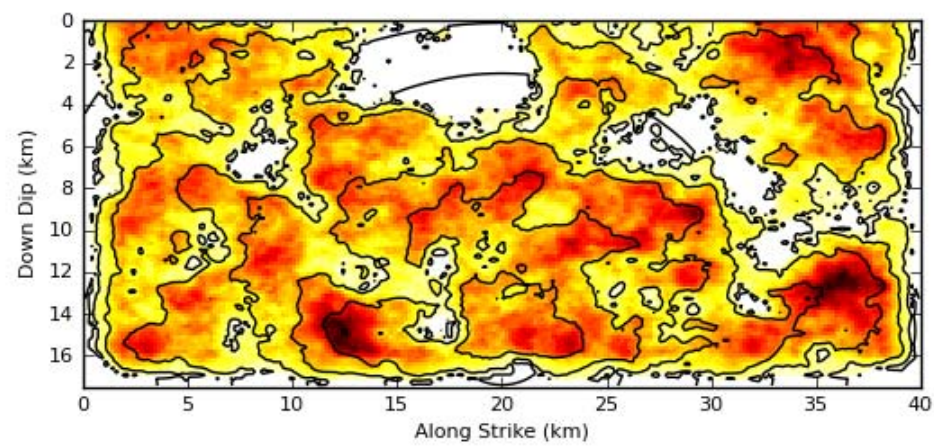
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Avg/Max Slip = 118/501



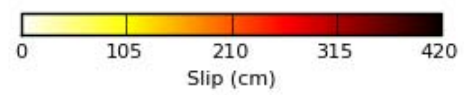
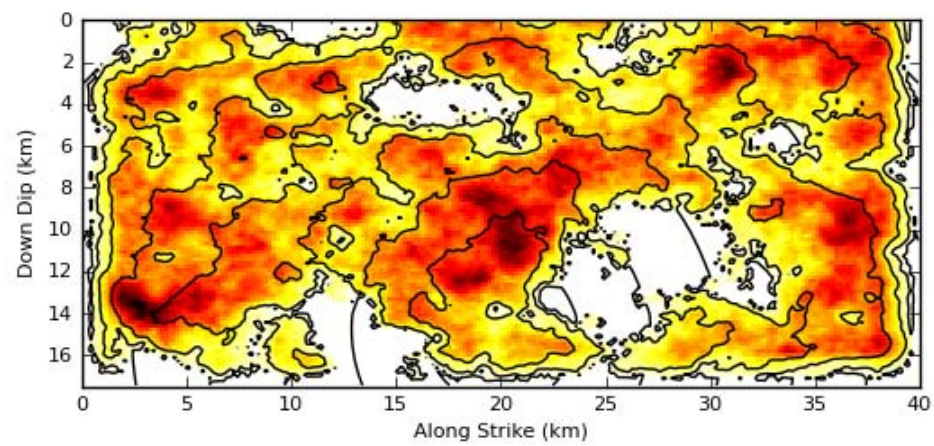
Rupture Model for lomap-sdsu-0013.srf
Avg/Max Slip = 120/458



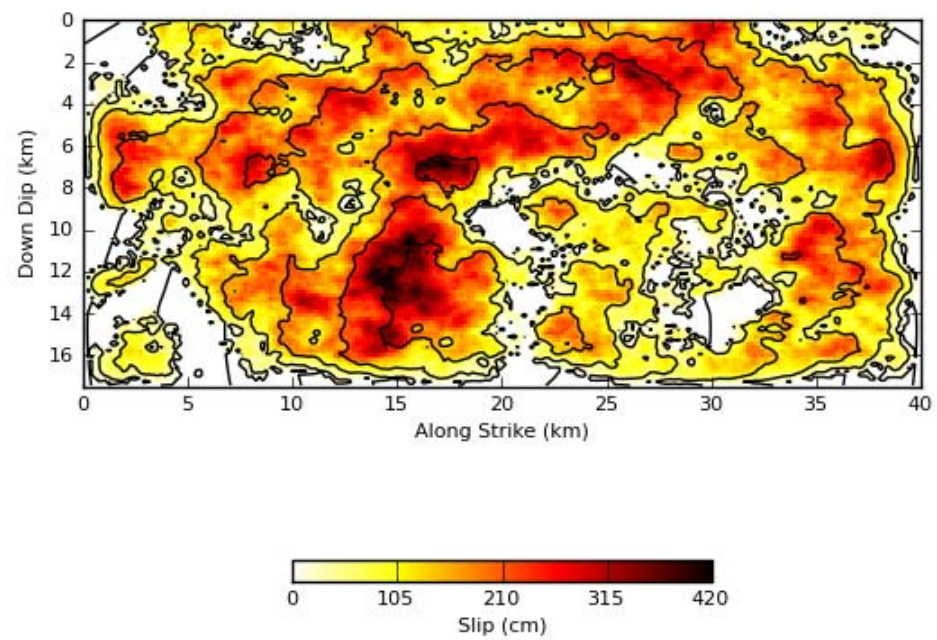
Rupture Model for lomap-sdsu-0014.srf
Avg/Max Slip = 115/422



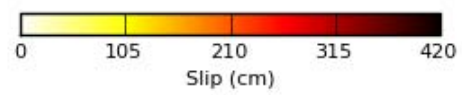
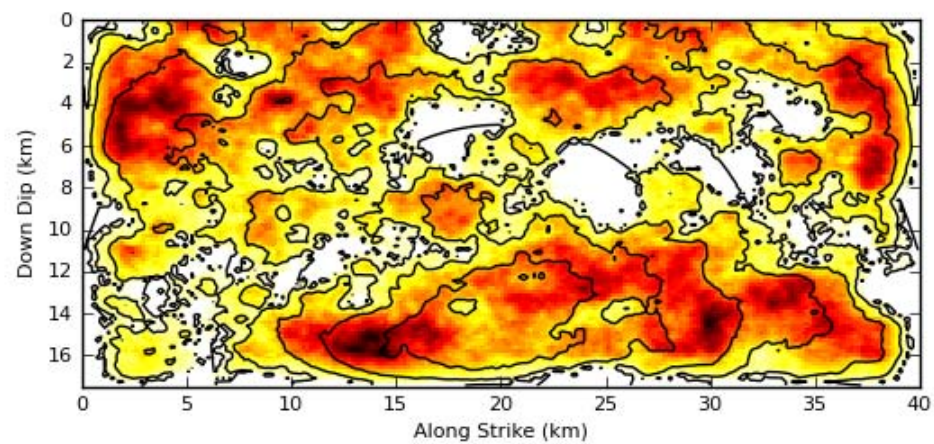
Rupture Model for lomap-sdsu-0015.srf
Avg/Max Slip = 117/434



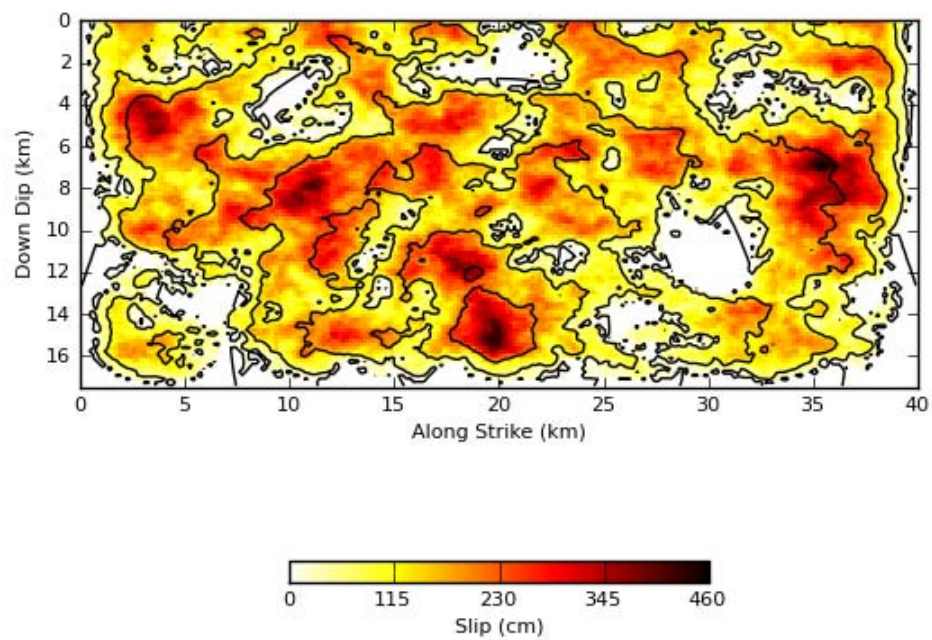
Rupture Model for lomap-sdsu-0016.srf
Avg/Max Slip = 117/434



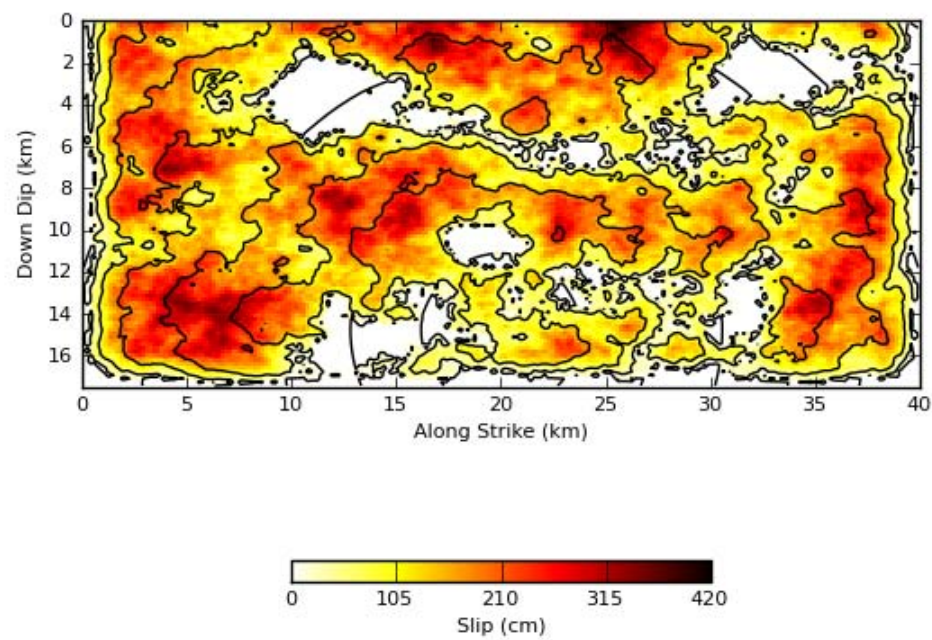
Rupture Model for lomap-sdsu-0017.srf
Avg/Max Slip = 116/425



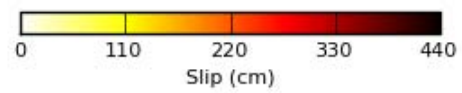
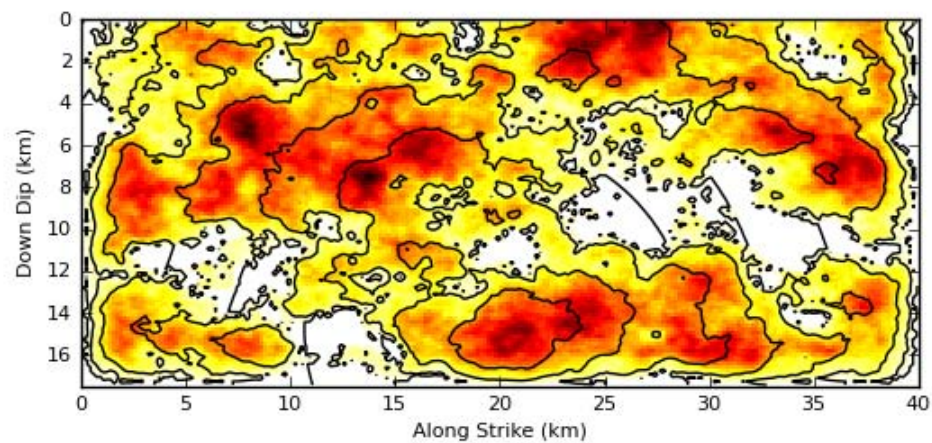
Rupture Model for lomap-sdsu-0018.srf
Avg/Max Slip = 116/460



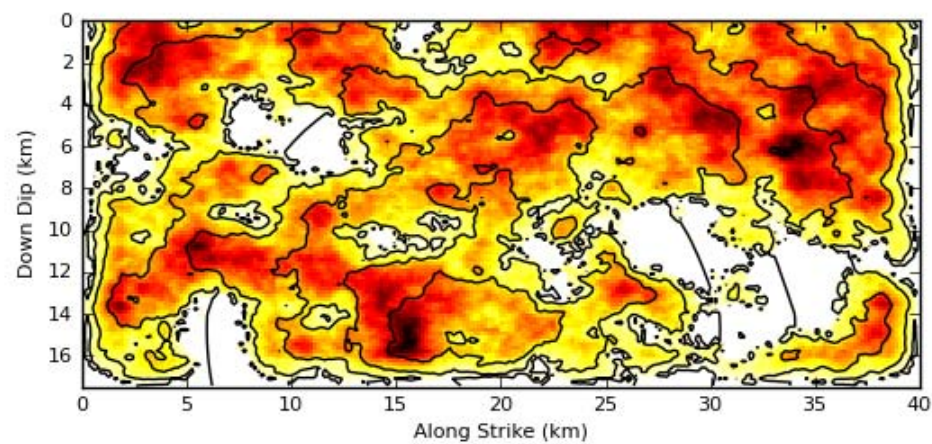
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Avg/Max Slip = 117/424



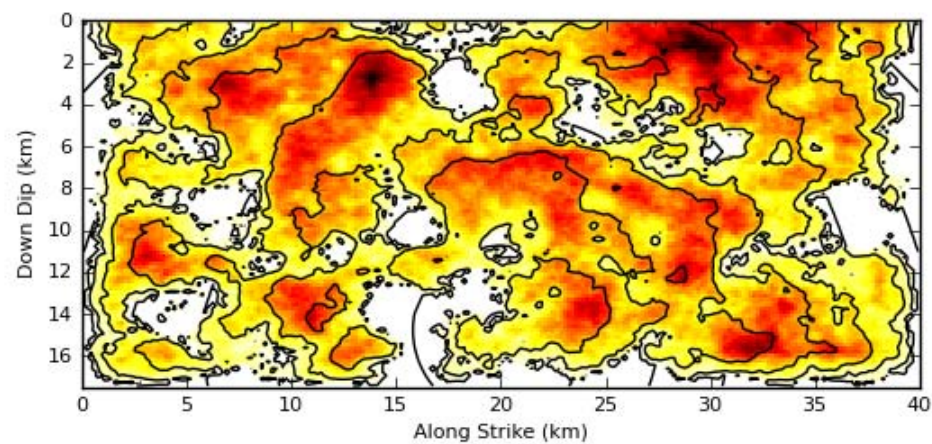
Rupture Model for lomap-sdsu-0020.srf
Avg/Max Slip = 116/440



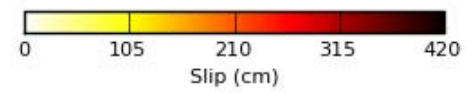
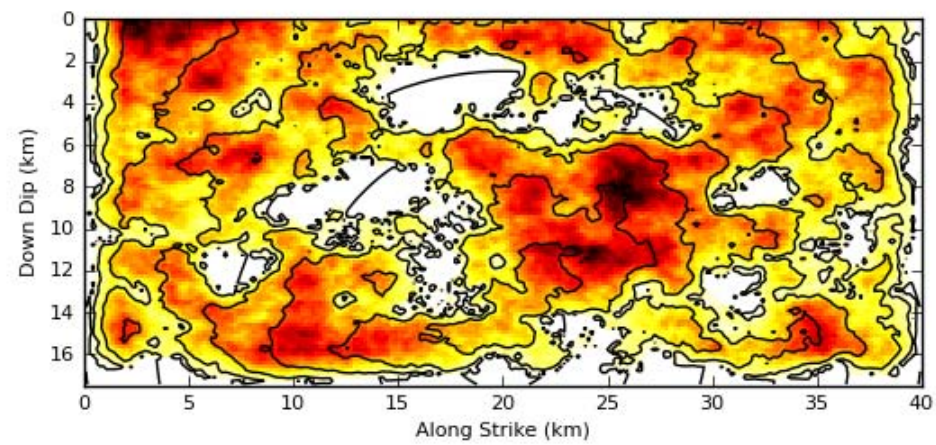
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Avg/Max Slip = 119/413



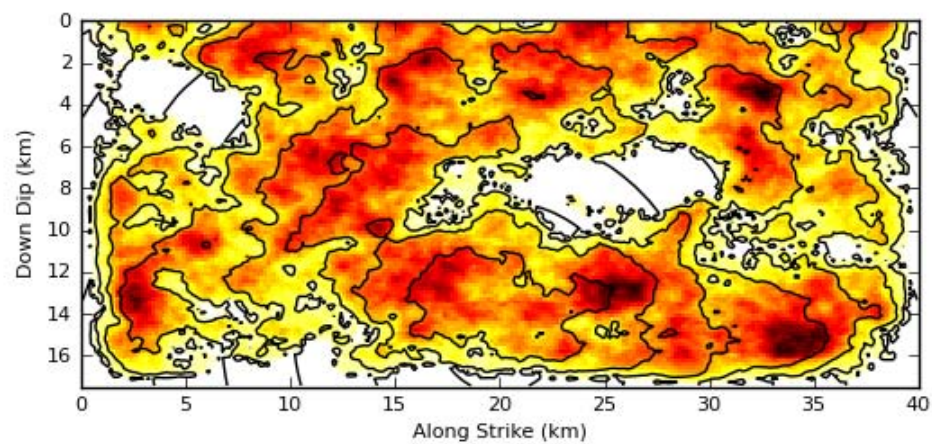
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Avg/Max Slip = 118/462



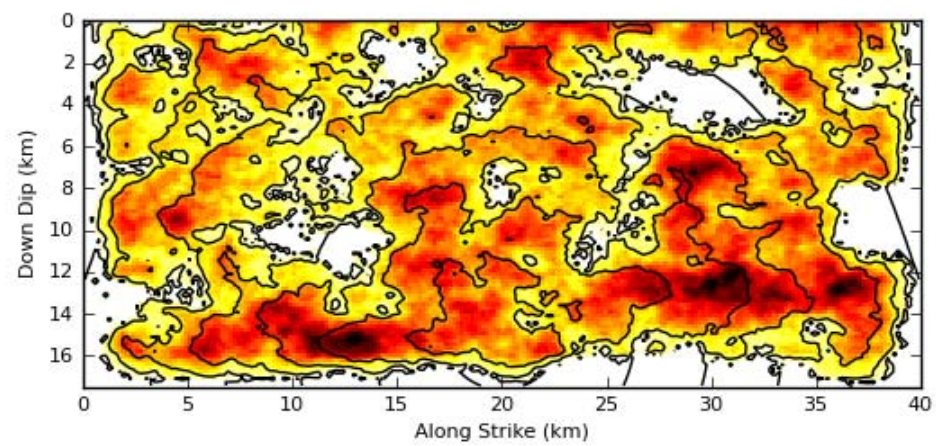
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Avg/Max Slip = 117/434



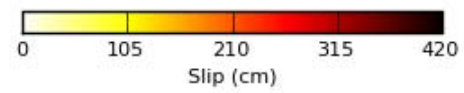
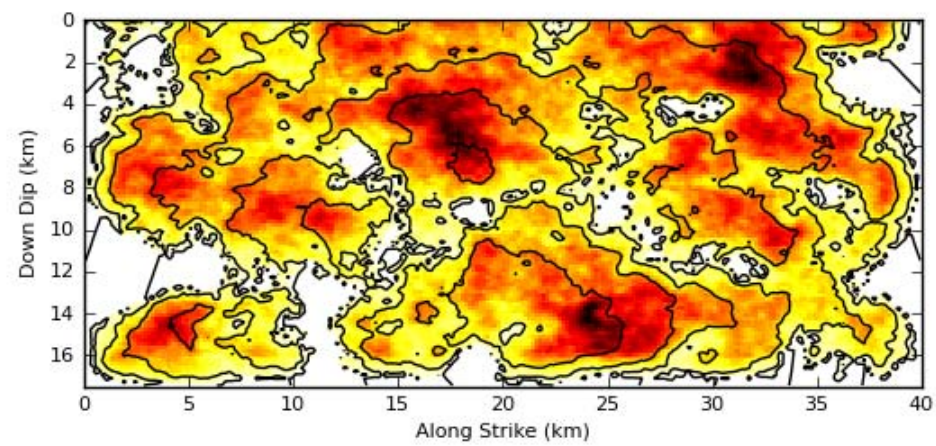
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Avg/Max Slip = 117/404



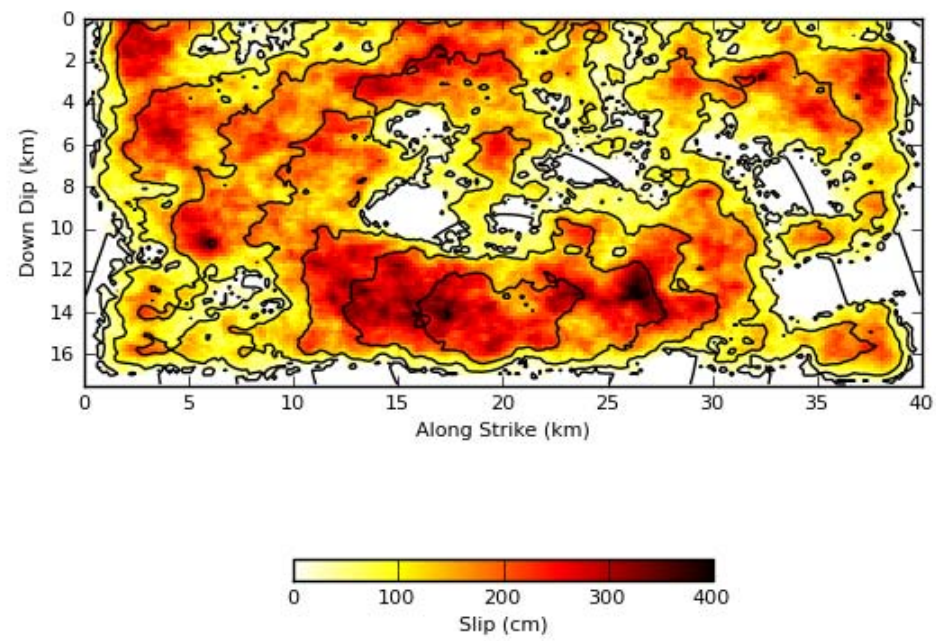
Rupture Model for lomap-sdsu-0025.srf
Avg/Max Slip = 115/415



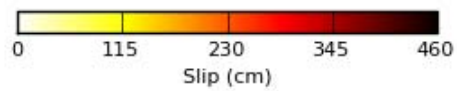
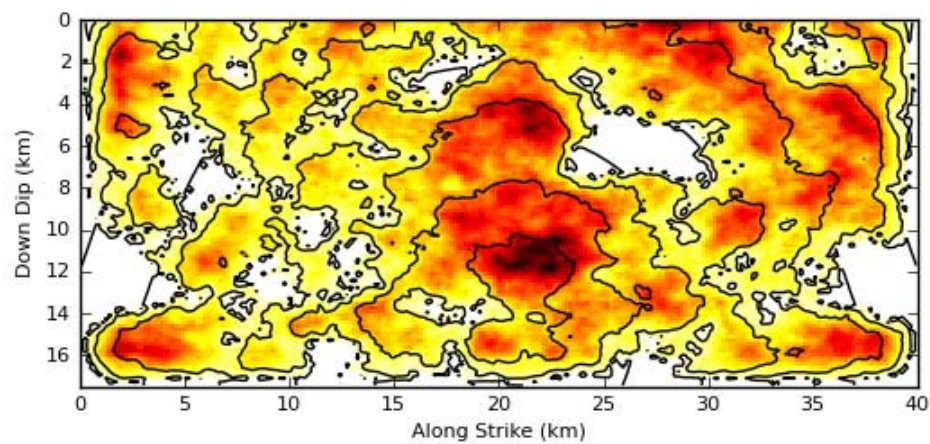
Rupture Model for lomap-sdsu-0026.srf
Avg/Max Slip = 117/436



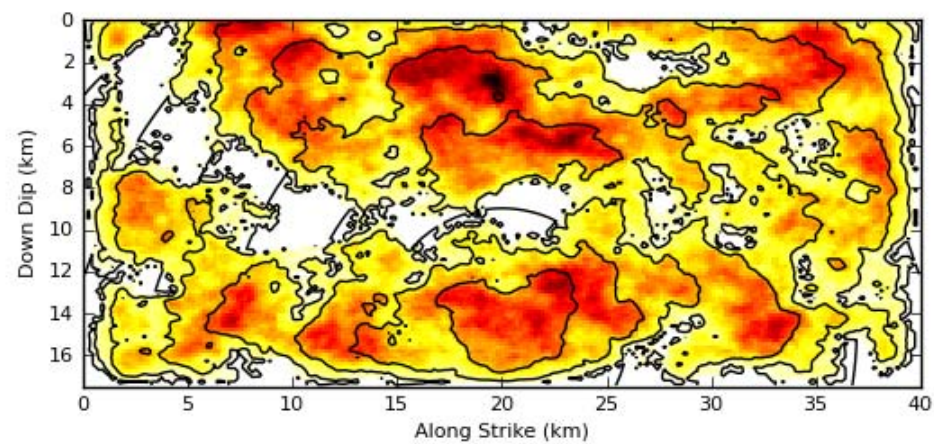
Rupture Model for lomap-sdsu-0027.srf
Avg/Max Slip = 116/415



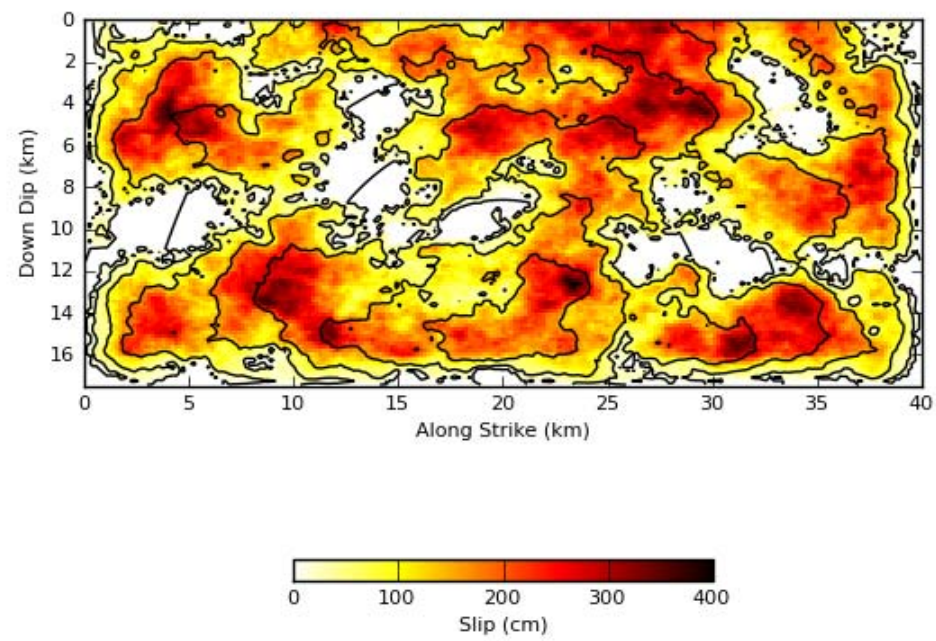
Rupture Model for lomap-sdsu-0028.srf
Avg/Max Slip = 117/467



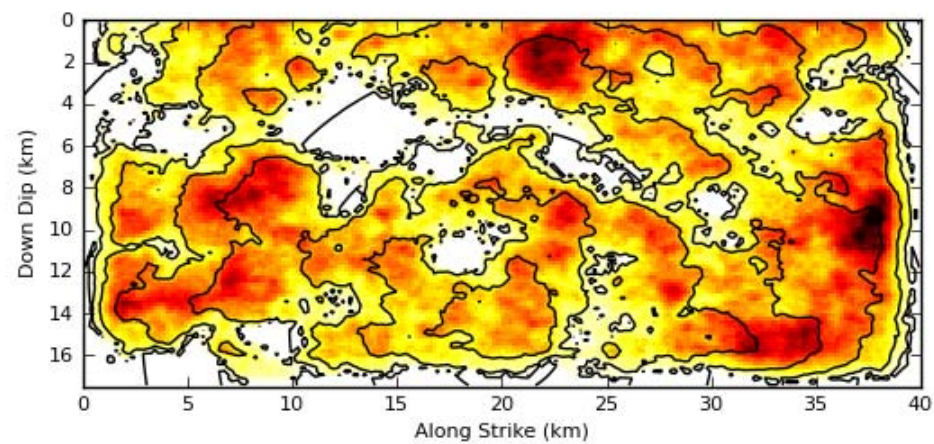
Rupture Model for lomap-sdsu-0029.srf
Avg/Max Slip = 117/460



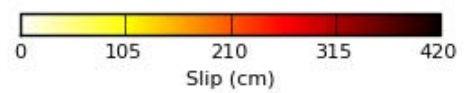
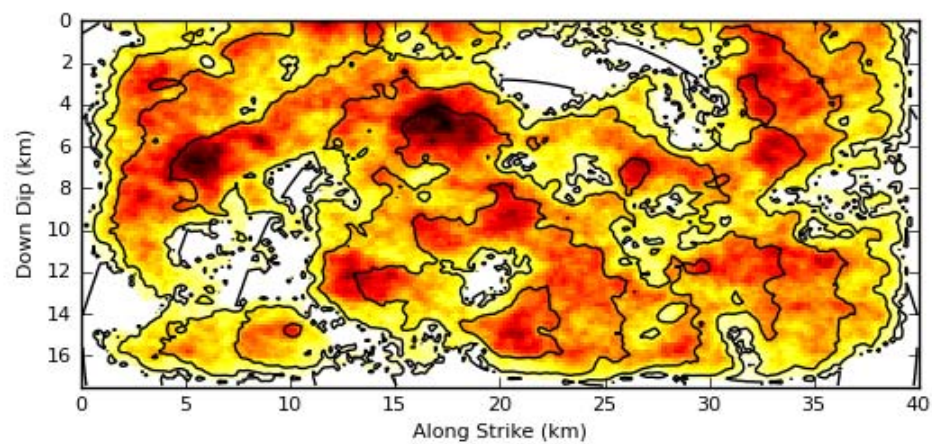
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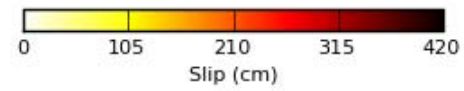
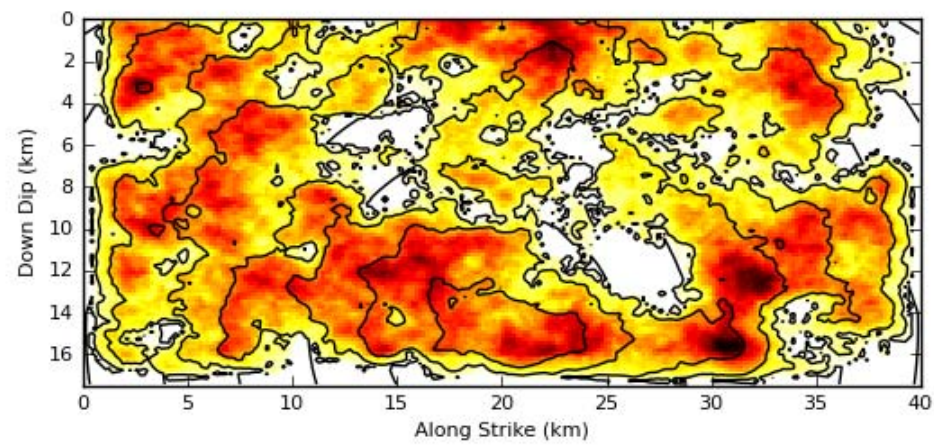
Rupture Model for lomap-sdsu-0031.srf
Avg/Max Slip = 117/454



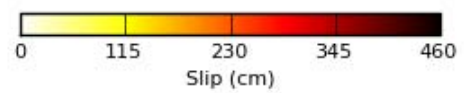
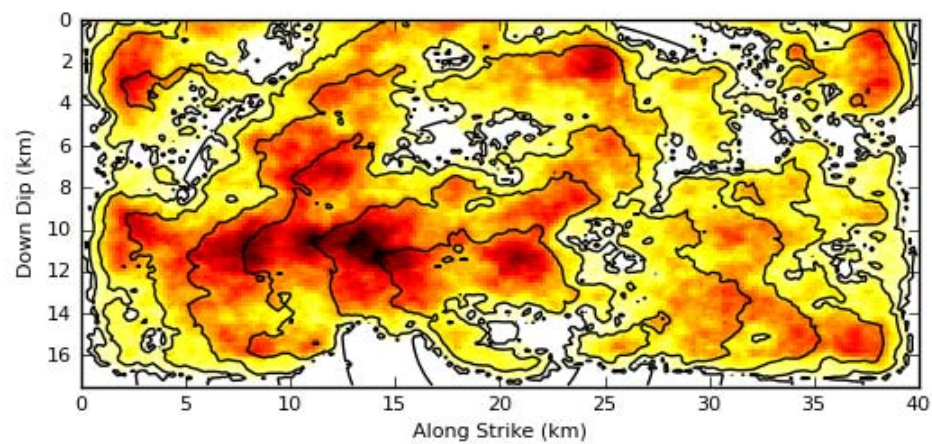
Rupture Model for lomap-sdsu-0032.srf
Avg/Max Slip = 117/427



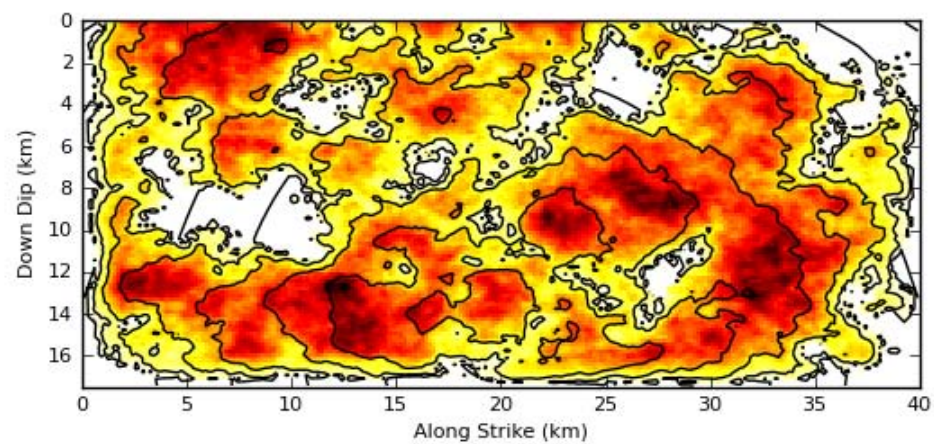
Rupture Model for lomap-sdsu-0033.srf
Avg/Max Slip = 116/430



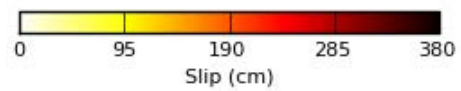
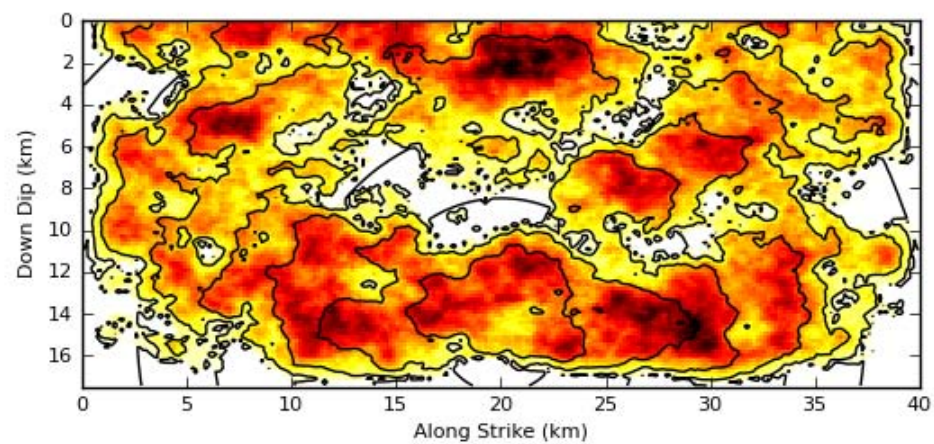
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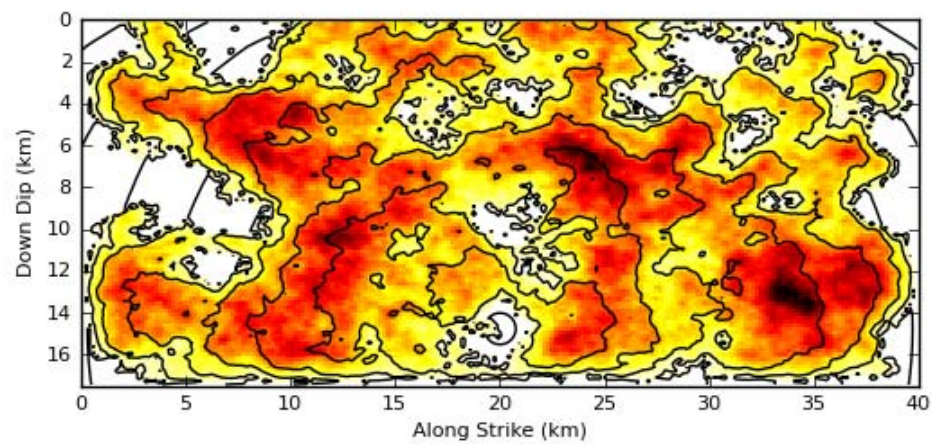
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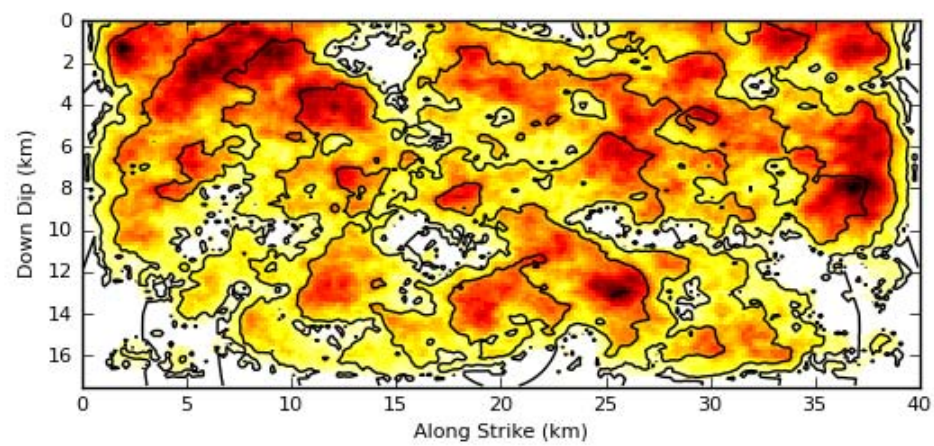
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Avg/Max Slip = 117/398



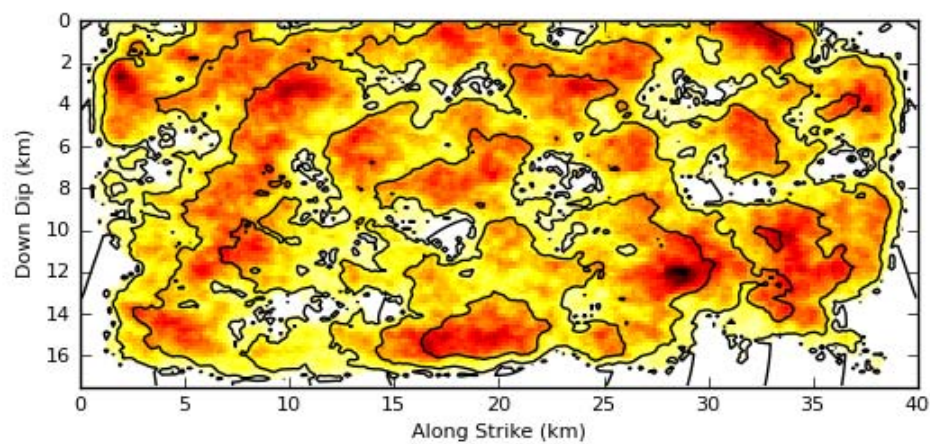
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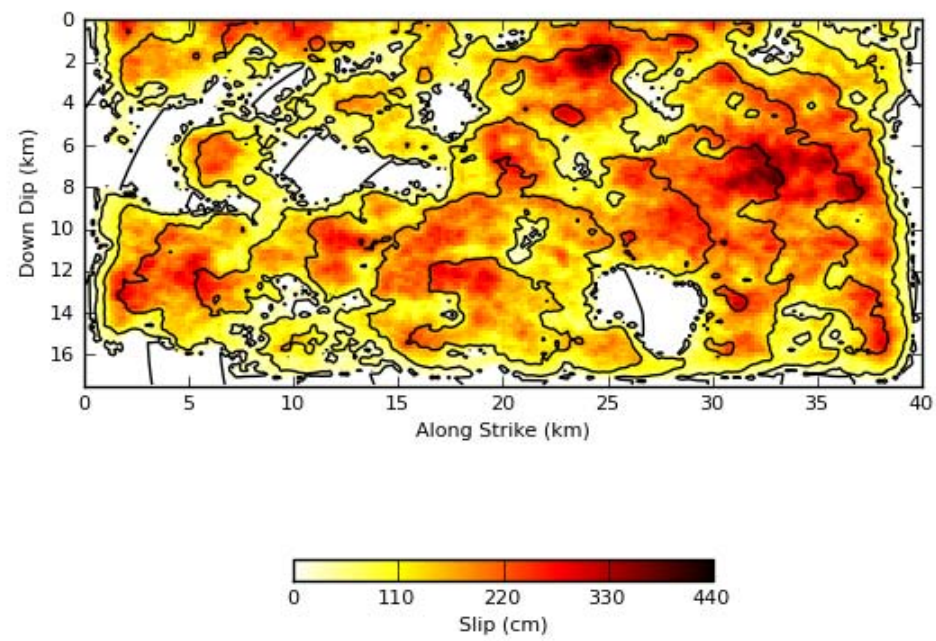
Rupture Model for lomap-sdsu-0038.srf
Avg/Max Slip = 120/441



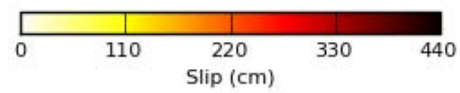
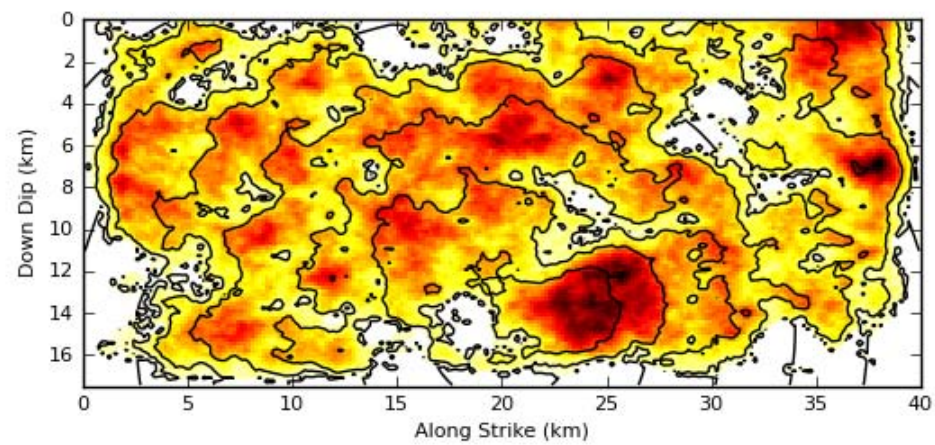
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Avg/Max Slip = 118/460



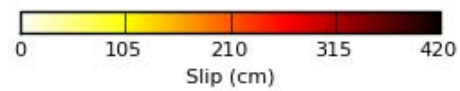
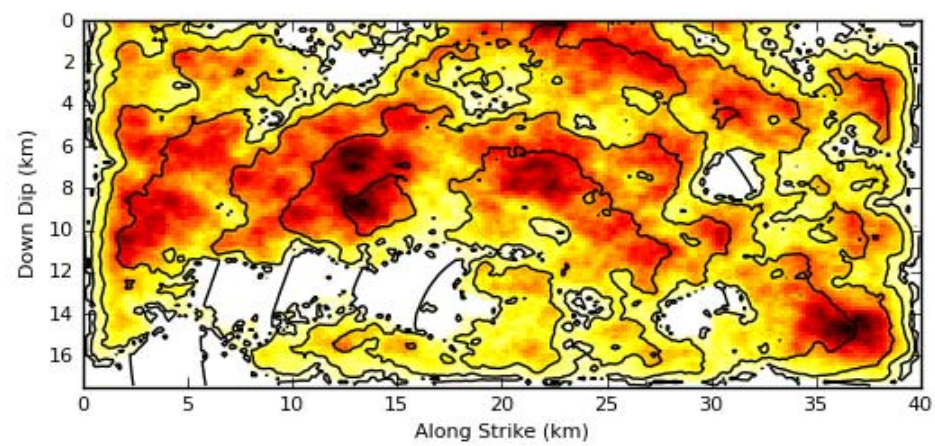
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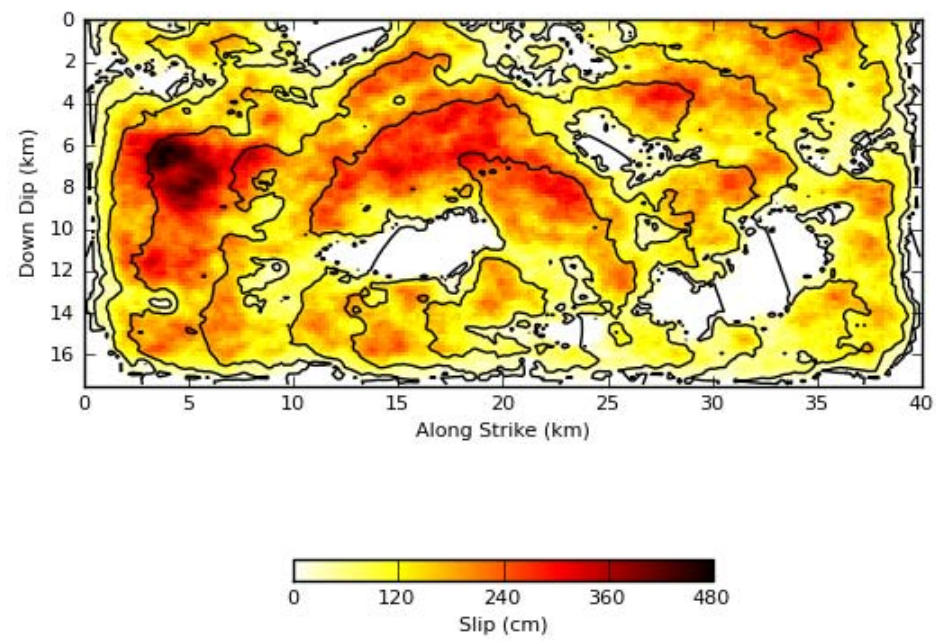
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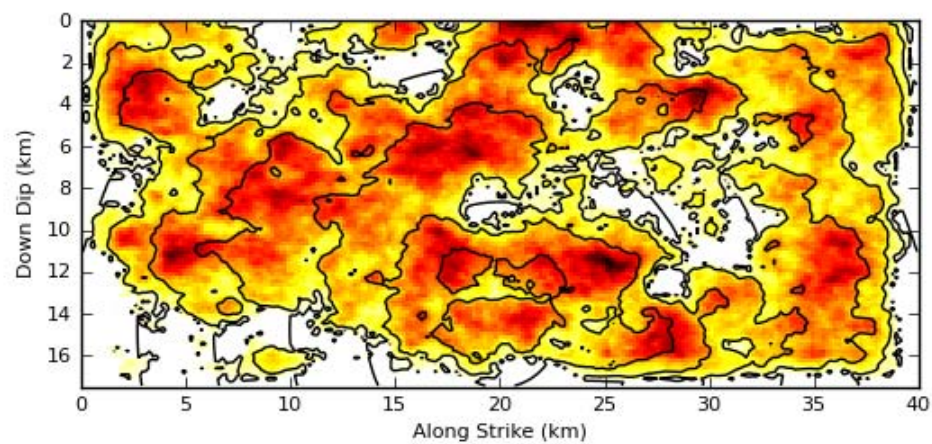
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Avg/Max Slip = 117/430



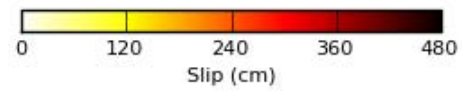
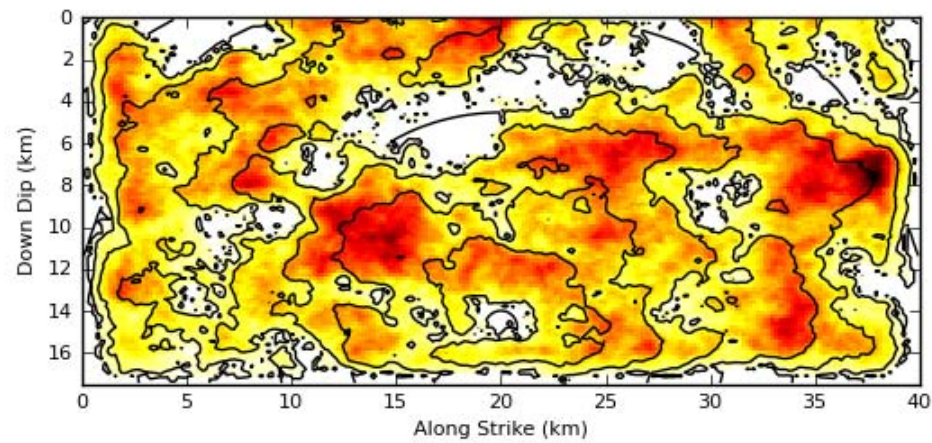
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Avg/Max Slip = 117/483



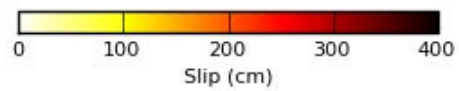
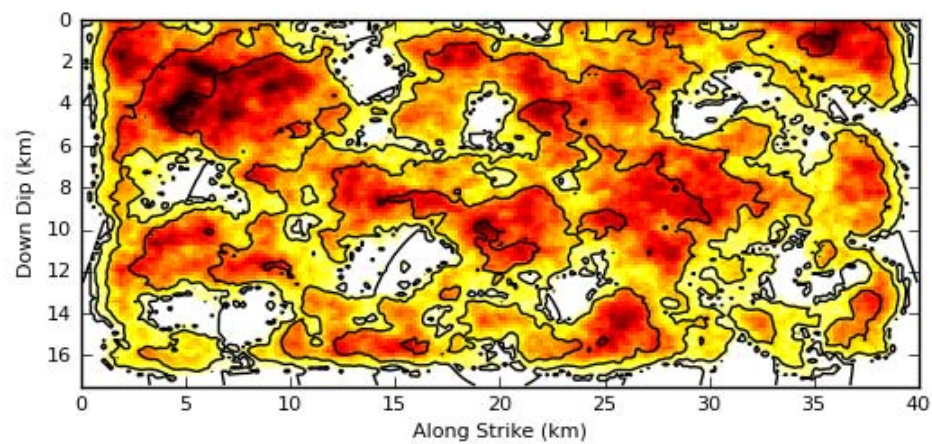
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Avg/Max Slip = 117/424



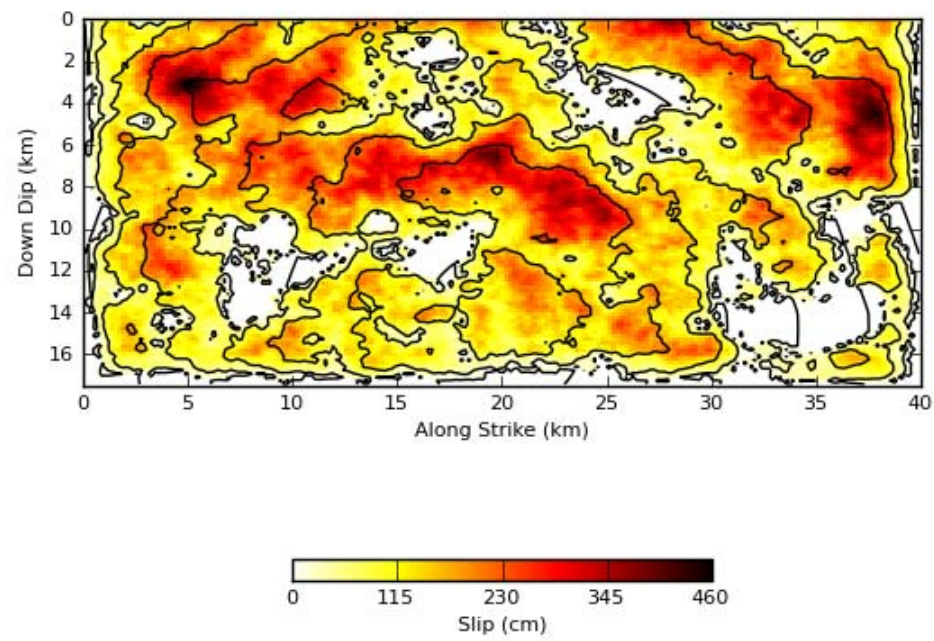
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Avg/Max Slip = 116/480



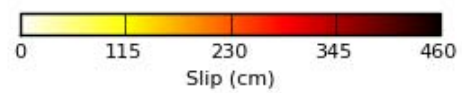
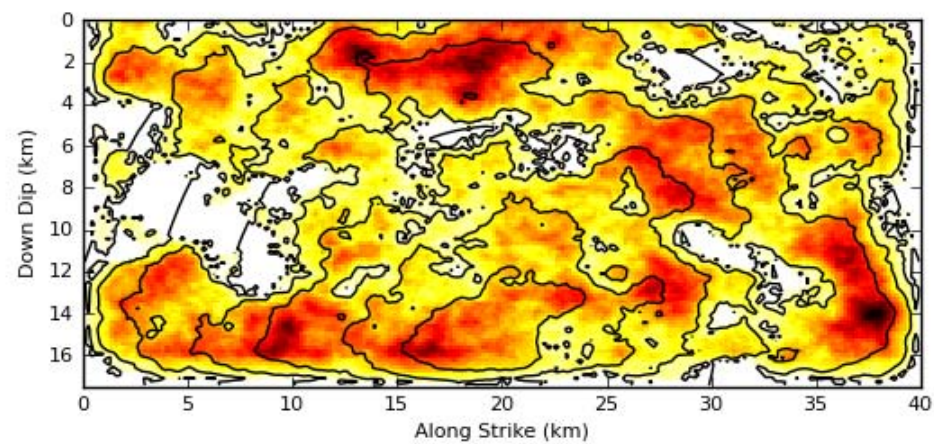
Rupture Model for lomap-sdsu-0046.srf
Avg/Max Slip = 118/404



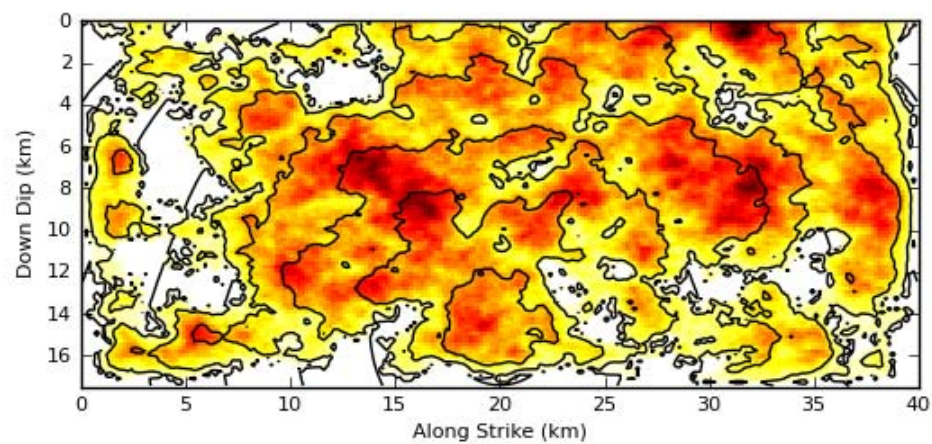
Rupture Model for lomap-sdsu-0047.srf
Avg/Max Slip = 118/477



Rupture Model for lomap-sdsu-0048.srf
Avg/Max Slip = 115/477



Rupture Model for lomap-sdsu-0049.srf
Avg/Max Slip = 117/469

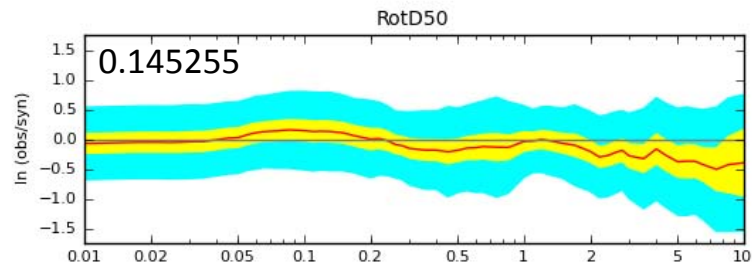


Ensembles of Source Realizations

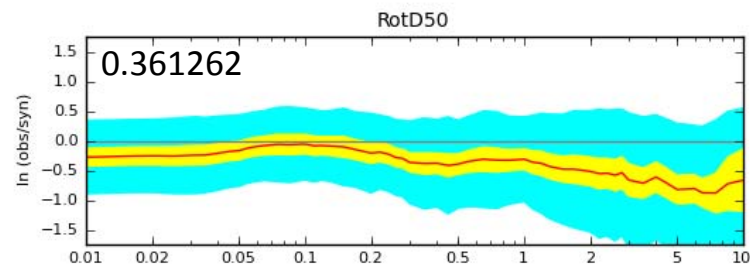
- Introduces uncertainty in estimates
- Median of realizations comparable to data
- Vary rupture history (slip, rupture speed, ...)

Landers

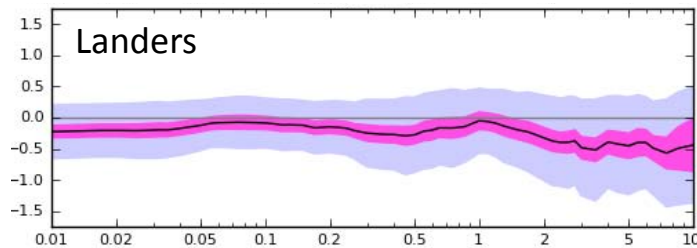
Smallest |GOF| Landers



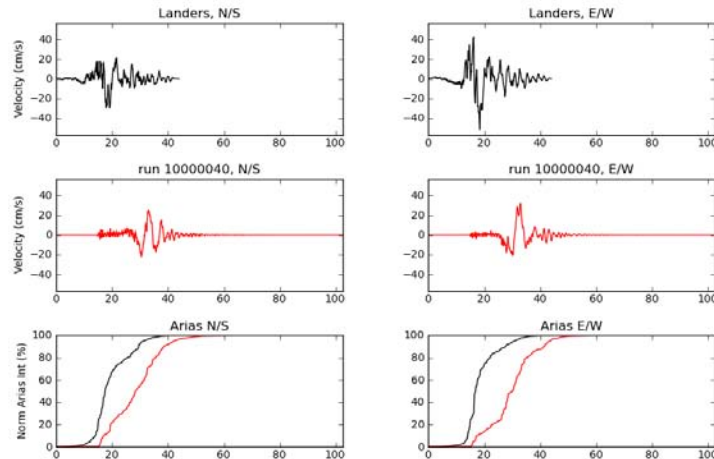
Largest |GOF| Landers



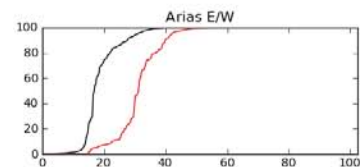
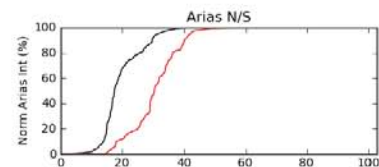
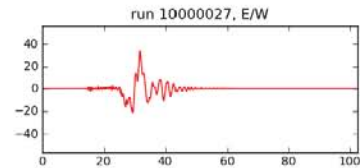
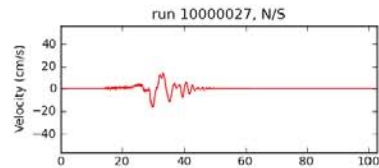
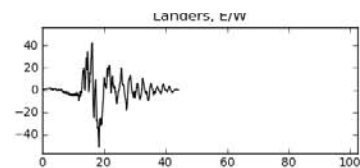
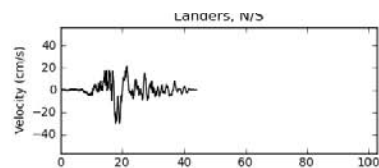
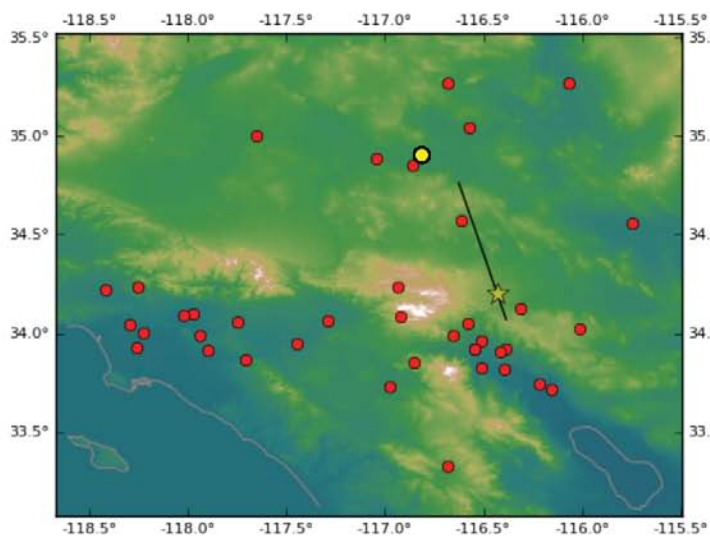
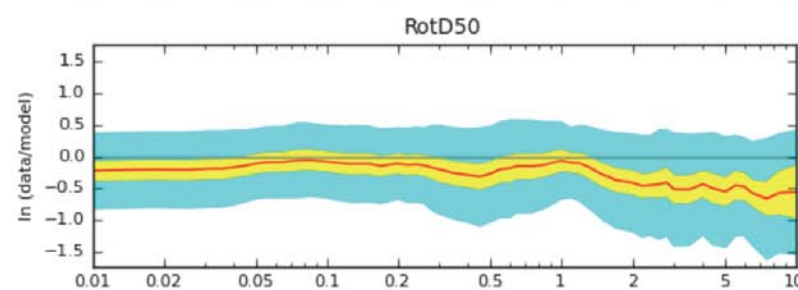
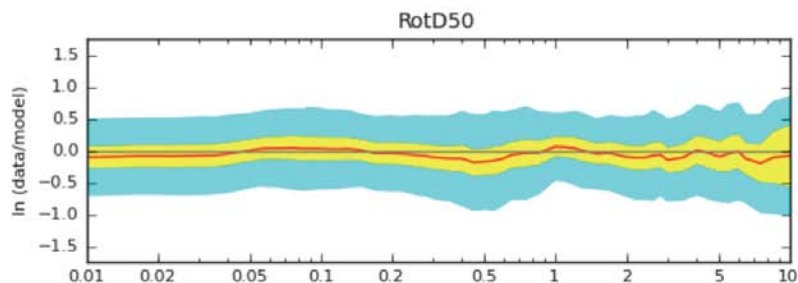
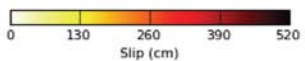
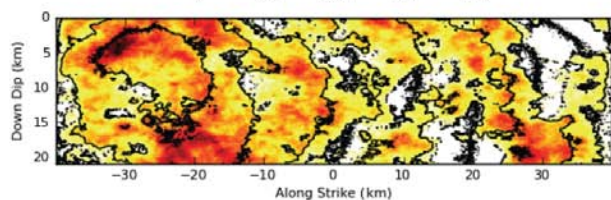
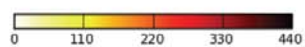
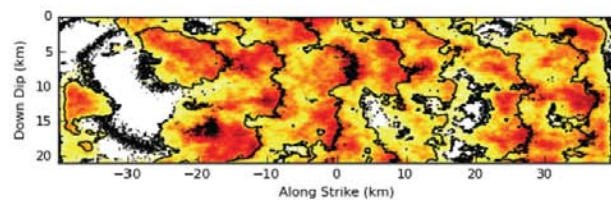
Ensemble Average



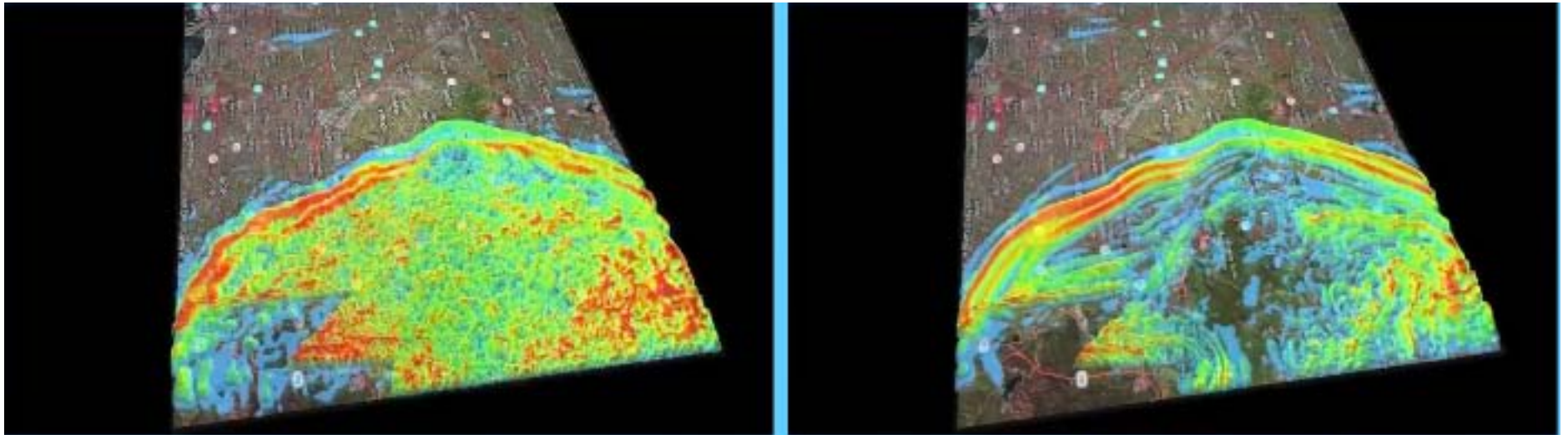
Landers vs. run 10000040, station 4006-YER



Simulation	Average Bias
10000040	0.145255
10000020	0.184751
10000043	0.194791
10000008	0.200322
10000016	0.205302
10000048	0.205685
10000013	0.206232
10000002	0.210312
10000012	0.213936
10000034	0.214638
10000031	0.216000
10000019	0.217733
10000018	0.218331
10000049	0.219801
10000014	0.220046
10000047	0.220104
10000004	0.222954
10000010	0.223977
10000011	0.227900
10000033	0.228365
10000003	0.232264
10000017	0.233471
10000022	0.238922
10000023	0.239782
10000027	0.241769
10000009	0.251068
10000042	0.263262
10000044	0.263435
10000030	0.268027
10000036	0.269801
10000028	0.271416
10000021	0.273601
10000001	0.274374
10000041	0.278330
10000006	0.286065
10000024	0.290665
10000046	0.293202
10000045	0.294136
10000007	0.296948
10000037	0.298380
10000039	0.306187
10000025	0.307114
10000000	0.325274
10000038	0.327012
10000035	0.335134
10000029	0.354691
10000015	0.355555
10000005	0.356290
10000032	0.356825
10000026	0.361262

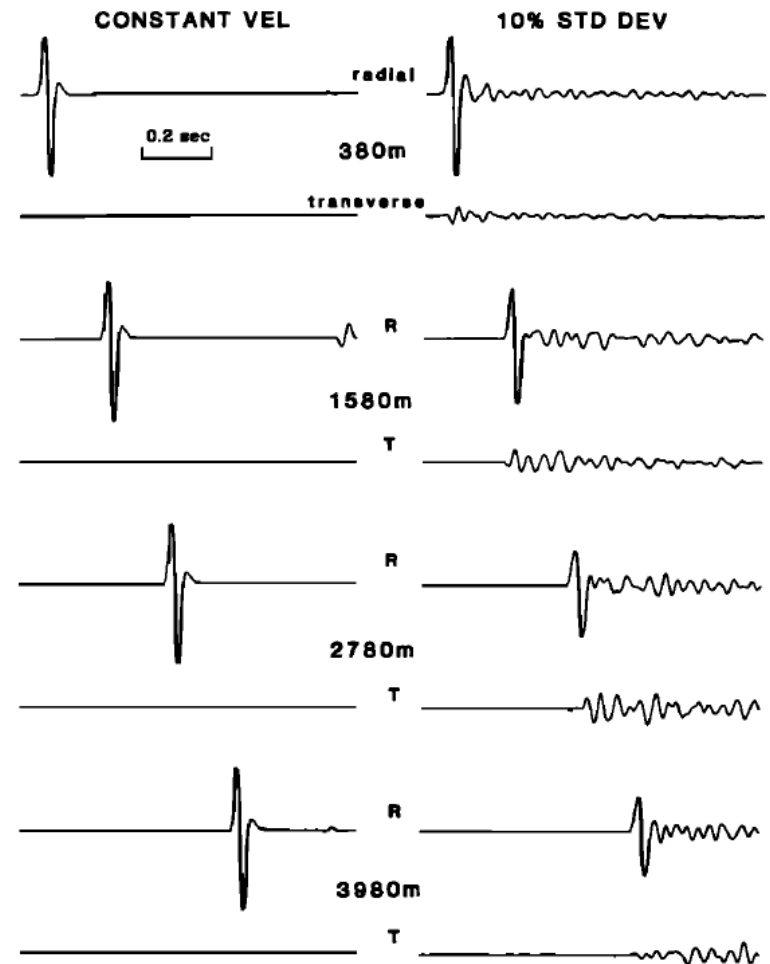
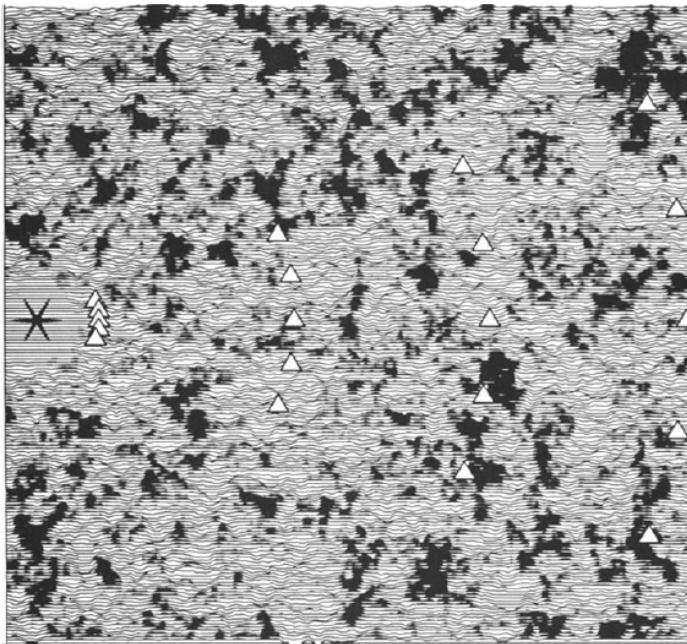


Media Complexity



Small-scale Media Heterogeneity

- Scattering in earth's crust is known to effect seismic ground motion



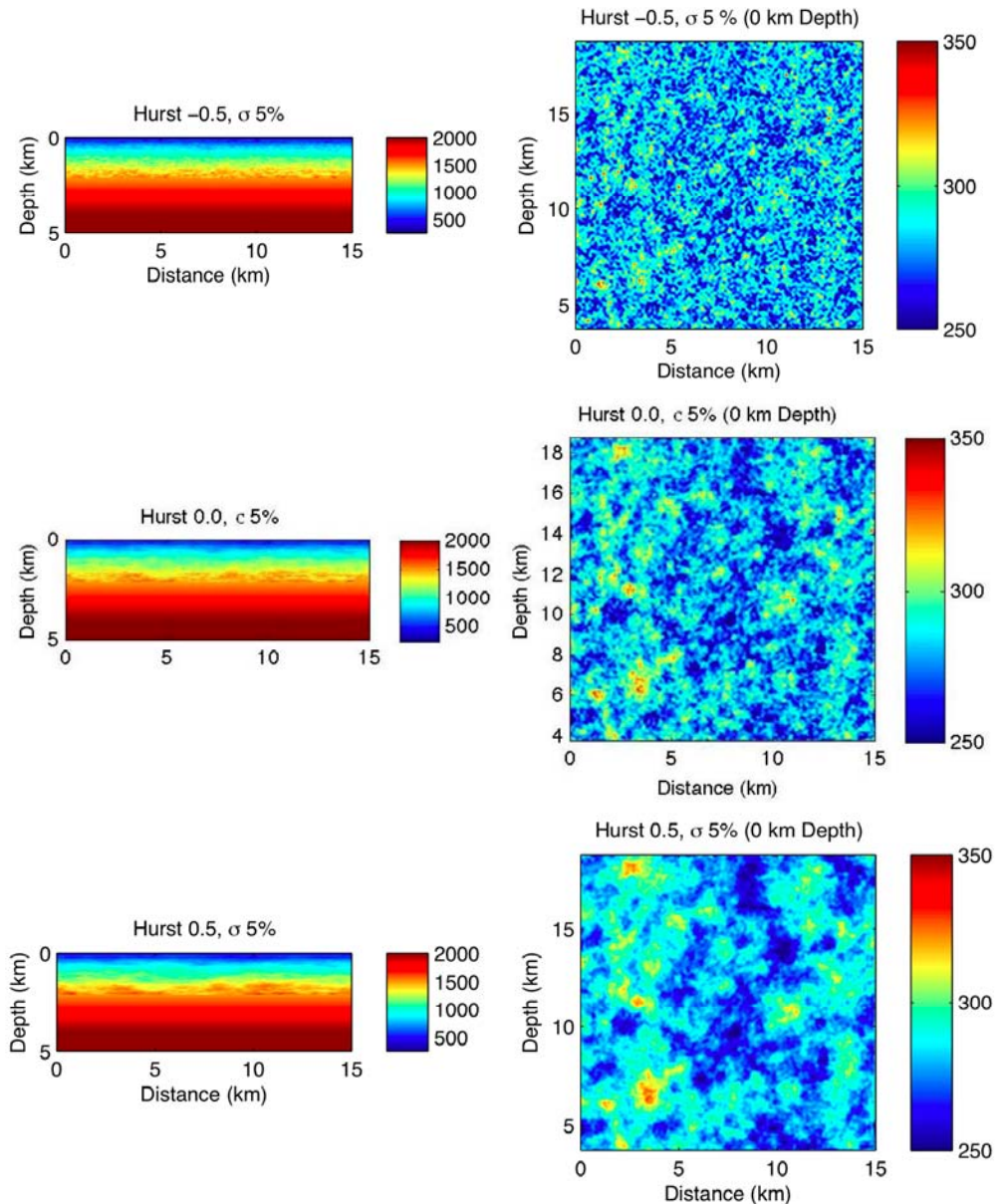
(Frankel and Clayton, 1986)

Media Complexity

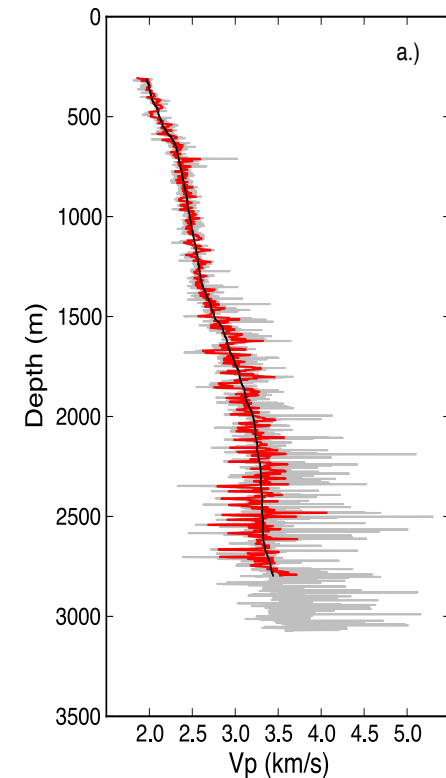
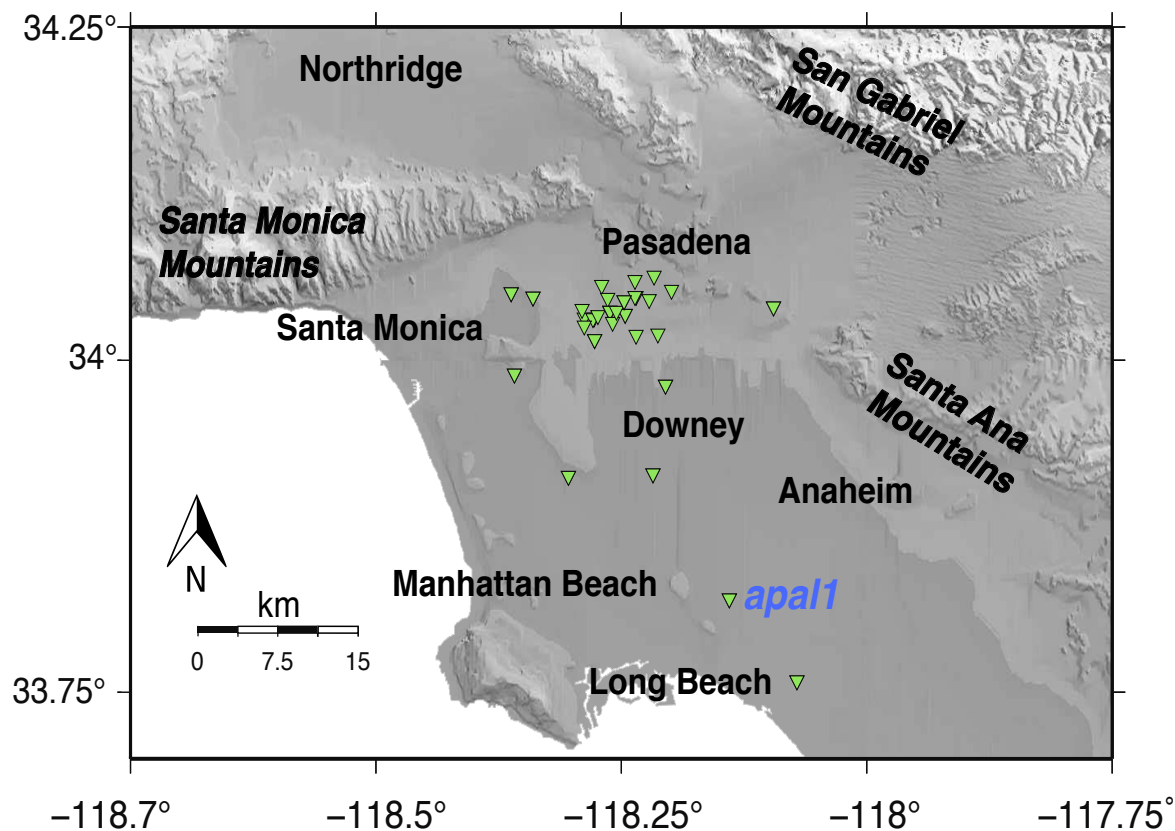
In 3D, a fractal distribution has a high wave-number decay of the power spectrum $P(k)$ as:

$$P(k) = P_0 \left(1 + \left(\frac{k}{k_{corner}} \right)^2 \right)^{-(1.5+H)}$$

where H is the Hurst number, k_{corner} is a wave number below which the spectrum is approximately constant



Small-scale Heterogeneities, CVM, Q Tests

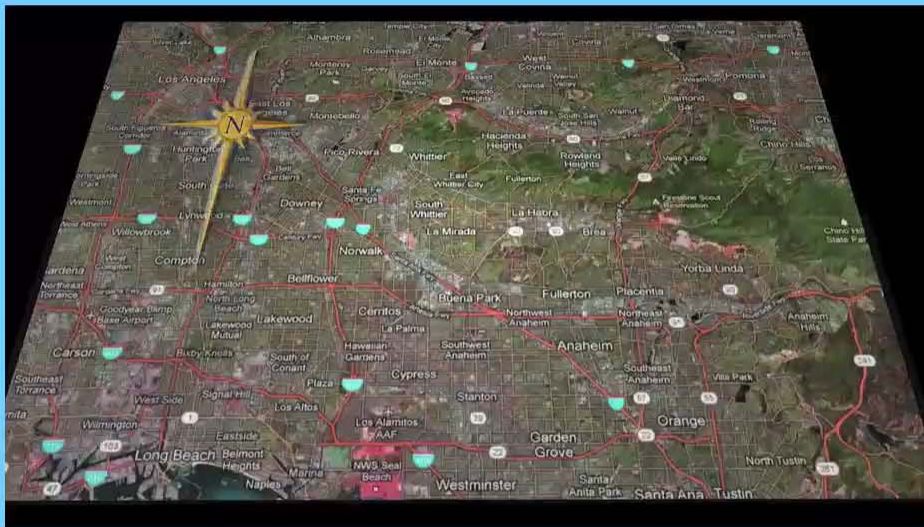


Analysis of
38 Sonic logs
from LA
basin

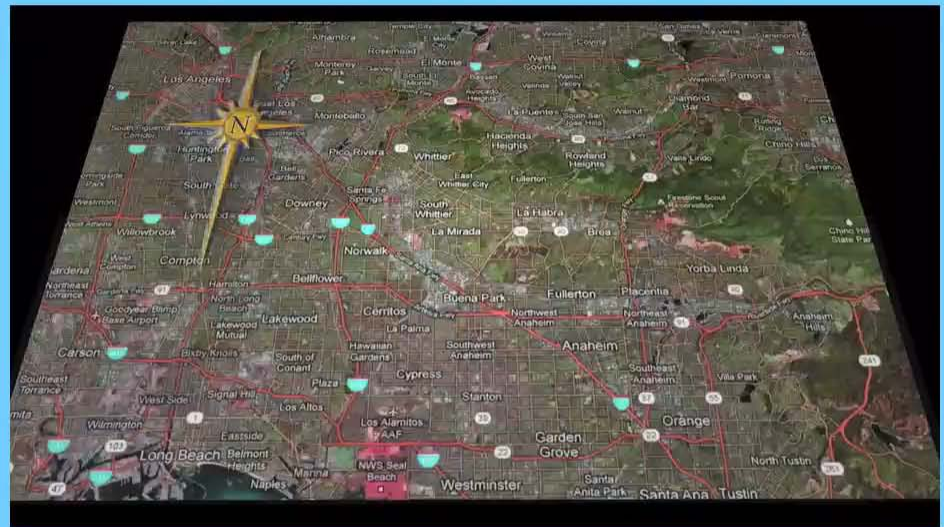
Illustration of Scattering Effects

**Simulated Wave Propagation for the Mw5.4 Chino Hills, CA, Earthquake,
Including a Statistical Model of Small-Scale Heterogeneities**

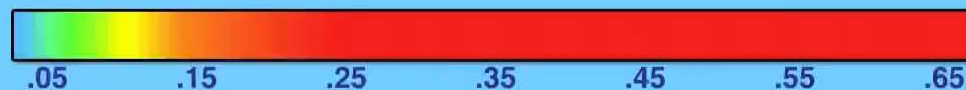
$t=02$ sec



Using California 3D geological model
with added small-scale geological complexities



Using Standard California 3D geological model



Velocity Magnitude (m/s)

**Visualization Of Deterministic High-Frequency
Ground Motions From Simulations Of Dynamic
Rupture Along Rough Faults With And Without
Medium Heterogeneity Using Petascale
Heterogeneous Supercomputers**

Scattering on BBP

- Deterministic calculation of small-scale scattering computationally expensive, hours on largest supercomputers
- Instead, we approximate high-frequency scattering by analytical expressions

Multiple S-S Scattering

$$E(\vec{r}, t) = \frac{\delta(t - \frac{r}{v})e^{-\eta vt}}{4\pi v r^2} + \sum_{n=1}^2 E_n(\vec{r}, t) + \left(\int_{-\infty}^{+\infty} \frac{e^{i\Omega}}{2\pi} d\Omega \right. \\ \left. \times \int_0^\infty \frac{(\frac{\eta_s}{k})^3 \times [\tan^{-1}(\frac{k}{\eta + i\Omega/v})]^4 \times \sin(kr)}{2\pi^2 v r [1 - \frac{\eta_s}{k} \tan^{-1}(\frac{k}{\eta + i\Omega/v})]} dk \right), \quad (1)$$

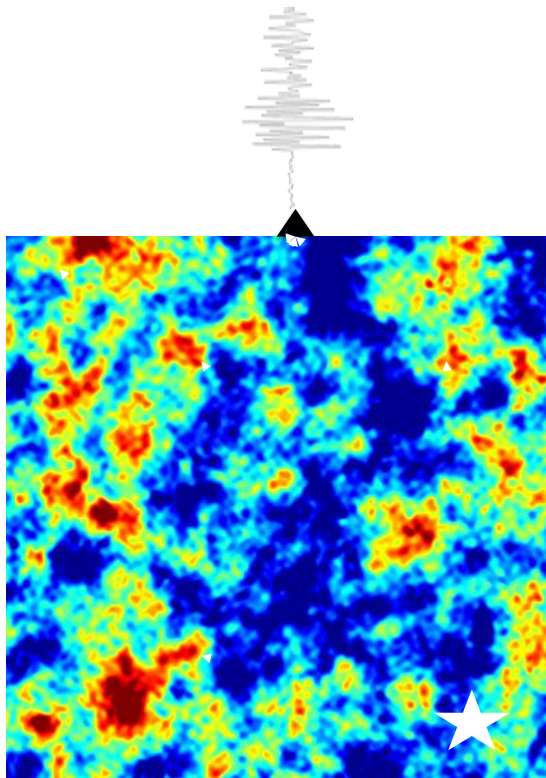
Zeng et al., 1991, 1993

Scattering/attenuation Parameters

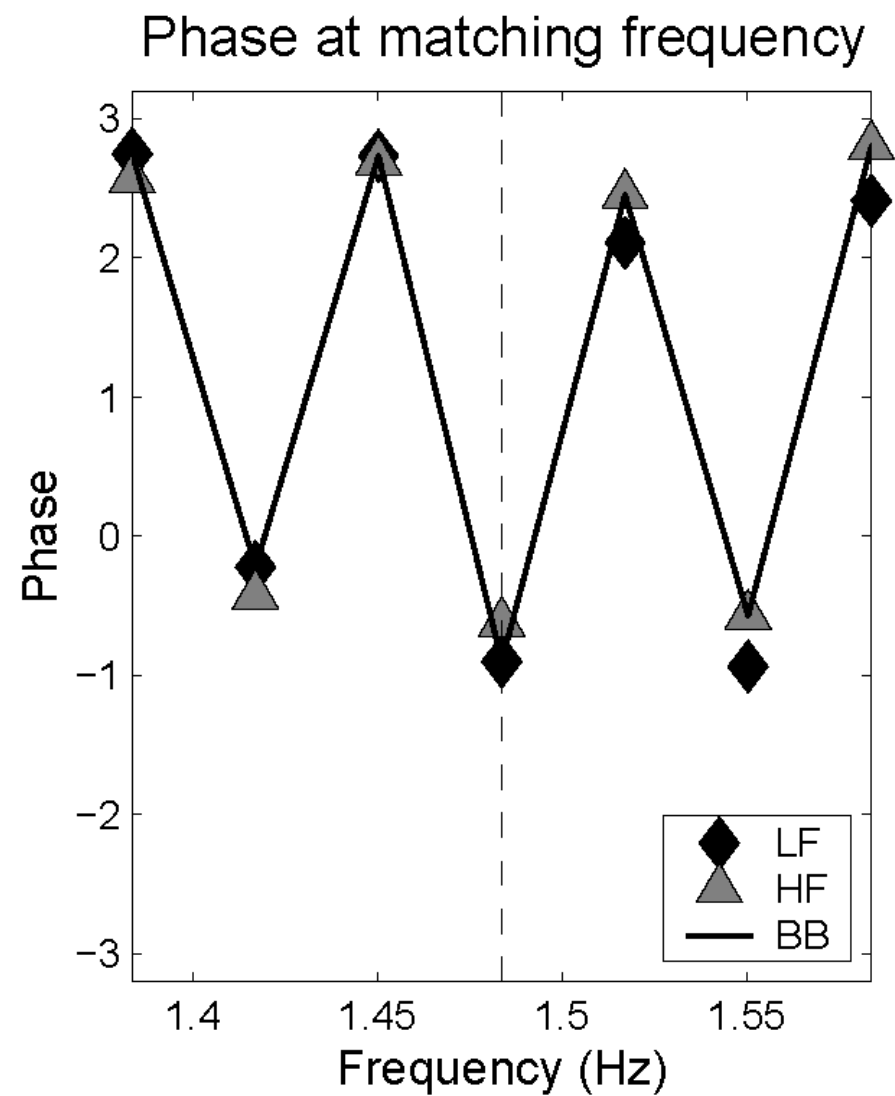
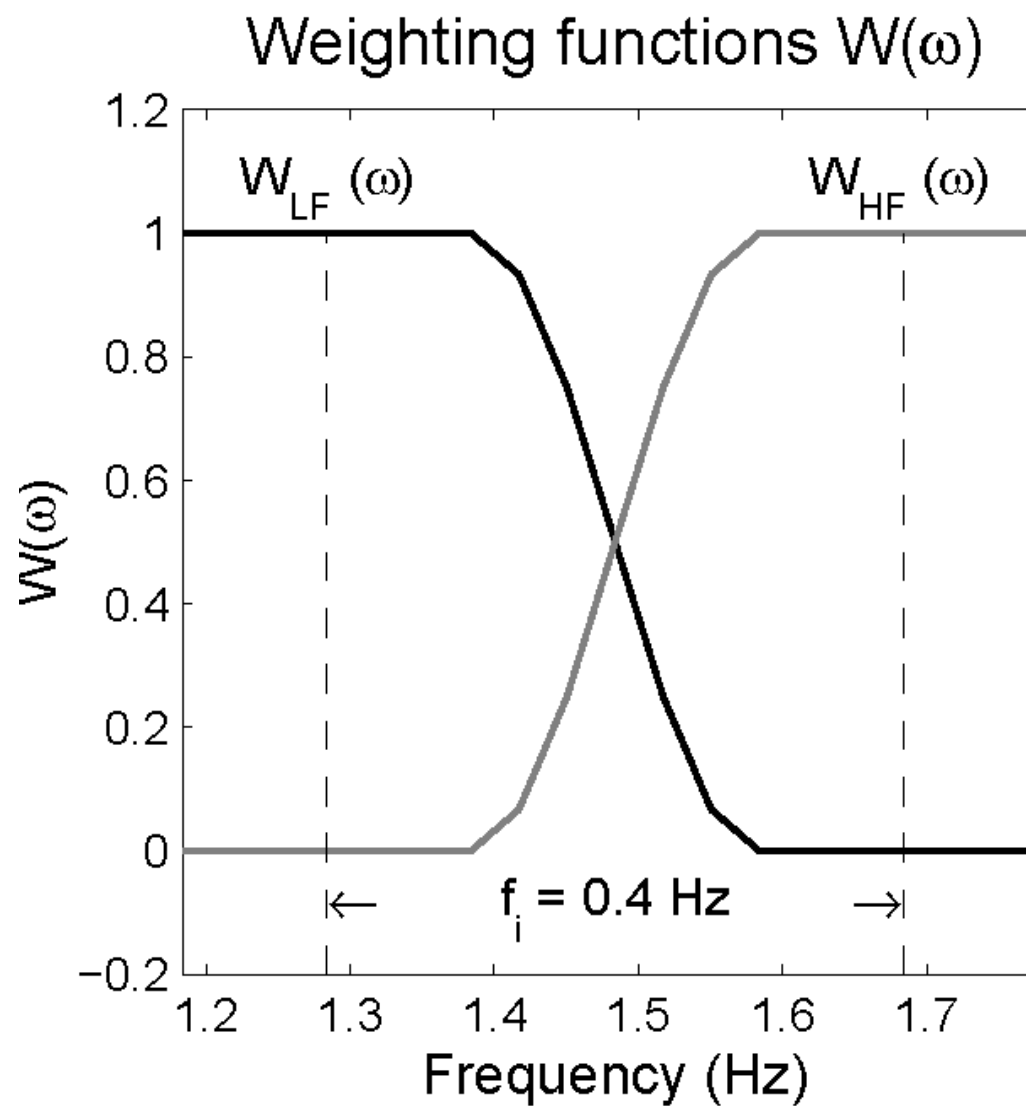
- $\eta = \eta_s + \eta_i$
- $L_e = 1/(\eta_s + \eta_i)$ extinction distance (primary S-wave energy decreased to $1/e$)
- $1/Q_s = \eta_s/k$
- $1/Q_i = \eta_i/k$

BBtoolbox V1.5

- Hybrid broadband seismograms are calculated from low-frequency deterministic synthetics and high-frequency scatterograms



Assumes that the high-frequency component of recorded seismic signals can be modeled as the scattering contribution from random media



BBtoolbox

Mai, P.M., W. Imperatori and K.B. Olsen (2010). Hybrid broadband ground-motion simulations: combining long-period deterministic synthetics with high-frequency multiple S-to-S backscattering, *Bull. Seis. Soc. Am.* 100, 5A, 2124-2142, doi: 10.1785/0120080194.

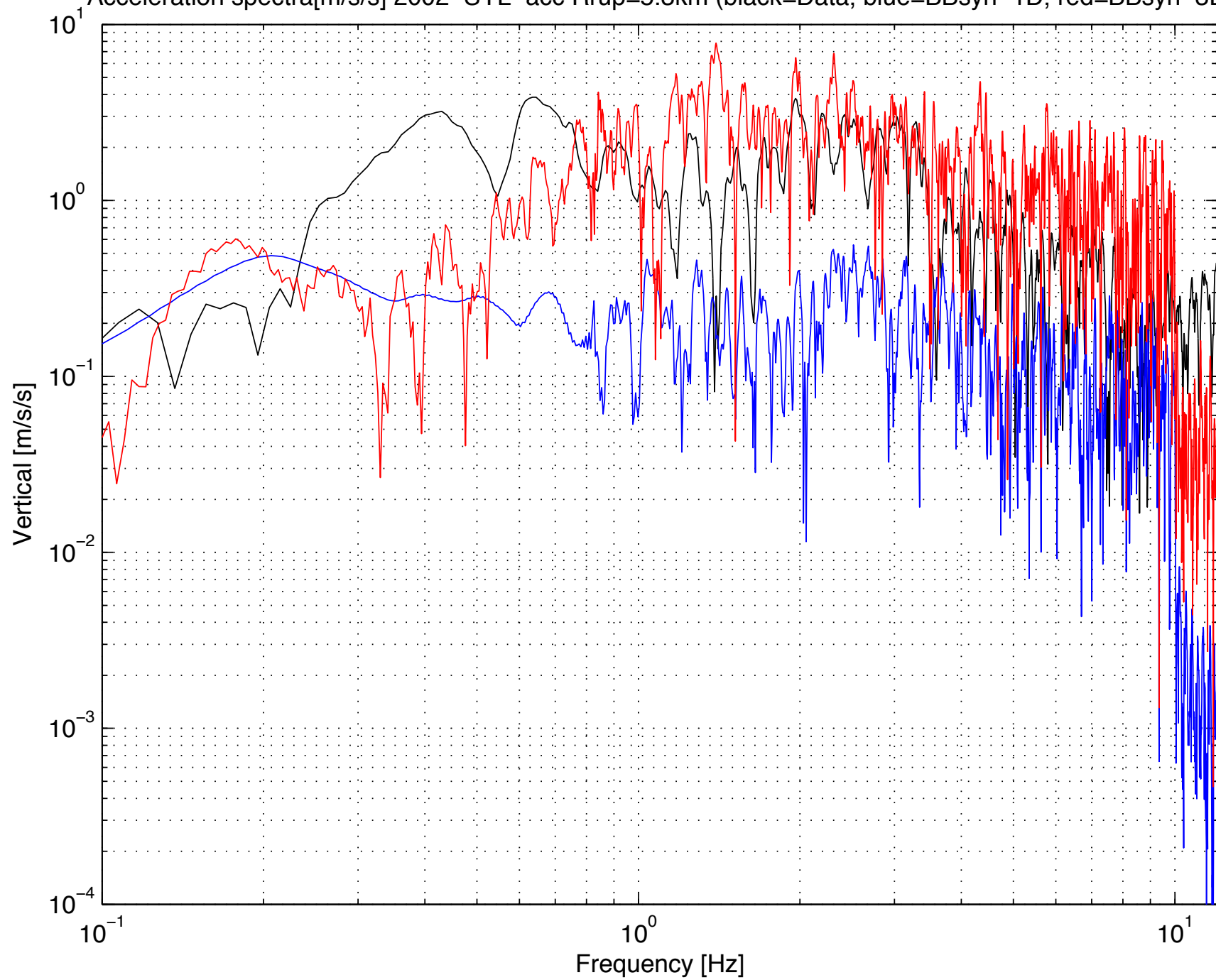
Mena, B., P.M. Mai, K.B. Olsen, M.D. Purvance, and J.N. Brune (2010). Hybrid broadband ground-motion simulation using scattering Green's functions: application to large-magnitude events, *Bull. Seis. Soc. Am.* **100**, 5A, 213-2122, doi: 10.1785/0120080318.

Olsen, K.B., and R. Takedatsu (2014). The SDSU Broadband Ground Motion Generation Module BBtoolbox Version 1.5, *Seis. Res. Lett.*, revised.

Mai et al. (2010) LF-HF Merging

- HFs scaled to LFs within a user-chosen (small) bandwidth (usually 1Hz)
- Rationale behind methods includes desire to minimize mismatch at merging frequency
- However, the accuracy of this technique depends critically on the LFs
- When 1D GFs are used, this method is not sufficiently accurate

Acceleration spectra[m/s/s] 2002-SYL-acc Rrup=5.3km (black=Data, blue=BBsyn-1D, red=BBsyn-3D)



V1.5 Merging Technique

- 'Anchoring' the HFs to an estimate of the acceleration amplitude spectrum at 1Hz:
- $A_i(f) = C_{ij} S_i(f) G_{ij}(f) P(f)$, where
- $C_{ij} = F_s R_{p_{ij}} / [4\pi\rho_i\beta_i^3]$ (radiation scale factor)
- $S_i = m_i (M_o/N) (2\pi f)^2 [1 + F(f/f_{ci})^2]^{-1}$ (source radiation term)
- $m_i = d_i \mu_i A_T / M_o$ (average subfault moment)
- $F = M_o / [N \text{ strfac } dl^3]$ (subfault scaling factor)
- $F_{ci} = c_o V_{Ri} / [\alpha_T \pi dl]$ (subfault corner frequency)
- $G_{ij}(f) = l_i(f) * \exp(-\pi f^{1-f_{dec}} \sum t_{ijk} / q_k) * / r_{ij}$ (path term)
- $q_k = a_{fac} + b_{fac} * V_s$
- $P(f) = \exp(-\pi \kappa f)$

Modified from Graves and Pitarka (2010)

Region-specific (Input) Parameters

- $a + b * V_s$ (scaling of HF only)
 - $Q_o f^n$
 - kappa
 - strfac
-
- From srf file: M_w , nsub, subfault areas, strike, dip, hypocenter location

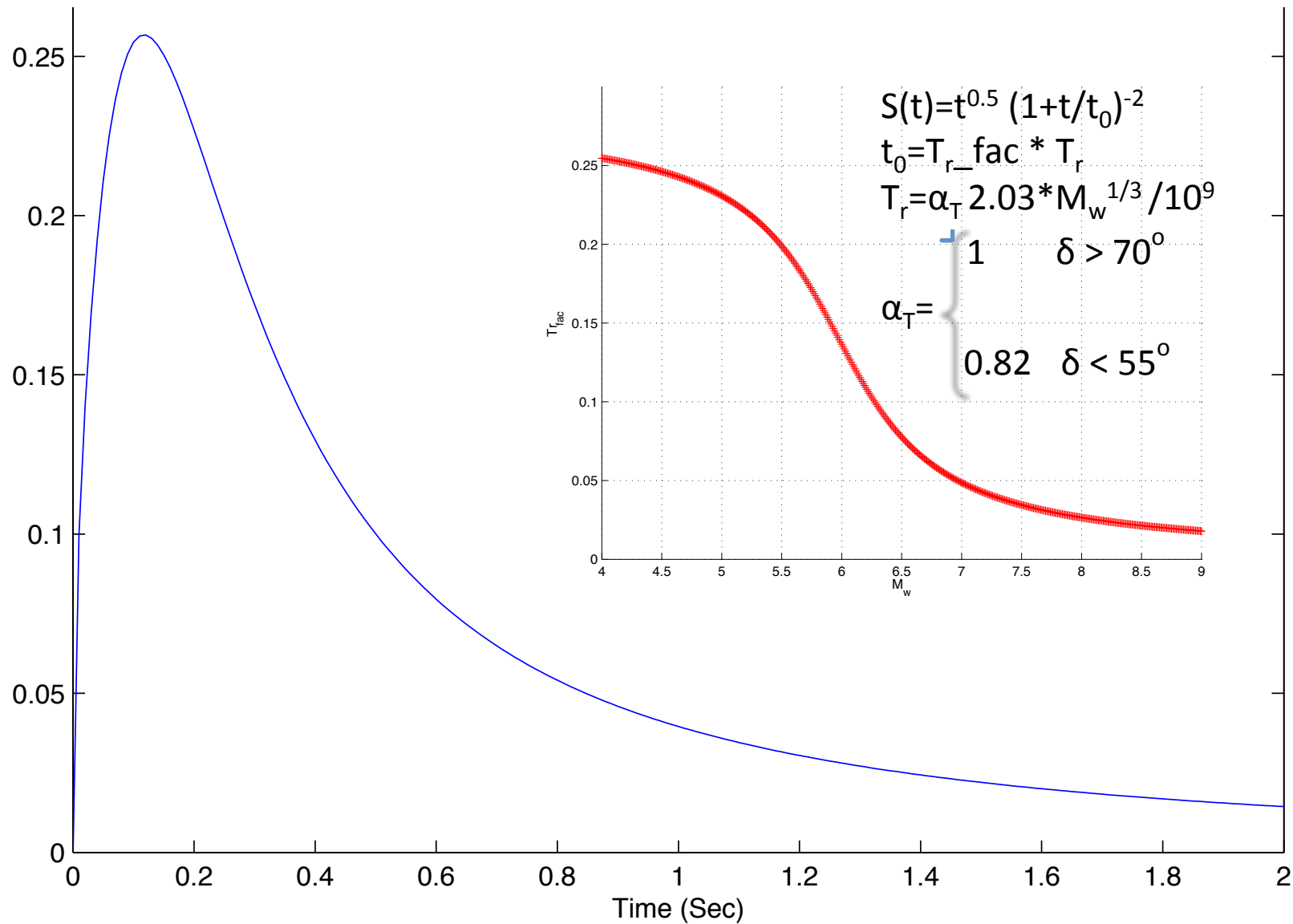
Fixed Parameters

- Scattering Coefficient (uniform 0.005 – 0.05)
- Absorption Coefficient (0.03)
- Number of Scattering Wavelets (1500)
- Number of Points in Coda Envelope (500)
- Seed Number (3000)

Scenario-specific (calculated) Parameters

- Tr_fac (determines rise time, calculated from moment)

HF Source-time Function Scaling



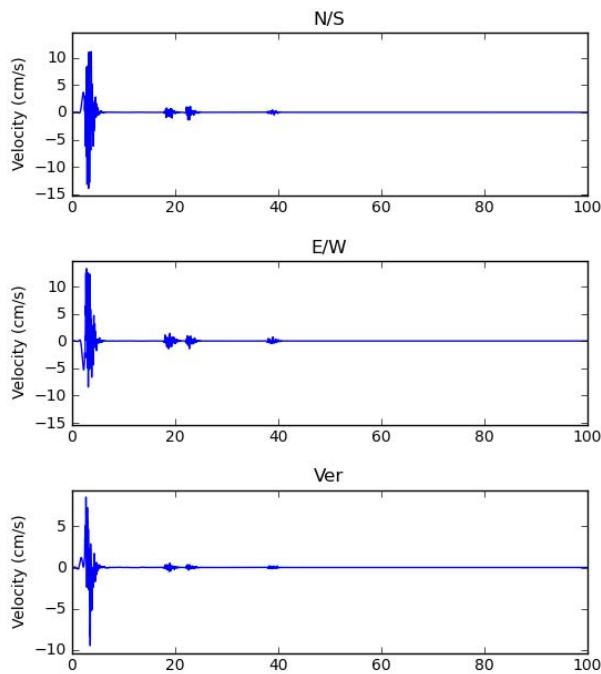
Region-specific (variable) Parameters:

Parameters	
$a + b * V_s$ (HF scaling only)	$41 + 34 * V_s$
$Q_o f^n$	$150 f^{0.8}$
kappa	0.04
strfac	50 bars

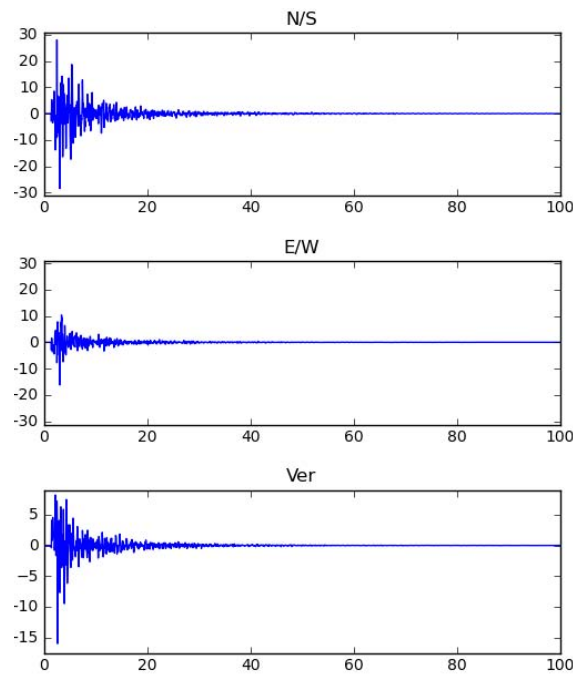
Synthetic Seismograms

Duration, other features depend on specific HF method!

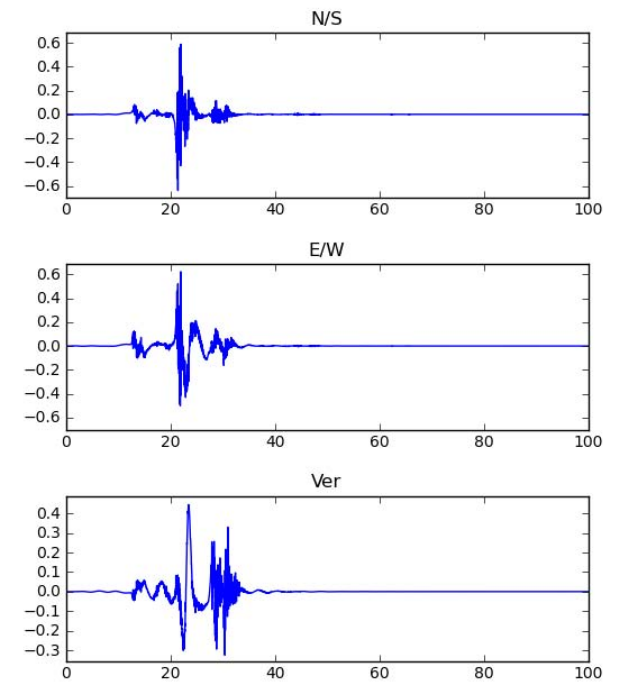
Seismograms for run 10000014, station sta-r0007



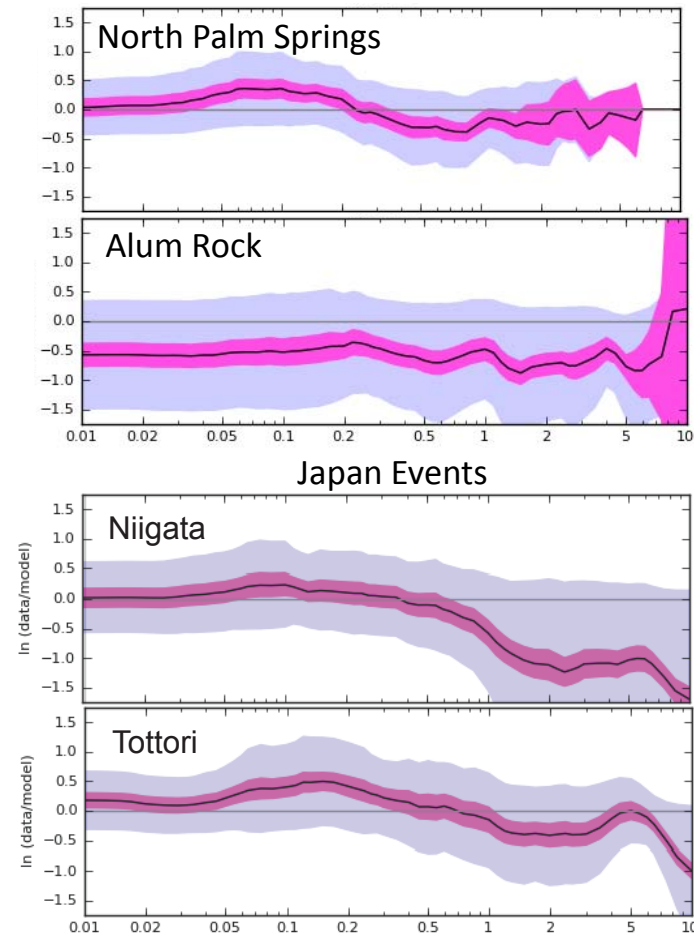
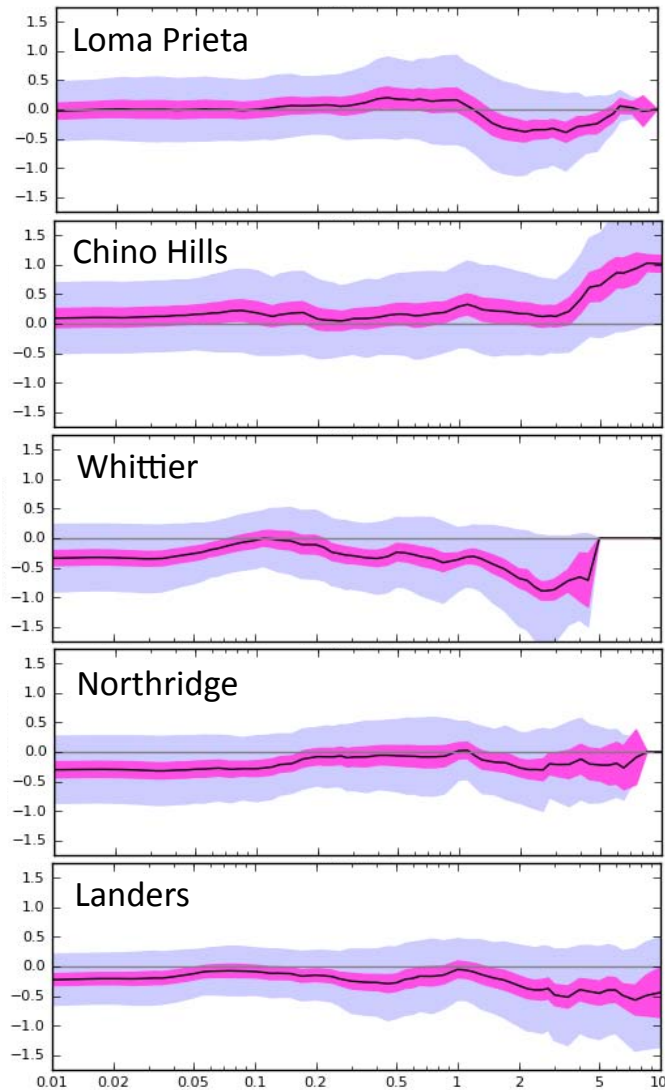
Seismograms for run 10000008, station sta-r0003



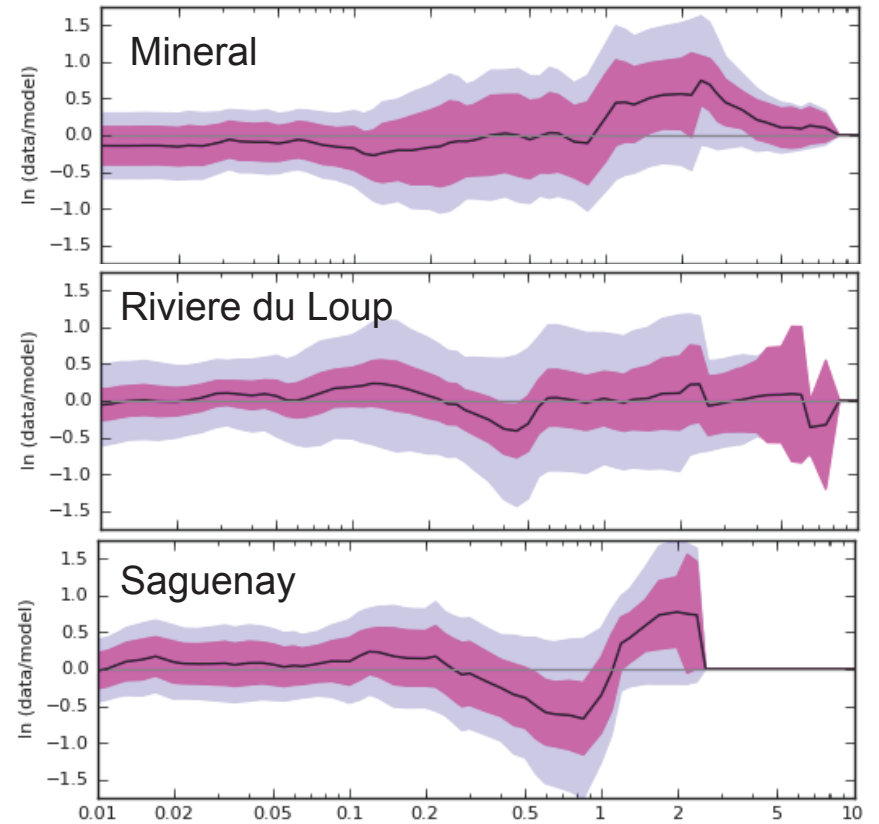
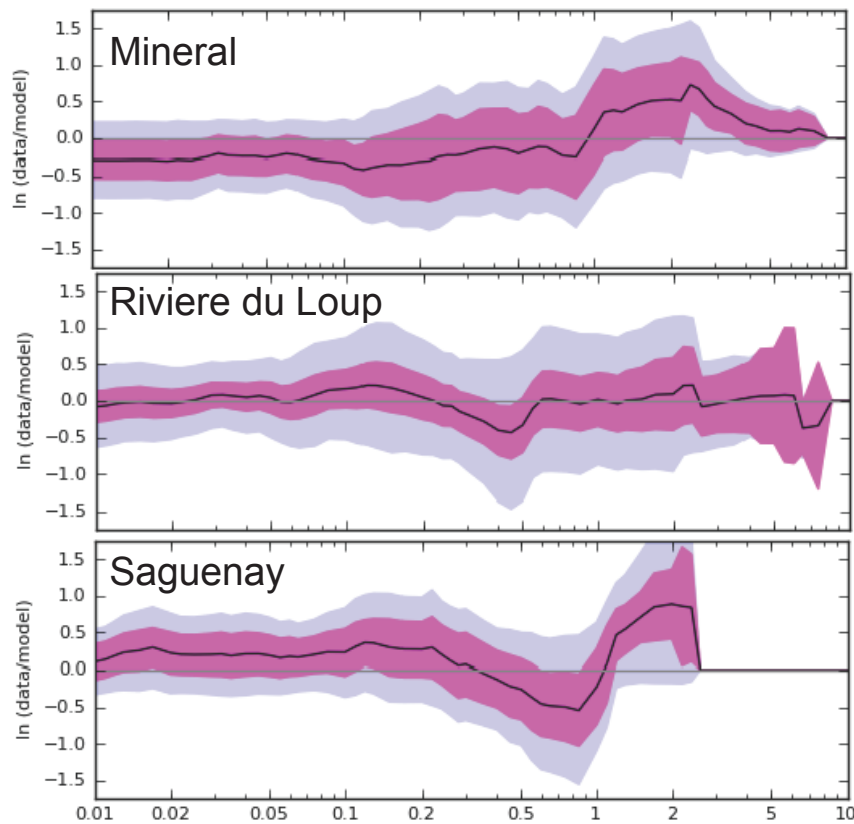
Seismograms for run 10000002, station sta-z0003



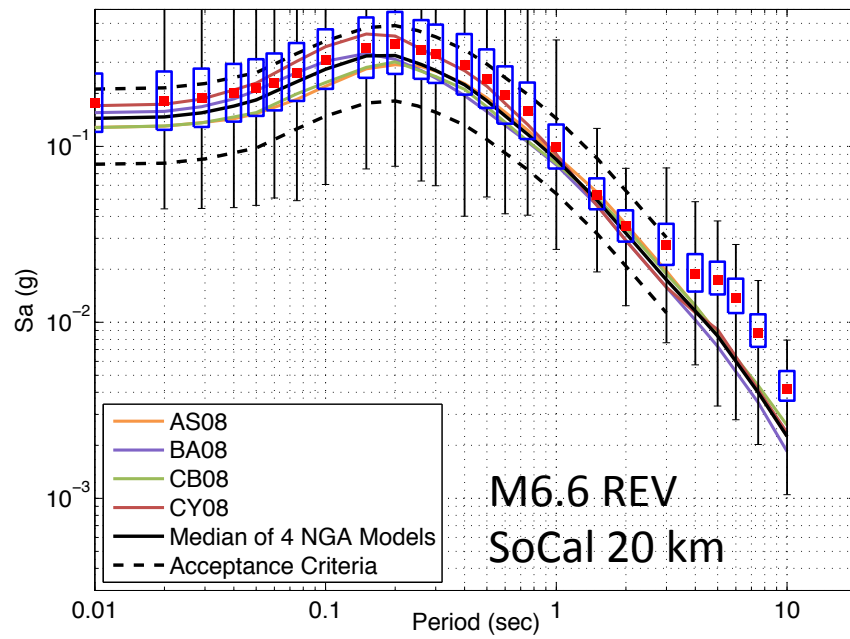
Ensemble Averages



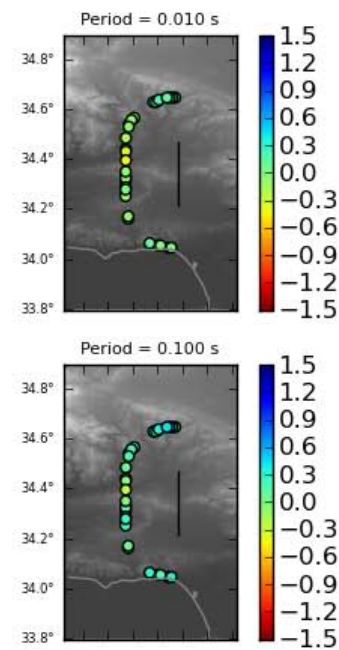
Ensemble Averages



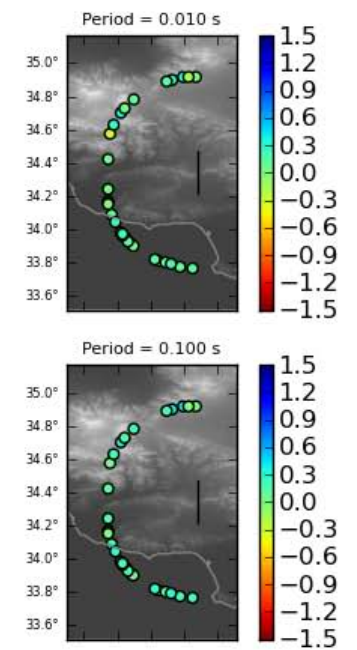
SDSU, Scenario: M6.6, REV, R=20 km, SOCAL



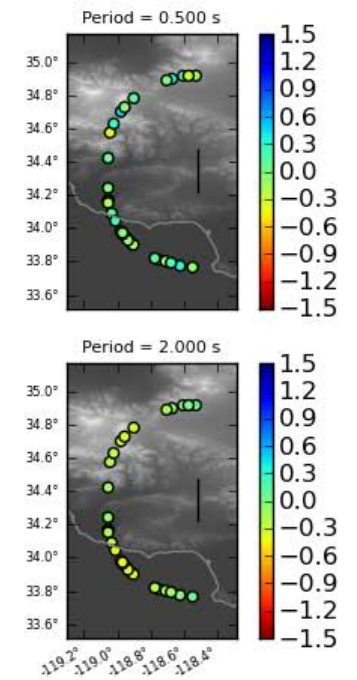
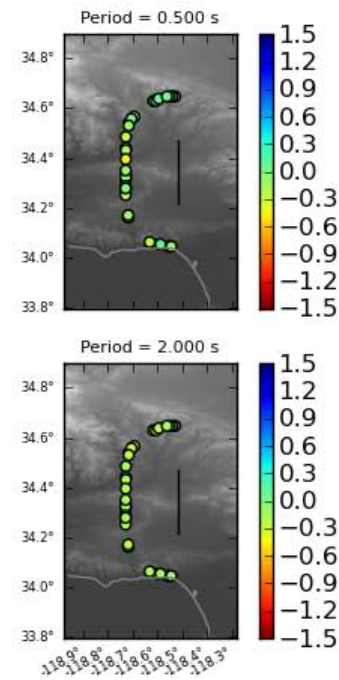
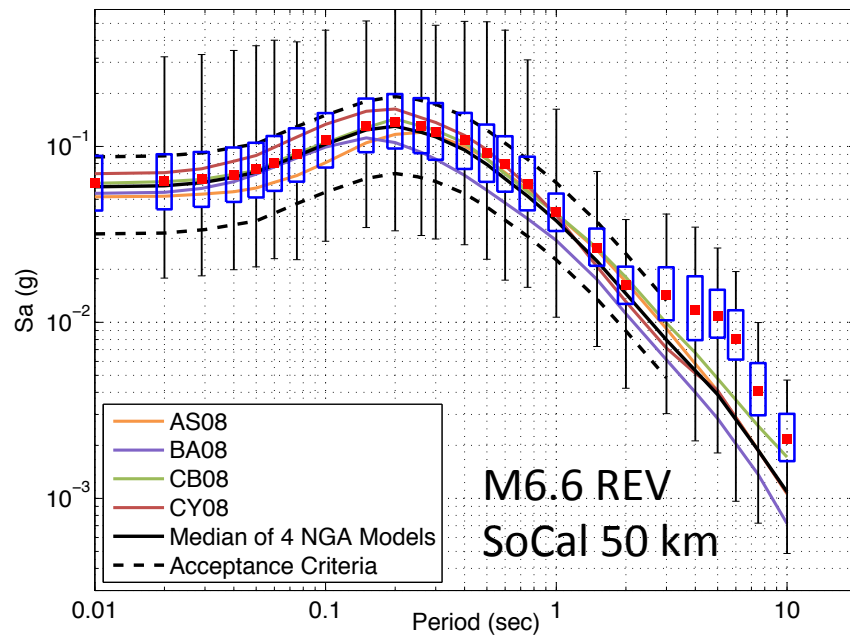
20 km

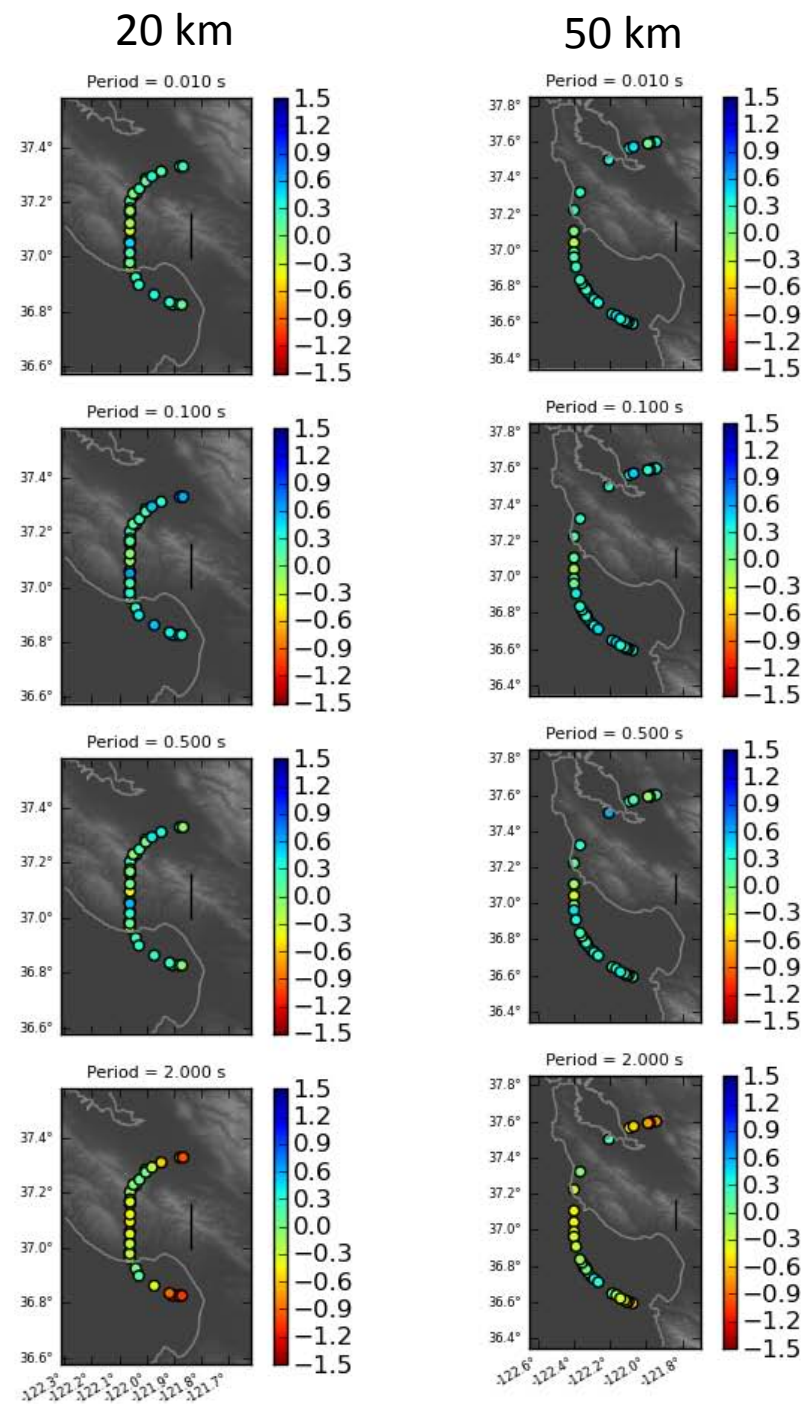
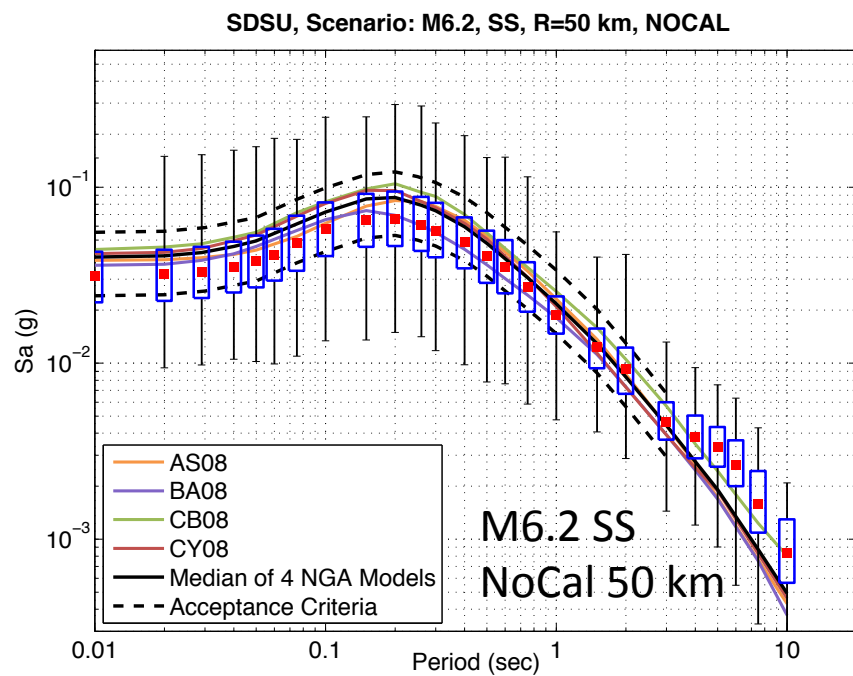
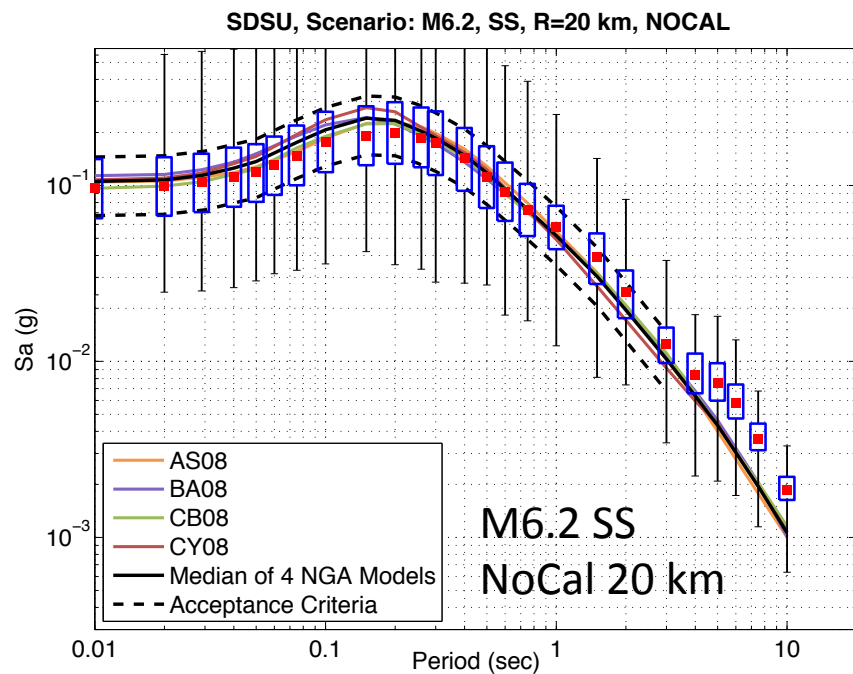


50 km



SDSU, Scenario: M6.6, REV, R=50 km, SOCAL





Part A Validation Summary

Event (Mw, Mech.)		SDSU 0.01-0.1s		SDSU 0.1-1s		SDSU 1-3s		SDSU >3s	
Rrup=[0-5] km	Chino Hills (5.39, ROBL)								
	Alum Rock (5.45, SS)	-0.65	0.65	-0.78	0.78	-1.32	1.32	-1.05	1.05
	Whittier Narrows (5.89, REV)								
	North Palm Springs (6.12, ROBL)	0.36	0.36	0.22	0.32	-0.51	0.51	-0.95	0.95
	Tottori (6.59, SS)	-0.40	0.40	0.40	0.51	-0.13	0.21	-0.31	0.31
	Niigata (6.65, REV)								
	Northridge (6.73, REV)								
	Loma Prieta (6.94, ROBL)	0.19	0.33	0.29	0.37	-0.12	0.53	-0.39	0.39
	Landers (7.22, SS)	0.92	0.92	0.45	0.45	0.53	0.53	0.44	0.44
	Riviere-du-Loup (4.6 REV)								
	Mineral (5.68 REV)								
	Saguenay (5.81 REV)								
	Average CA	0.20	0.48	0.13	0.44	-0.28	0.66	-0.24	0.54
	Average CENA								
	Average ALL	0.11	0.47	0.16	0.45	-0.26	0.60	-0.25	0.49

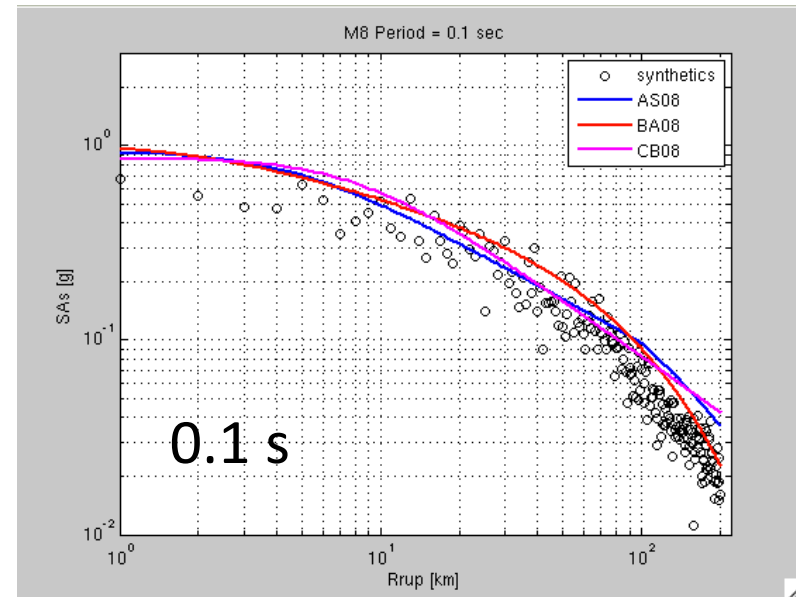
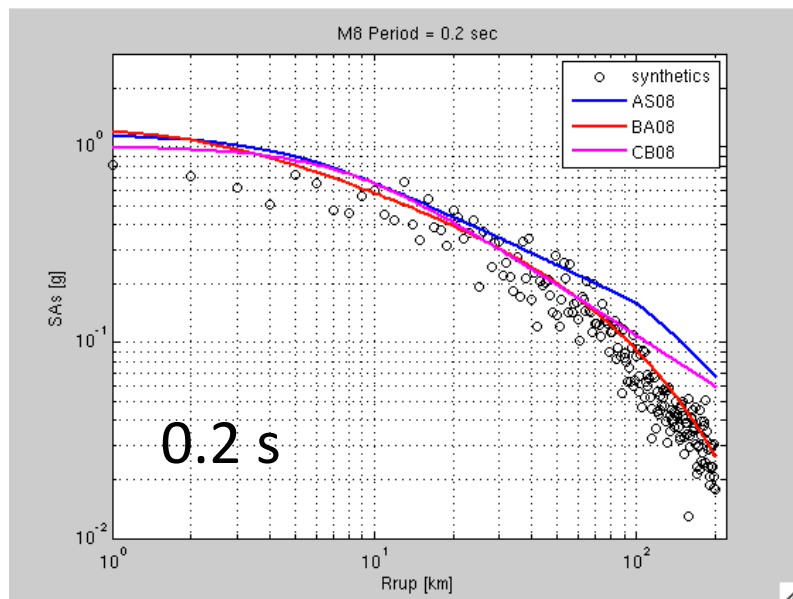
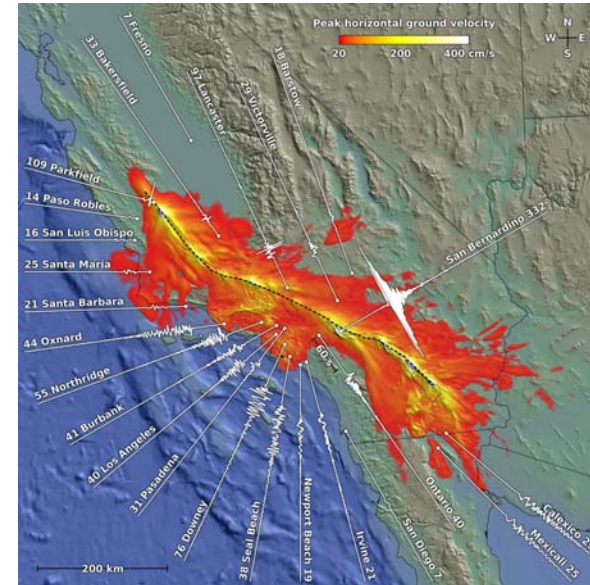
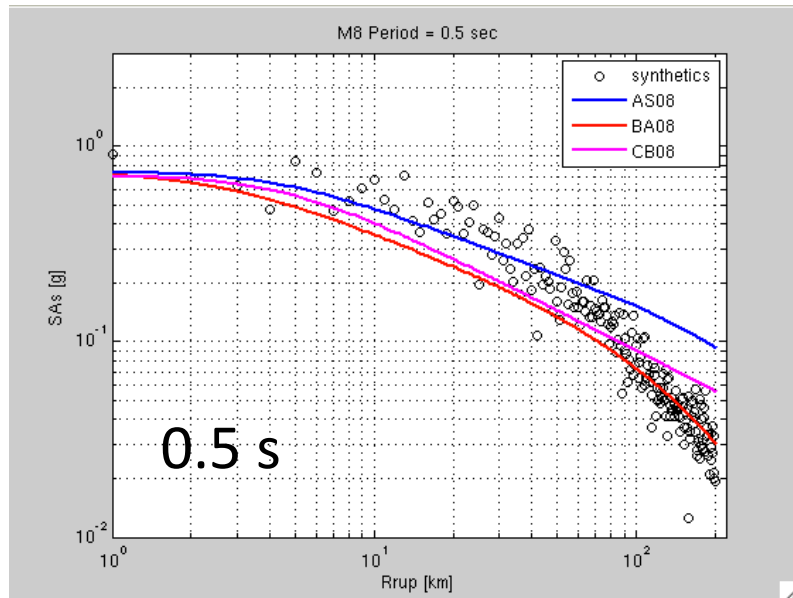
Rrup=[5-20] km	Chino Hills (5.39, ROBL)	0.17	0.28	0.29	0.38	0.65	0.65	0.84	0.84
	Alum Rock (5.45, SS)	-0.13	0.25	-0.03	0.38	-0.27	0.60	-0.17	0.68
	Whittier Narrows (5.89, REV)	-0.28	0.43	-0.16	0.40	-0.54	0.55	-1.01	1.01
	North Palm Springs (6.12, ROBL)	-0.11	0.33	-0.17	0.41	-0.30	0.65	-0.05	0.24
	Tottori (6.59, SS)	-0.29	0.32	0.08	0.38	-0.01	0.49	0.04	0.44
	Niigata (6.65, REV)	-0.15	0.52	-0.01	0.44	-0.53	0.81	-0.55	0.68
	Northridge (6.73, REV)	-0.06	0.37	0.16	0.42	-0.14	0.35	-0.10	0.32
	Loma Prieta (6.94, ROBL)	0.18	0.35	0.20	0.39	-0.32	0.40	-0.25	0.28
	Landers (7.22, SS)	-0.29	0.66	-0.02	0.54	-0.36	0.51	-0.85	0.85
	Riviere-du-Loup (4.6 REV)	-0.02	0.35	0.13	1.17	0.57	1.02	1.20	1.20
	Mineral (5.68 REV)	-0.66	0.66	-0.68	0.68	-0.23	0.23	-0.25	0.25
	Saguenay (5.81 REV)								
	Average CA	-0.06	0.37	0.05	0.41	-0.21	0.48	-0.07	0.51
	Average CENA	-0.24	0.45	-0.14	1.01	0.25	0.71	0.84	0.96
	Average ALL	-0.09	0.38	0.04	0.43	-0.19	0.52	-0.10	0.53

Rrup=[20-70] km	Chino Hills (5.39, ROBL)	0.01	0.47	-0.02	0.50	0.10	0.47	0.55	0.63
	Alum Rock (5.45, SS)	-0.72	0.80	-0.70	0.79	-0.81	0.86	-0.55	0.58
	Whittier Narrows (5.89, REV)	-0.27	0.43	-0.25	0.51	-0.51	0.61	-0.49	0.49
	North Palm Springs (6.12, ROBL)	0.30	0.52	-0.01	0.50	-0.15	0.42	-0.43	0.43
	Tottori (6.59, SS)	0.29	0.44	-0.02	0.59	-0.62	0.70	-0.44	0.57
	Niigata (6.65, REV)	0.04	0.43	-0.10	0.55	-0.95	1.07	-1.09	1.13
	Northridge (6.73, REV)	-0.54	0.55	-0.37	0.46	-0.22	0.53	-0.33	0.80
	Loma Prieta (6.94, ROBL)	-0.33	0.43	-0.18	0.42	-0.45	0.57	-0.18	0.36
	Landers (7.22, SS)	-0.27	0.35	-0.27	0.44	-0.55	0.64	-0.73	0.75
	Riviere-du-Loup (4.6 REV)	0.09	0.47	-0.08	0.60	-0.10	0.63	-0.25	0.30
	Mineral (5.68 REV)	-0.16	0.31	-1.18	1.19	-0.05	1.00	-0.07	0.10
	Saguenay (5.81 REV)	0.25	0.35	-1.33	1.33	-1.98	1.98		
	Average CA	-0.25	0.50	-0.26	0.52	-0.38	0.59	-0.35	0.62
	Average CENA	0.08	0.44	-0.34	0.75	-0.11	0.69	-0.23	0.28
	Average ALL	-0.15	0.49	-0.23	0.55	-0.45	0.66	-0.54	0.72

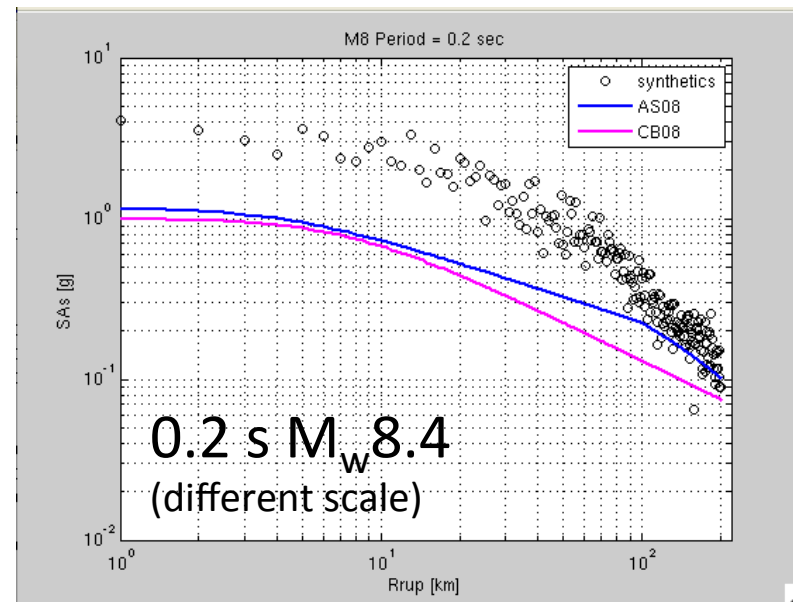
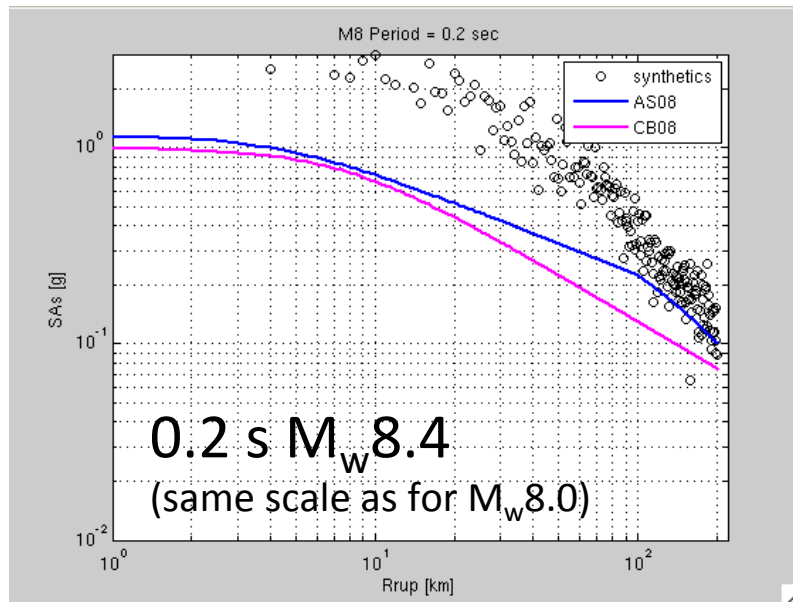
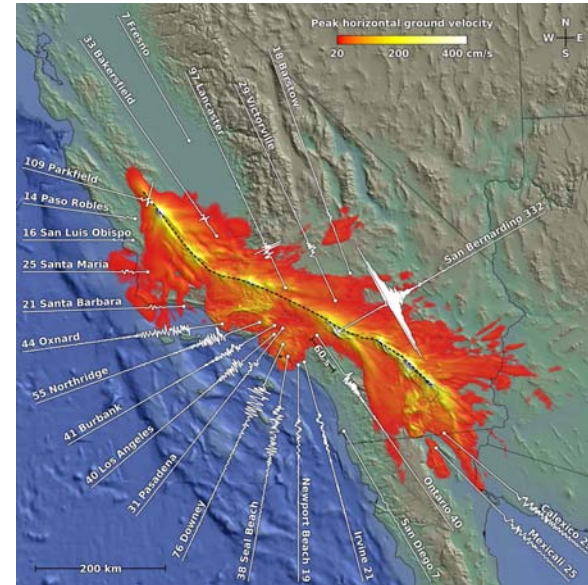
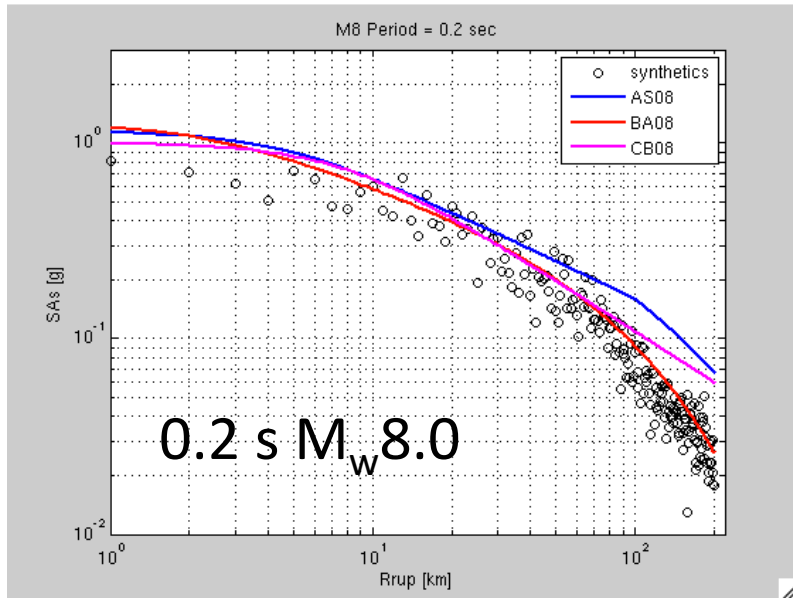
Part A Validation Summary

Rrup=[70-300] km	Chino Hills (5.39, ROBL)	0.31	0.55	0.31	0.60	0.19	0.73	0.58	0.91
	Alum Rock (5.45, SS)	-0.54	0.80	-0.48	0.77	-0.85	0.86	-0.86	0.86
	Whittier Narrows (5.89, REV)								
	North Palm Springs (6.12, ROBL)	-0.23	0.26	-0.46	0.50	0.23	0.36		
	Tottori (6.59, SS)	0.36	0.51	0.51	0.67	-0.32	0.70	-0.31	0.58
	Niigata (6.65, REV)	0.22	0.62	0.02	0.63	-1.33	1.36	-1.49	1.50
	Northridge (6.73, REV)	-0.05	0.28	0.19	0.49	-0.32	0.56	-0.31	0.31
	Loma Prieta (6.94, ROBL)	0.54	0.54	0.74	0.77	0.51	0.92	0.03	0.62
	Landers (7.22, SS)	-0.08	0.21	-0.14	0.35	0.03	0.39	0.03	0.47
	Riviere-du-Loup (4.6 REV)	-0.07	0.38	0.04	0.63	0.24	1.00	0.58	0.58
	Mineral (5.68 REV)	-0.03	0.38	0.31	0.51	0.79	0.81	0.20	0.28
	Saguenay (5.81 REV)	0.03	0.38	0.10	0.49	0.50	0.62	-0.13	0.13
	Average CA	-0.01	0.48	0.01	0.57	-0.06	0.65	0.00	0.69
	Average CENA	-0.01	0.38	0.15	0.53	0.58	0.77	0.18	0.27
	Average ALL	0.08	0.49	0.12	0.59	-0.22	0.80	-0.52	0.86
Mechanism	Reverse (REV)	-0.11	0.45	-0.11	0.54	-0.42	0.76	-0.80	0.95
	Reverse-Oblique (ROBL)	0.10	0.45	0.07	0.49	-0.05	0.56	0.16	0.54
	Strike-Slip (SS)	-0.18	0.49	-0.16	0.57	-0.45	0.66	-0.40	0.61
	Normal (NM)								
Total	Average CA	-0.15	0.47	-0.13	0.50	-0.26	0.58	-0.20	0.60
	Average CENA	0.01	0.41	-0.08	0.66	0.28	0.74	0.09	0.33
	Average ALL	-0.07	0.46	-0.08	0.53	-0.33	0.67	-0.44	0.72

Self Assessment Supporting Information for $>M_w 7.3$: M8 Generally Agrees with GMPEs



Potential Issues for $M_w > 8.0$



Self Assessment – Expected Performance

SDSU Module ('Bbtoolbox')

		PSA period range			
Magnitude		[0.01-0.1] s	]0.1-1] s	]1-3] s	> 3s*
Rrup=[0-20] km	5-6	Expected to work	Expected to work	Expected to work	Expected to work
	6-7	Expected to work	Expected to work	Expected to work	Expected to work
	7-8	Expected to work	Expected to work	Expected to work	Expected to work
	>8	Not sure / potential issues	Not sure / potential issues	Not sure / potential issues	Not sure / potential issues
Rrup=[20-70] km	5-6	Expected to work	Expected to work	Expected to work	Expected to work
	6-7	Expected to work	Expected to work	Expected to work	Expected to work
	7-8	Expected to work	Expected to work	Expected to work	Expected to work
	>8	Not sure / potential issues	Not sure / potential issues	Not sure / potential issues	Not sure / potential issues
Rrup=[70-200] km	5-6	Expected to work	Expected to work	Expected to work	Expected to work
	6-7	Expected to work	Expected to work	Expected to work	Expected to work
	7-8	Expected to work	Expected to work	Expected to work	Expected to work
	>8	Not sure / potential issues	Not sure / potential issues	Not sure / potential issues	Not sure / potential issues
Mechanism	Reverse (REV)	Expected to work	Expected to work	Expected to work	Expected to work
	Reverse-Oblique (ROBL)	Expected to work	Expected to work	Expected to work	Expected to work
	Strike-Slip (SS)	Expected to work	Expected to work	Expected to work	Expected to work
	Normal (NM)	Expected to work	Expected to work	Expected to work	Expected to work

Expected Performance Level

Expected to work

Not sure / potential issues

Definite issues

* dependent on rupture generator

Computer Exercises

- Running BBtoolbox

Computer Exercises

- 1) Northridge SRC file, SoCal velocity structure, 5 stations within 40 km of fault (Epicentral distance is limited so that Green's functions are computed for less time.) This fault has top of rupture at 5.0 km. Choose 5 stations that are distributed at various distances from fault and various azimuths (Figure 1).
 - Students will compute 3-component time histories, Fourier amplitude spectrum (FAS), and response spectrum.
 - Plot the 3-components of ground motion at each site using the data.
 - At the same scale as part b, plot the 3-components of synthetic ground motion.
 - Compute the FAS for each component of the data and plot on log-log scale.
 - Compute the FAS for each component of the synthetic and plot on log-log scale.
 - Compare response spectrum from synthetic with that from GMPE (overlay two plots).
 - For students own homework, run a different realization of the kinematic model and compare with the results from parts c and d.

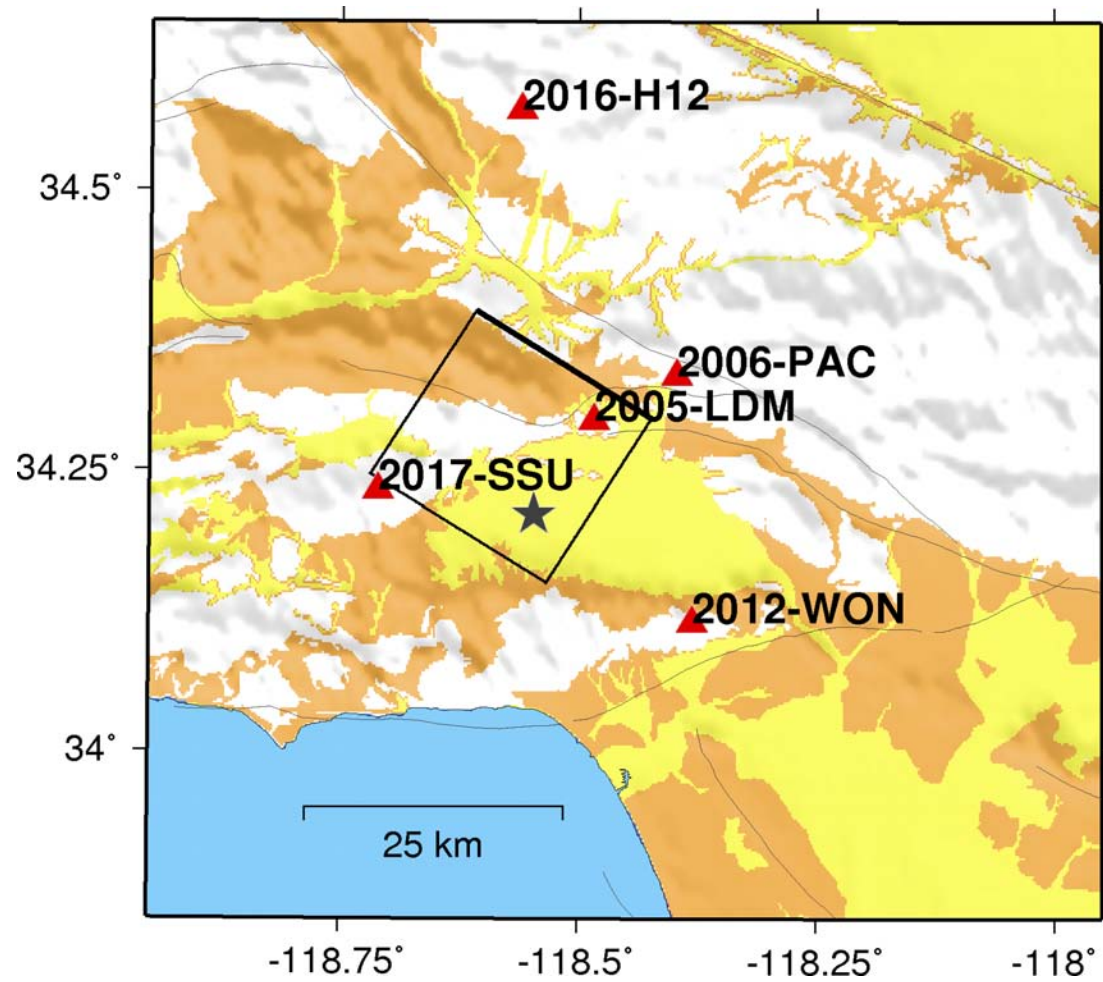
Computer Exercises

- 2) Northridge, but SRC file will have fault coming to the surface, SoCal velocity structure, 5 stations within 40 km of fault. The dip here should be same as that for Ex. 1. However, this fault has top of rupture at 0.0 km. Students can see the difference of surface vs buried rupture.
- Students to compute 3 component time histories, FAS, and response spectrum at the same 5 stations chosen in Exercise 1.
 - Compare response spectrum from synthetic with that from GMPE (overlay two plots).
 - Compare ground motions between surface rupture (Ex. 1) and buried rupture. Plot synthetics from this exercise (Ex. 2) and those from Ex. 1 on the same plot. Use SAC.

Computer Exercises

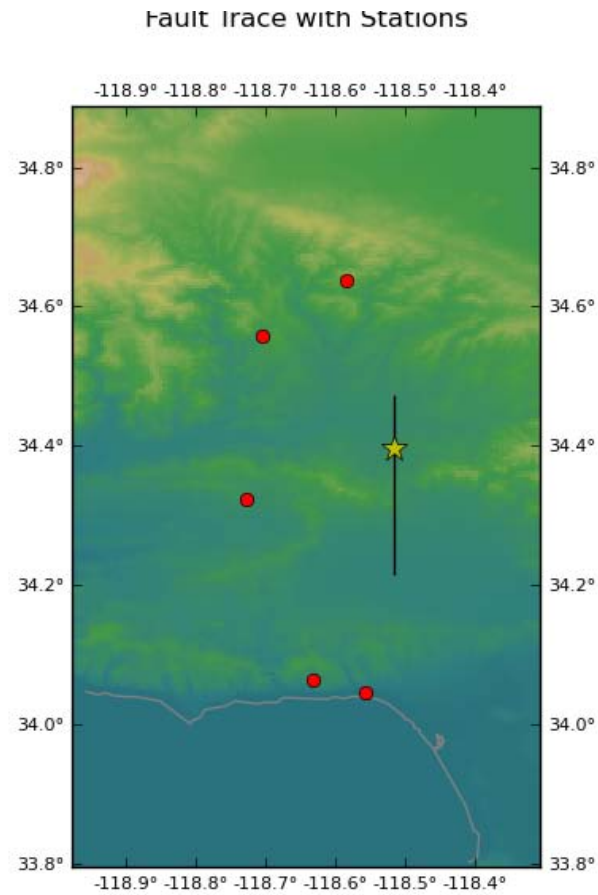
- 3) Strike slip, M 6.6, SoCal velocity structure, surface rupture, 5 stations. All stations are located 20 km from the fault. Hypocenter is random.
- Compute 3-component time histories, FAS, and response spectrum for each station.
 - Compare response spectrum from synthetic with that from GMPE (overlay two plots).
 - If you have time, repeat parts a and b with a different realization.

5 Station Locations



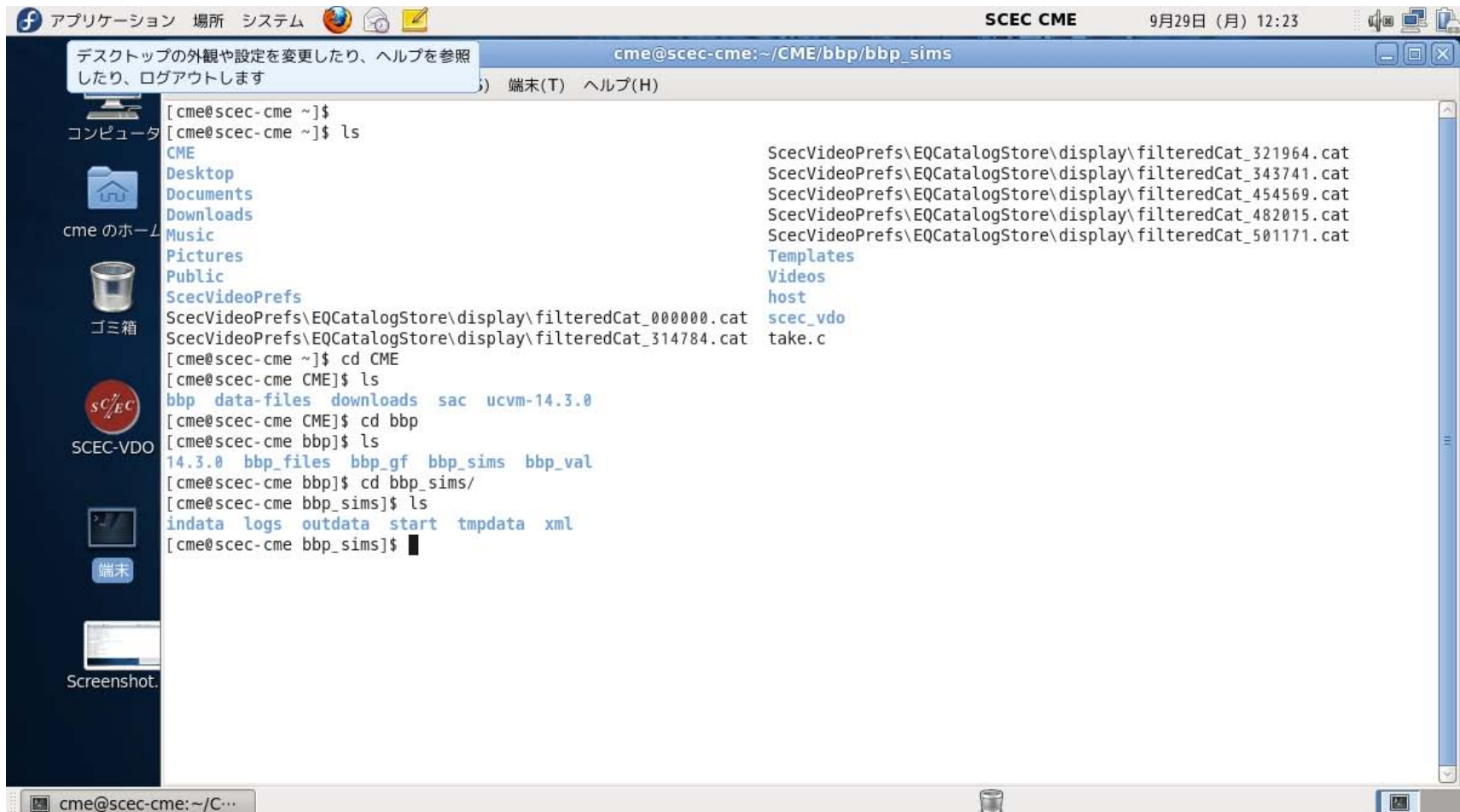
Station Locations

□



BB simulations

/home/cme/CME/bbp/bbp_sims



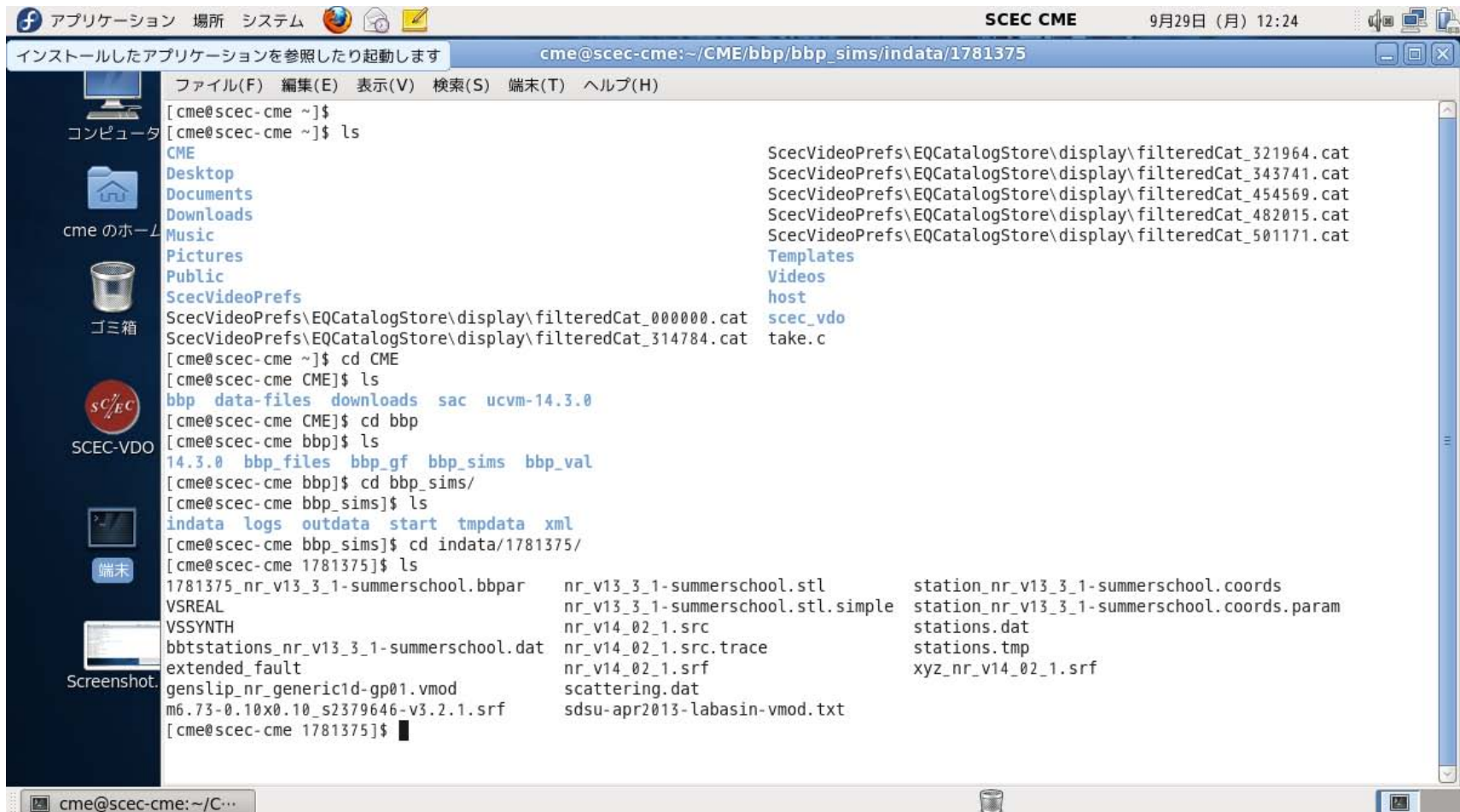
The screenshot shows a Linux desktop with a terminal window open. The terminal displays the following commands and output:

```
[cme@scec-cme ~]$  
[cme@scec-cme ~]$ ls  
CME  
Desktop  
Documents  
Downloads  
Music  
Pictures  
Public  
ScecVideoPrefs  
ScecVideoPrefs\EQCatalogStore\display\filteredCat_000000.cat  
ScecVideoPrefs\EQCatalogStore\display\filteredCat_314784.cat  
[cme@scec-cme ~]$ cd CME  
[cme@scec-cme CME]$ ls  
bbp data-files downloads sac ucvm-14.3.0  
[cme@scec-cme CME]$ cd bbp  
[cme@scec-cme bbp]$ ls  
14.3.0 bbp_files bbp_gf bbp_sims bbp_val  
[cme@scec-cme bbp]$ cd bbp_sims/  
[cme@scec-cme bbp_sims]$ ls  
indata logs outdata start tmpdata xml  
[cme@scec-cme bbp_sims]$
```

The terminal window title is "cme@scec-cme: ~/CME/bbp/bbp_sims". The desktop background is dark blue with icons for "アプリケーション", "場所", "システム", "コンピュータ", "cme のホーム", "ゴミ箱", "SCEC-VDO", "端末", and "Screenshot". The system tray at the bottom shows the date and time as "9月29日 (月) 12:23".

BB simulations are created under bbp_sims

input files
/home/cme/CME/bbp/bbp_sims/indata/



The screenshot shows a terminal window with the following commands and output:

```
[cme@scec-cme ~]$  
[cme@scec-cme ~]$ ls  
CME  
Desktop  
Documents  
Downloads  
Music  
Pictures  
Public  
ScecVideoPrefs  
ScecVideoPrefs\EQCatalogStore\display\filteredCat_000000.cat  
ScecVideoPrefs\EQCatalogStore\display\filteredCat_314784.cat  
[cme@scec-cme ~]$ cd CME  
[cme@scec-cme CME]$ ls  
bbp data-files downloads sac ucvm-14.3.0  
[cme@scec-cme CME]$ cd bbp  
[cme@scec-cme bbp]$ ls  
14.3.0 bbp_files bbp_gf bbp_sims bbp_val  
[cme@scec-cme bbp]$ cd bbp_sims/  
[cme@scec-cme bbp_sims]$ ls  
indata logs outdata start tmpdata xml  
[cme@scec-cme bbp_sims]$ cd indata/1781375/  
[cme@scec-cme 1781375]$ ls  
1781375_nr_v13_3_1-summerschool.bbpar    nr_v13_3_1-summerschool.stl    station_nr_v13_3_1-summerschool.coords  
VSREAL                                  nr_v13_3_1-summerschool.stl.simple  station_nr_v13_3_1-summerschool.coords.param  
VSSYNTH                                nr_v14_02_1.src                stations.dat  
bbtstations_nr_v13_3_1-summerschool.dat  nr_v14_02_1.src.trace          stations.tmp  
extended_fault                          nr_v14_02_1.srf                xyz_nr_v14_02_1.srf  
genslip_nr_generic1d-gp01.vmod          scattering.dat  
m6.73-0.10x0.10_s2379646-v3.2.1.srf    sdsu-apr2013-labasin-vmod.txt  
[cme@scec-cme 1781375]$
```

Input files for BBtoolbox code are created under bbp_sims/indata/

input files: *_nr_v13_3_1-summerscholl.bbpar
/home/cme/CME/bbp/bbp_sims/indata/

```
インストールしたアプリケーションを参照したり起動します cme@scec-cme:~/CME/bbp/bbp_sims/indata/1781375
ファイル(F) 編集(E) 表示(V) 検索(S) 端末(T) ヘルプ(H)
/* MODALITY FLAG: [0] LF-HF MERGING, [1] LF-SCATTERING, [2] LF-ISOCHRONE */
1
/* OUTPUT DIRECTORY */
"/home/cme/CME/bbp/bbp_sims/tmpdata/1781375/bbtoolbox_nr_v13_3_1-summerscholl"
/* VELOCITY MODEL FILE (3D MODEL OR 1D MODEL) */
"/home/cme/CME/bbp/bbp_sims/indata/1781375/sdsu-apr2013-labasin-vmod.txt"
/* STATIONS FILE REPORTING [X-Y] COORDINATES, FILENAMES AND PARAMETERS */
"/home/cme/CME/bbp/bbp_sims/indata/1781375/bbtstations_nr_v13_3_1-summerscholl.dat"
/* OPTIONAL 2ND STATIONS FILE REPORTING ONLY FILENAMES - ONLY FOR MODALITY = 0 */
2ndstations.dat
/* FAULT MODEL TYPE: [POINT], [EXTENDED FAULT-MODEL FILE] */
extended "/home/cme/CME/bbp/bbp_sims/indata/1781375/extended_fault"
/* HYPOCENTER COORDINATES [X-Y-Z] IN KM */
24.86 19.85 18.21
/* GRID DEFINITION [X-Y-Z] FOR RAYTRACING: "NEAR-SIDE", GRID-SPACING (IN KM) */
0.0 0.0 0.0 1.0
/* GRID DEFINITION [X-Y-Z] FOR RAYTRACING: "FAR-SIDE" (IN KM) */
72.0 91.0 125.0
/* SCATTERING PARAMETERS FILE */
"/home/cme/CME/bbp/bbp_sims/indata/1781375/scattering.dat"
/* EVENT MAGNITUDE */
6.73
/* DOMINANT SOURCE MECHANISM [SS RS NS AL] */
rs
/* SOURCE TIME FUNCTION [TRI BOX YOF DREG LIU USER-DEF] */
new
/* VERBOSE MODE [ON OFF] */
off
/* SRF FILE */
"/home/cme/CME/bbp/bbp_sims/indata/1781375/xyz_nr_v14_02_1.srf"

"1781375_nr_v13_3_1-summerscholl.bbpar" [読込専用] 30L, 1271C
1,1 全て
```

*.bbpar file:

input files: bbtstations_nr_v14_4_1-summerschool.dat
/home/cme/CME/bbp/bbp_sims/indata/

```
インストールしたアプリケーションを参照したり起動します cme@scec-cme:~/CME/bbp/bbp_sims/indata/1781375
ファイル(F) 編集(E) 表示(V) 検索(S) 端末(T) ヘルプ(H)
/* STATIONS FILE FOR BROAD-BAND COMPUTATION CODE (P.M. MAI & K.B.OLSEN) */
/* STATIONS COORDINATES ARE IN THE X-Y SYSTEM REPORTED IN FIG.1 OF APPENDIX A */

/* INPUT DIRECTORY */
/home/cme/CME/bbp/bbp_sims/tmpdata/1781375/bbtoolbox_nr_v13_3_1-summerschool/1781375.

/* FILES FORMAT [RGF BIN CMP 3SF] */
3SF

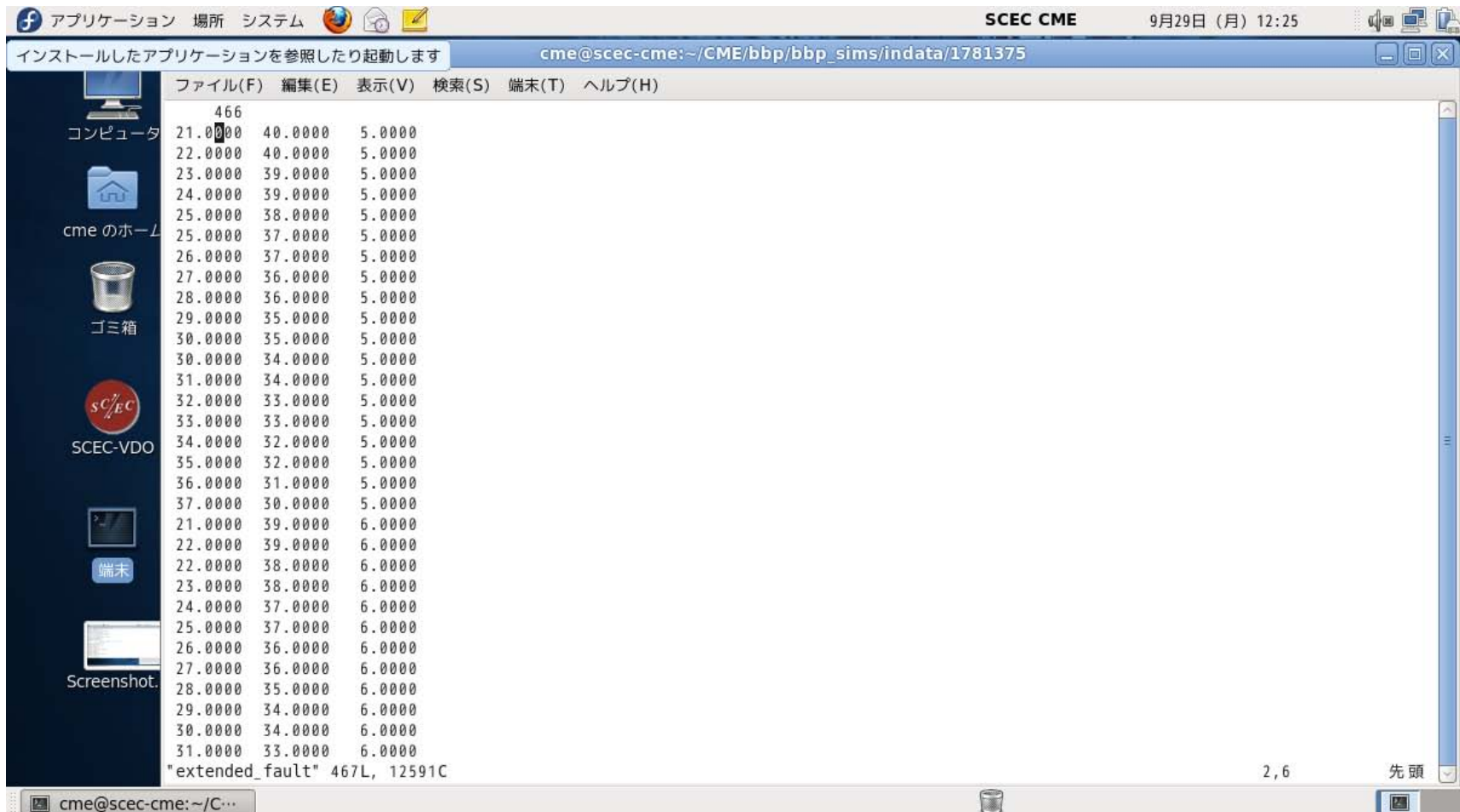
/* FILES EXTENSION OR BINARY FILE NAME */
-lf.bbp

/*      X      Y      NAME  Vs      Rho      Kappa */
32.368900  29.955400  2005-LDM  -1    -1    -1
40.371700  34.401500  2006-PAC  -1    -1    -1
11.459400  23.086900  2017-SSU  -1    -1    -1
41.885500  10.000000  2012-WON  -1    -1    -1
25.282100  60.680900  2016-H12  -1    -1    -1

"bbtstations_nr_v13_3_1-summerschool.dat" 18L, 603C
```

station file:

input files: extended_fault
/home/cme/CME/bbp/bbp_sims/indata/



The screenshot shows a terminal window titled "cme@scec-cme:~/CME/bbp/bbp_sims/indata/1781375". The window displays a file listing for "extended_fault" with 466 entries. The listing is organized into three columns: a line number (e.g., 21.0000, 22.0000, etc.), a value (e.g., 40.0000, 39.0000, etc.), and another value (e.g., 5.0000, 6.0000, etc.). The window also shows a sidebar with icons for "コンピュータ" (Computer), "cme のホーム" (cme's Home), "ゴミ箱" (Trash), "SCEC-VDO", "端末" (Terminal), and "Screenshot". The status bar at the bottom indicates "cme@scec-cme:~/C..." and "2, 6" pages.

Line	Value 1	Value 2
21.0000	40.0000	5.0000
22.0000	40.0000	5.0000
23.0000	39.0000	5.0000
24.0000	39.0000	5.0000
25.0000	38.0000	5.0000
26.0000	37.0000	5.0000
27.0000	36.0000	5.0000
28.0000	36.0000	5.0000
29.0000	35.0000	5.0000
30.0000	35.0000	5.0000
31.0000	34.0000	5.0000
32.0000	33.0000	5.0000
33.0000	33.0000	5.0000
34.0000	32.0000	5.0000
35.0000	32.0000	5.0000
36.0000	31.0000	5.0000
37.0000	30.0000	5.0000
21.0000	39.0000	6.0000
22.0000	39.0000	6.0000
23.0000	38.0000	6.0000
24.0000	37.0000	6.0000
25.0000	37.0000	6.0000
26.0000	36.0000	6.0000
27.0000	36.0000	6.0000
28.0000	35.0000	6.0000
29.0000	34.0000	6.0000
30.0000	34.0000	6.0000
31.0000	33.0000	6.0000

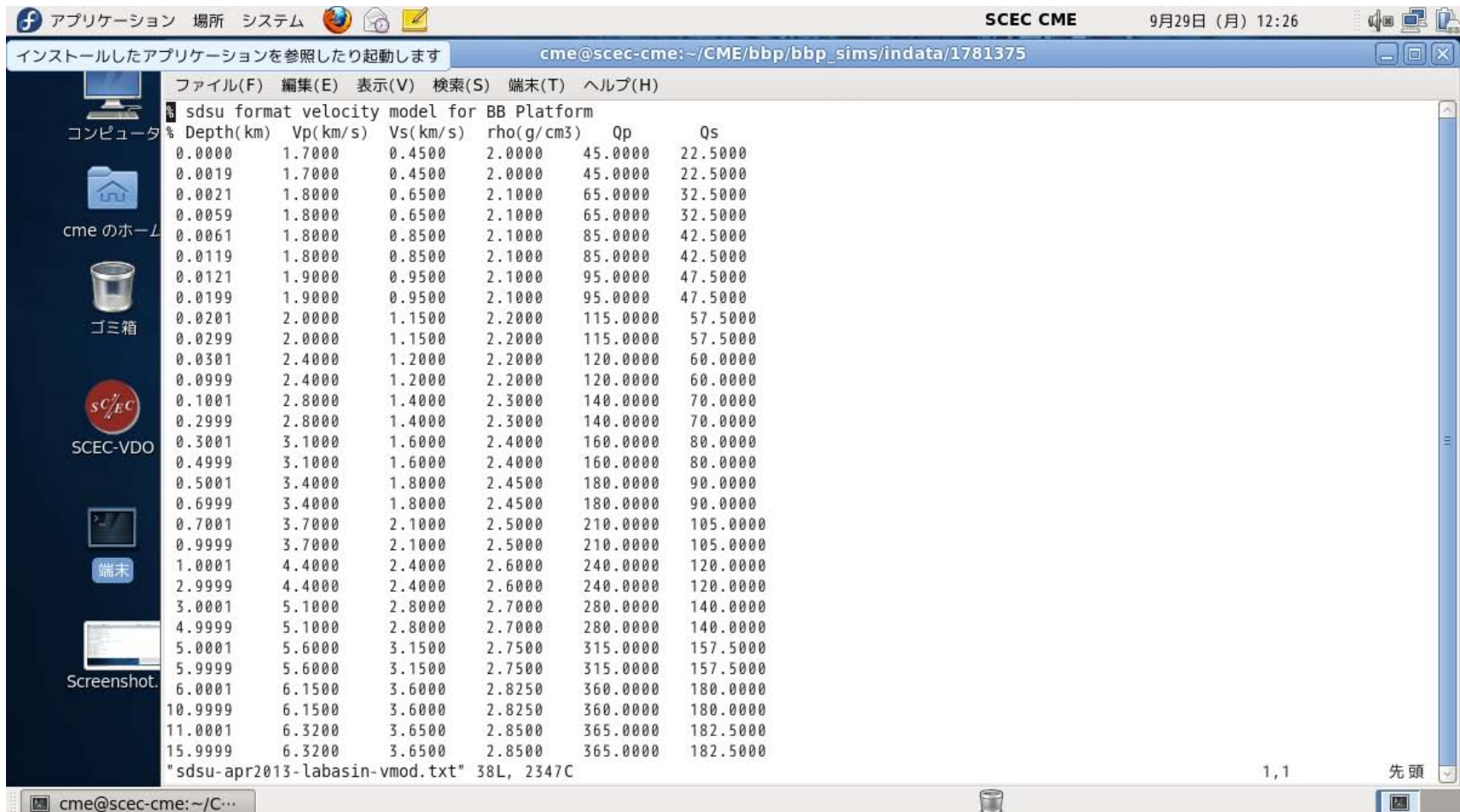
extended fault file:

input files: scattering.dat
/home/cme/CME/bbp/bbp_sims/indata/

```
cme@scec-cme:~/CME/bbp/bbp_sims/indata/1781375
ファイル(F) 編集(E) 表示(V) 検索(S) 端末(T) ヘルプ(H)
\* Parameters file for scattering code
\* -----The following parameters can be changed----- *\
6104 \* iseed - seed number for scattering wavelets -> [-1]:random value, [0]:default value, [int]:user-defined
0 \* s_seed - seed number for medium properties -> [-1]:random value, [0]:default value, [int]:user-defined
150.0 \* Q - Q for the coda waves -> [0.0]:default value, [1.0]:drawn from normal distribution, [real]:user-defined
0.01 \* scatcoeff - scattering coefficient -> [0.0]:default value, [1.0]:drawn from uniform distribution, [real]:user-defined
0.040 \* kappa - kappa at the site -> [0.0]:default value, [1.0]:drawn from uniform distribution, [real]:user-defined
0.80 \* fdec - see equation Q=Qf*f*fdec -> [0.0]:default value, [real]:user-defined
0.2 \* hpass - highpass corner of the cosine filter -> [0.0]:default value, [real]:user-defined
\* -----Additional parameters can be changed----- *\
100.00 \* fmax - previously set in module_bbtoolbox.f90 -> [0.0]:default value (100.0Hz), [real]:user-defined
2 \* imerg - flag to determine style of combining LF and HF -> [0]:old merging, [1]:1 fault, [2]:many subfaults
5.00e+07 \* str_fac - Brune stress parameter (50 bars) G&P (2010) eqn (12) -> [0.0]:default value (50.e6), [real]:user-defined
41.0 \* afac - qk factor 'a' from G&P (2010) eqn (15) -> [0.0]:default value (41.0), [real]:user-defined
34.0 \* bfac - qk factor 'b' from G&P (2010) eqn (15) -> [0.0]:default value (34.0), [real]:user-defined
0.0750 \* Tr_sca - scaling factor for Tr for a new stf -> [0.0]:default value (0.1), [real]:user-defined
3 \* time_step - decimation factor to be used in bbtoolbox -> [1]: no decimation, [int > 1]:user-defined
1.00 \* gs_flag - determine type of tectonic region -> [1]:active, e.g. west
ern CA, [2]:stable, e.g. eastern North America
"scattering.dat" 22L, 1998C
```

scattering.dat file:

input files: sdsu-apr2013-labasin-vmod.txt
/home/cme/CME/bbp/bbp_sims/indata/



アプリケーション 場所 システム SSEC CME 9月29日 (月) 12:26

インストールしたアプリケーションを参照したり起動します cme@scec-cme:~/CME/bbp/bbp_sims/indata/1781375

ファイル(F) 編集(E) 表示(V) 検索(S) 端末(T) ヘルプ(H)

sdsu format velocity model for BB Platform

% Depth(km)	Vp(km/s)	Vs(km/s)	rho(g/cm3)	Qp	Qs
0.0000	1.7000	0.4500	2.0000	45.0000	22.5000
0.0019	1.7000	0.4500	2.0000	45.0000	22.5000
0.0021	1.8000	0.6500	2.1000	65.0000	32.5000
0.0059	1.8000	0.6500	2.1000	65.0000	32.5000
0.0061	1.8000	0.8500	2.1000	85.0000	42.5000
0.0119	1.8000	0.8500	2.1000	85.0000	42.5000
0.0121	1.9000	0.9500	2.1000	95.0000	47.5000
0.0199	1.9000	0.9500	2.1000	95.0000	47.5000
0.0201	2.0000	1.1500	2.2000	115.0000	57.5000
0.0299	2.0000	1.1500	2.2000	115.0000	57.5000
0.0301	2.4000	1.2000	2.2000	120.0000	60.0000
0.0999	2.4000	1.2000	2.2000	120.0000	60.0000
0.1001	2.8000	1.4000	2.3000	140.0000	70.0000
0.2999	2.8000	1.4000	2.3000	140.0000	70.0000
0.3001	3.1000	1.6000	2.4000	160.0000	80.0000
0.4999	3.1000	1.6000	2.4000	160.0000	80.0000
0.5001	3.4000	1.8000	2.4500	180.0000	90.0000
0.6999	3.4000	1.8000	2.4500	180.0000	90.0000
0.7001	3.7000	2.1000	2.5000	210.0000	105.0000
0.9999	3.7000	2.1000	2.5000	210.0000	105.0000
1.0001	4.4000	2.4000	2.6000	240.0000	120.0000
2.9999	4.4000	2.4000	2.6000	240.0000	120.0000
3.0001	5.1000	2.8000	2.7000	280.0000	140.0000
4.9999	5.1000	2.8000	2.7000	280.0000	140.0000
5.0001	5.6000	3.1500	2.7500	315.0000	157.5000
5.9999	5.6000	3.1500	2.7500	315.0000	157.5000
6.0001	6.1500	3.6000	2.8250	360.0000	180.0000
10.9999	6.1500	3.6000	2.8250	360.0000	180.0000
11.0001	6.3200	3.6500	2.8500	365.0000	182.5000
15.9999	6.3200	3.6500	2.8500	365.0000	182.5000

"sdsu-apr2013-labasin-vmod.txt" 38L, 2347C

1,1 先頭

cme@scec-cme:~/C...

velocity model file:

input files: xyz_nr_v14_02_1.srf
/home/cme/CME/bbp/bbp_sims/indata/

```

1.0
PLANE 1
29.429934176 35.5224477901 200 270 20.01 27.01
122 40 5.00 6.00 19.40
POINTS 54000
20.9493461878 40.7146113607 5.0321 122 40 1.00000e+08 10.2441 2.50000e-02
150 14.54 19 0.00 0 0.00 0
0.00000e+00 6.55184e+01 1.40559e+02 1.33371e+02 6.12998e+01 2.81113e+01
2.64769e+01 2.44106e+01 2.19899e+01 1.93058e+01 1.64591e+01 1.35567e+01
1.07076e+01 8.01882e+00 5.59137e+00 3.51641e+00 1.87186e+00 7.19499e-01
1.02607e-01
21.0412822054 40.6701908074 5.0321 122 40 1.00000e+08 10.1934 2.50000e-02
150 24.48 29 0.00 0 0.00 0
0.00000e+00 3.71677e+01 9.55031e+01 1.45141e+02 1.59045e+02 1.31306e+02
8.04830e+01 3.89513e+01 2.98837e+01 2.88092e+01 2.75402e+01 2.60961e+01
2.44987e+01 2.27723e+01 2.09429e+01 1.90384e+01 1.70875e+01 1.51199e+01
1.31653e+01 1.12535e+01 9.41335e+00 7.67276e+00 6.05813e+00 4.59392e+00
3.30232e+00 2.20292e+00 1.31237e+00 6.44180e-01 2.08470e-01
21.1240173468 40.6146829661 5.0321 122 40 1.00000e+08 10.0259 2.50000e-02
153 31.00 27 0.00 0 0.00 0
0.00000e+00 5.61606e+01 1.42387e+02 2.07444e+02 2.10781e+02 1.54168e+02
7.96392e+01 4.15705e+01 3.98911e+01 3.81271e+01 3.60765e+01 3.37752e+01
3.12637e+01 2.85861e+01 2.57893e+01 2.29224e+01 2.00357e+01 1.71798e+01
1.44049e+01 1.17597e+01 9.29059e+00 7.04086e+00 5.05002e+00 3.35300e+00
1.97957e+00 9.53834e-01 2.93795e-01
21.2067534723 40.5591758642 5.0321 122 40 1.00000e+08 9.9974 2.50000e-02
153 36.42 9 0.00 0 0.00 0
0.00000e+00 7.18956e+02 3.12987e+02 1.35381e+02 1.12418e+02 8.41189e+01
5.46983e+01 2.85376e+01 9.53267e+00
21.2894905819 40.5036695018 5.0321 122 40 1.00000e+08 10.0126 2.50000e-02
153 33.17 25 0.00 0 0.00 0
0.00000e+00 7.47154e+01 1.85114e+02 2.52574e+02 2.28242e+02 1.37701e+02
"xyz_nr_v14_02_1.srf" 365244L, 26378605C
  
```

srf file:

tmp files

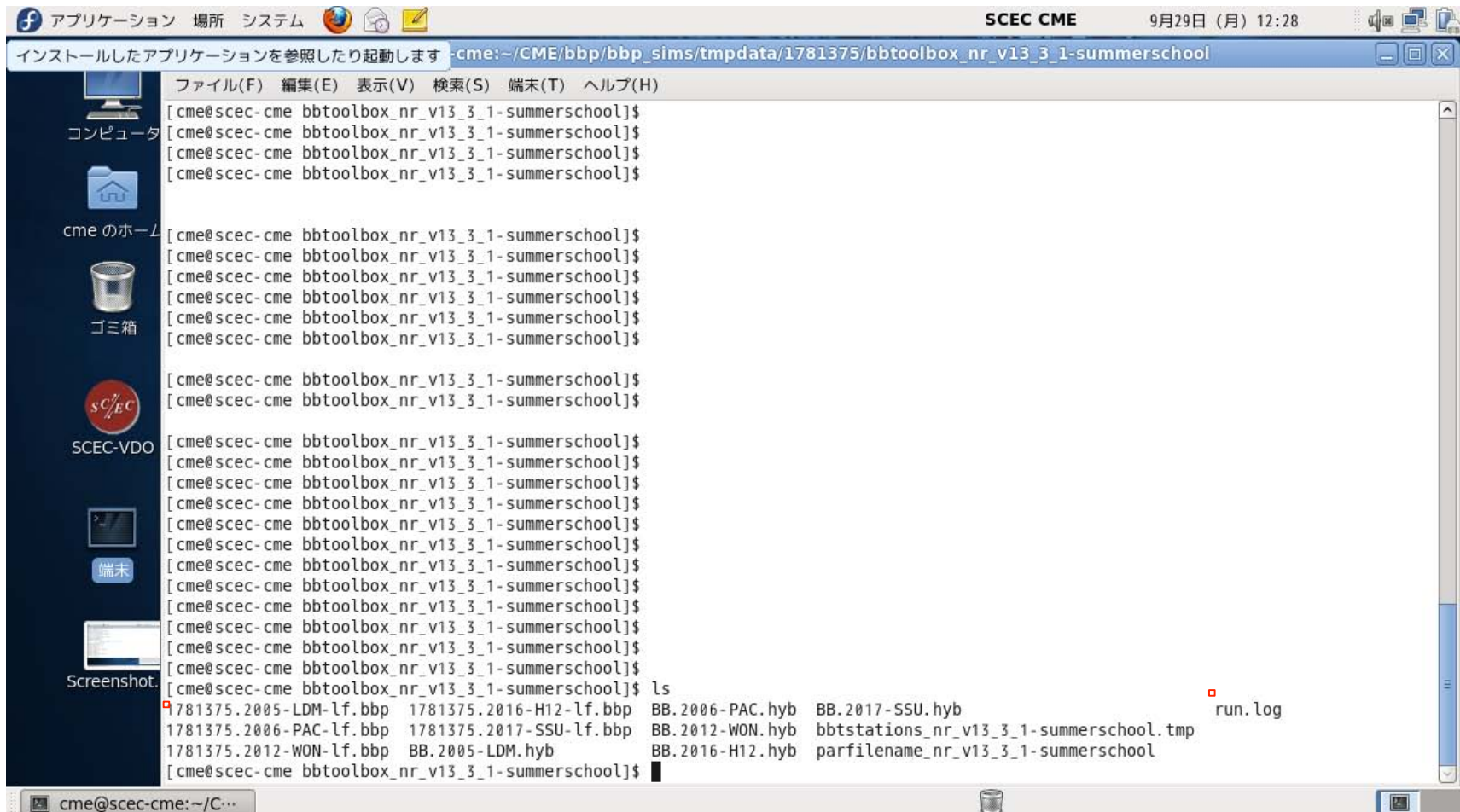
/home/cme/CME/bbp/bbp_sims/tmpdata/

```
cme@scec-cme: ~/CME/bbp/bbp_sims/tmpdata/1781375
[1781375]
[cme@scec-cme tmpdata]$ cd 1781375/
[cme@scec-cme 1781375]$ ls
1781375.2005-LDM-1f.bbp      1781375.2006-PAC.rd50      1781375.2016-H12.acc.090    1781375.2017-SSU_rsp.000
1781375.2005-LDM.000      1781375.2006-PAC.rsp      1781375.2016-H12.acc.bbp    1781375.2017-SSU_rsp.090
1781375.2005-LDM.090      1781375.2006-PAC.vel.bbp  1781375.2016-H12.acc.ver    1781375.2017-SSU_rsp.ver
1781375.2005-LDM.acc.000  1781375.2006-PAC.ver      1781375.2016-H12.bbp      1781375_nr_v13_3_1-summerschool.bin
1781375.2005-LDM.acc.090  1781375.2006-PAC_rsp.000  1781375.2016-H12.peer_e.acc 2005-LDM.000
1781375.2005-LDM.acc.bbp  1781375.2006-PAC_rsp.090  1781375.2016-H12.peer_n.acc 2005-LDM.090
1781375.2005-LDM.acc.ver  1781375.2006-PAC_rsp.ver  1781375.2016-H12.peer_z.acc 2005-LDM.ver
1781375.2005-LDM.bbp      1781375.2012-WON-1f.bbp   1781375.2016-H12.rd50      2006-PAC.000
1781375.2005-LDM.peer_e.acc 1781375.2012-WON.000     1781375.2016-H12.rsp      2006-PAC.090
1781375.2005-LDM.peer_n.acc 1781375.2012-WON.090     1781375.2016-H12.vel.bbp  2006-PAC.ver
1781375.2005-LDM.peer_z.acc 1781375.2012-WON.acc.000  1781375.2016-H12.ver      2012-WON.000
1781375.2005-LDM.rd50     1781375.2012-WON.acc.090  1781375.2016-H12_rsp.000   2012-WON.090
1781375.2005-LDM.rsp      1781375.2012-WON.acc.bbp  1781375.2016-H12_rsp.090   2012-WON.ver
1781375.2005-LDM.vel.bbp  1781375.2012-WON.acc.ver  1781375.2016-H12_rsp.ver   2016-H12.000
1781375.2005-LDM.ver      1781375.2012-WON.bbp     1781375.2017-SSU-1f.bbp    2016-H12.090
1781375.2005-LDM_rsp.000  1781375.2012-WON.peer_e.acc 1781375.2017-SSU.000      2016-H12.ver
1781375.2005-LDM_rsp.090  1781375.2012-WON.peer_n.acc 1781375.2017-SSU.090      2017-SSU.000
1781375.2005-LDM_rsp.ver  1781375.2012-WON.peer_z.acc 1781375.2017-SSU.acc.000   2017-SSU.090
1781375.2006-PAC-1f.bbp   1781375.2012-WON.rd50     1781375.2017-SSU.acc.090   2017-SSU.ver
1781375.2006-PAC.000      1781375.2012-WON.rsp     1781375.2017-SSU.acc.bbp   amp_fac.out
1781375.2006-PAC.090      1781375.2012-WON.vel.bbp  1781375.2017-SSU.acc.ver   amp_fac_nr_v13_3_1-summerschool
1781375.2006-PAC.acc.000  1781375.2012-WON.ver      1781375.2017-SSU.bbp      bbtoolbox_nr_v13_3_1-summerschool
1781375.2006-PAC.acc.090  1781375.2012-WON_rsp.000  1781375.2017-SSU.peer_e.acc list_nr_v13_3_1-summerschool.txt
1781375.2006-PAC.acc.bbp  1781375.2012-WON_rsp.090  1781375.2017-SSU.peer_n.acc m6.73-0.10x0.10.gsf
1781375.2006-PAC.acc.ver  1781375.2012-WON_rsp.ver  1781375.2017-SSU.peer_z.acc metadata.txt
1781375.2006-PAC.bbp      1781375.2016-H12-1f.bbp   1781375.2017-SSU.rd50     nr_v14_02_1.slip
1781375.2006-PAC.peer_e.acc 1781375.2016-H12.000     1781375.2017-SSU.rsp      nr_v14_02_1.srf
1781375.2006-PAC.peer_n.acc 1781375.2016-H12.090     1781375.2017-SSU.vel.bbp  nr_v14_02_1.tinit
1781375.2006-PAC.peer_z.acc 1781375.2016-H12.acc.000  1781375.2017-SSU.ver      rotd50_inp.cfg
[cme@scec-cme 1781375]$
```

LFs are saved under tmpdata.bbtoolbox_nr_v13_3_1-summerschool:

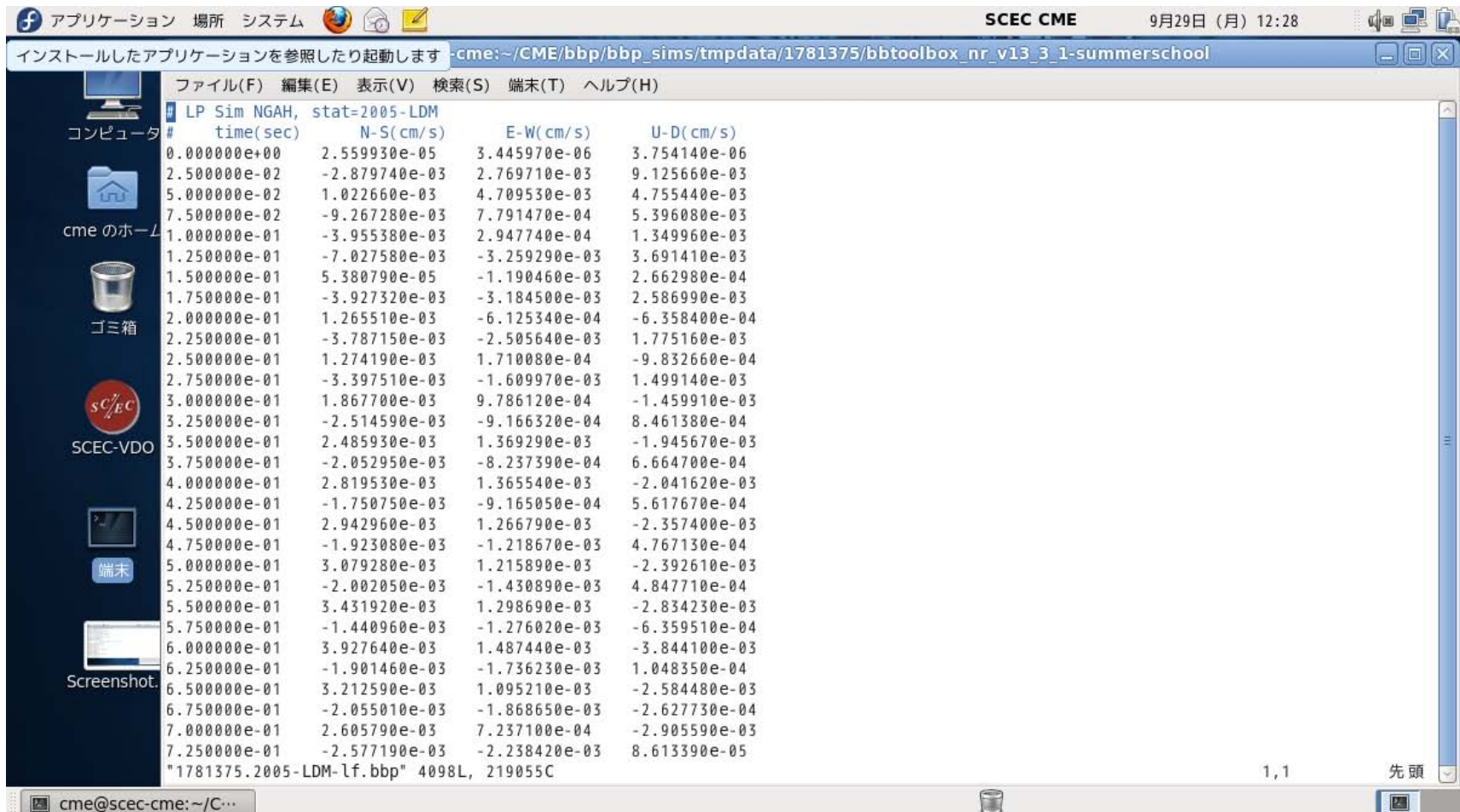
tmp files: LFs (*-lf.bbp)

```
/home/cme/CME/bbp/bbp_sims/tmpdata/1781375/
```

bbtoolbox_nr_v14_4_1-summerschool/

LFs are saved under tmpdata.bbtoolbox_nr_v13_3_1-summerschool/*-lf.bbp:

tmp files: LFs (*-lf.bbp)
 /home/cme/CME/bbp/bbp_sims/tmpdata/1781375/
 bbtoolbox_nr_v14_4_1-summarschool/



an example of LFs :

tmp files: run.log
/home/cme/CME/bbp/bbp_sims/tmpdata/1781375/
bbtoolbox_nr_v14_4_1-summernschool/

```
アプリケーション 場所 システム SSEC CME 9月29日 (月) 12:29
インストールしたアプリケーションを参照したり起動します cme:~/CME/bbp/bbp_sims/tmpdata/1781375/bbtoolbox_nr_v13_3_1-summernschool
ファイル(F) 編集(E) 表示(V) 検索(S) 端末(T) ヘルプ(H)
*** LOG-FILE FOR BROADBAND HYBRID COMPUTATION CODE (P.M.MAI & K.B.OLSEN) ***
Current date and time: 26/09/2014 22:08:38.701
Code running in modality: 1
----- RAYTRACING PROPERTIES -----
Domain dimensions [x y z] : [72 91 125]
Domain discretization (pts) : [73 92 126]
----- MEDIUM PROPERTIES -----
Num. of layers for 1D model : 36
----- SOURCE PROPERTIES -----
An extended-source model of 466 subfaults has been used
Hypocenter position at : [24.860 19.850 18.210]
----- STF PROPERTIES -----
Npts in STF : 4802
Time length : 15.000 Time-step : .003
----- MATCHING PROPERTIES -----
Target frequency : 1.000 Bandwidth for search : .050
----- SCATTERING PROPERTIES -----
Source density : 2.900 Source S-wave speed : 3.700
Maximum frequency : 100.000 Start time for coda waves : .000
Scattering wavelets : 1500 Number of pts coda envelope : 500
Scattering fft points : 512 Seed number for parameters : 461
Coda tolerance : .001
Absorption coefficient : .010 Scattering coefficient : .010
Q0 value : 150.000 Q frequency decay factor : .800
"run.log" 77L, 4139C
1,2 先頭
```

run.log are saved under tmpdata.bbtoolbox_nr_v13_3_1-summernschool:

scattering_generic.dat

/home/cme/CME/bbp/14.3.0/mod_data/sdsu/

```
インストールしたアプリケーションを参照したり起動します
cme@scec-cme:~/CME/bbp/14.3.0/mod_data/sdsu

ファイル(F) 編集(E) 表示(V) 検索(S) 端末(T) ヘルプ(H)
\* Parameters file for scattering code
\* -----The following parameters can be changed----- \*
3000 \* iseed - seed number for scattering wavelets -> [-1]:random value, [0]:default value, [int]:user-defined
0 \* s_seed - seed number for medium properties -> [-1]:random value, [0]:default value, [int]:user-defined
150.0 \* Q - Q for the coda waves -> [0.0]:default value, [1.0]:drawn from normal distribution, [real]:user-defined
0.01 \* scatcoeff - scattering coefficient -> [0.0]:default value, [1.0]:drawn from uniform distribution, [real]:user-defined
0.01 \* kappa - kappa at the site -> [0.0]:default value, [1.0]:drawn from uniform distribution, [real]:user-defined
0.8 \* fdec - see equation Q=Qf*f*fdec -> [0.0]:default value, [real]:user-defined
0.2 \* hpass - highpass corner of the cosine filter -> [0.0]:default value, [real]:user-defined
\* -----Additional parameters can be changed----- \*
100.0 \* fmax - previously set in module_bbtoolbox.f90 -> [0.0]:default value (100.0Hz), [real]:user-defined
2 \* imerg - flag to determine style of combining LF and HF -> [0]:old merging, [1]:1 fault, [2]:many subfaults
50.e6 \* str_fac - Brune stress parameter (50 bars) G&P (2010) eqn (12) -> [0.0]:default value (50.e6), [real]:user-defined
41.0 \* afac - qk factor 'a' from G&P (2010) eqn (15) -> [0.0]:default value (41.0), [real]:user-defined
34.0 \* bfac - qk factor 'b' from G&P (2010) eqn (15) -> [0.0]:default value (34.0), [real]:user-defined
0.075 \* Tr_sca - scaling factor for Tr for a new stf -> [0.0]:default value (0.1), [real]:user-defined
3 \* time_step - decimation factor to be used in bbtoolbox -> [1]: no decimation, [int > 1]:user-defined
1 \* gs_flag - determine type of tectonic region -> [1]:active, e.g. west
ern CA, [2]:stable, e.g. eastern North America

"scattering_generic.dat" 22L, 1993C
```

users can change parameters in scattering_generic.dat:

src and station files

/home/cme/CME/bbp/bbp_sims/start

```
[cme@scec-cme 14.3.0]$ ls
LICENSE.TXT  README  checksums  comps  examples  manifest.txt  mod_data  patches  plot  ref_data  src  start  tests  utils
[cme@scec-cme 14.3.0]$ cd mod_data/
[cme@scec-cme mod_data]$ ls
irikura  sdsu  ucsb
[cme@scec-cme mod_data]$ cd sdsu/
[cme@scec-cme sdsu]$ ls
scattering_generic.dat
[cme@scec-cme sdsu]$ pwd
/home/cme/CME/bbp/14.3.0/mod_data/sdsu
[cme@scec-cme sdsu]$ cd ../
[cme@scec-cme mod_data]$ ls
irikura  sdsu  ucsb
[cme@scec-cme mod_data]$ cd ../
[cme@scec-cme 14.3.0]$ ls
LICENSE.TXT  README  checksums  comps  examples  manifest.txt  mod_data  patches  plot  ref_data  src  start  tests  utils
[cme@scec-cme 14.3.0]$ cd ../
[cme@scec-cme bbp]$ ls
14.3.0  bbp_files  bbp_gf  bbp_sims  bbp_val
[cme@scec-cme bbp]$ cd bbp_sims/
[cme@scec-cme bbp_sims]$ ls
indata  logs  outdata  start  tmpdata  xml
[cme@scec-cme bbp_sims]$ cd start
[cme@scec-cme start]$ ls
nr_v13_3_1-summerschool.stl  nr_v14_02_1.src
[cme@scec-cme start]$ vi nr_v13_3_1-summerschool.stl
[cme@scec-cme start]$ ls
nr_v13_3_1-summerschool.stl  nr_v14_02_1.src
[cme@scec-cme start]$ pwd
/home/cme/CME/bbp/bbp_sims/start
[cme@scec-cme start]$ ls
nr_v13_3_1-summerschool.stl  nr_v14_02_1.src
[cme@scec-cme start]$
```

users can save own src file and station file (*.stl) in the start directory:
add/extract stations from the *.stl file.


```
[cme@scec-cme comps]$ python run_bbp.py
Welcome to the SCEC Broadband Platform.
Please select the modules you want to run.
Do you want to perform a validation run (y/n)? n

Please select a velocity model (number or name are ok):

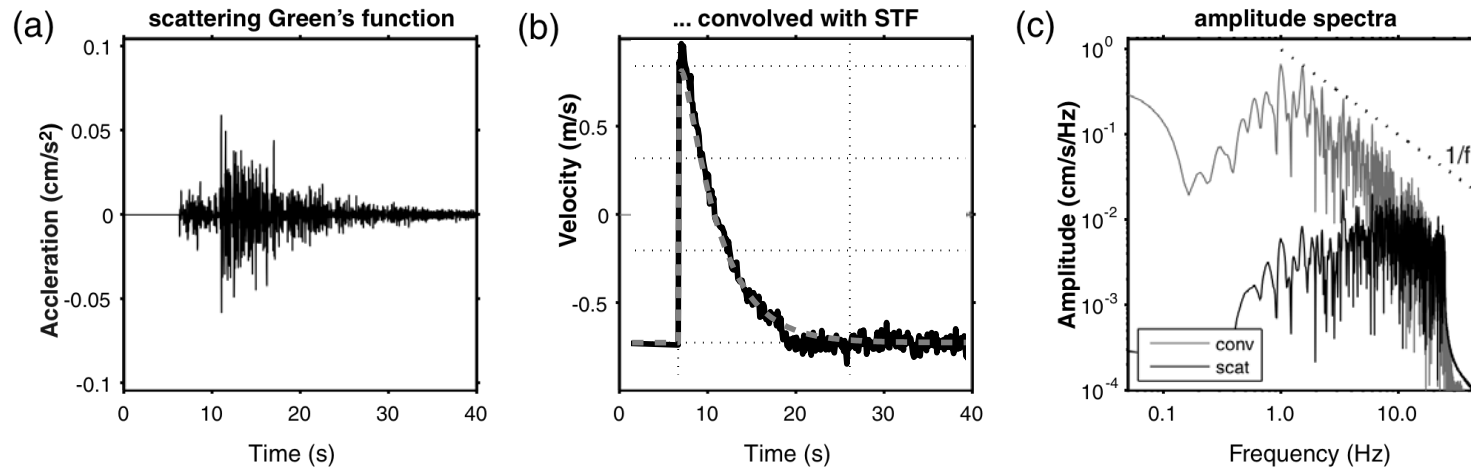
(1) LABasin
? 1
Choose a Method to use in a Broadband forward simulation:
(1) GP (Graves & Pitarka)
(2) UCSB
(3) SDSU
(4) EXSIM
(5) CSM
(6) Irikura
? 3
Do you want to run a rupture generator (y/n)? y
Do you want to
(1) select a source description in /home/cme/CME/bbp/bbp_sims/start
(2) enter a path of a source description file
? 2
Enter path and filename of source description: /home/cme/CME/bbp/bbp_val/NR/gp/nr_v14_02_1.src

Do you want to
(1) select a BBP station list in /home/cme/CME/bbp/bbp_sims/start
(2) enter a path of a BBP station list file
? 2
Enter path and filename of BBP station list: /home/cme/CME/data-files/nr_v13_3_1-summerschool.stl
Do you want to run the site response module (y/n)? n
Do you want to plot velocity seismograms (y/n)? y
Do you want to plot acceleration seismograms (y/n)? y

Running Genslip
```

Site-Specific Scattering Functions

- Scattering Green's functions computed for each component of motion based on Zeng et al. (1991, 1993) and P and S arrivals from 3D ray tracing (Hole, 1992) convolved with a dynamically-consistent source-time function, generating $1/f$ spectral decay
- Site-scattering parameters (scattering and attenuation coefficient, site kappa, intrinsic attenuation) are taken from the literature and are partly based on the site-specific velocity structure.
- Assuming scattering operators and moment release originate throughout the fault, but starts at the hypocenter



- Hybrid broadband seismograms are calculated from low-frequency and high-frequency synthetics in the frequency domain using a simultaneous amplitude and phase matching algorithm (Mai and Beroza, 2003)

No Bias From Depth to Top of Fault

Event	Depth	GOF
• Landers (ss)	0.00	0.15-0.36
• Tottori (ss)	0.10	0.18-0.27
• Niigata (rev)	1.09	0.38-0.46
• LOMAP (robl)	3.85	0.13-0.35
• N P Springs (robl)	4.00	0.20-0.32
• Northridge (rev)	5.00	0.11-0.32
• Whittier (rev)	12.00	0.19-0.29
• M6.6 ss	0.00	best GMPE
• M6.6 rv	3.00	good
• M6.2 ss	4.00	as good

Mechanism

	GOF			
	<0.1s	0.1-1s	1-3s	>3s
Rev	0.57	0.61	0.76	1.00
ROBL	0.60	0.63	0.67	0.48
SS	0.48	0.60	0.68	0.70
NM	-----			
Av-CA	0.57	0.61	0.61	0.66
Av-All	0.55	0.61	0.71	0.79

Mechanism, Overall Bias

0.01-0.1s

0.1-1s

1-3s

>3s

Mechanism																								
	0.01-0.1s						0.1-1s						1-3s						>3s					
	Reverse (REV)	0.47	0.32	0.27	0.35	0.48	0.82	0.34	0.32	0.35	0.37	0.51	0.35	0.55	0.64	0.52	0.76	0.28	0.88	0.93	0.59			
	Reverse-Oblique (ROBL)	0.30	0.40	0.26	0.28	0.28	0.57	0.31	0.25	0.28	0.26	0.54	0.34	0.29	0.31	0.26	0.45	0.51	0.35	0.35	0.37			
Total	Strike-Slip (SS)	0.47	0.35	0.38	0.43	0.38	0.33	0.43	0.46	0.43	0.38	0.37	0.42	0.54	0.65	0.45	0.41	0.37	0.50	0.55	0.30			
	Normal (NM)																							
Total	Average CA	0.34	0.27	0.33	0.31	0.36	0.58	0.28	0.35	0.32	0.32	0.49	0.35	0.40	0.42	0.36	0.48	0.35	0.40	0.40	0.33			
	Average CENA	1.47	0.38	0.50	0.25	1.27	2.19	0.52	0.57	0.34	0.76	1.90	0.57	0.76	0.46	0.43	0.48	0.77	0.23	0.22	0.47			
	Average ALL	0.33	0.29	0.27	0.32	0.35	0.63	0.27	0.34	0.33	0.31	0.47	0.34	0.47	0.55	0.42	0.42	0.36	0.58	0.62	0.38			

Summary

- Plan B scenarios
 - All within specified tolerances
 - Strike-slip scenarios at or slightly below median
 - Reverse scenarios at or slightly above median
 - No significant dependence on velocity model
- Plan A scenarios
 - |Bias| generally < 0.2
 - Time histories look reasonable
 - No significant distance bias, (two) Plan A near-fault (1-3 km) OK
 - No known issues with mechanism, depth to top of fault
 - General overprediction at LFs (as do the GMPEs...)
- Projection to lower and higher magnitudes
 - $5 < M_w < 5.9$ expected to work with modified input parameter
 - $5.9 < M_w < 8$ expected to work as is
 - $M_w > 8$ not sure/potential issues – no saturation of synthetics
- Known Issues:
 - Raytracer domain size (no show stopper)