Implementation of Source Simulations for Ground Motion Calculations

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SCEC Rupture Dynamics Code Verification Workshop
USGS Menlo Park, California
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OUTLINE

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   a) User Specified Inputs
   b) Output Files
   c) Platform Modes

2) Southwest US SSHAC Simulations
   a) Project Overview
   b) Purpose of Simulations
   c) Considered Rupture Scenarios

3) Using Dynamic Rupture Modeling to Inform Scenarios

THE BBP: User Specified Inputs

Earthquake Source Inputs:

```
~~MOMENT = 7.54297215e+19~~
MAGNITUDE = 7.2
FAULT_LENGTH = 106.890000
FAULT_WIDTH = 15.000000
DEPTH_TO_TOP = 0.0
STRIKE = 338.1446
RAKE = 180
DIP = 90
LAT_TOP_CENTER = 36.366200
LON_TOP_CENTER = -121.552200
HYPO_ALONG_STK = 22.28
HYPO_DOWN_DIP = 9.87
DWID = 0.1
DLEN = 0.1
DT = 0.1
SEED = 1343642
```

Station Inputs:

```
#BBP Station List for Scenario 123
#SLong     SLat      RSN
-118.093 34.091   5003-A-GRN
-117.974 34.100   5010-A-NHO
-118.222 34.088   5006-A-CYP
```

THE BBP: User Specified Inputs

Earthquake Source Inputs:

M-A Scaling

~~MOMENT = 7.54297215e+19~~

```
MAGNITUDE = 7.2
FAULT_LENGTH = 106.890000
FAULT_WIDTH = 15.000000
DEPTH_TO_TOP = 0.0
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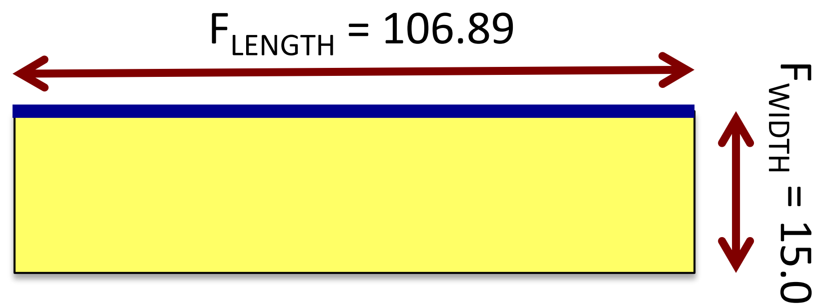

$$M_W = \log(A) + 4$$

$$M_O = 10^\wedge(3/2 M_W + 9.1050)$$

where: M_O (Nm)

THE BBP: User Specified Inputs

Earthquake Source Inputs:

Fault Parameters

~~MOMENT = 7.54297215e+19~~
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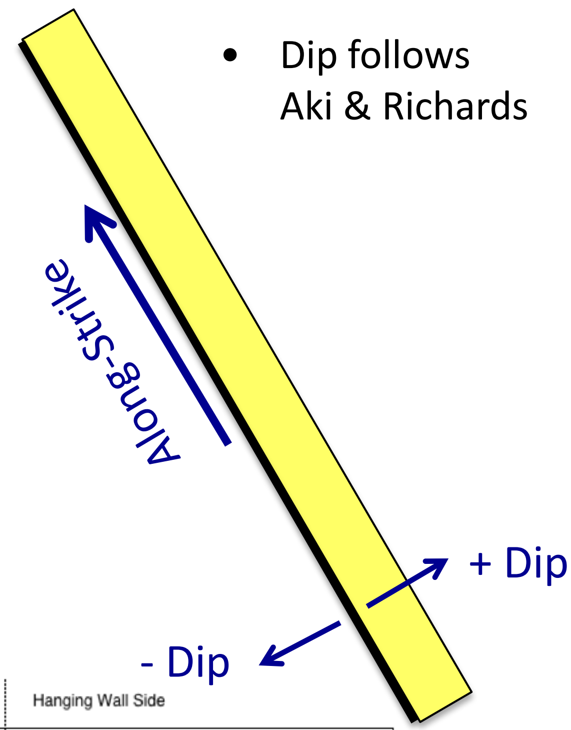
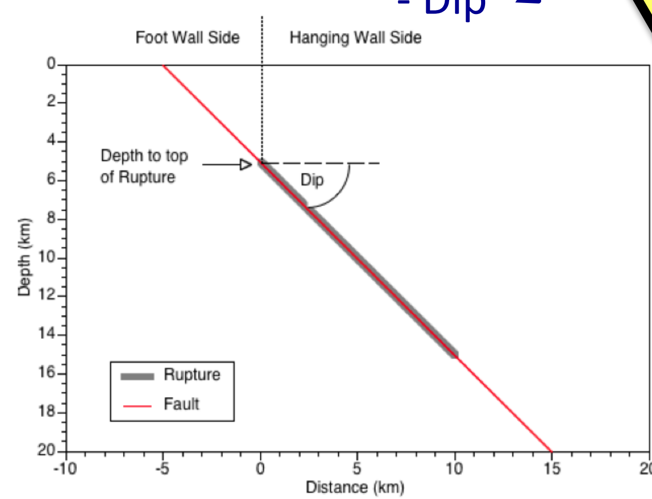
HYPO_DOWN_DIP = 9.87
DWID = 0.1
DLEN = 0.1
DT = 0.1
SEED = 1343642

STRIKE = 338

- Dip follows Aki & Richards





THE BBP: User Specified Inputs

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MAGNITUDE = 7.2
FAULT_LENGTH = 106.890000
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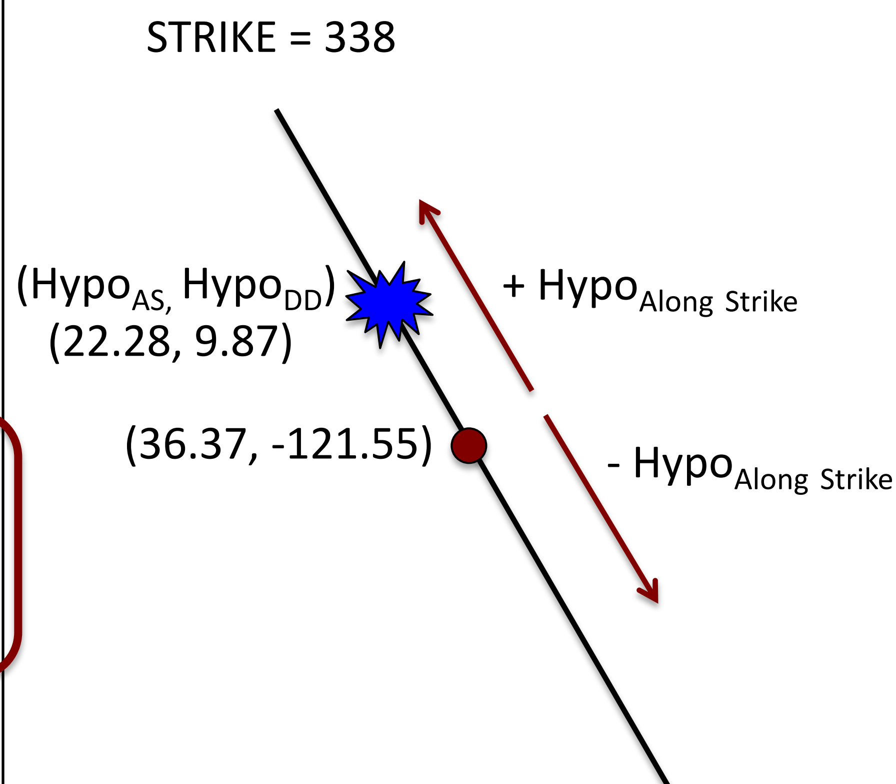
DEPTH_TO_TOP = 0.0
STRIKE = 338.1446
RAKE = 180
DIP = 90

Hypocenter

LAT_TOP_CENTER = 36.366200
LON_TOP_CENTER = -121.552200
HYPO_ALONG_STK = 22.28
HYPO_DOWN_DIP = 9.87

DWID = 0.1
DLEN = 0.1
DT = 0.1
SEED = 1343642



THE BBP: User Specified Inputs

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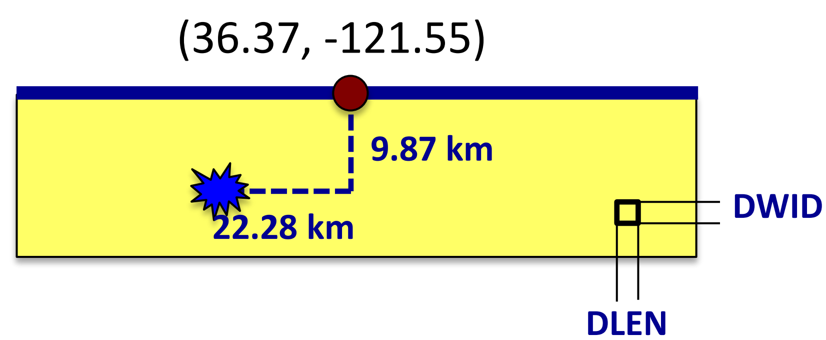
LON_TOP_CENTER = -121.552200
HYPO_ALONG_STK = 22.28
HYPO_DOWN_DIP = 9.87

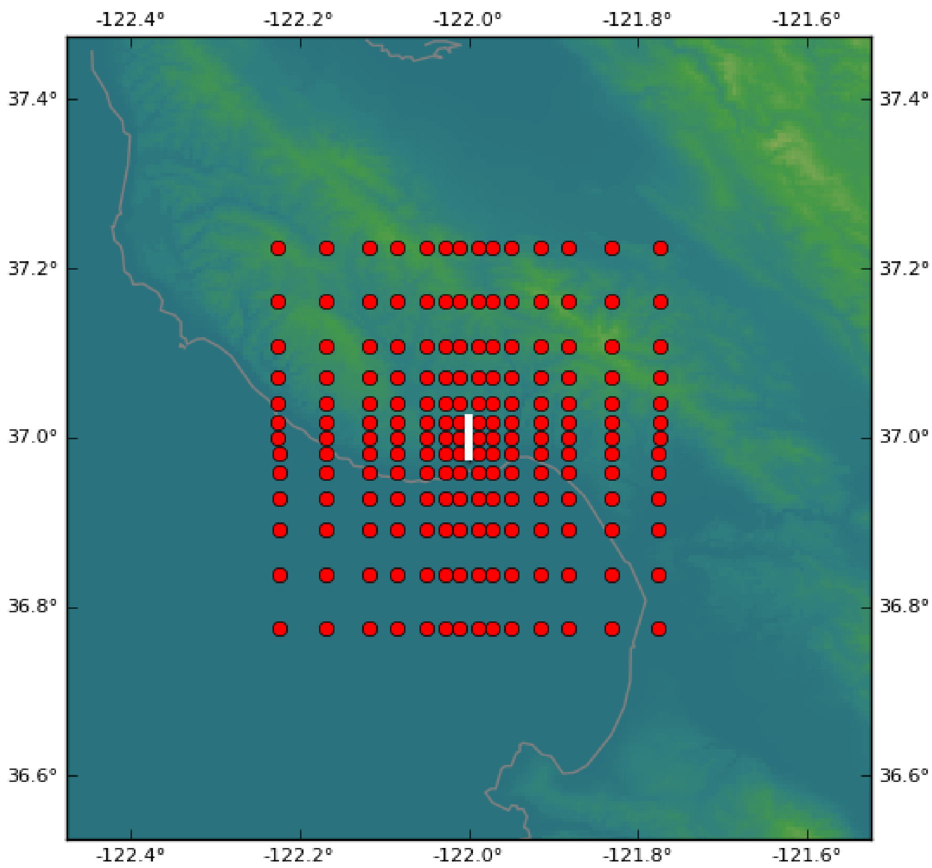
Rupture Generator

DWID = 0.1
DLEN = 0.1
~~DT = 0.1~~
SEED = 1343642

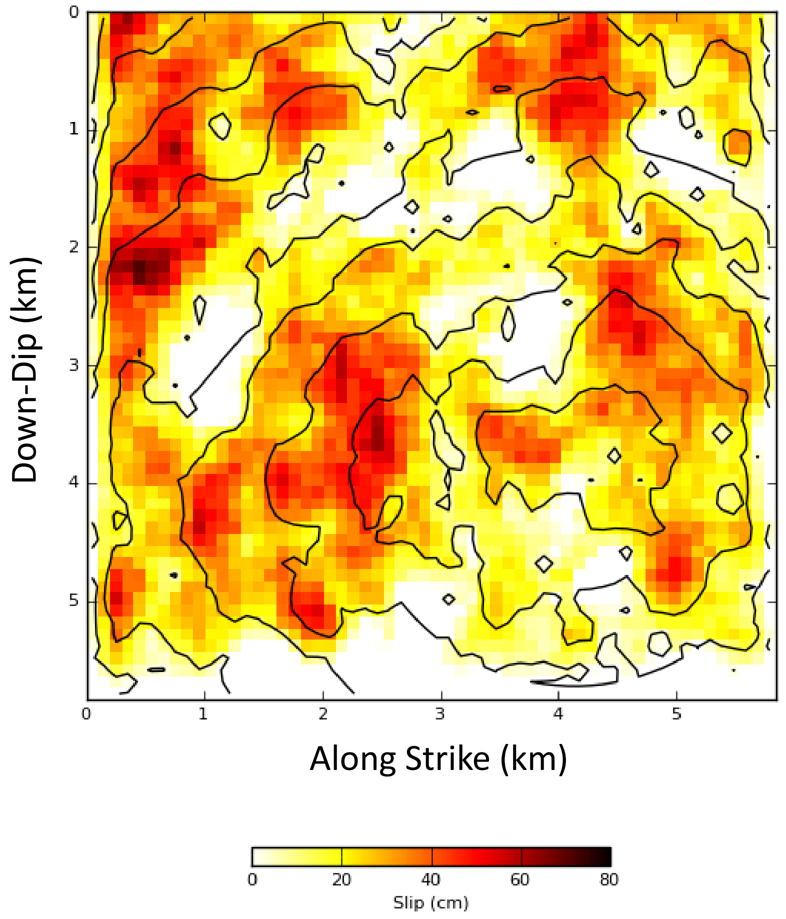


THE BBP: Output Files

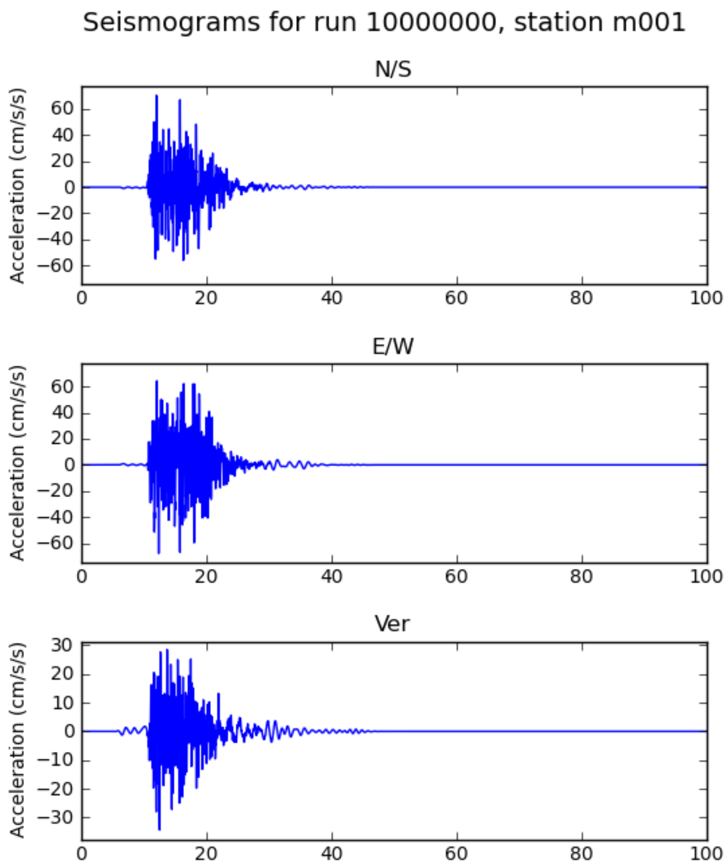
FAULT TRACE AND STATION MAP

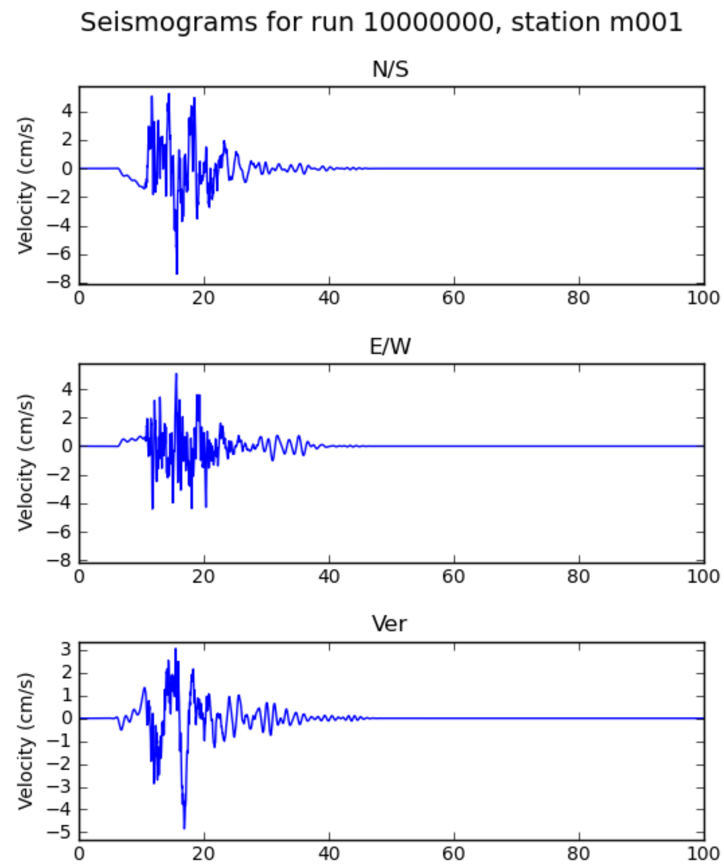


SOURCE RUPTURE MODEL



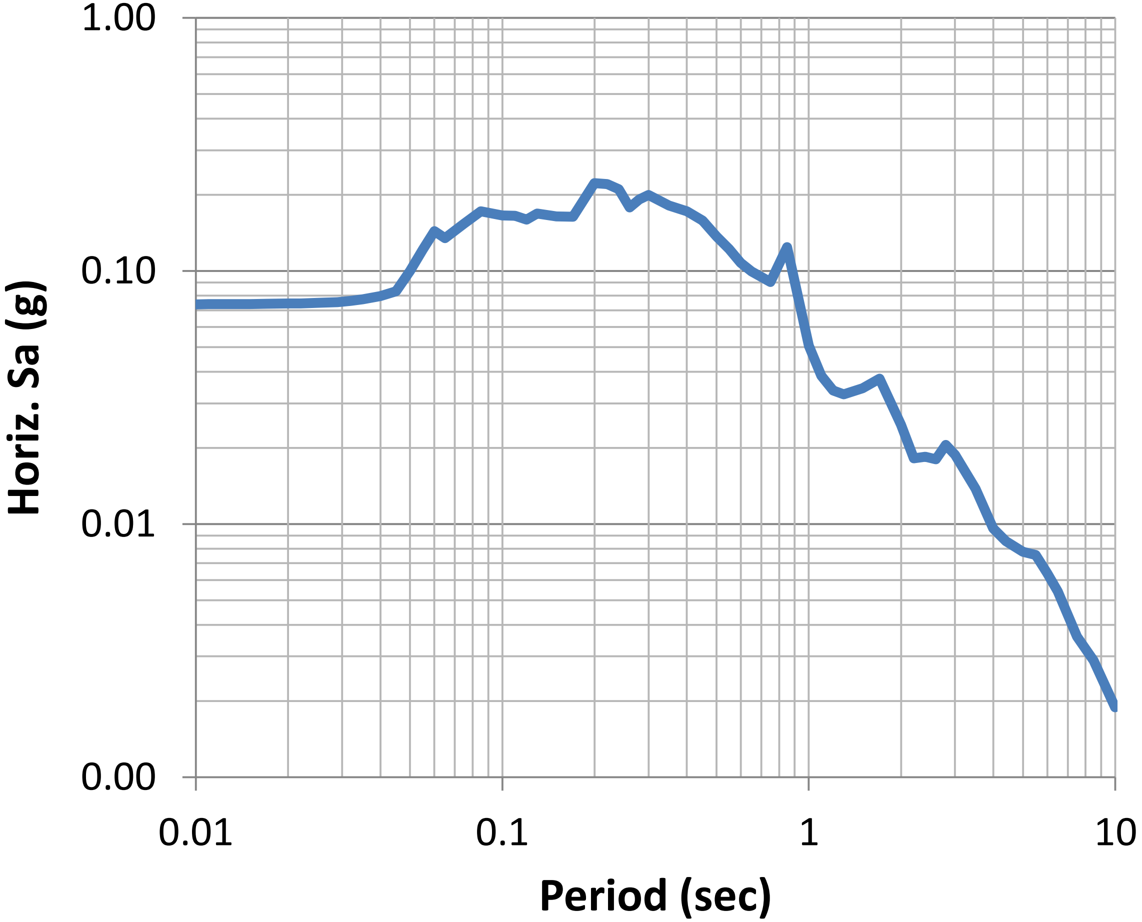
THE BBP: Output Files





- Velocity and Acceleration Time Histories (3 Components)
- ASCII and PNG Format

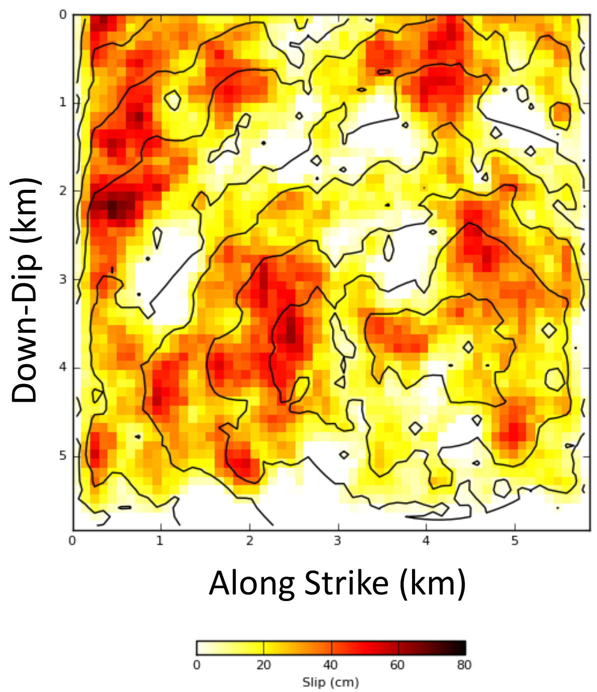
THE BBP: Output Files



- Horiz. RotD50 Response Spectrum
- ASCII Format

THE BBP: Simulation Modes

Mode	Rupture Generator	Hypocenter	Description
1	Random Slip	Random Hypocenter	Mode used for Part B: GMPE Comparisons
2	Random Slip	Fixed Hypocenter	Mode used for Part A: Event Validation
3	Fixed Slip	Random Hypocenter	Keep SEED the same, change hypocenter (needs evaluation)
4	Fixed Slip	Fixed Hypocenter	Fix SEED and Hypocenter, all realizations produce identical results



SWUS SSHAC Project Overview

- The objective of the SWUS SSHAC study is to provide a ground motion (GM) model that can be used to assess seismic hazard at Palo Verde and Diablo Canyon.

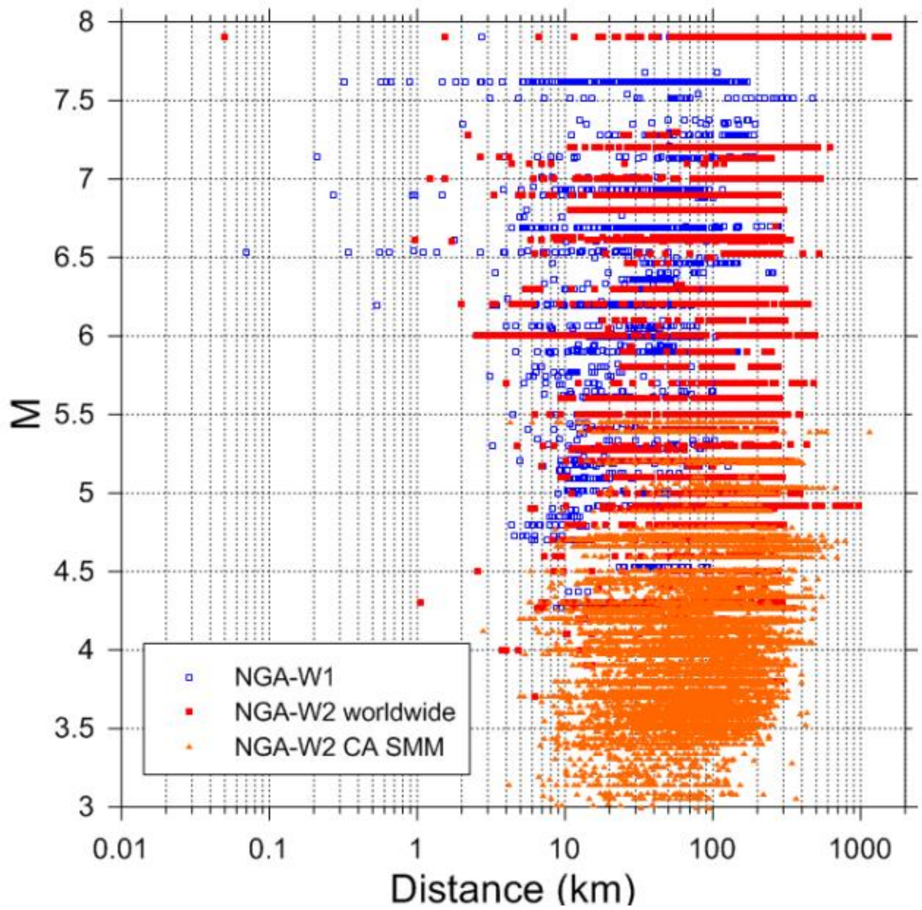
- Development of the GM model begins with an analysis of published Ground Motion Attenuation Equations (GMPE) for their applicability to the project locations, site conditions, and source characterization

- Inputs to the GMPE's include:
  - Magnitude (M_w)
  - Distance (R_{rup}, R_x, and R_{JB})
  - Style-of_Faulting
  - HW/FW
  - Depth to Top of Rupture (Z_{TOR})
  - Dip
  - Site parameter (V_S30)

SWUS SSHAC Simulations

Purpose:

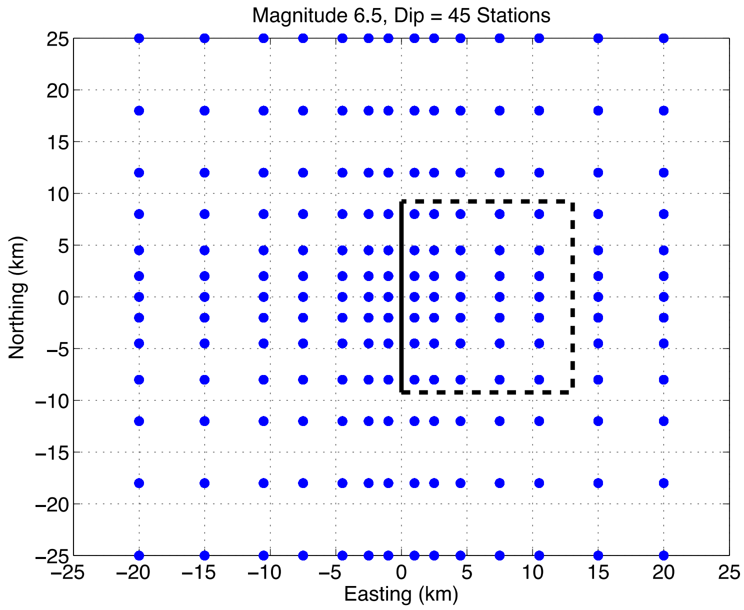
- Augment the empirical dataset in area where earthquake data is lacking or insufficient:
  - Close-in Distances (< 10 km)
  - Large Magnitudes

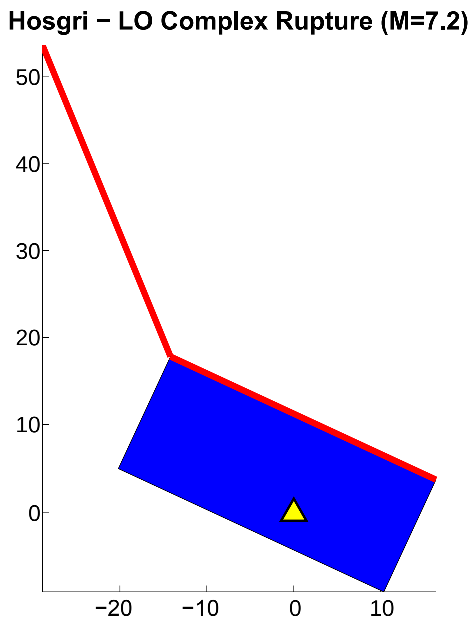


SWUS SSHAC Simulations

Purpose:

- Generate datasets that can be used to study a particular effect:
  - The hanging-wall effect
  - The effect of fault geometrical complexity on near fault ground motions (e.g. Complex & Splay faults)

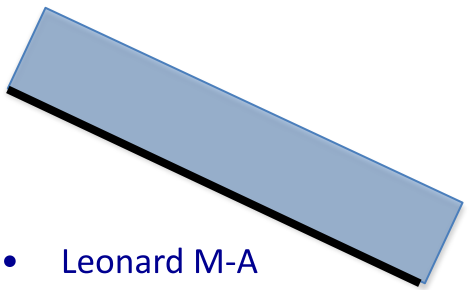




SWUS SSHAC Simulations

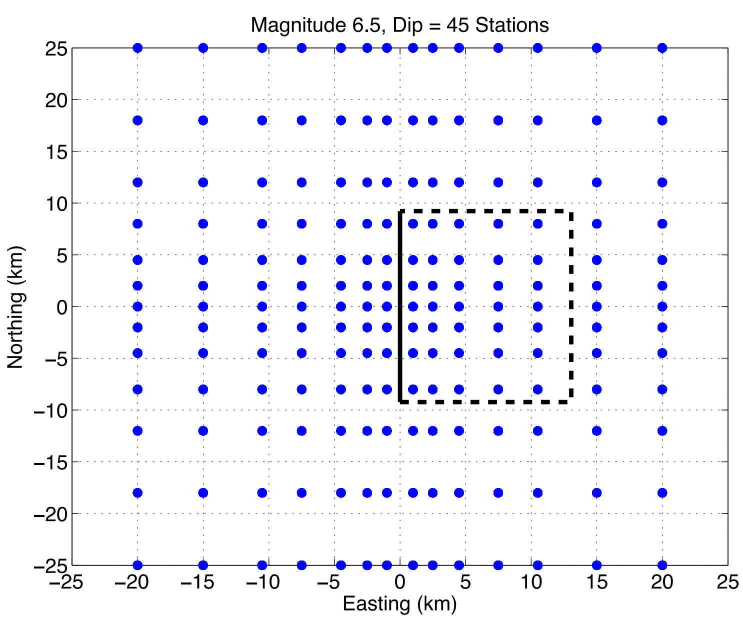
SINGLE FAULT RUPTURES:

- Purpose:
  - Constrain hanging-wall effect for low magnitude scenarios (M5.5 and M6)
  - Compare hanging-wall scaling between models in mid-magnitude range (M6.5 and M7)



- Leonard M-A Scaling

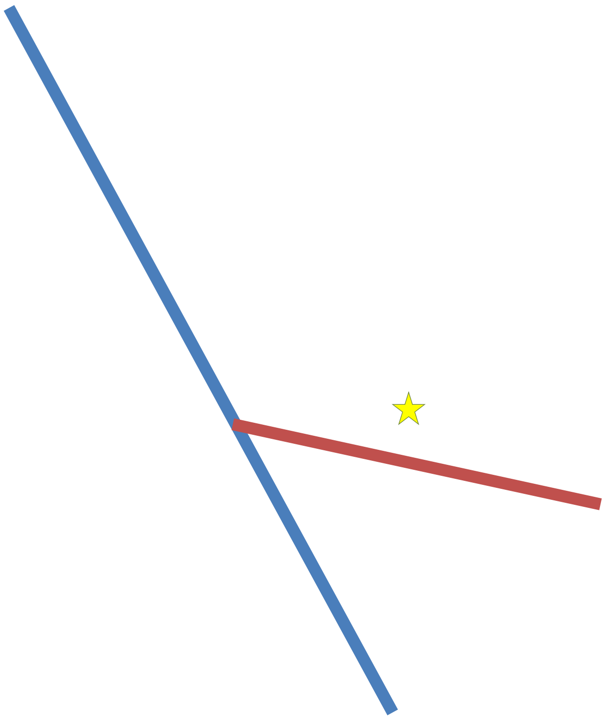
- Description of Scenarios:
  - 37 Scenarios:
    - Mode 1 (Random Slip & Random Hypocenter)
    - Mw5.5 – Mw7.0
    - Reverse Slip (Rake = 90 degrees)
    - Dip (10 – 60 degrees)
    - Ztor (0 - ~12 km)
  - 32 Realizations per. Scenario
  - 3 Methods
    - Graves and Pitarka
    - SDSU
    - ExSIM
  - 182 Stations
  - **646,464** Seismograms



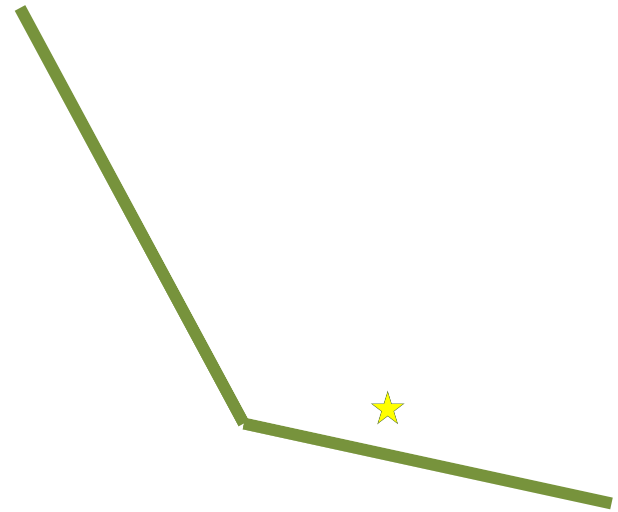
SWUS SSHAC Simulations

COMPLEX & SPLAY FAULT RUPTURES:

Splay



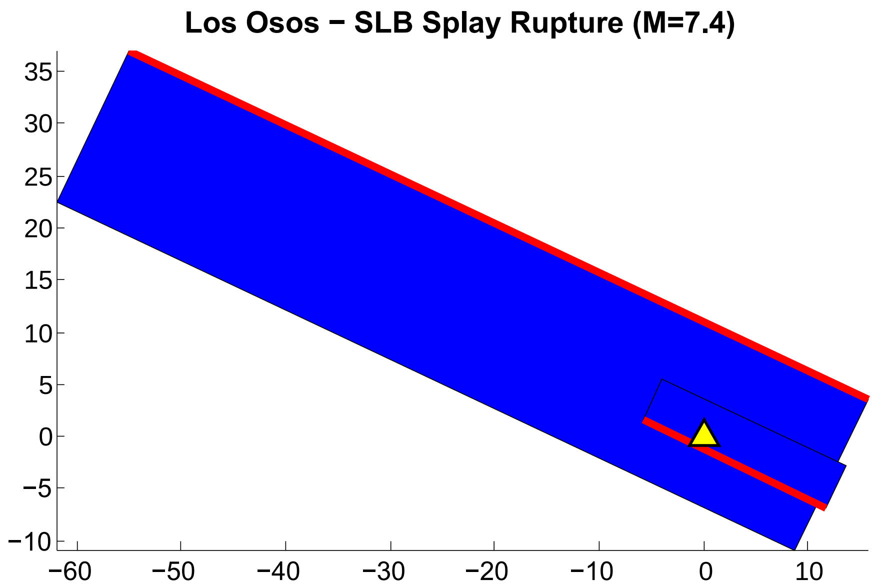
Complex



SWUS SSHAC Simulations

PURPOSE OF COMPLEX & SPLAY FAULT SCENARIOS:

- To develop simulated ground motions for the complicated fault geometries near DCPP that help inform our decision of how to most appropriately compute the GMPE input parameters.

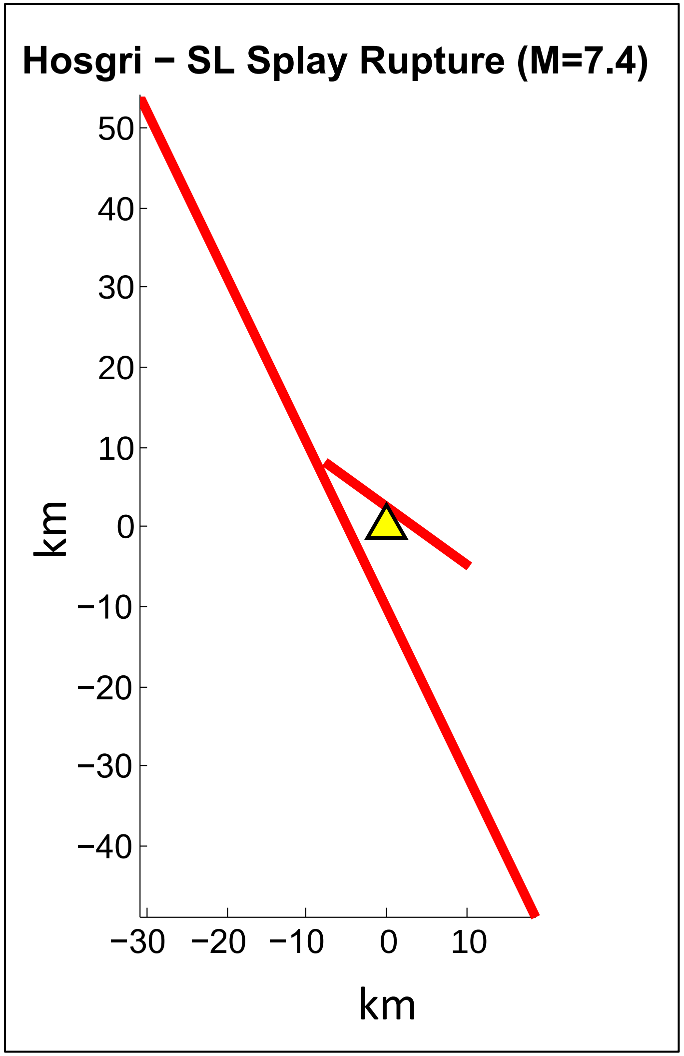


	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Los Osos	8.57	0.0	9.90	7.40	60.0	90	32.0
San Luis Bay	1.00	0.0	1.07	6.40	70.0	90	12.7

SWUS SSHAC Simulations

METHODOLOGY TO COMPARE SPLAY FAULT SCENARIOS AGAINST GMPEs:

- Compute Simulated GMs for the Combined Splay Rupture:
  - Synthetics are generated for both Primary and Splay rupture (GP, SDSU, and ExSIM)
  - Waveforms are combined in the time domain
  - Response spectra and rotD50 spectra are computed
- Compute Simulated GMs for the Primary Segment alone.
- Compute Splay Fault Rupture Adjustment Factors from the Simulation Results:
  - Factors are a ratio between the rotD50 of the Combined rupture and the simulated Primary rupture (ln units)
- Compare factors computed from the 4 GMPE approaches against the factors derived from the simulations to inform our decision about which GMPE approach to use.



SWUS SSHAC Simulations

GROUND MOTIONS FOR SPLAY RUPTURES:

- Method 1: SRSS Multiple Fault Segments
  - Compute response spectrum for each segment (or fault) at the closest point (using that segment's dip, rake, $width_{DD}$, distance, and magnitude)
  - SRSS the two segments:

$$Sa_{SRSS} = \sqrt{Sa^2_{Hosgri} + Sa^2_{Shoreline}}$$

- Method 2: Single Fault with Fault Parameters Averaged by Area
  - Use total magnitude for full splay rupture
  - Compute weighted avG. of fault parameters (rake, dip, and $width_{DD}$) by area
  - Response spectrum computed at closest point

Segment	Length	Width	Area	Rake	Dip	Strike
Hosgri	107.0	15.0	1605.0	180.0	90.0	338.0
SLB	18.0	16.0	287.3	90.0	70.0	99.0
Method 2	125.0	15.1	1892.3	167.0	87.1	303.6

SWUS SSHAC Simulations

GROUND MOTIONS FOR SPLAY RUPTURES:

- Method 3: Single Fault with Fault Parameters Averaged by $1/R^2$
  - Use total magnitude for full splay rupture
  - Discretize fault and compute weighted average of fault parameters (rake, dip, and width_{DD}) weighted by $1/R^2$
  - Response spectrum computed at closest point

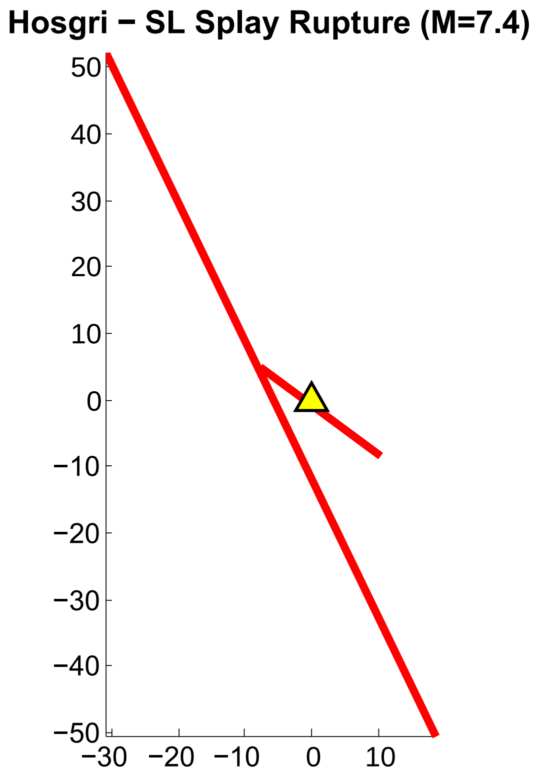
$$Dip_{rms} = \frac{\sum \left(Dip_i \times \frac{1}{R_i^2} \right)}{\sum \frac{1}{R_i^2}}$$

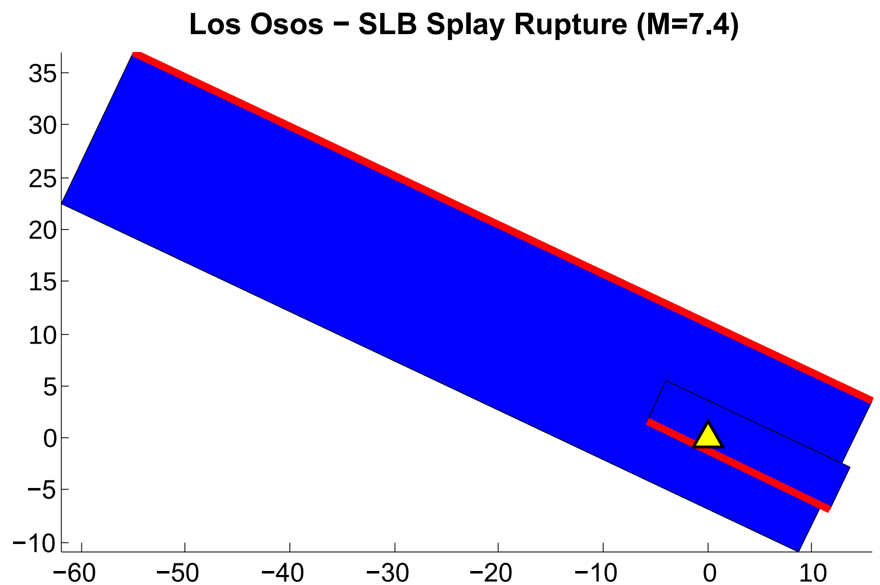
- Method 4: Single Fault with Closest Segment Parameters
  - Use Magnitude for full splay rupture
  - Fault parameters taken from the closest segment
  - Response spectrum computed at closest point

SWUS SSHAC Simulations

SPLAY FAULT SCENARIOS:

1) Primary Hosgri rupture; secondary Shoreline rupture
2) Primary Los Osos rupture; secondary San Luis Bay rupture



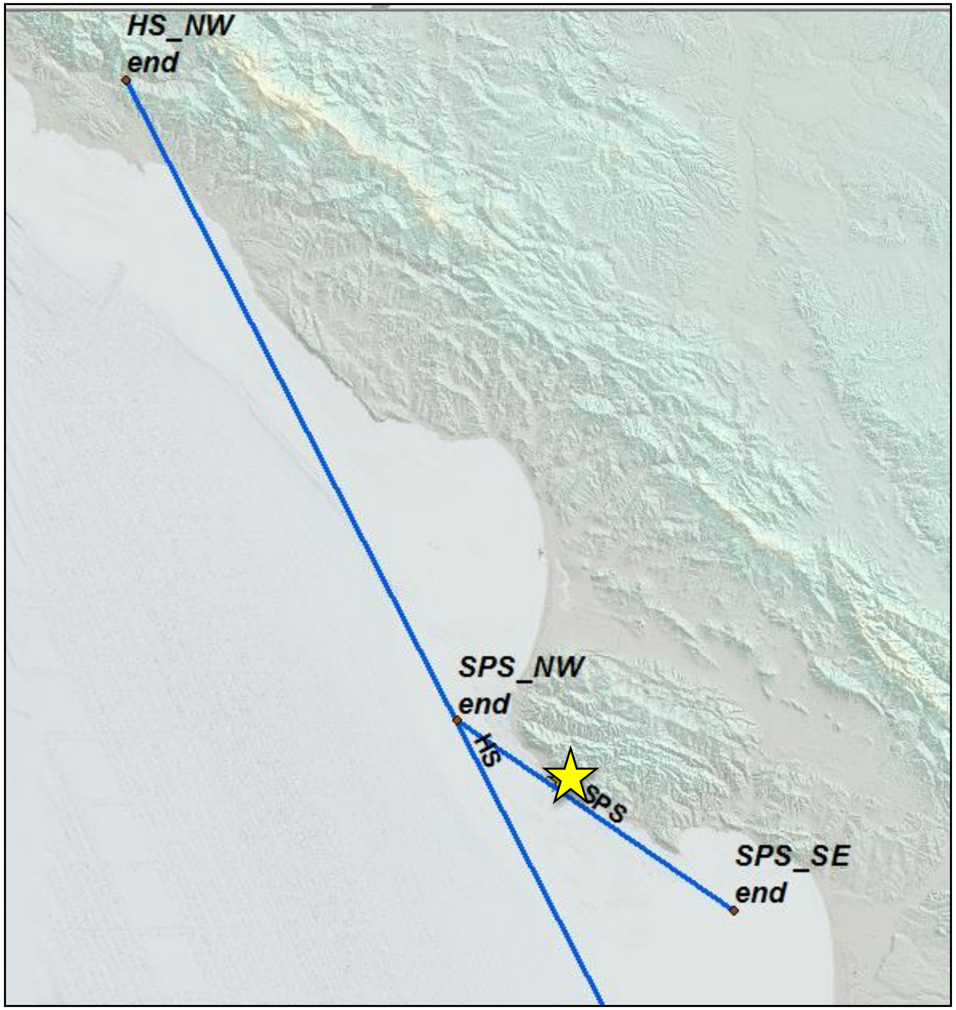


* 32 randomized realizations of each scenario computed

SWUS SSHAC Simulations

SPLAY FAULT SCENARIOS: HOSGRI + SHORELINE

- SSC: Slip rate on Shoreline is 10% of slip rate on Hosgri for moment balancing
- Lengths
  - Hosgri = varies
  - Shoreline = 25.6 km
- Dip = 90
- Rake = 180 (RL-SS)



Splay 1: Hosgri – Shoreline

Method for Determining Scenario Properties

<u>Hosgri (Primary Segment)</u>

1. Define Hosgri Mw
2. Mw -> A, W, L (Leonard 2010)
3. Fix SE end at SSC-specified location
4. Run Simulation

Splay 1: Hosgri – Shoreline

Method for Determining Scenario Properties

Shoreline (Secondary Segment)

Compute avg slip from Hosgri sims

Scale Hosgri slip by 30%, use this slip for Shoreline (secondary)

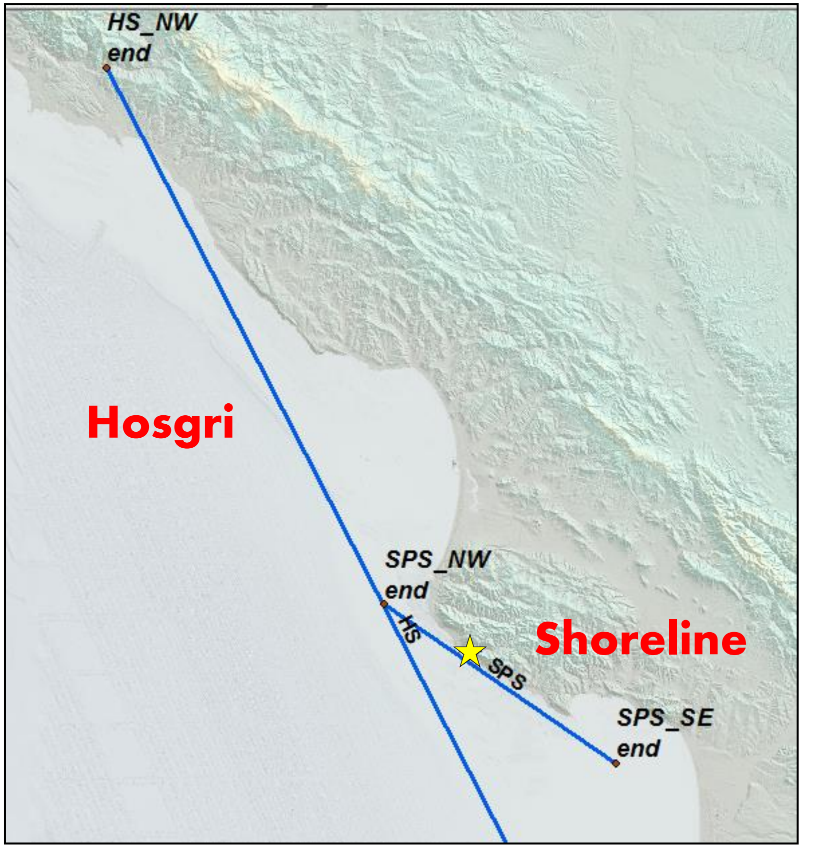
Slip→ L→ W→ A→ Mw (Leonard 2010)

Fix NW end at Hosgri intersection

Run Simulation

Splay 1: Hosgri - Shoreline

This presentation will focus on the Hosgri Mw=7.4, Shoreline Mw=6.43 case

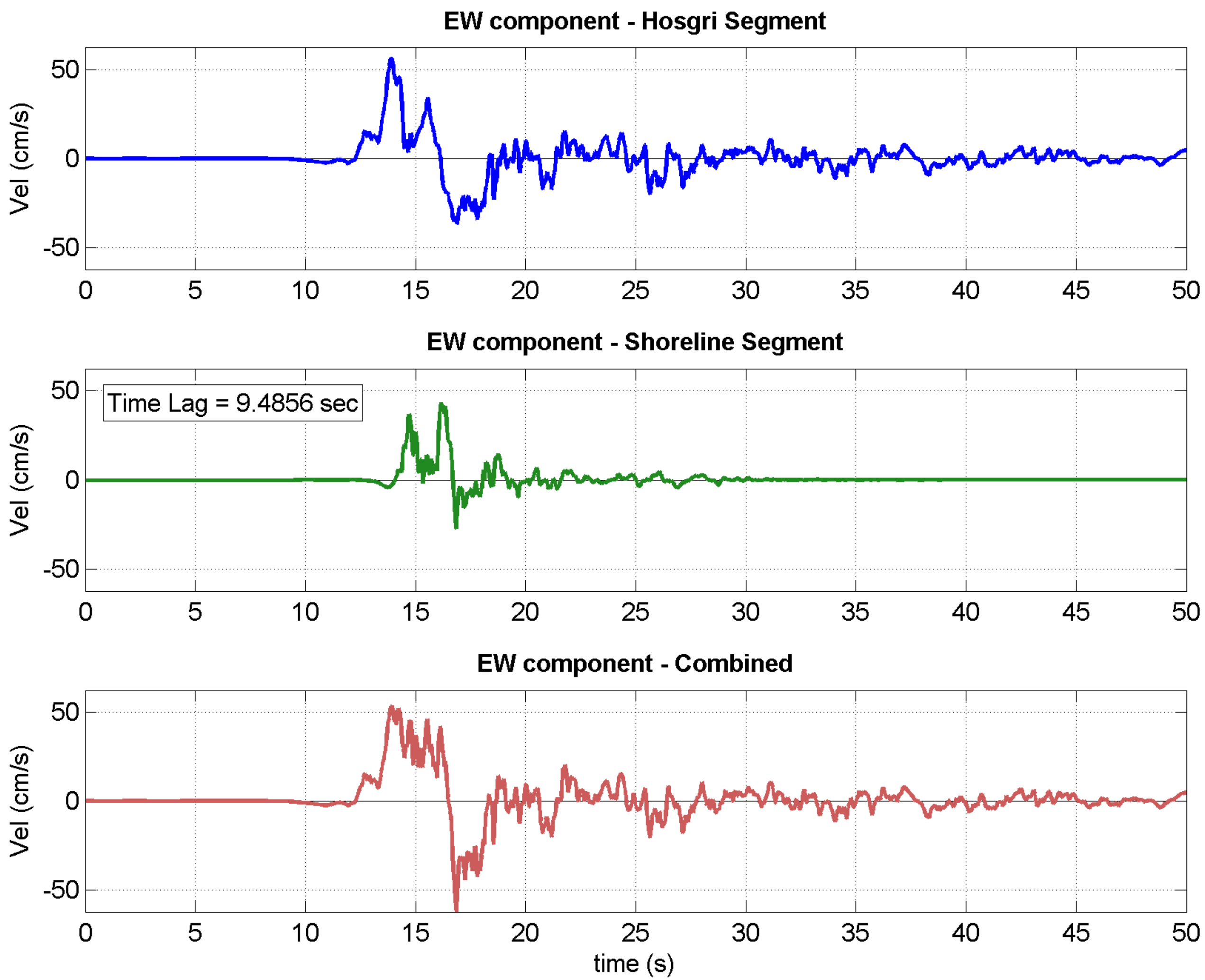


Segment	Rrup	Rjb	Rx
Hosgri	5.1	5.1	5.1
SL	0.66	0.66	0.66

Segment	Mw	Strike	Rake	Dip	Ztor	L	W
Hosgri	7.4	334.2	180	90	0	114.18	22.0
SL	6.43	305.7	180	90	0	22.44	11.93

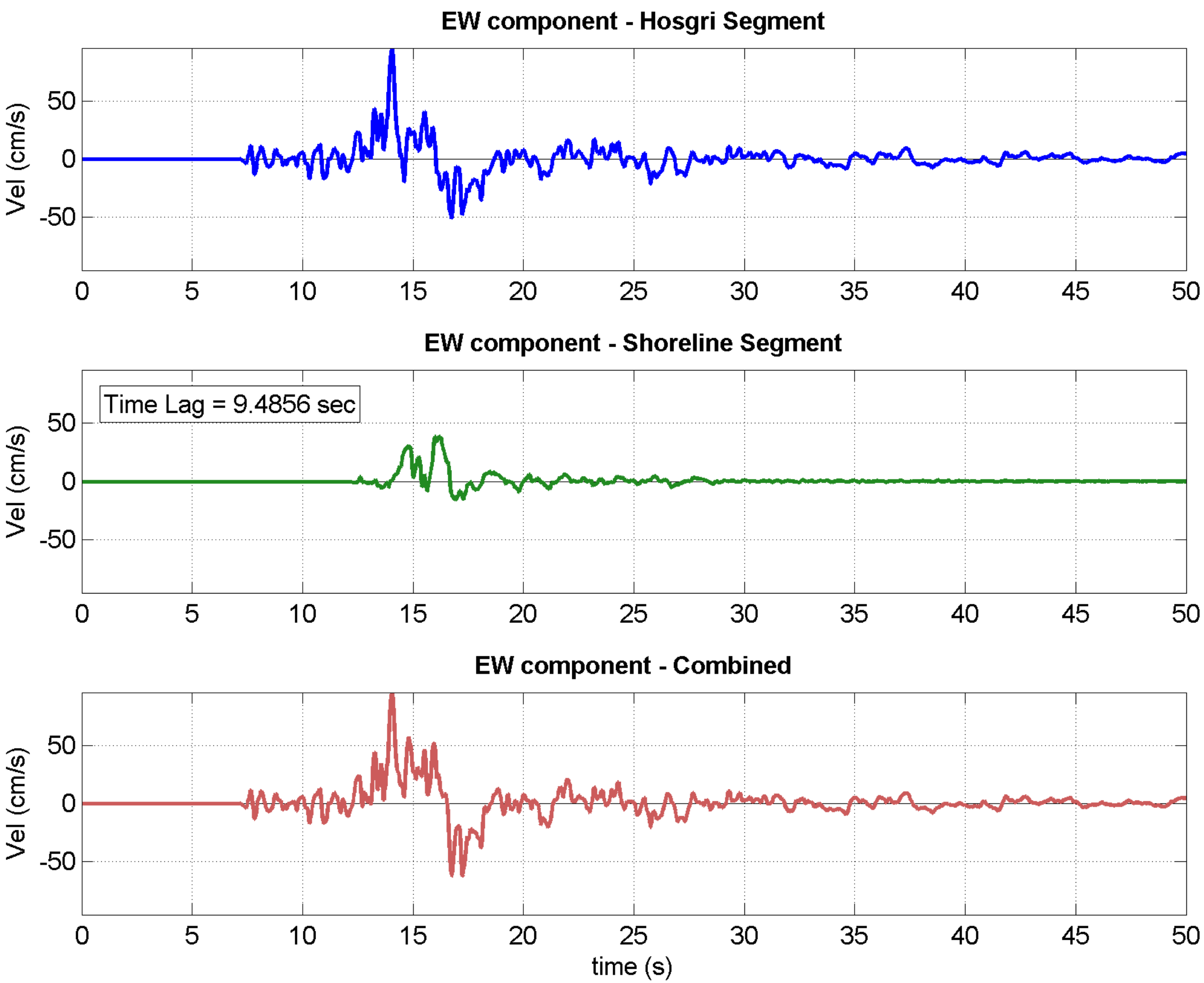
Splay 1: Hosgri – Shoreline

Example Waveforms - (GP Method, Realization 18)



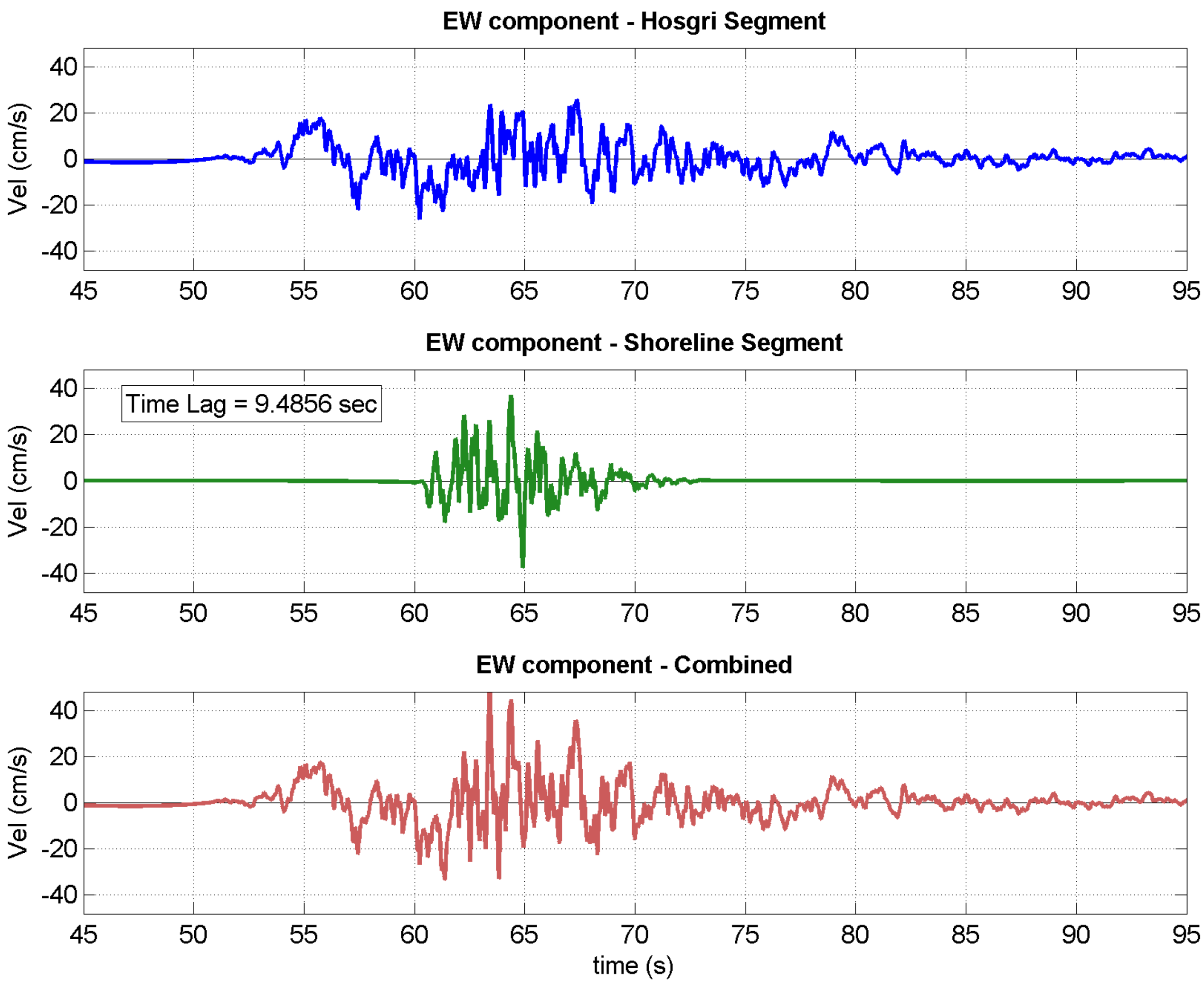
Splay 1: Hosgri – Shoreline

Example Waveforms - (SDSU Method, Realization 18)



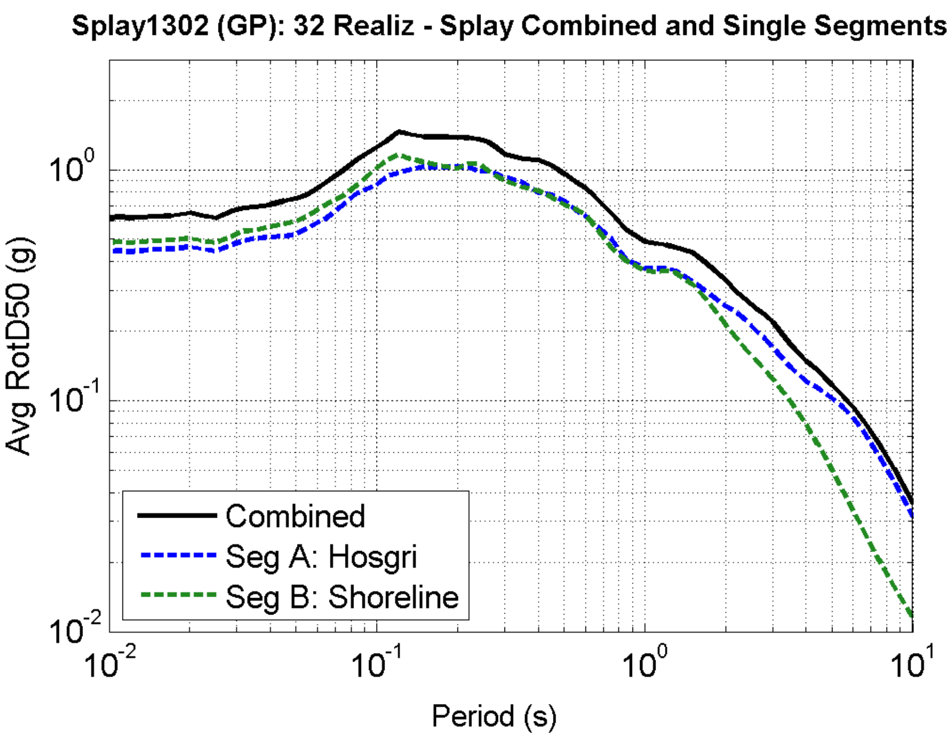
Splay 1: Hosgri – Shoreline

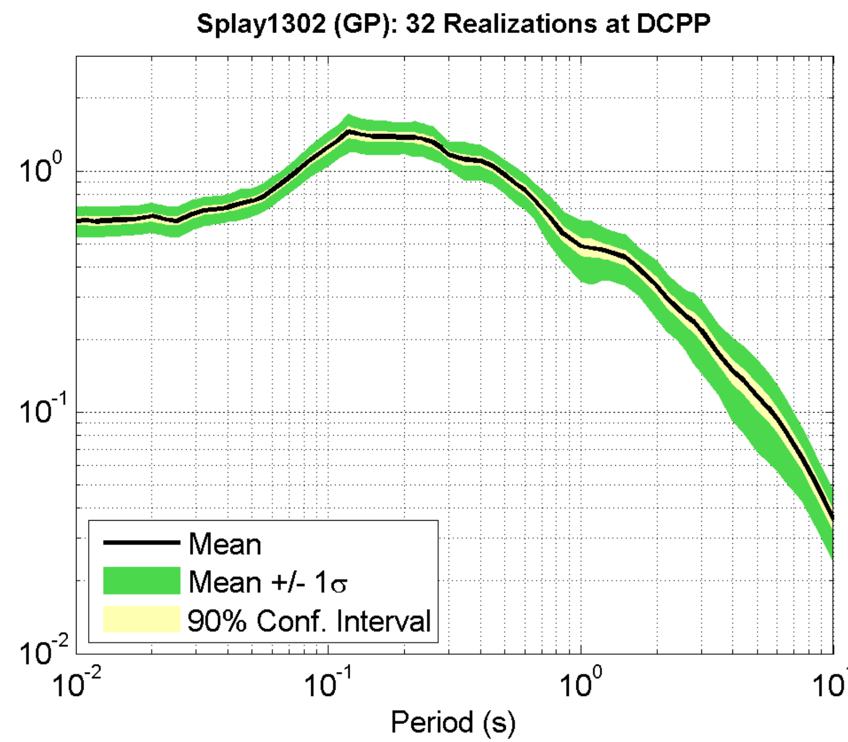
Example Waveforms - (ExSim Method, Realization 18)



Splay 1: Hosgri - Shoreline

Results - GP



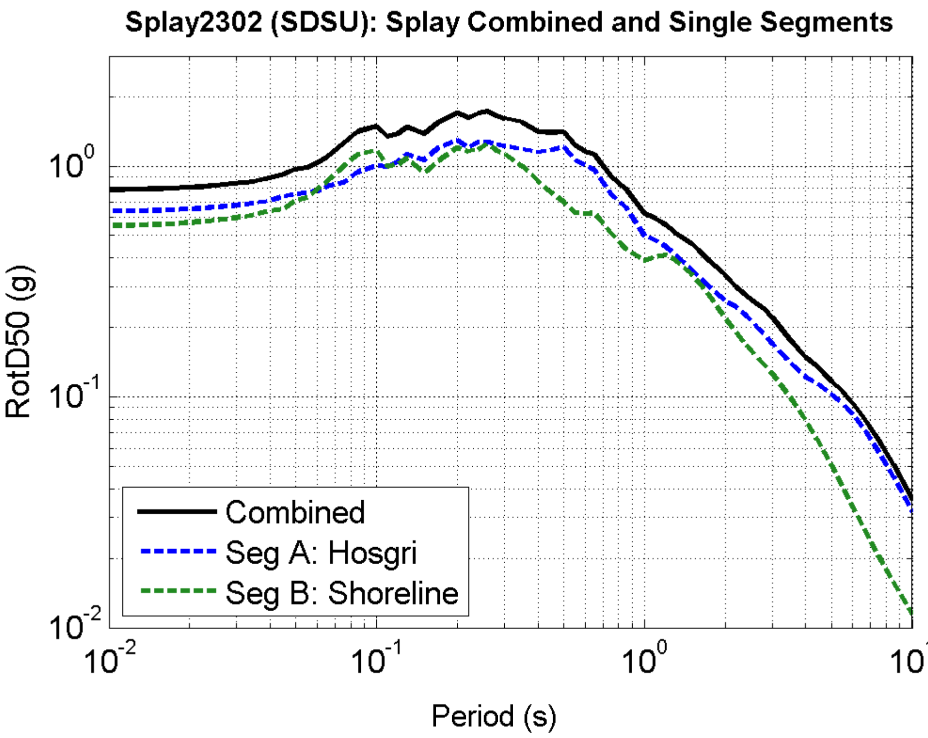


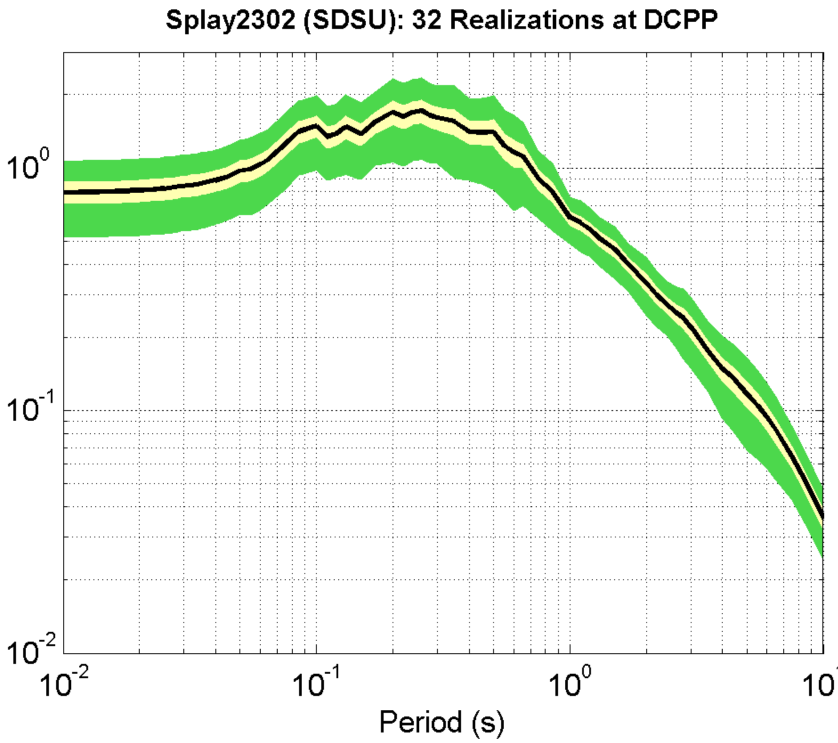
Segment A: Hosgri Mw=7.4, R=5.1

Segment B: Shoreline Mw=6.43, R=0.66

Splay 1: Hosgri - Shoreline

Results - SDSU



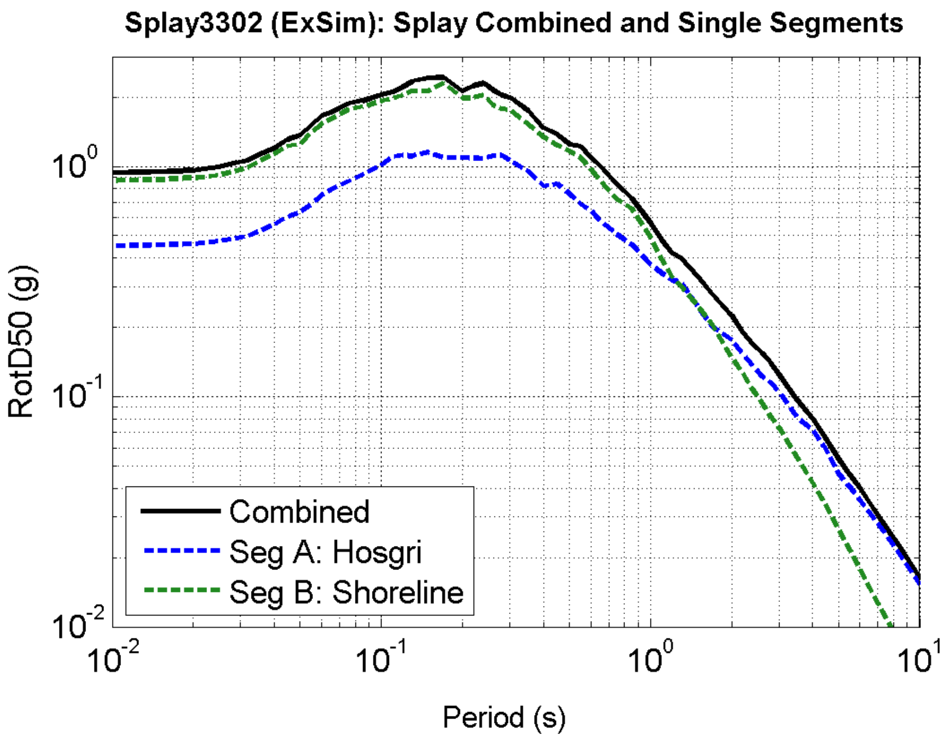


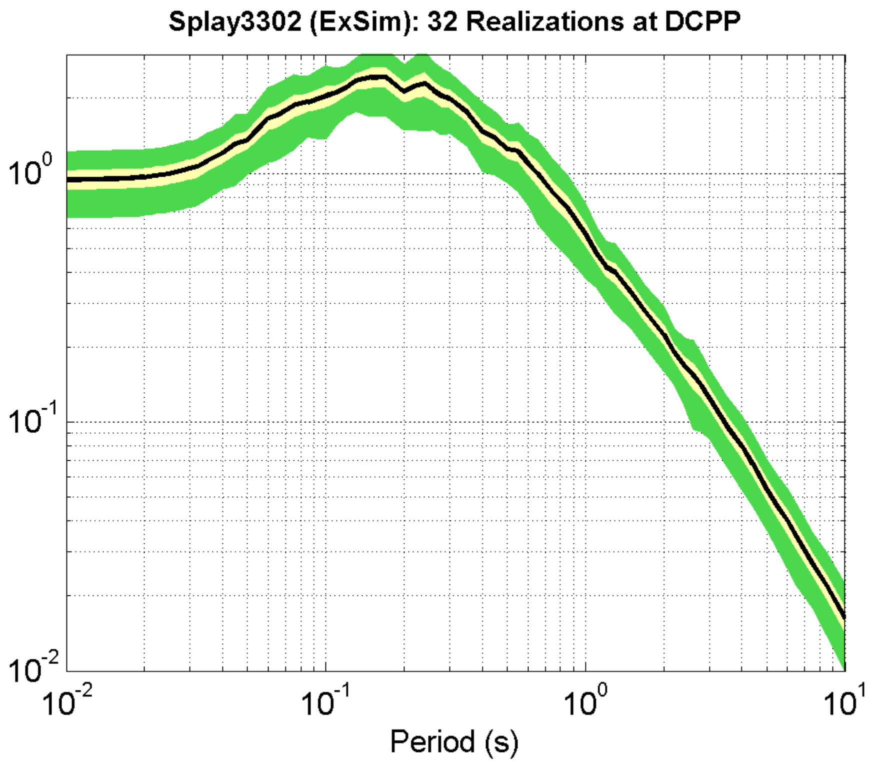
Segment A: Hosgri Mw=7.4, R=5.1

Segment B: Shoreline Mw=6.43, R=0.66

Splay 1: Hosgri - Shoreline

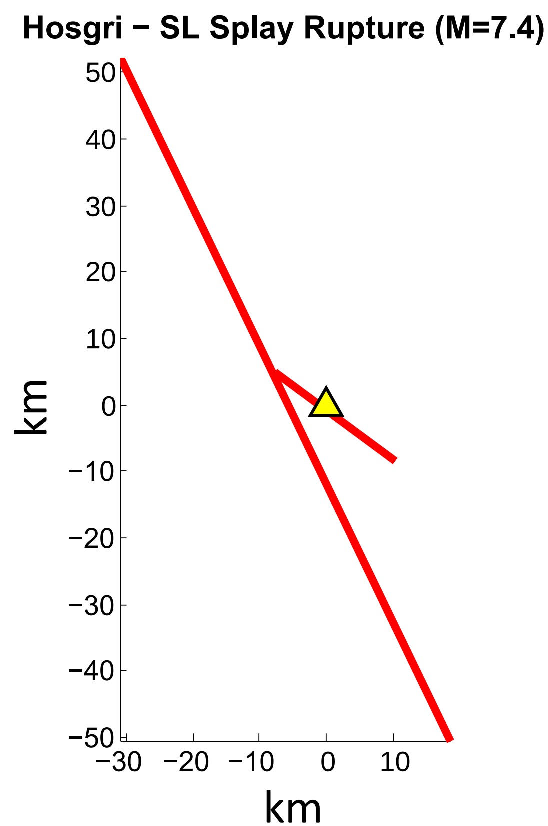
Results - ExSim



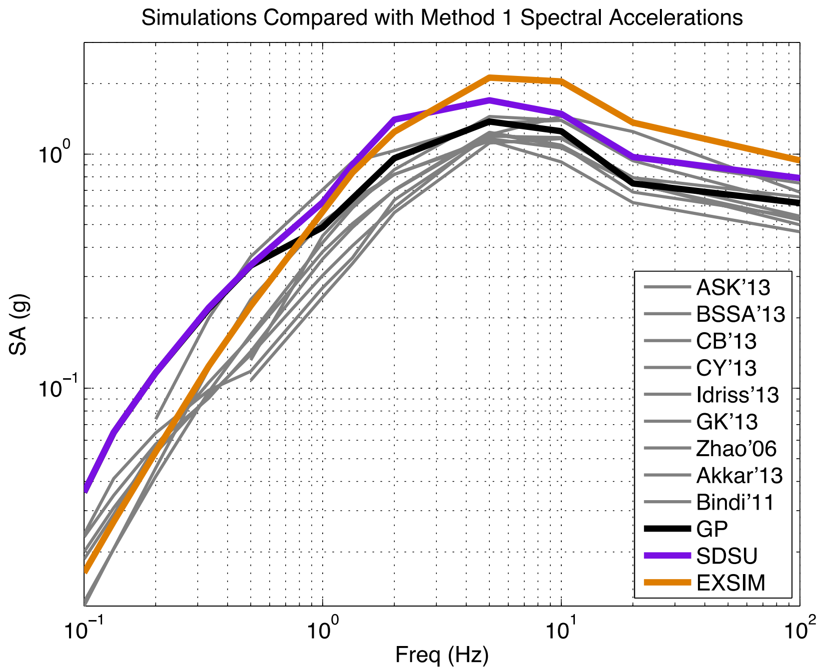


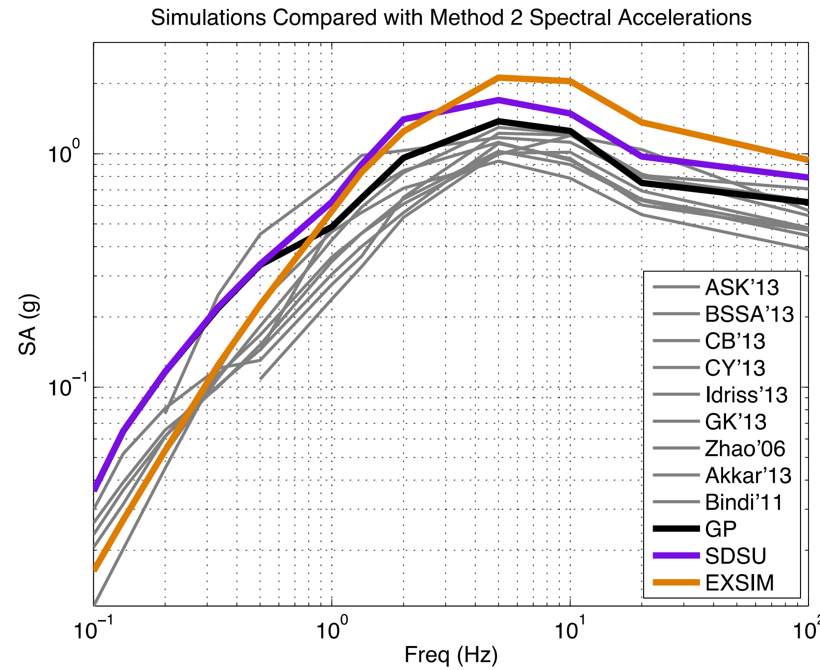
Segment A: Hosgri Mw=7.4, R=5.1

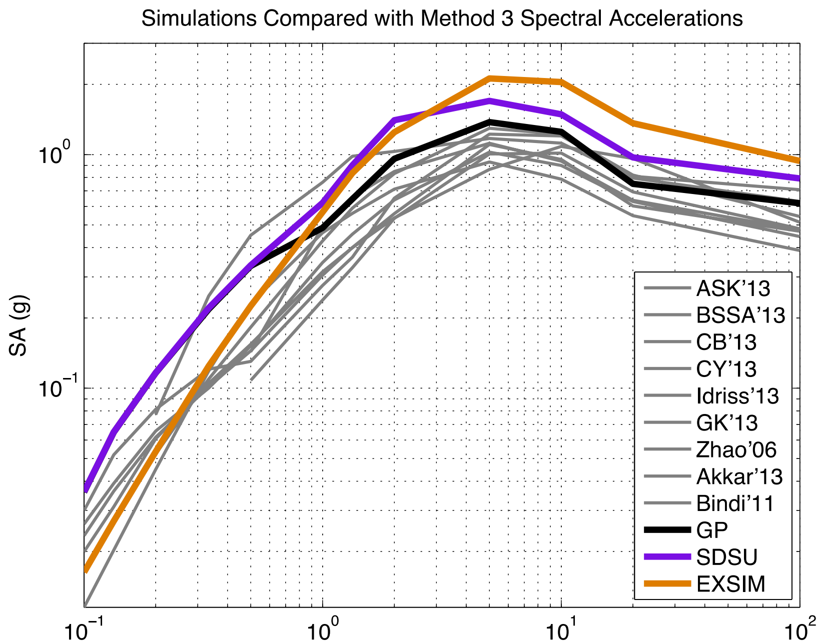
Segment B: Shoreline Mw=6.43, R=0.66

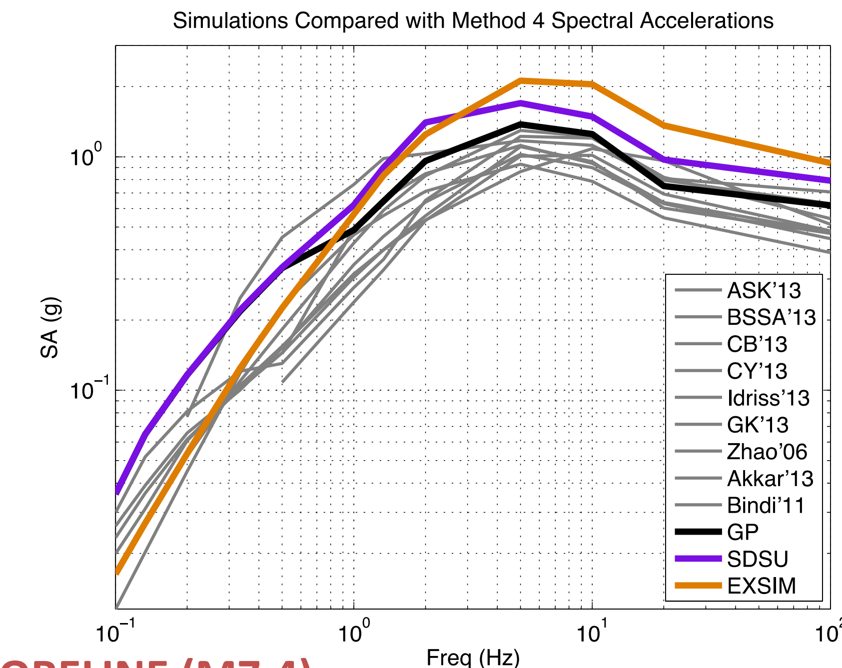


	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Hosgri M1	5.10	5.10	5.10	7.40	90	180	22.00
Shoreline M1	0.66	0.66	0.66	6.43	90	180	11.93
Splay M2	0.66	0.66	0.66	7.44	90	180	20.35
Splay M3	0.66	0.66	0.66	7.44	90	180	13.06
Splay M4	0.66	0.66	0.66	7.44	90	180	11.93







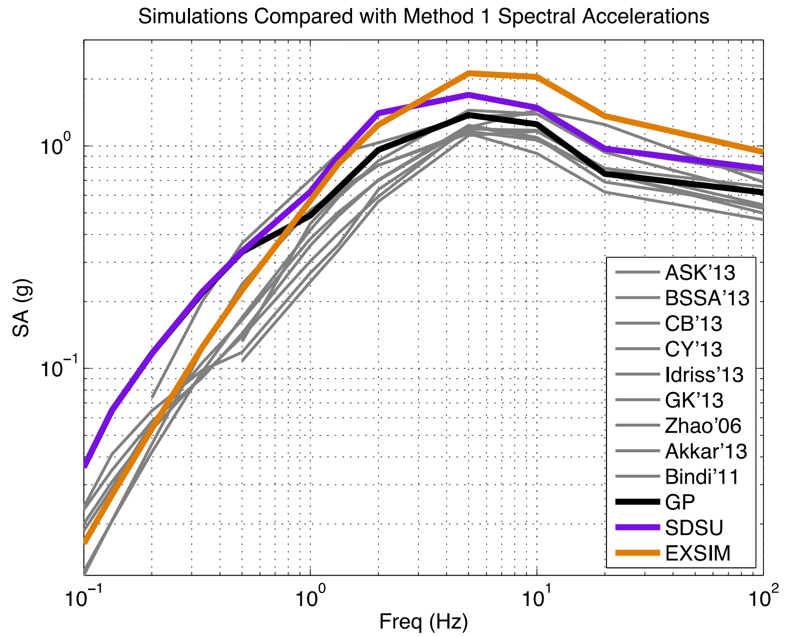


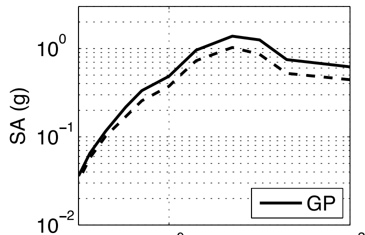
HOSGRI + SHORELINE (M7.4)

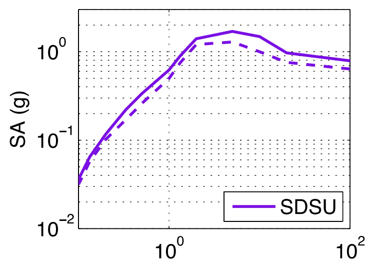
RESULTS FOR METHOD 5: SIMULATIONS

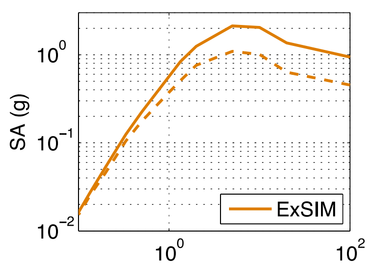
NUMERATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	DDwidth (km)
Hosgri M5	5.10	5.10	5.10	7.40	90	180	22.00
Shoreline M5	0.66	0.66	0.66	6.43	90	180	11.93

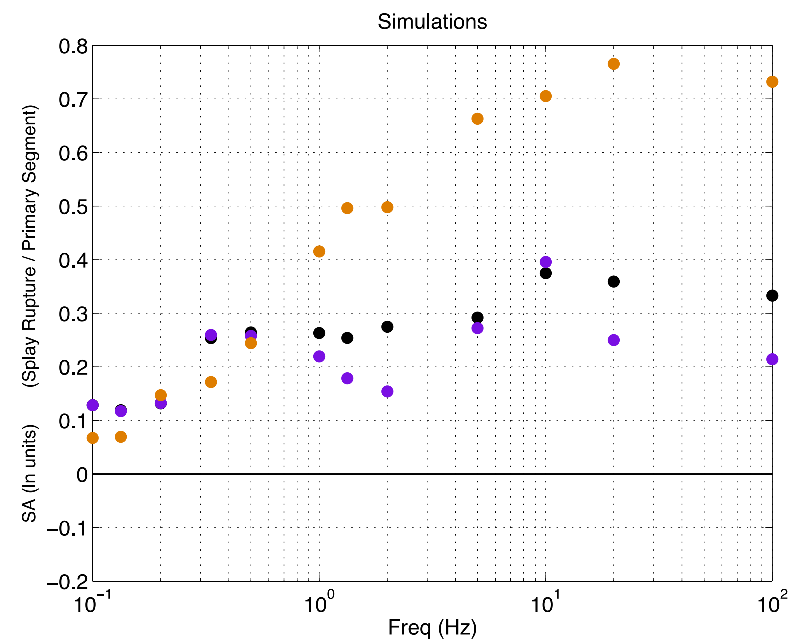
DENOMINATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	DDwidth (km)
Hosgri	5.10	5.10	5.10	7.40	90	180	22.00







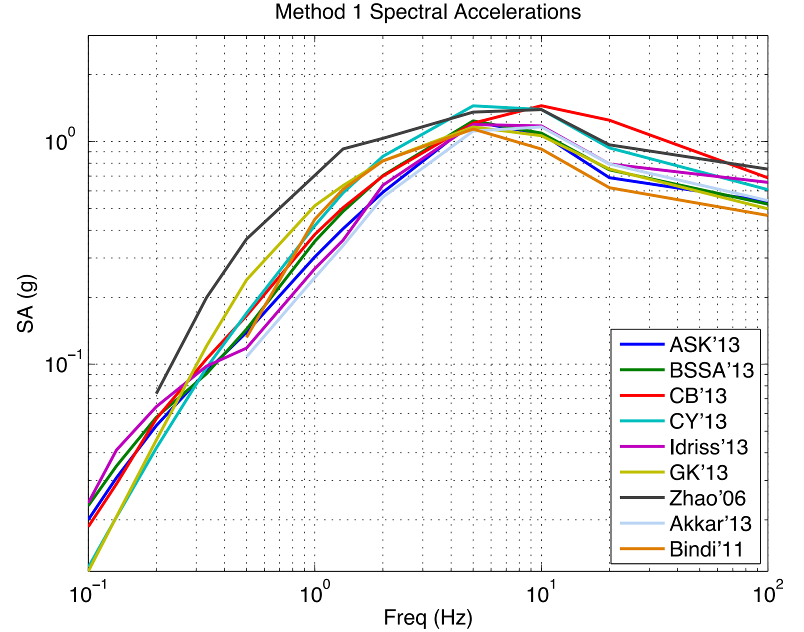


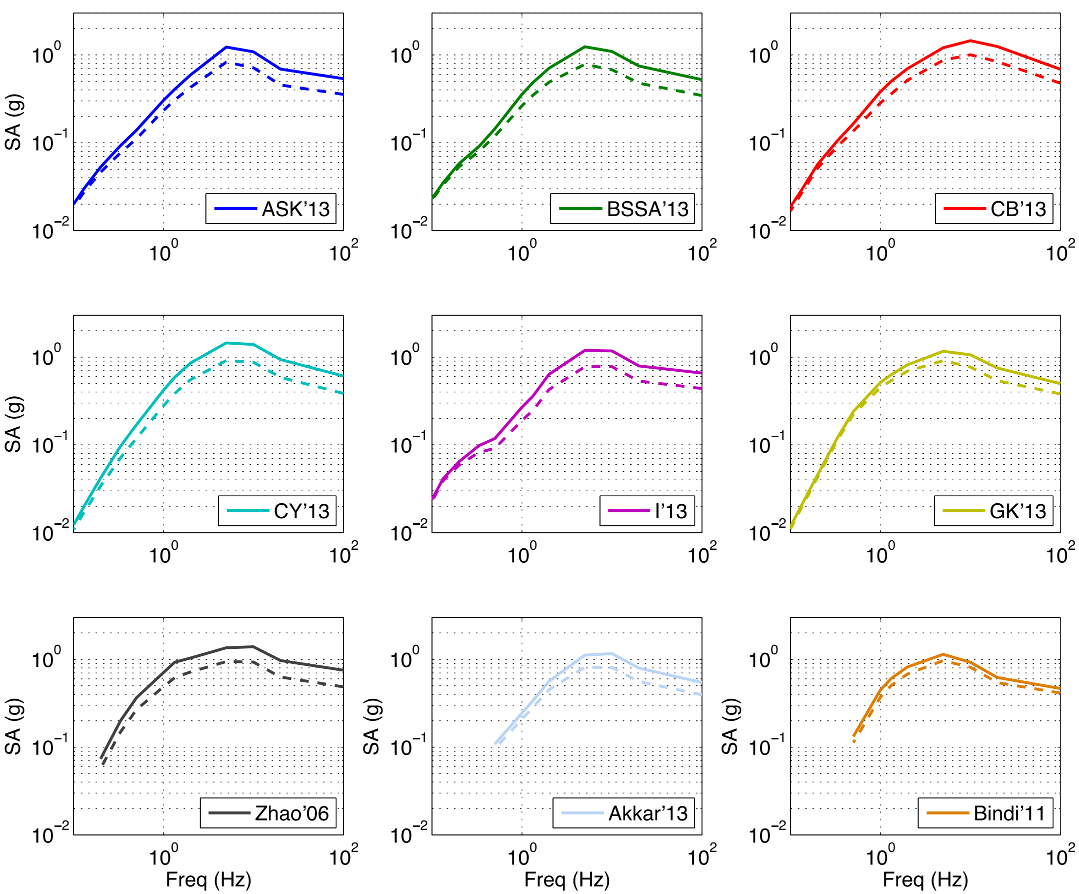


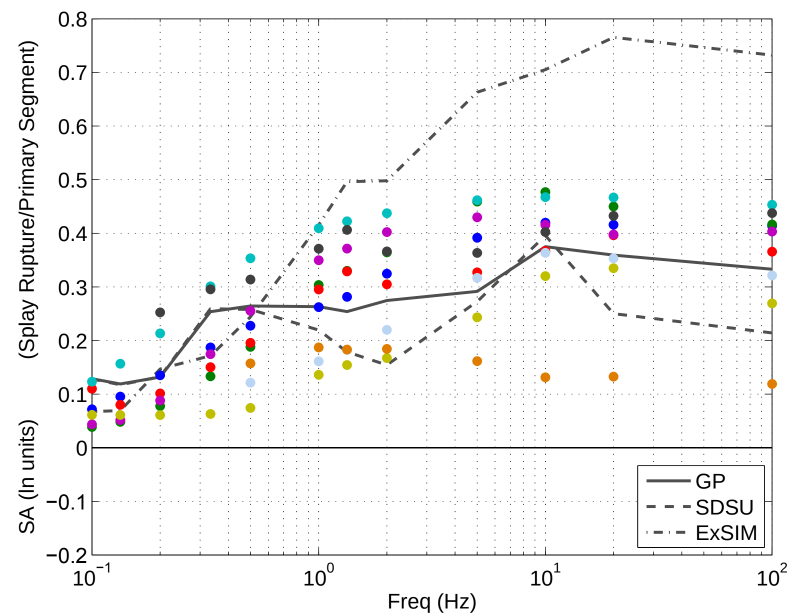
RESULTS FOR METHOD 1: SRSS SINGLE SEGMENT SPECTRA

NUMERATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Hosgri M1	5.10	5.10	5.10	7.40	90	180	22.00
Shoreline M1	0.66	0.66	0.66	6.43	90	180	11.93

DENOMINATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Hosgri	5.10	5.10	5.10	7.40	90	180	22.00



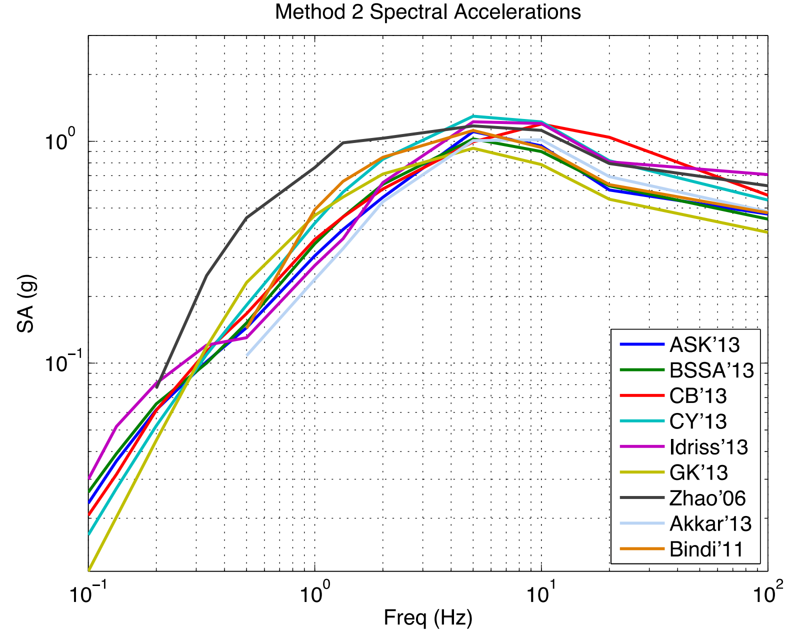


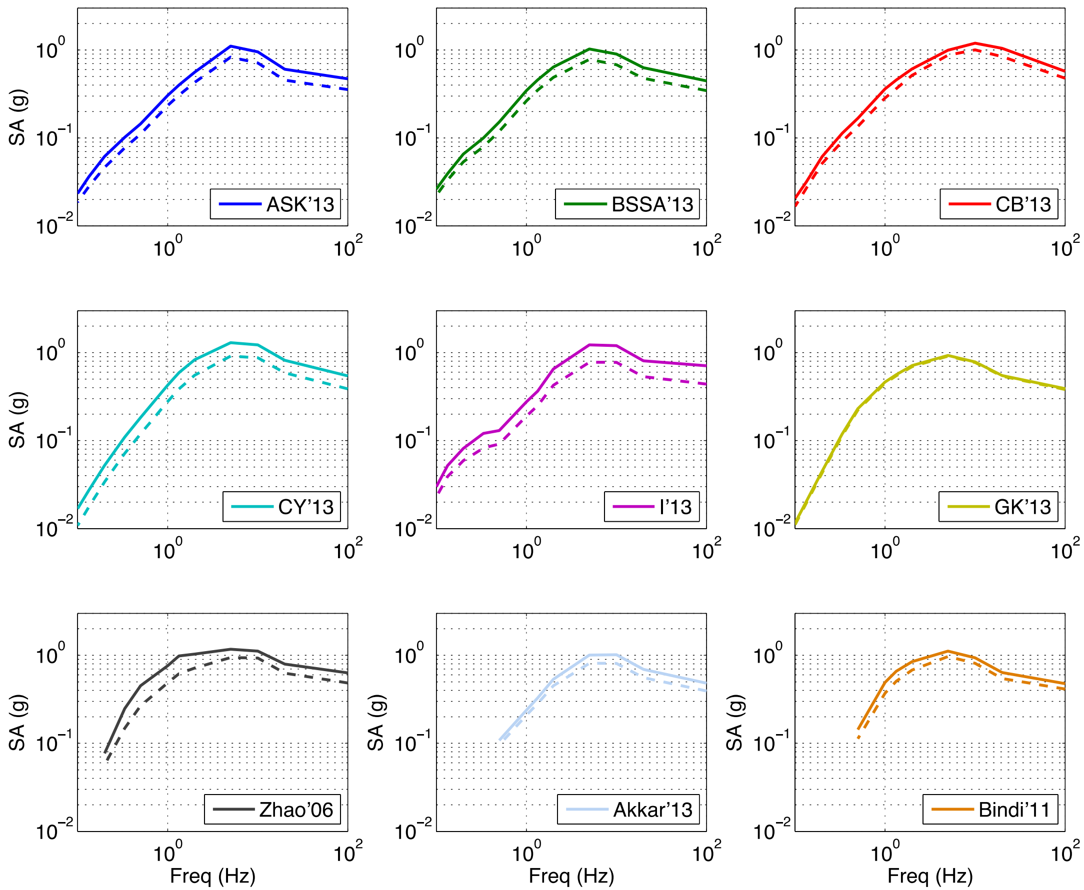


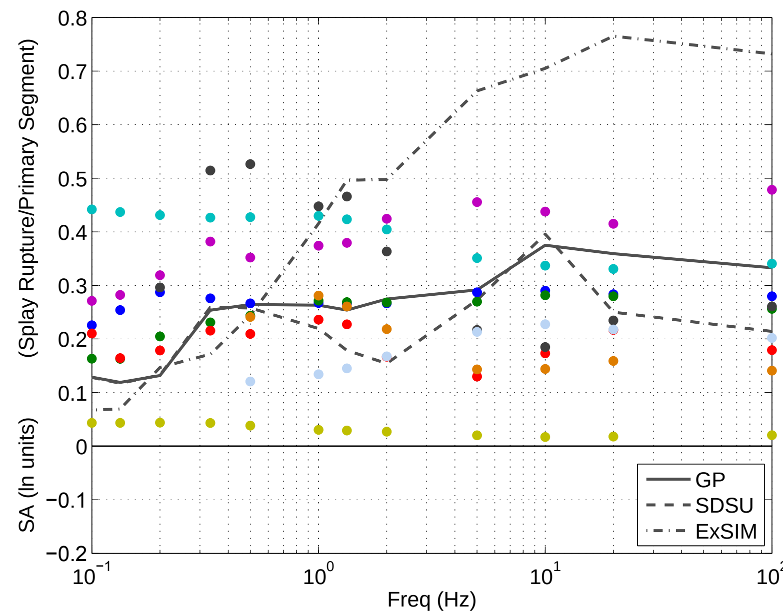
RESULTS FOR METHOD 2: AVG. PARAMETERS (AREA)

NUMERATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Splay M2	0.66	0.66	0.66	7.44	90	180	20.35

DENOMINATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Hosgri	5.10	5.10	5.10	7.40	90	180	22.00



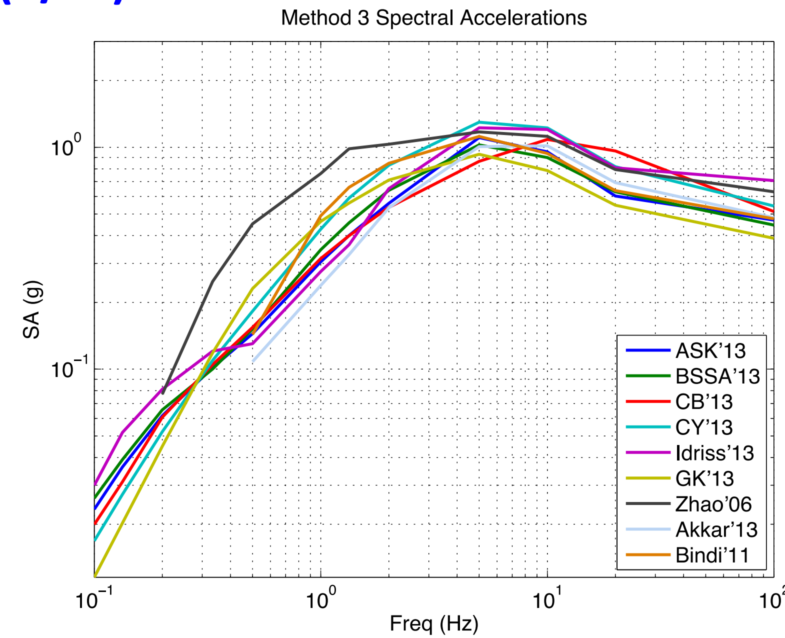


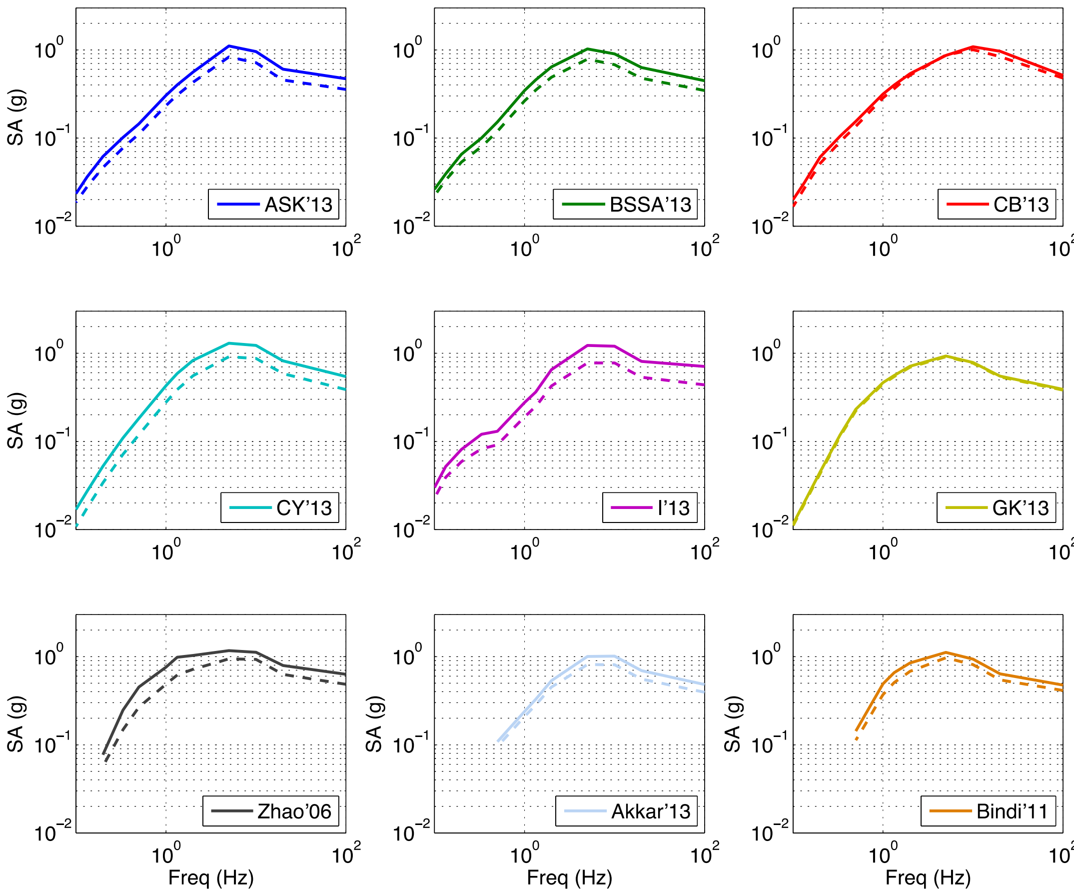


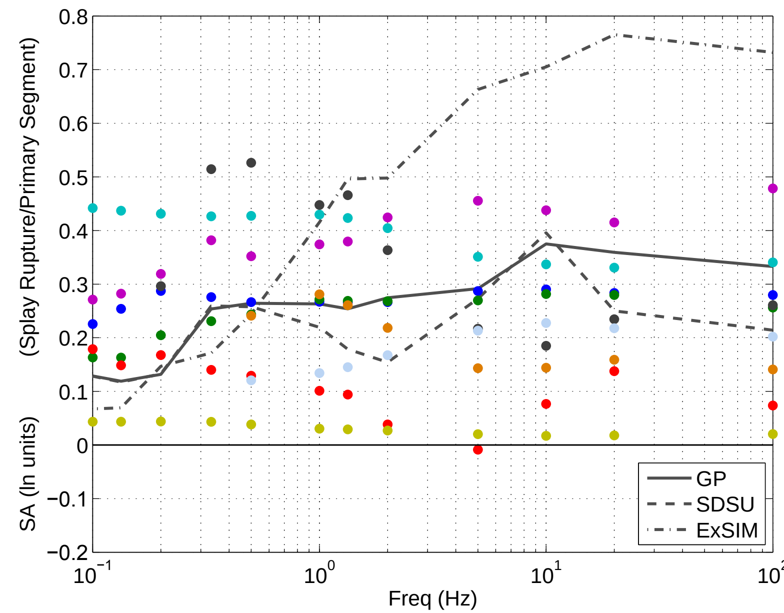
RESULTS FOR METHOD 3: AVG. PARAMETERS ($1/R^2$)

NUMERATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Splay M3	0.66	0.66	0.66	7.44	90	180	13.06

DENOMINATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Hosgri	5.10	5.10	5.10	7.40	90	180	22.00



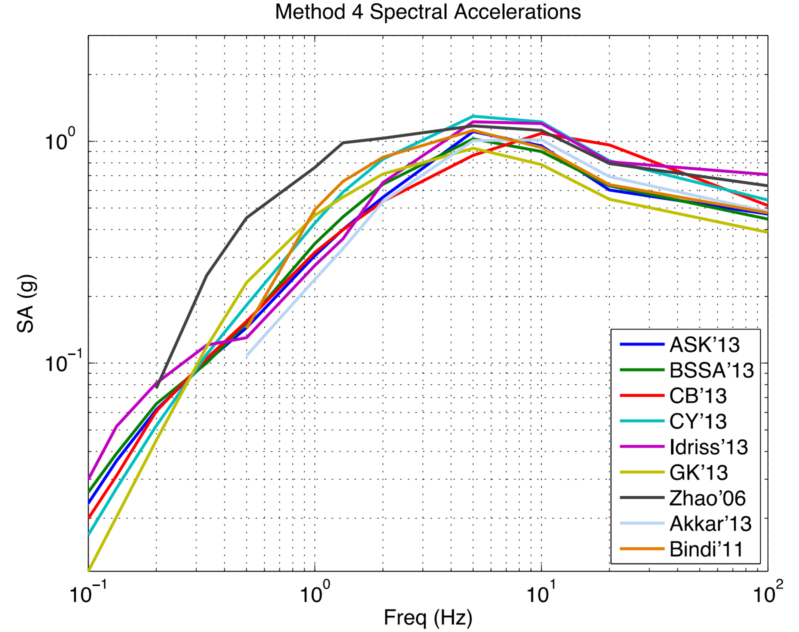


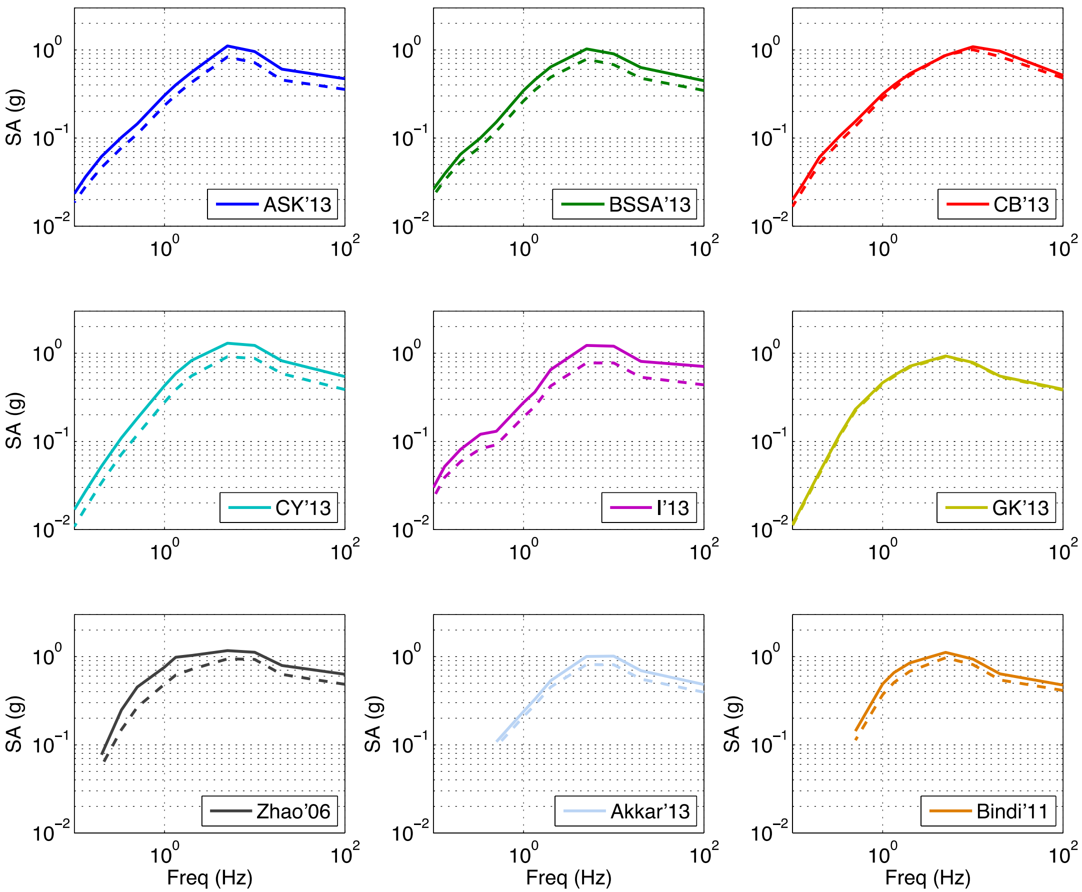


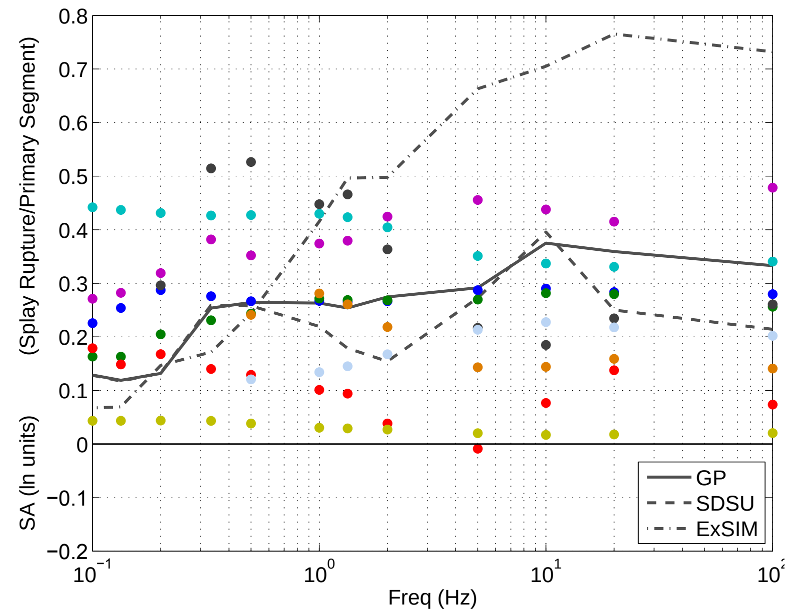
RESULTS FOR METHOD 4: CLOSEST SEGMENT PARAMETERS

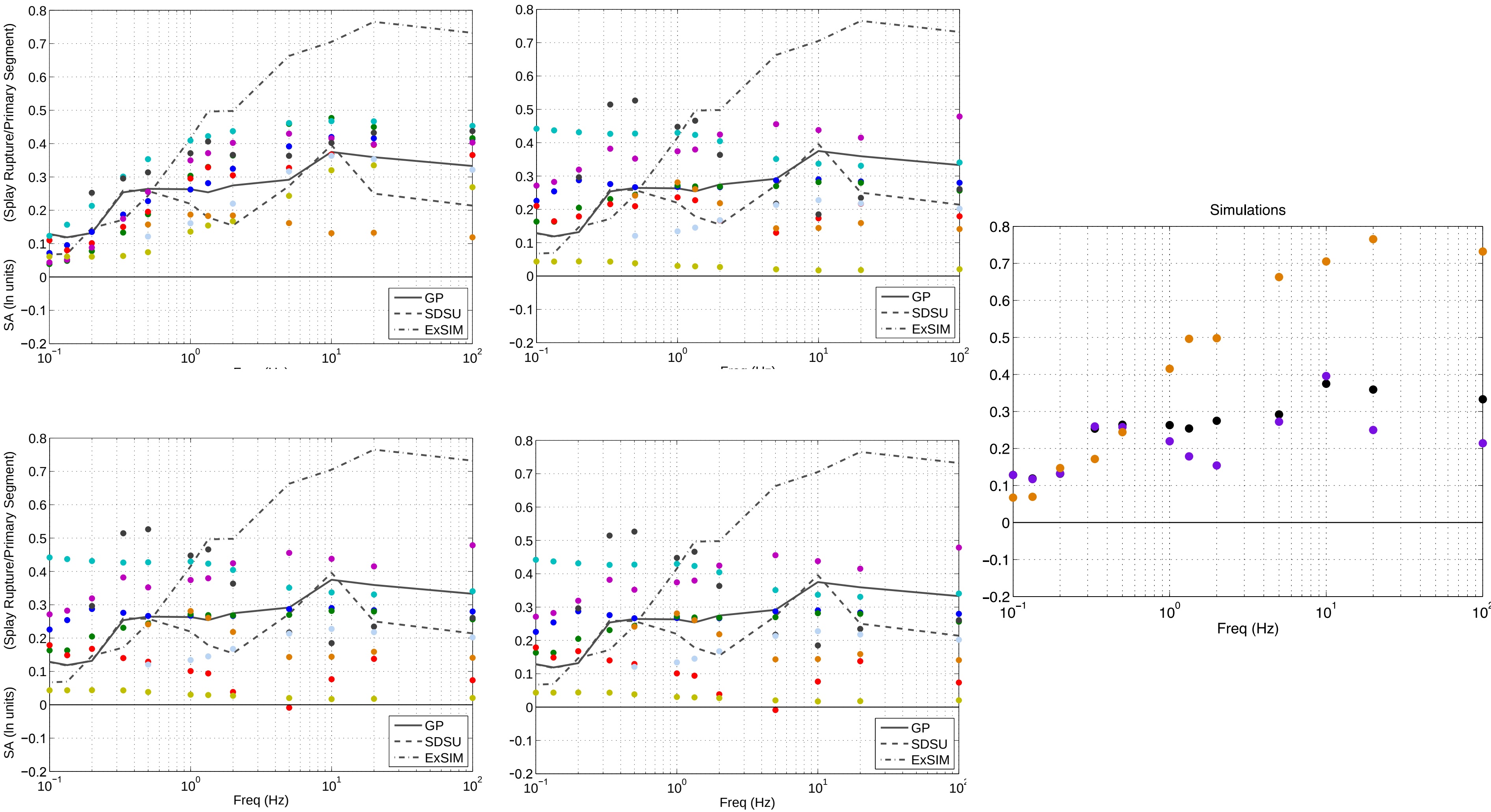
NUMERATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	width$_{DD}$ (km)
Splay M4	0.66	0.66	0.66	7.44	90	180	11.93

DENOMINATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	width$_{DD}$ (km)
Hosgri	5.10	5.10	5.10	7.40	90	180	22.00







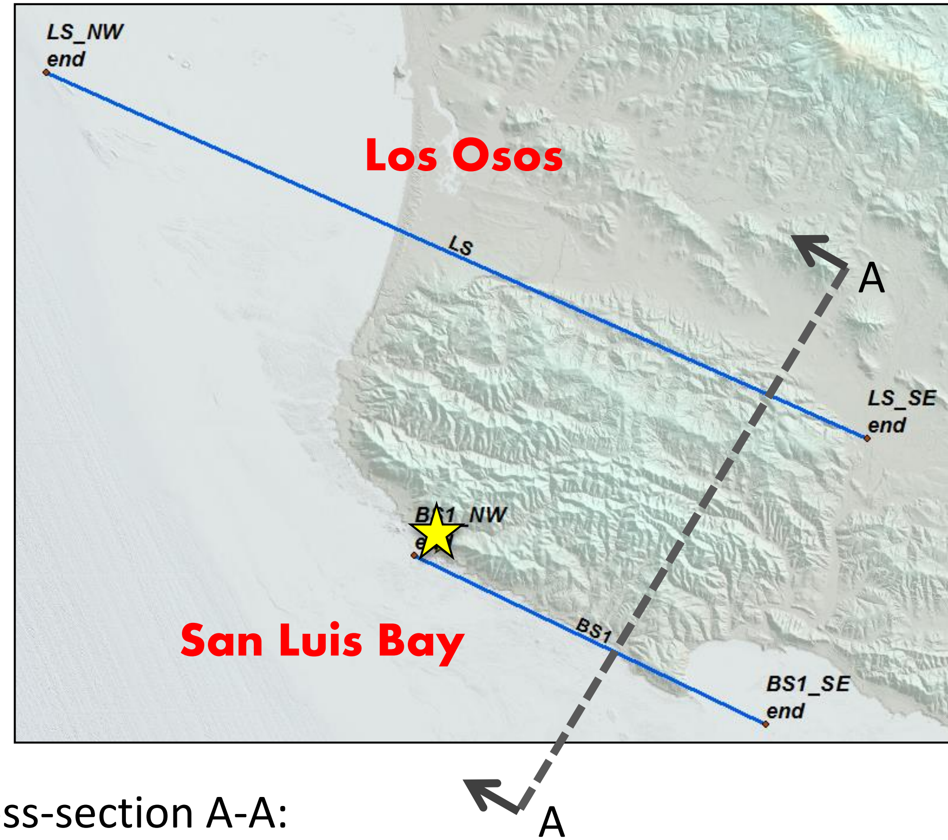


HOSGRI + LOS OSOS (M7.4)

SWUS SSHAC Simulations

SPLAY FAULT SCENARIOS: LOS OSOS + SAN LUIS BAY

- SSC: Slip rate on San Luis Bay is 10% of slip rate on Los Osos for moment balancing
- Hypocenters at base
- Lengths
  - Los Osos (LS) = varies
  - San Luis Bay 1 (BS1) = 14.4 km
- Dip of Los Osos = 50 SW
- Dip of San Luis Bay = 70 NE
- Rake (both faults) = 90 (Rev)
- Depth to top: 0 km

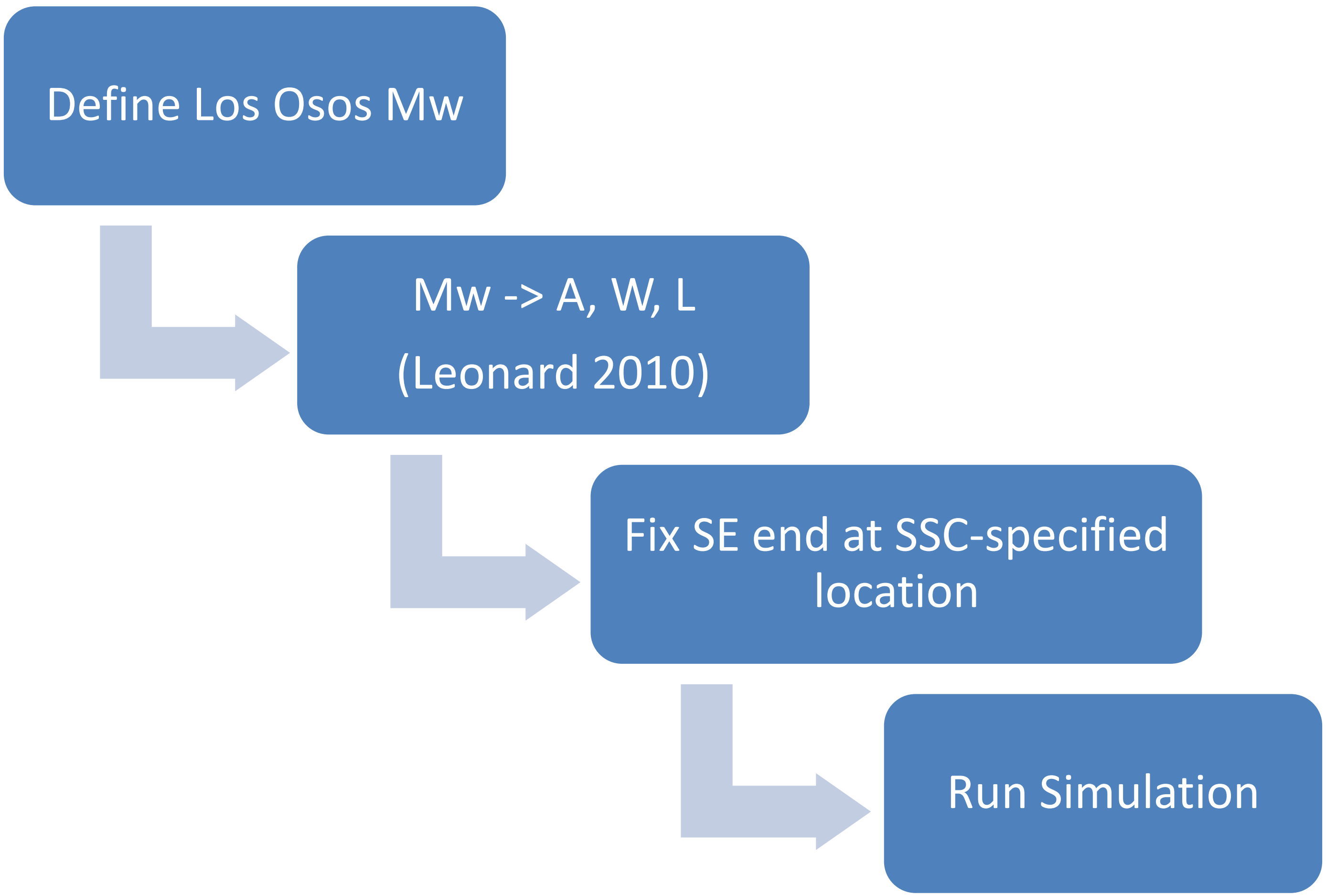


Cross-section A-A:

Splay 2: Los Osos – San Luis Bay

Method for Determining Scenario Properties

Los Osos (Primary Segment)



Splay 2: Los Osos – San Luis Bay

Method for Determining Scenario Properties

SLB (Secondary Segment)

W=12.7 km fixed from SSC recommendations

W→ L→ A→ Mw
(Leonard 2010)

Fix SE end at SSC-specified location

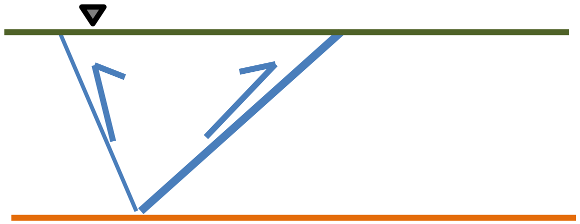
Run Simulation

Splay 2: Los Osos – San Luis Bay

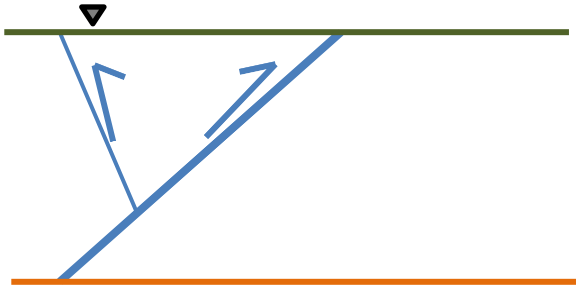
Summary of Scenario Properties

- SLB using fixed SSC defined W=12.7 km
  - Leonard (2010): Mw=6.39, L=19.55 km
- LO (primary) using Mw= 7.0, 7.2, 7.4
  - Leonard gives: W=22, 26.6, 32 km respectively
  - SLB slip is 50% , 40%, 32% of LO slip, respectively
  - LO extends beyond depth of SLB

So instead of this:

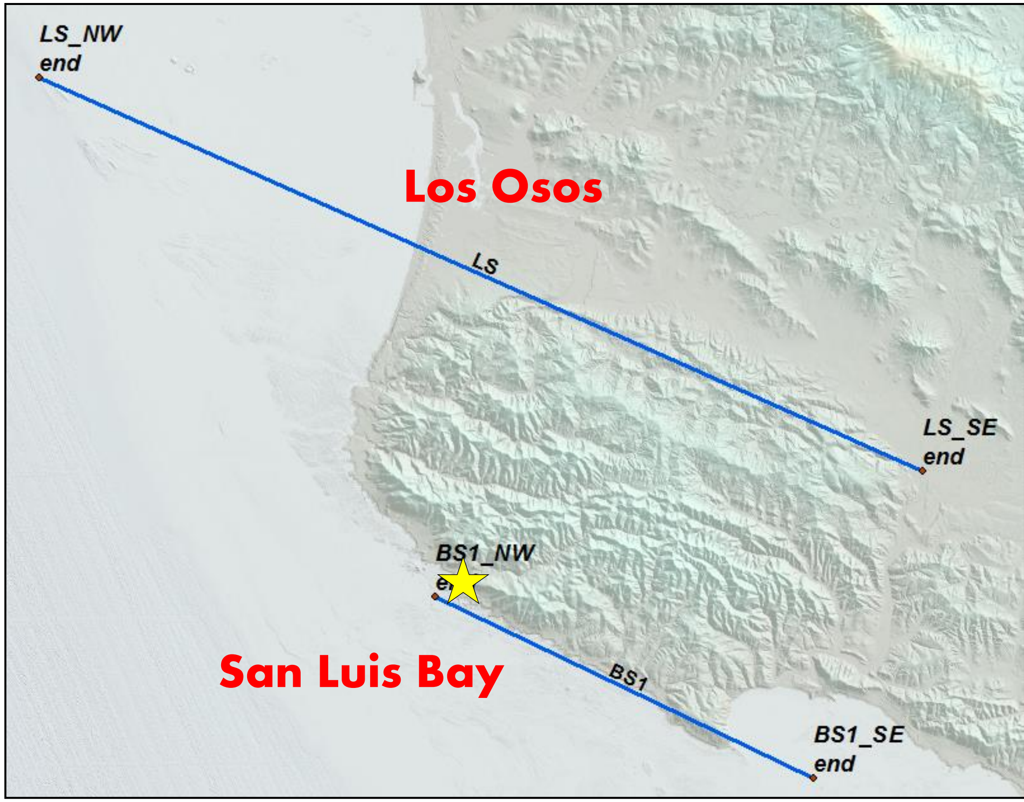


We have this:



Splay 2: Los Osos – San Luis Bay

This presentation will focus on the
Los Osos Mw=7.4,
Shoreline Mw=6.39 case

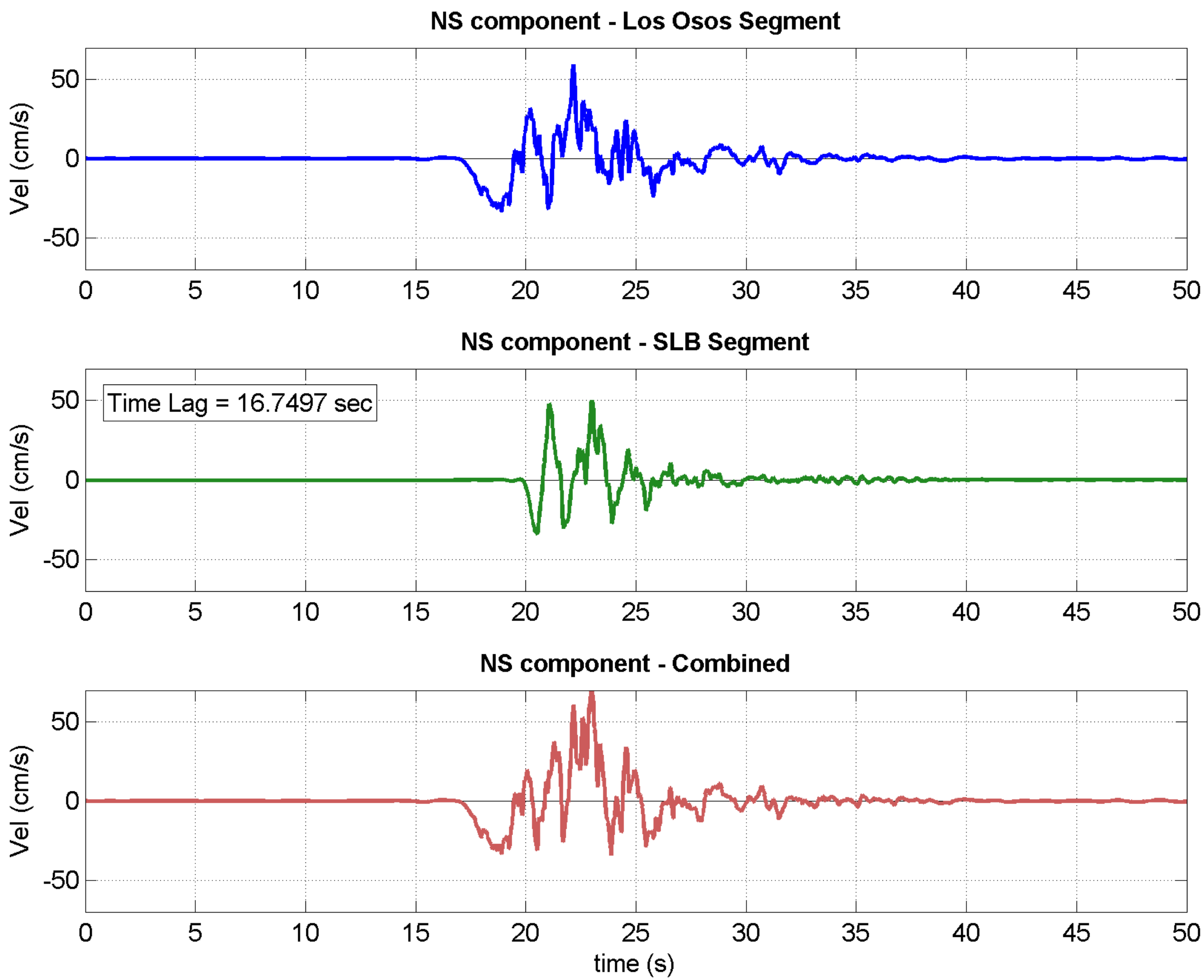


Segment	Rrup	Rjb	Rx
Los Osos	8.57	0.00	9.90
SLB	1.00	0.00	1.07

Segment	Mw	Strike	Rake	Dip	Ztor	L	W
Los Osos	7.4	115.4	90	60	0	78.19	32.0
SLB	6.39	295.4	90	70	0	19.55	12.7

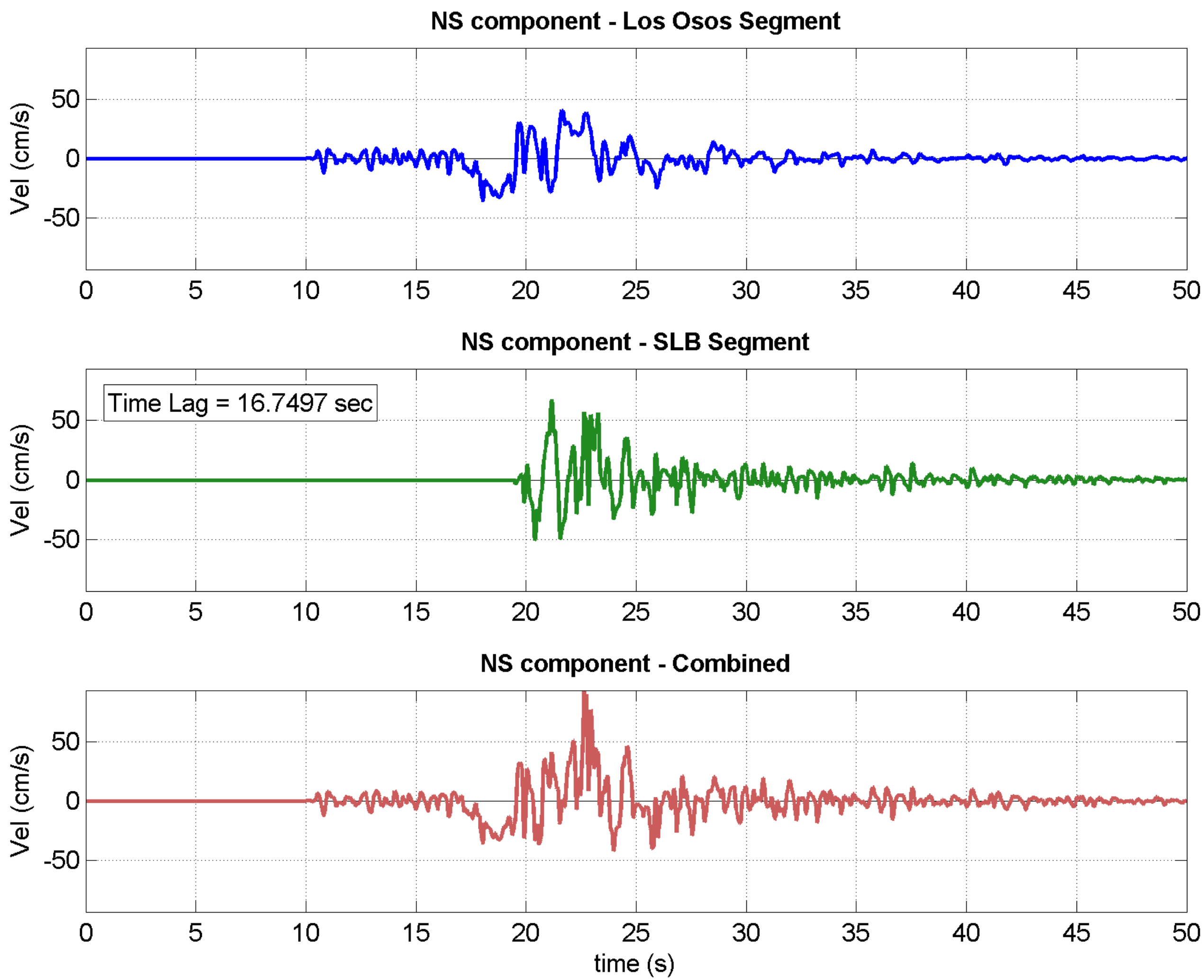
Splay 2: Los Osos – San Luis Bay

Example Waveforms - (GP Method, Realization 06)



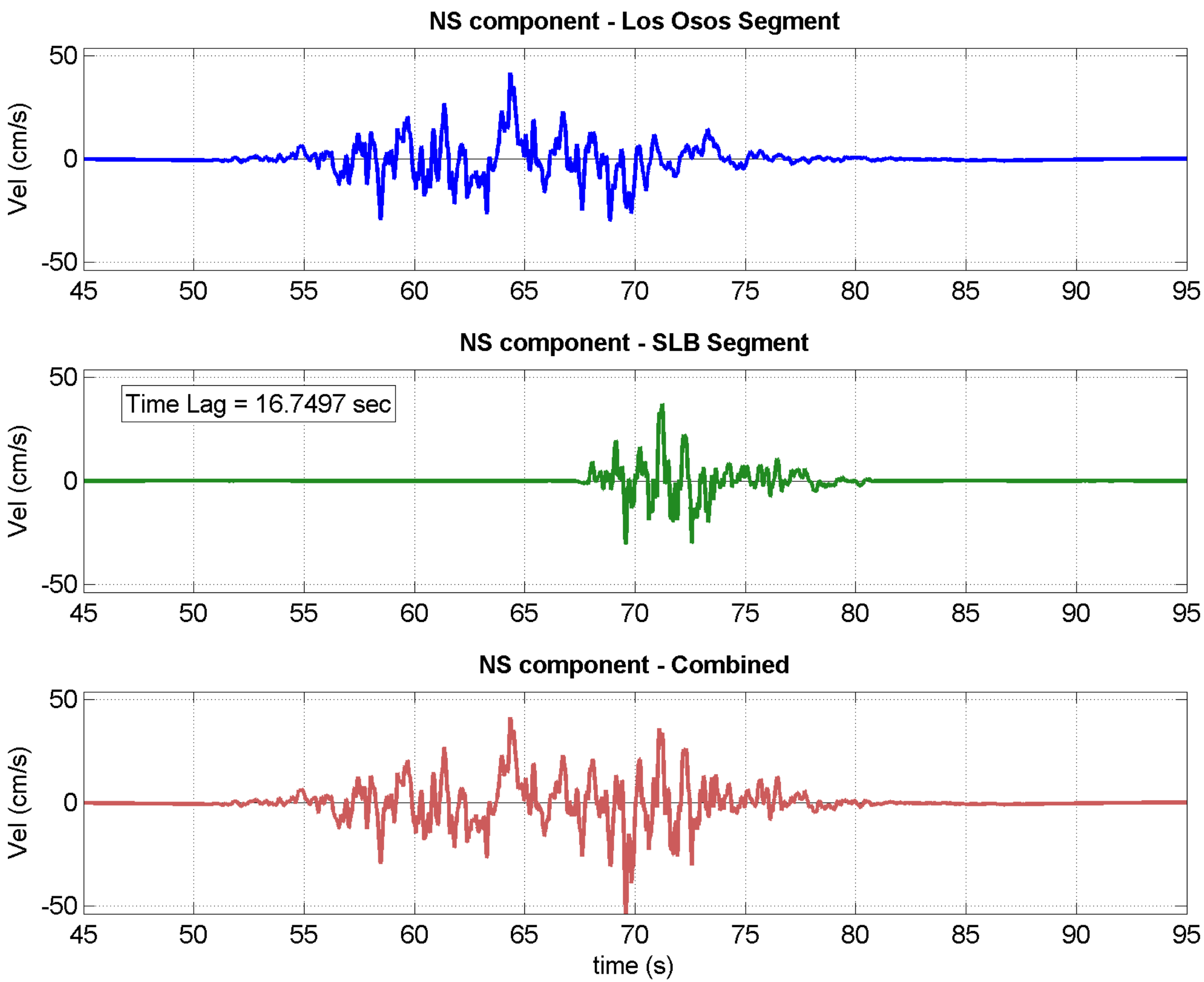
Splay 2: Los Osos – San Luis Bay

Example Waveforms - (SDSU Method, Realization 06)



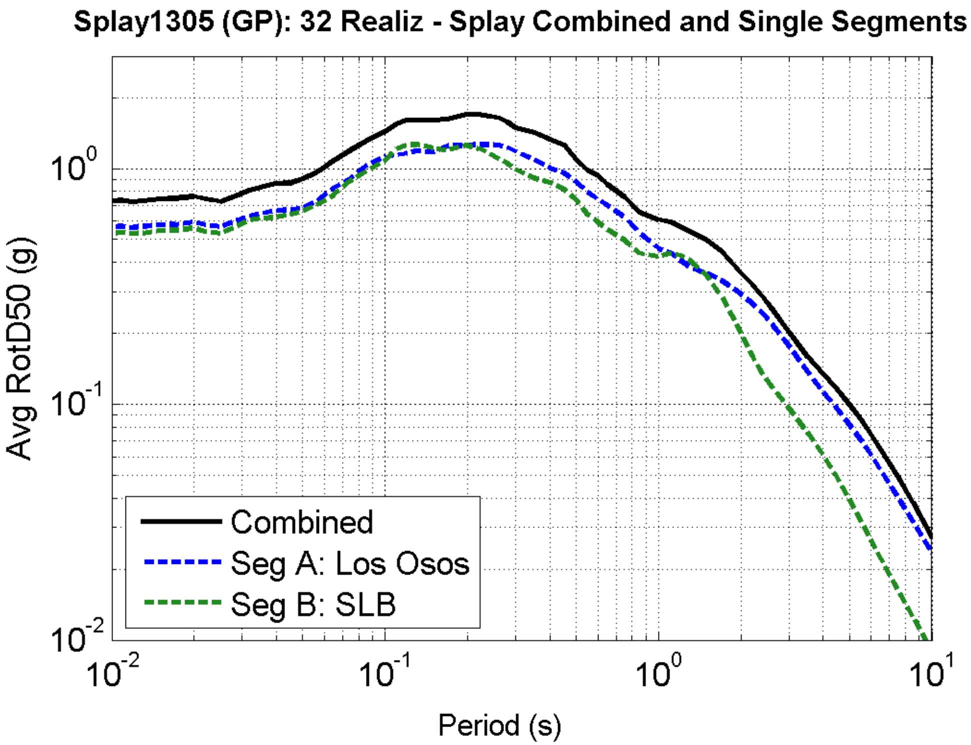
Splay 2: Los Osos – San Luis Bay

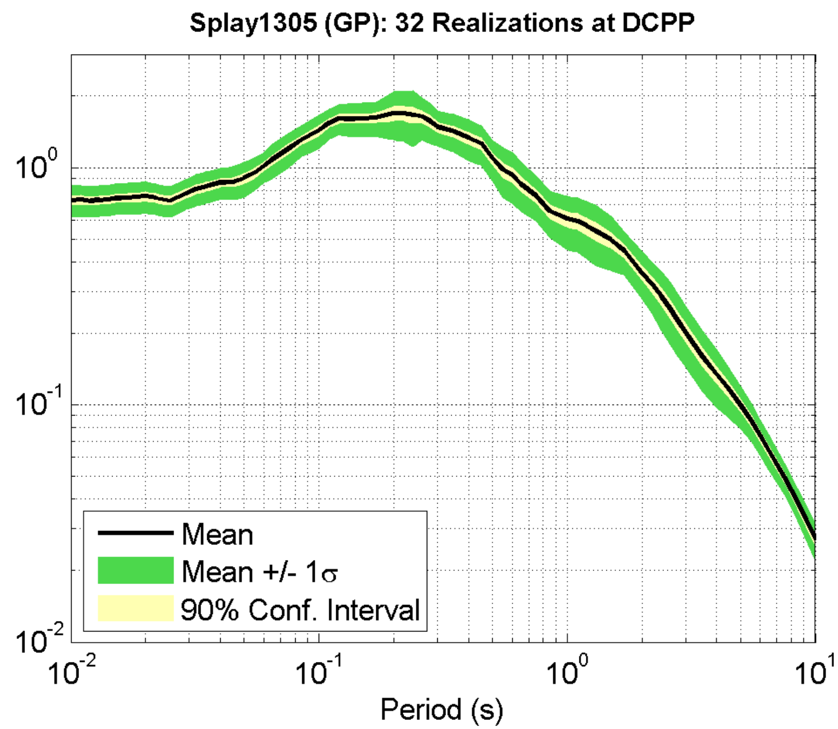
Example Waveforms - (ExSim Method, Realization 06)



Splay 2: Los Osos – San Luis Bay

Results - GP

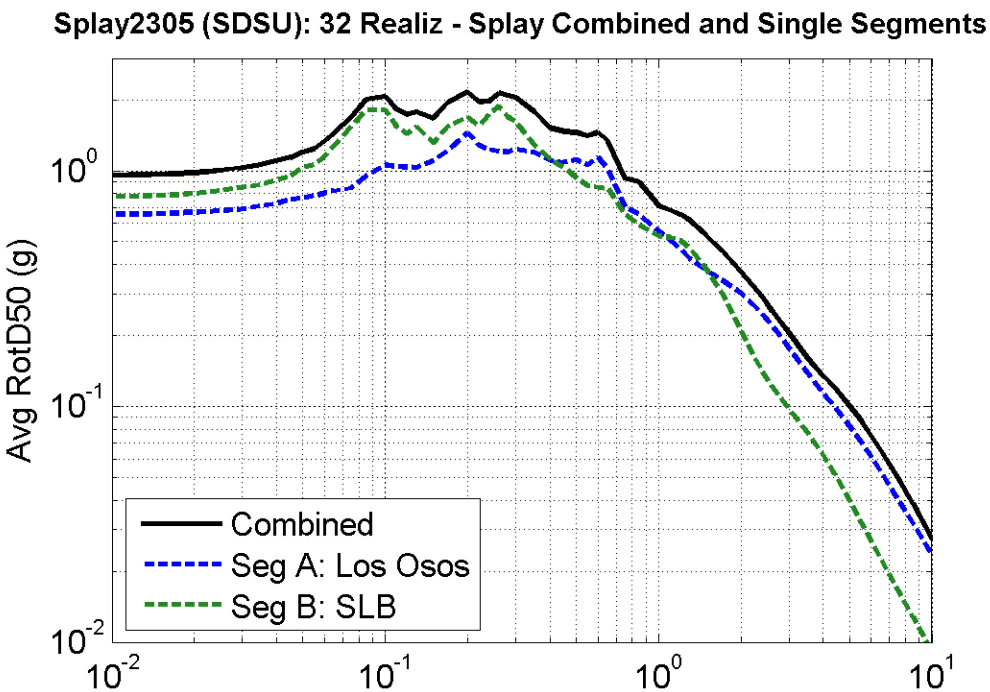


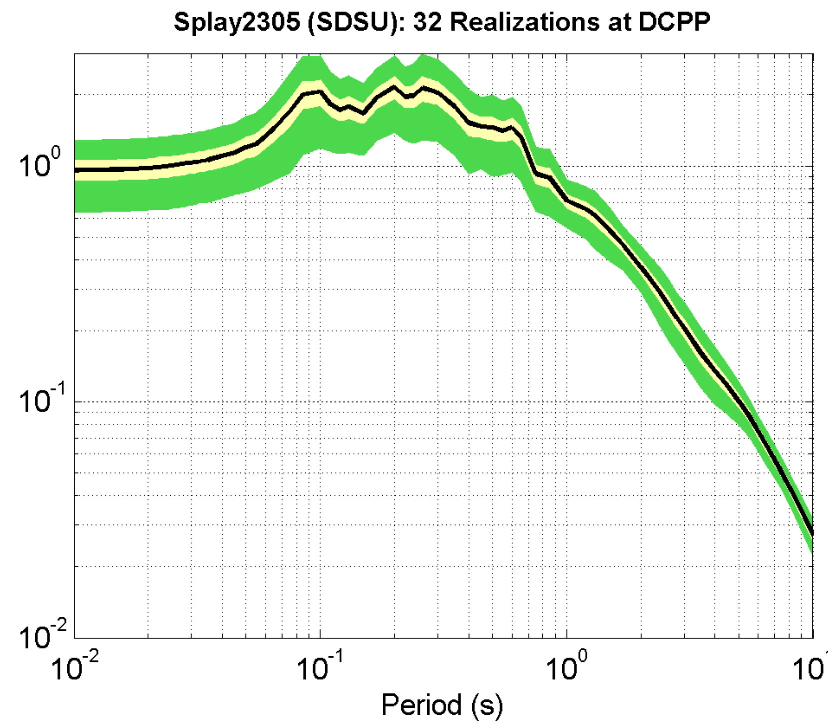


Segment A: Los Osos	Mw=7.4, Rx=9.9
Segment B: SLB	Mw=6.39, Rx=1.07

Splay 2: Los Osos – San Luis Bay

Results - SDSU

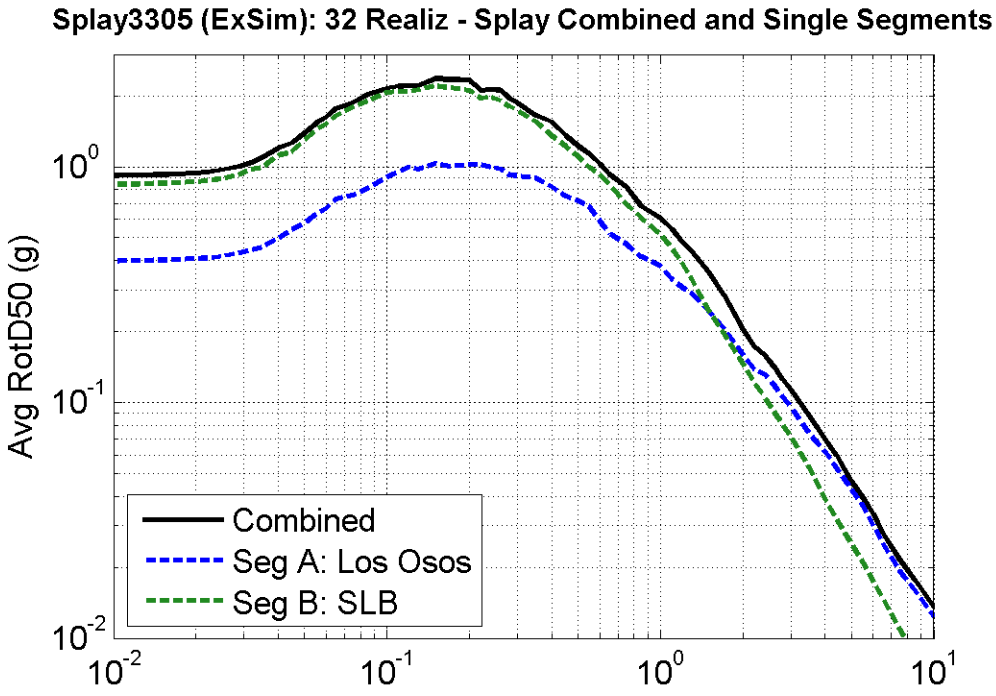


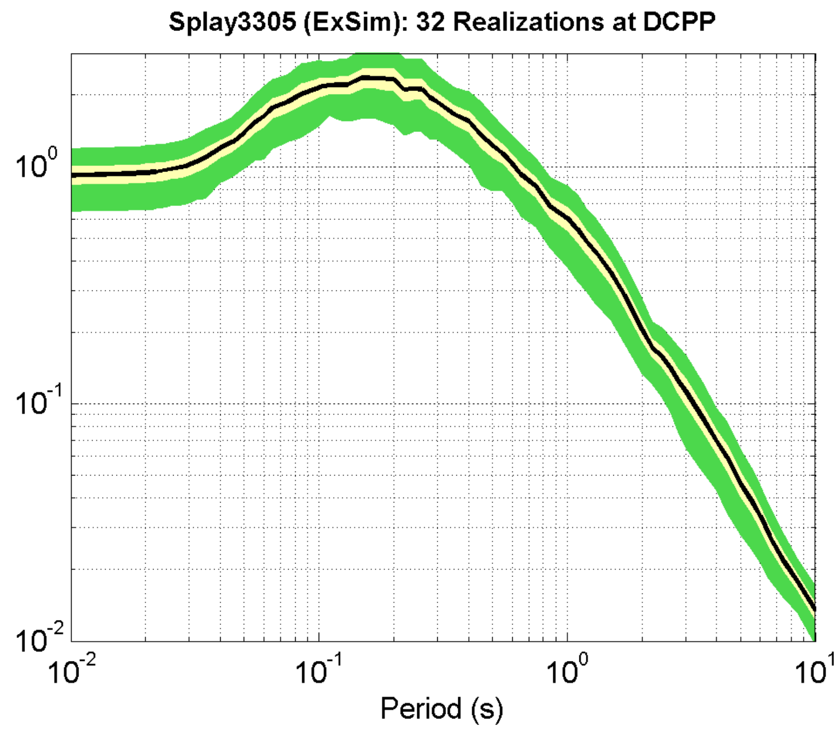


Segment A: Los Osos	Mw=7.4, Rx=9.9
Segment B: SLB	Mw=6.39, Rx=1.07

Splay 2: Los Osos – San Luis Bay

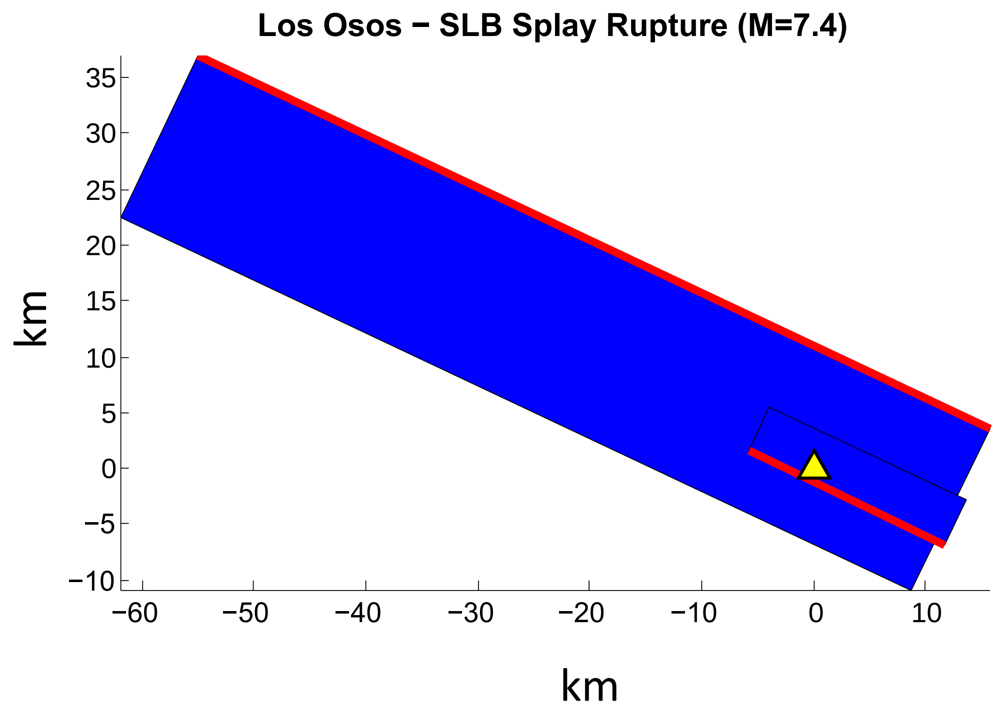
Results - ExSim



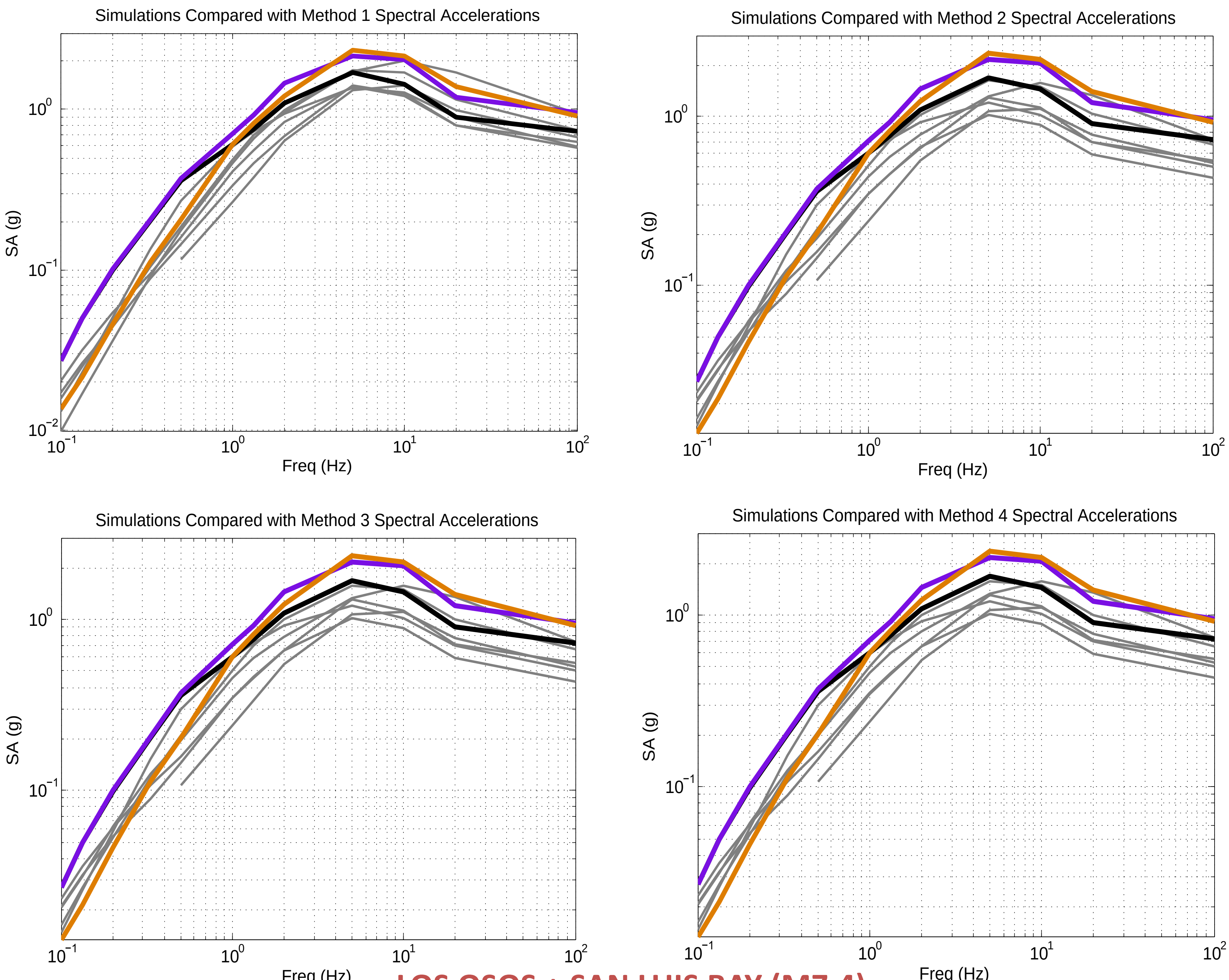


Segment A: Los Osos Mw=7.4, Rx=9.9

Segment B: SLB Mw=6.39, Rx=1.07



	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Los Osos M1	8.57	0.0	9.90	7.40	60.0	90	32.0
San Luis Bay M1	1.00	0.0	1.07	6.40	70.0	90	12.7
Splay M2	1.00	0.0	1.07	7.44	62.00	90	28.14
Splay M3	1.00	0.0	1.07	7.44	69.20	90	14.24
Splay M4	1.00	0.0	1.07	7.44	70.0	90	12.7

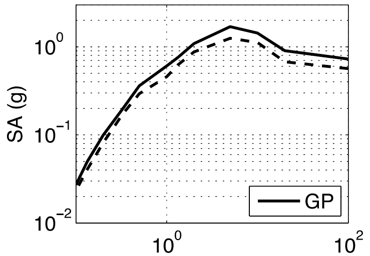


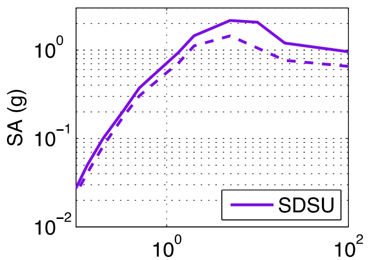
LOS OSOS + SAN LUIS BAY (M7.4)

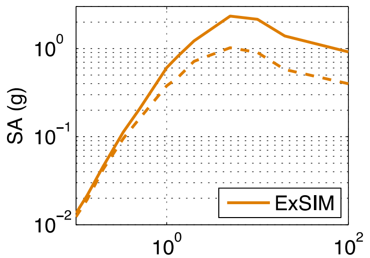
RESULTS FOR METHOD 5: SIMULATIONS

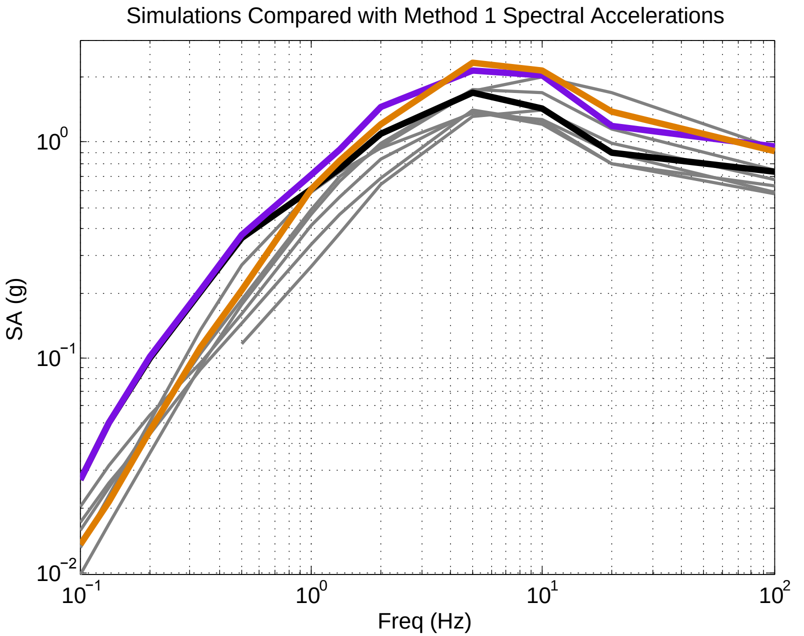
NUMERATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Los Osos M5	8.57	0.0	9.90	7.40	60	90	32.00
San Luis Bay M5	1.00	0.0	1.07	6.40	70	90	12.70

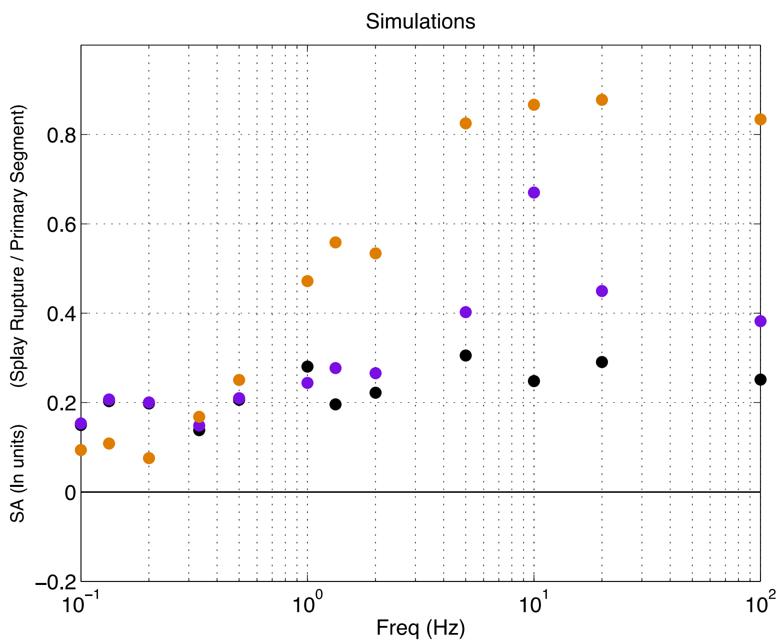
DENOMINATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Los Osos	8.57	0.0	9.90	7.40	60	90	32.00







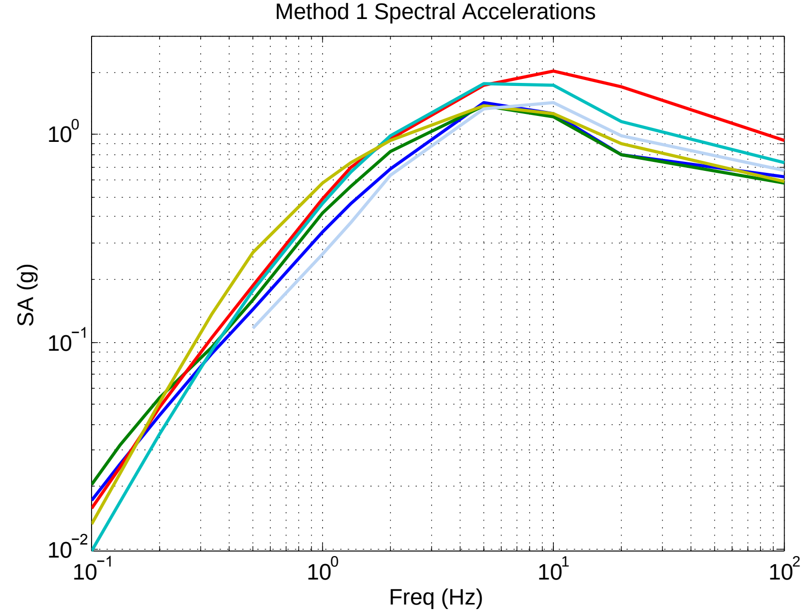


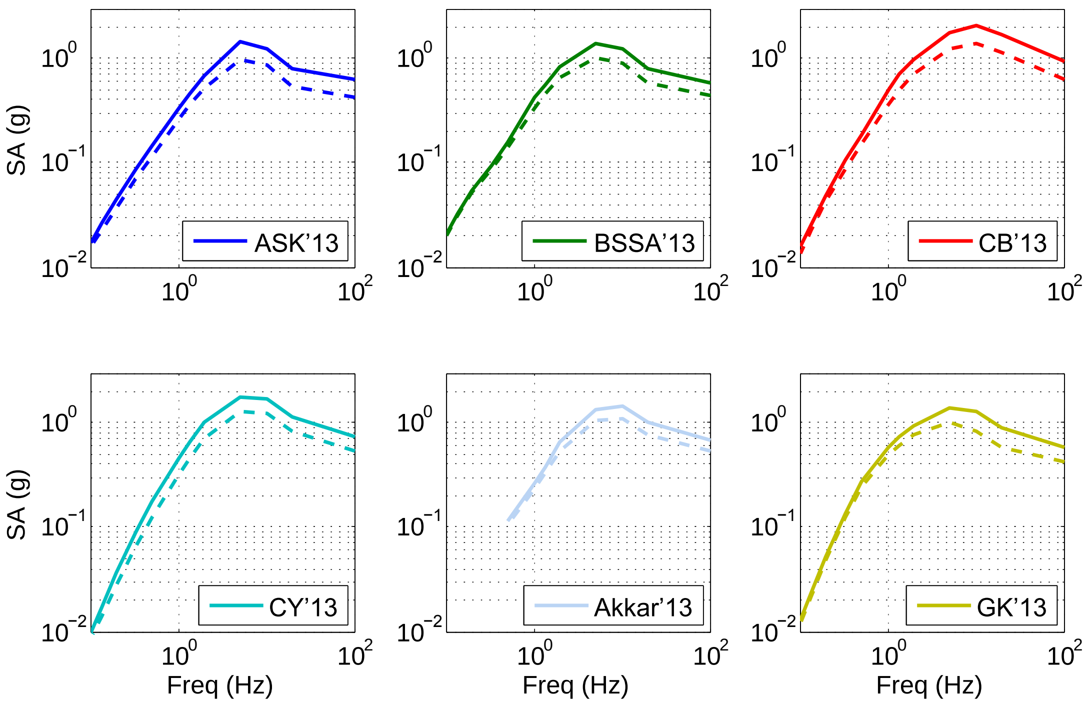


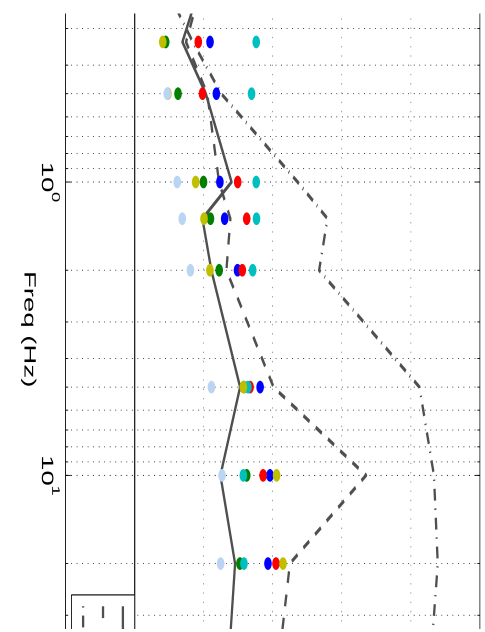
RESULTS FOR METHOD 1: SRSS SINGLE SEGMENT SPECTRA

NUMERATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Los Osos M1	8.57	0.0	9.90	7.40	60	90	32.00
San Luis Bay M1	1.00	0.0	1.07	6.40	70	90	12.70

DENOMINATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Los Osos	8.57	0.0	9.90	7.40	60	90	32.00



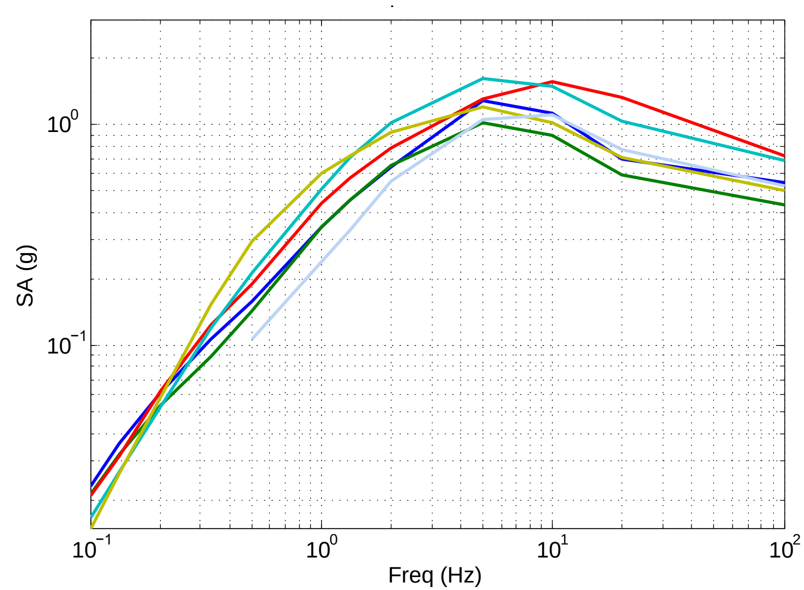


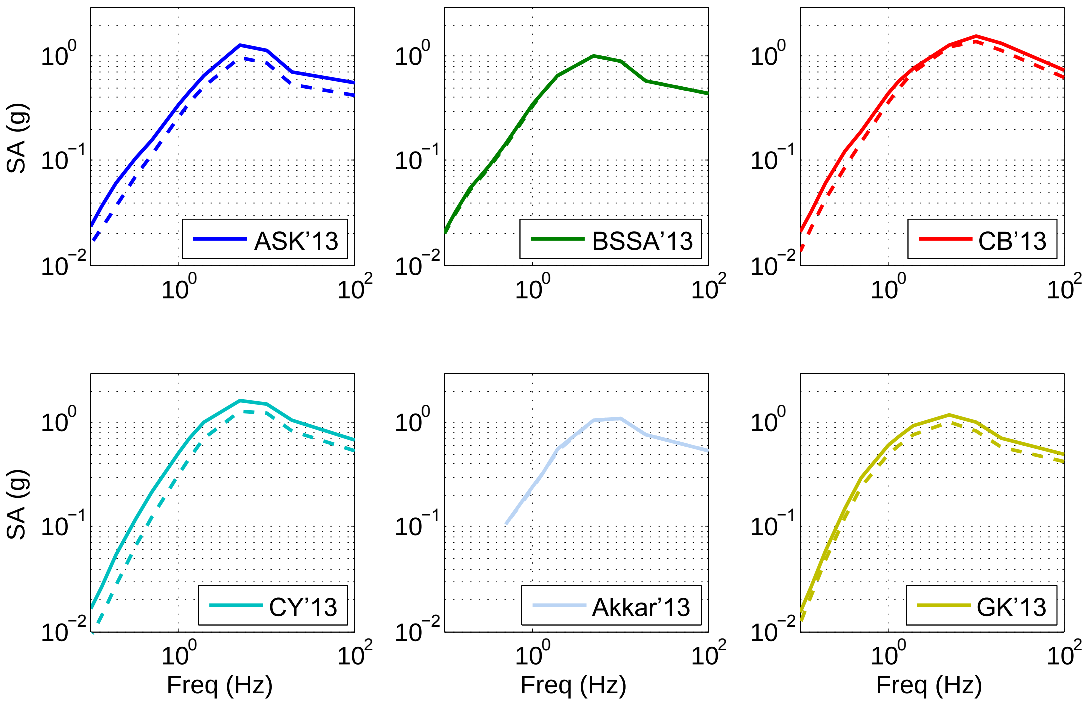


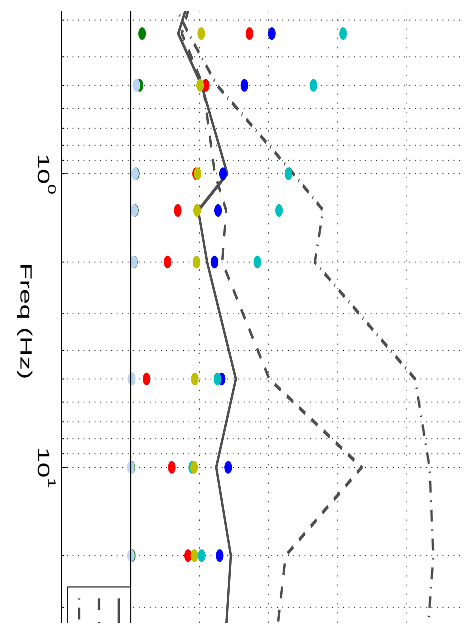
RESULTS FOR METHOD 2: AVG. PARAMETERS (AREA)

NUMERATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	width$_{DD}$ (km)
Splay M2	1.00	0.0	1.07	7.44	62.0	90	28.14

DENOMINATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	width$_{DD}$ (km)
Los Osos	8.57	0.0	9.90	7.40	60	90	32.00



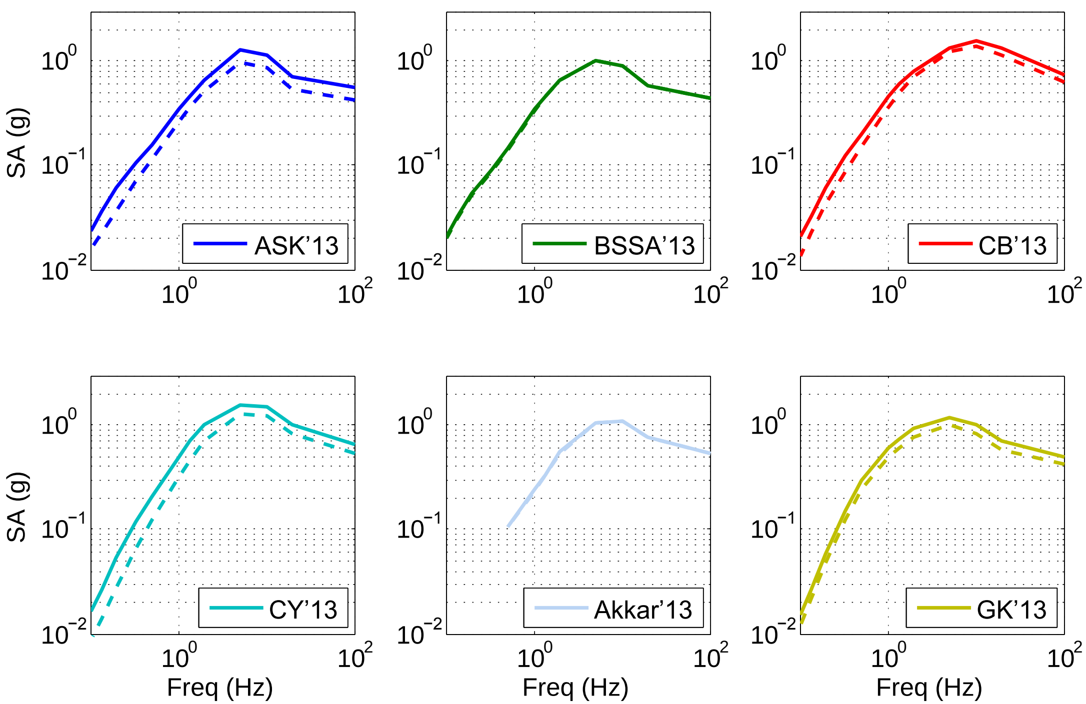


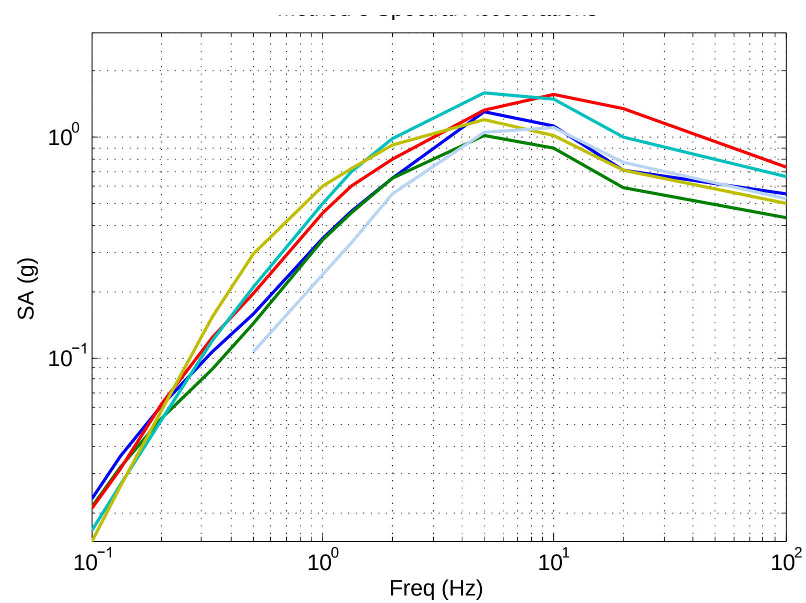


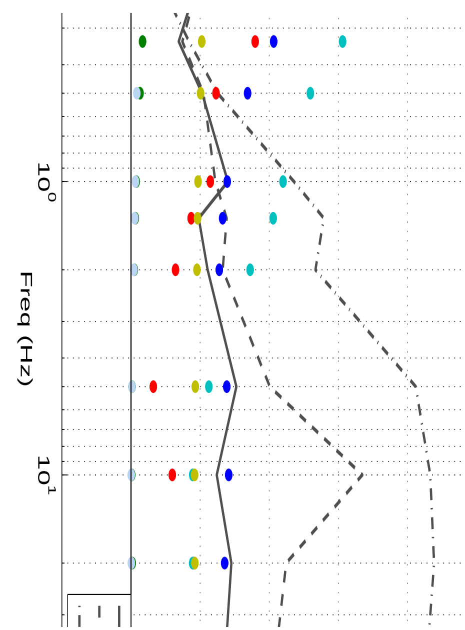
RESULTS FOR METHOD 3: AVG. PARAMETERS (1/R²)

NUMERATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Splay M3	1.00	0.0	1.07	7.44	69.2	90	14.24

DENOMINATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Los Osos	8.57	0.0	9.90	7.40	60	90	32.0



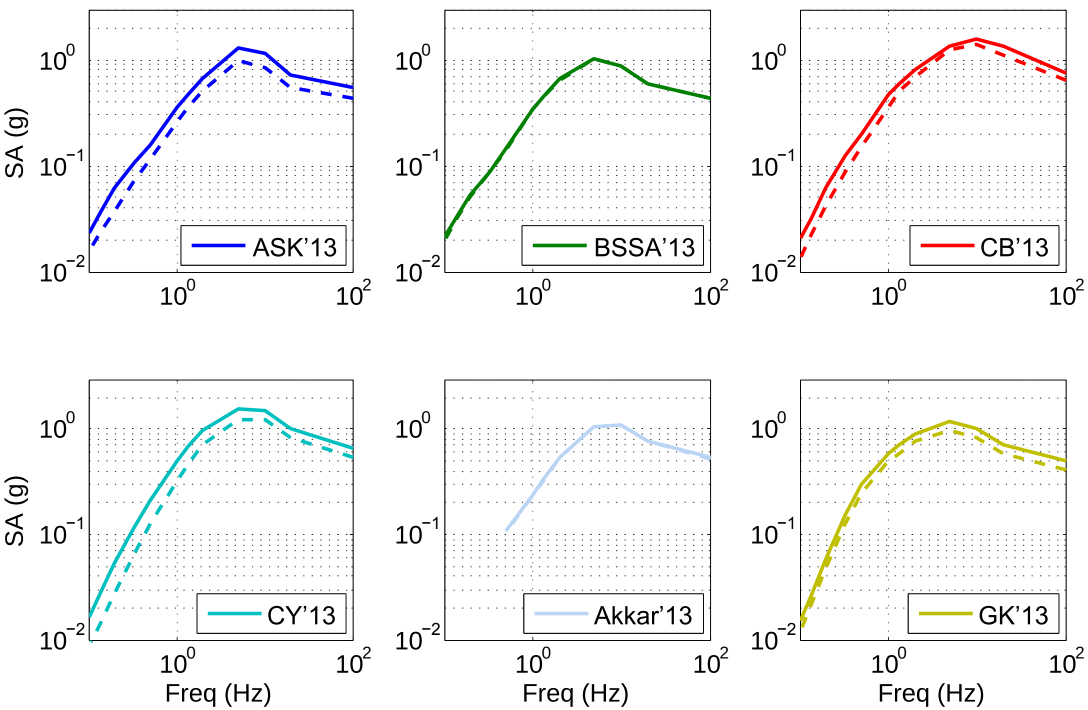


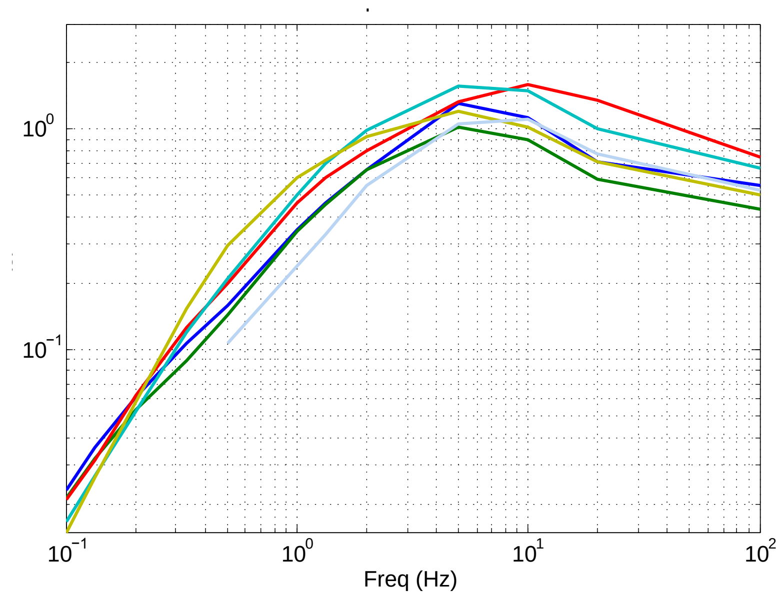


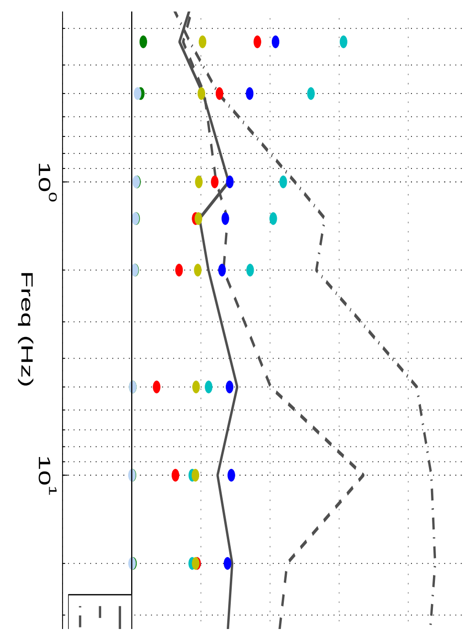
RESULTS FOR METHOD 4: CLOSEST SEGMENT PARAMETERS

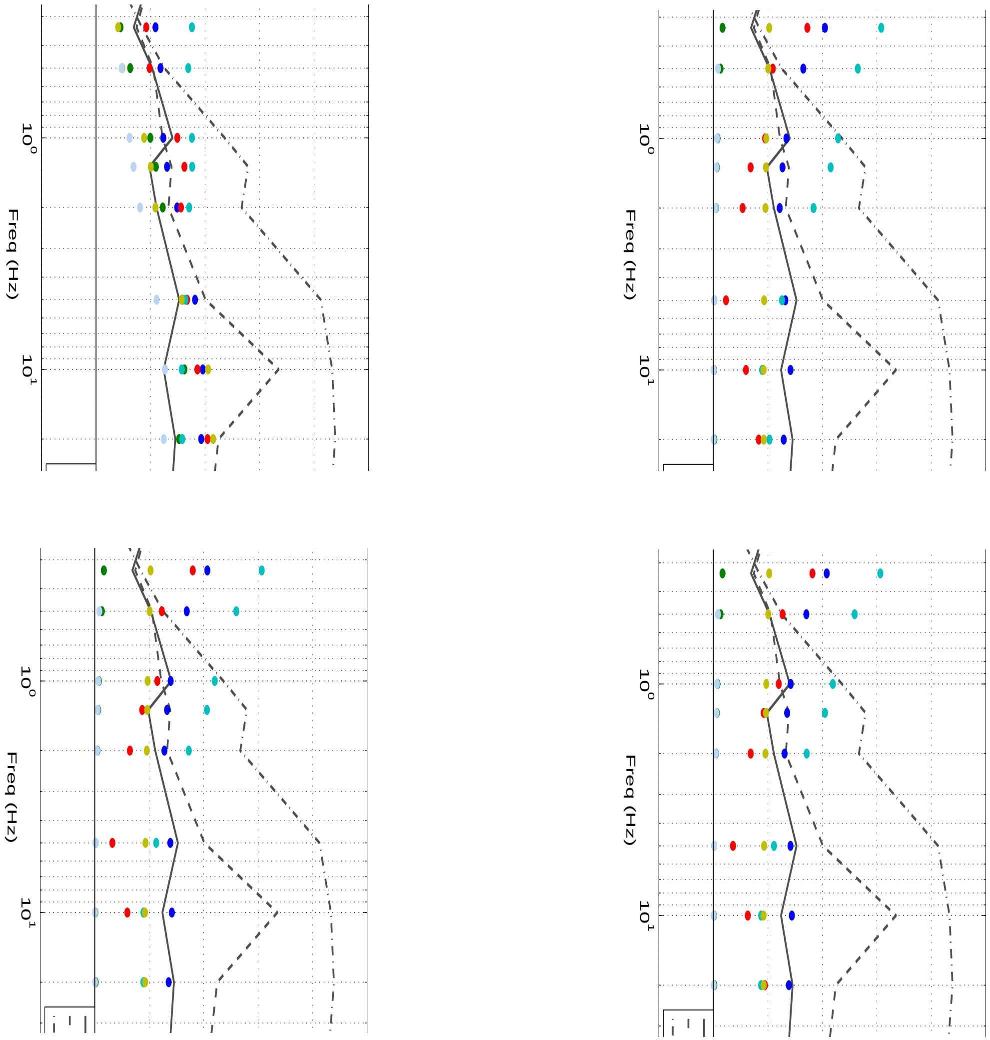
NUMERATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Splay M4	1.00	0.0	1.07	7.44	70.0	90	12.70

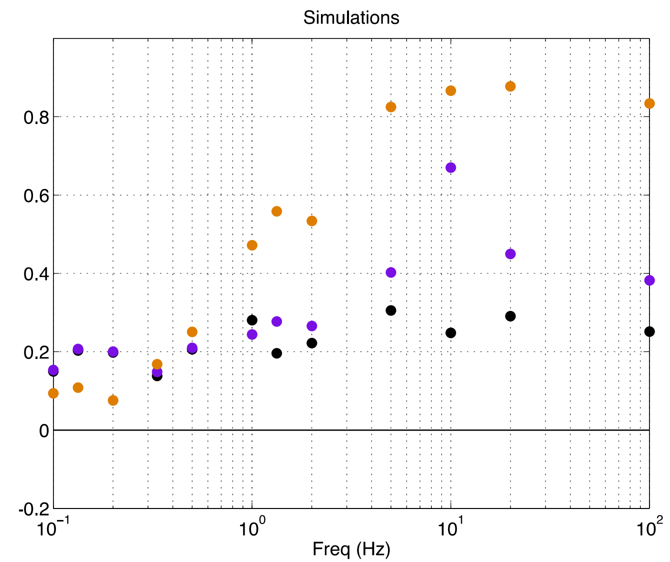
DENOMINATOR	Rrup (km)	Rjb (km)	Rx (km)	Mag	dip	rake	$width_{DD}$ (km)
Los Osos	8.57	0.0	9.90	7.40	60	90	32.00







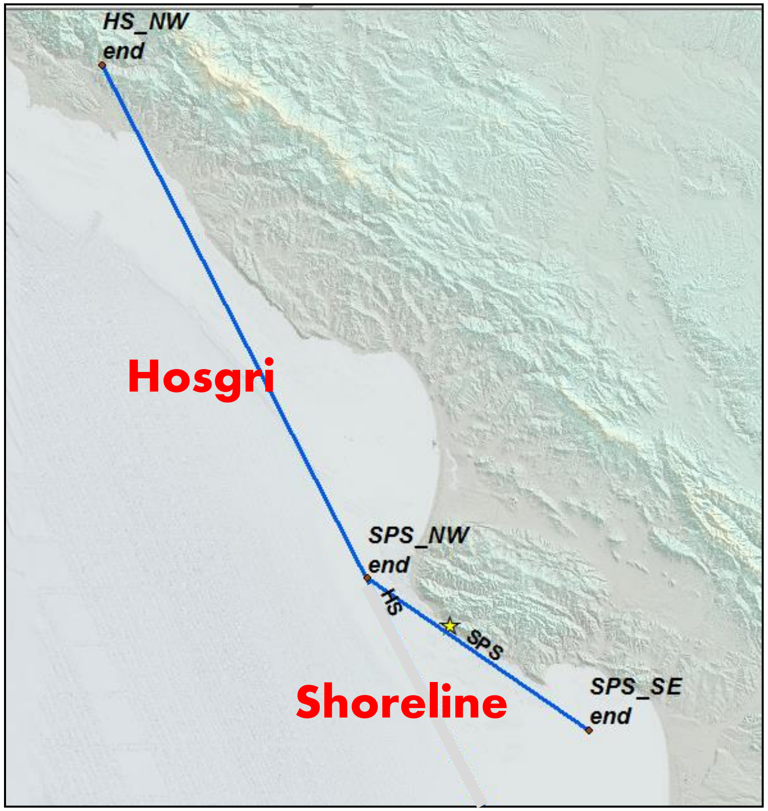


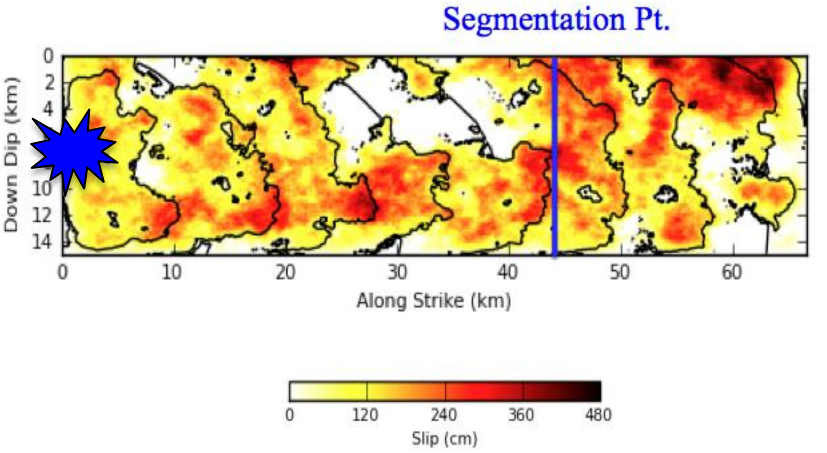


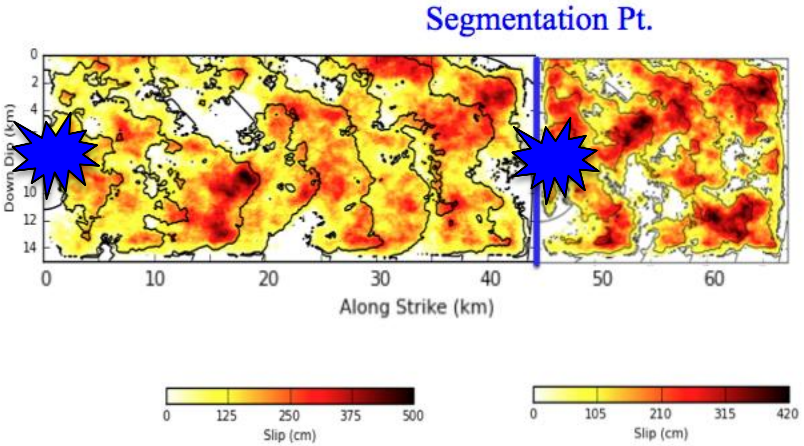
LOS OSOS + SAN LUIS BAY (M7.4)

Dynamic Rupture Modeling Informed Scenarios

LINKING ASSUMPTIONS:
HOSGRI + SHORELINE

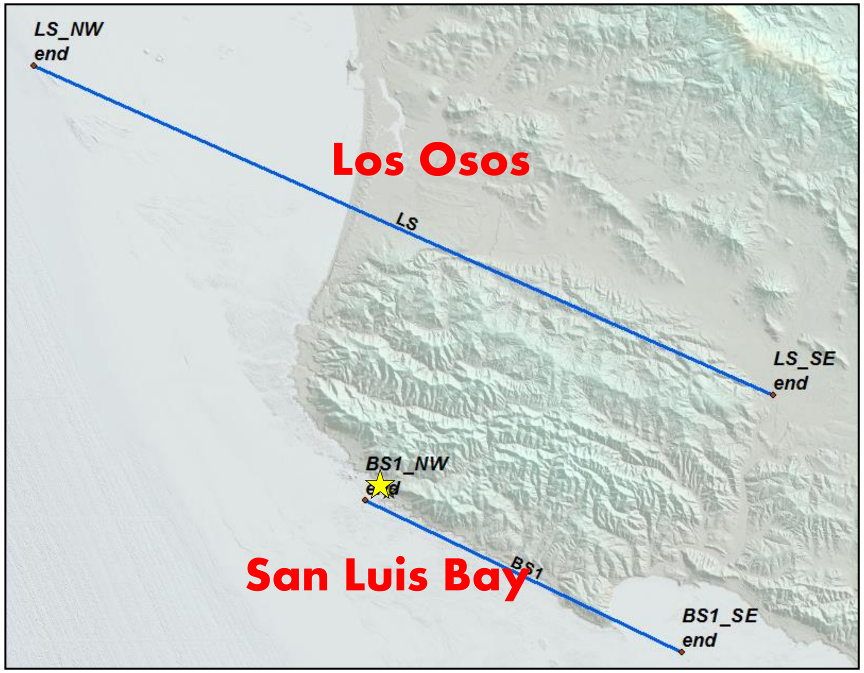






Dynamic Rupture Modeling Informed Scenarios

LINKING ASSUMPTIONS:
LOS OSOS + SAN LUIS BAY SPLAY

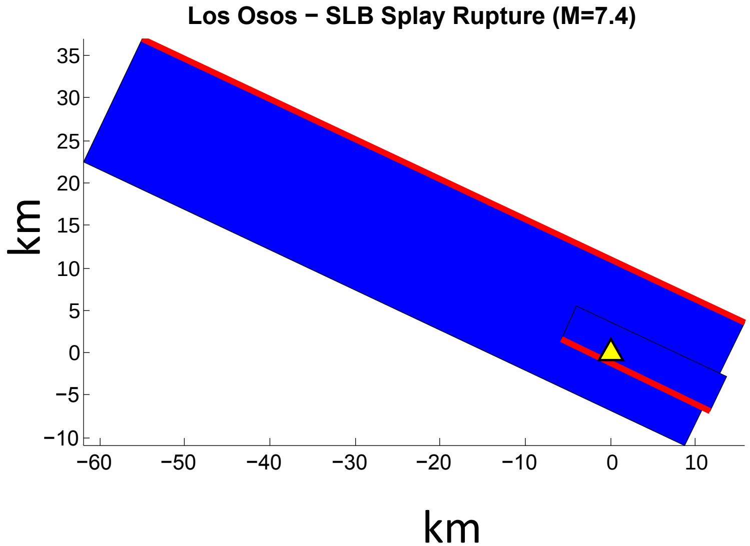


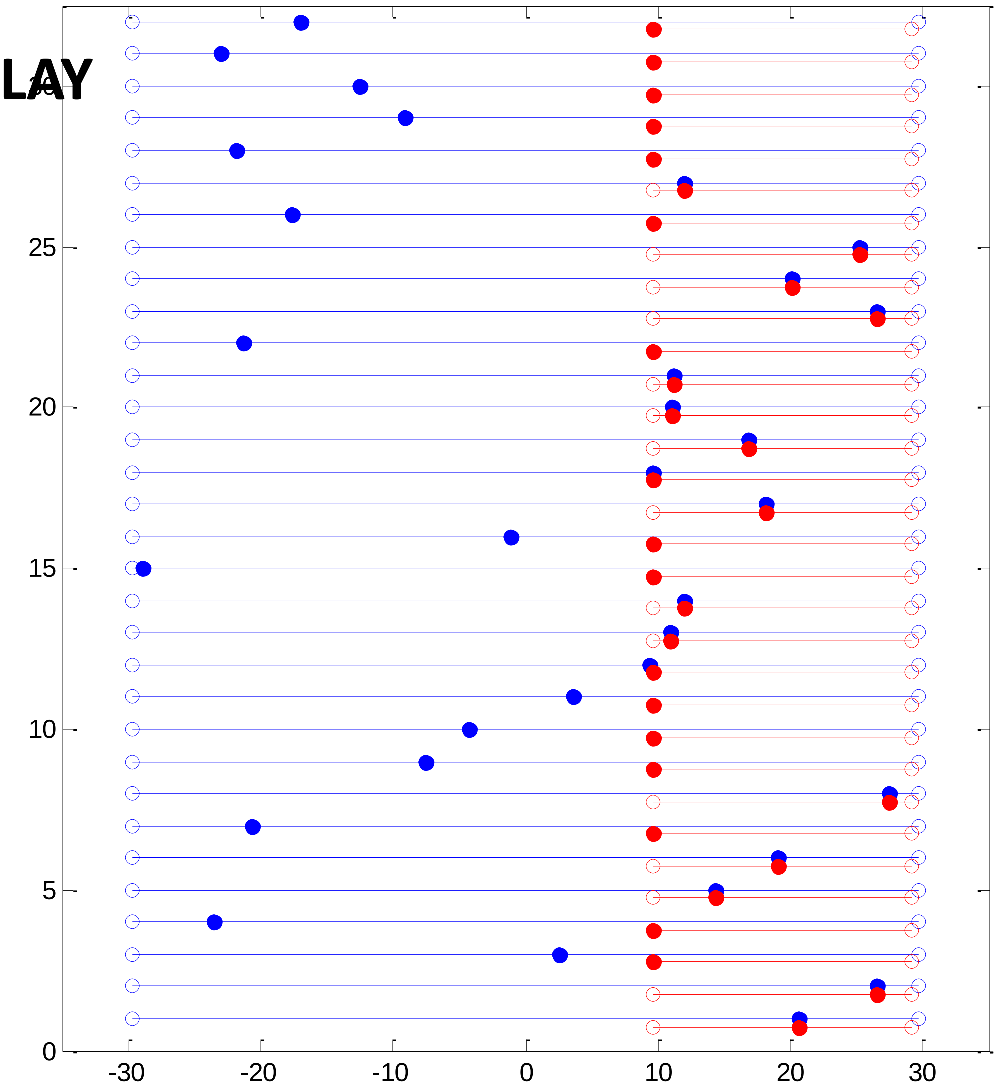
- LO (primary) hypocenters are at bottom of LO fault plane, but vary along strike
- SLB (secondary) hypocenters are at bottom of SLB fault plane, matching position of LO hypo along strike, or at NW end if LO hypo is outside range

Dynamic Rupture Modeling Informed Scenarios

LINKING ASSUMPTIONS:

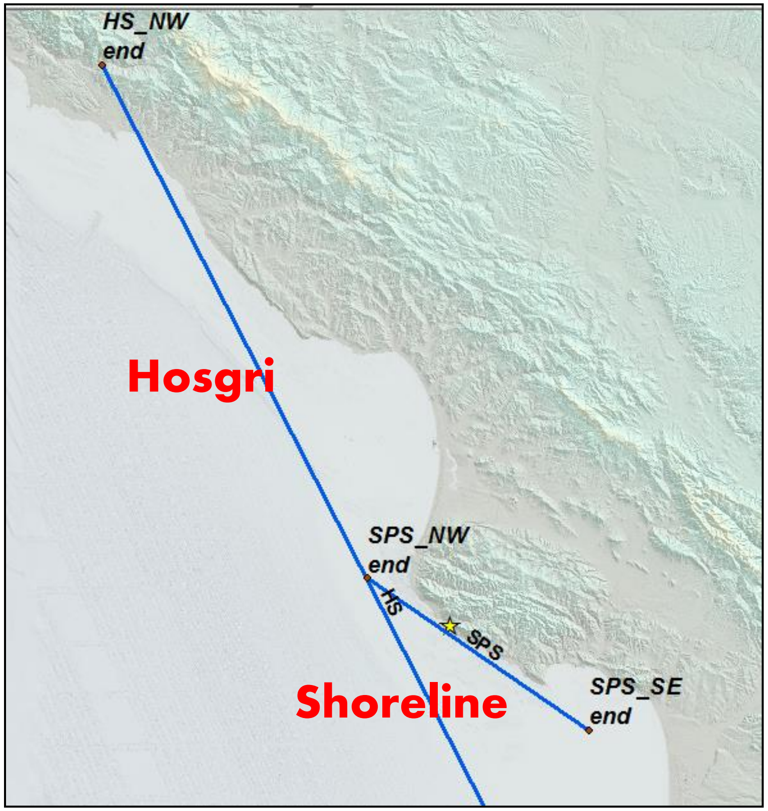
LOS OSOS + SAN LUIS BAY SPLAY





Dynamic Rupture Modeling Informed Scenarios

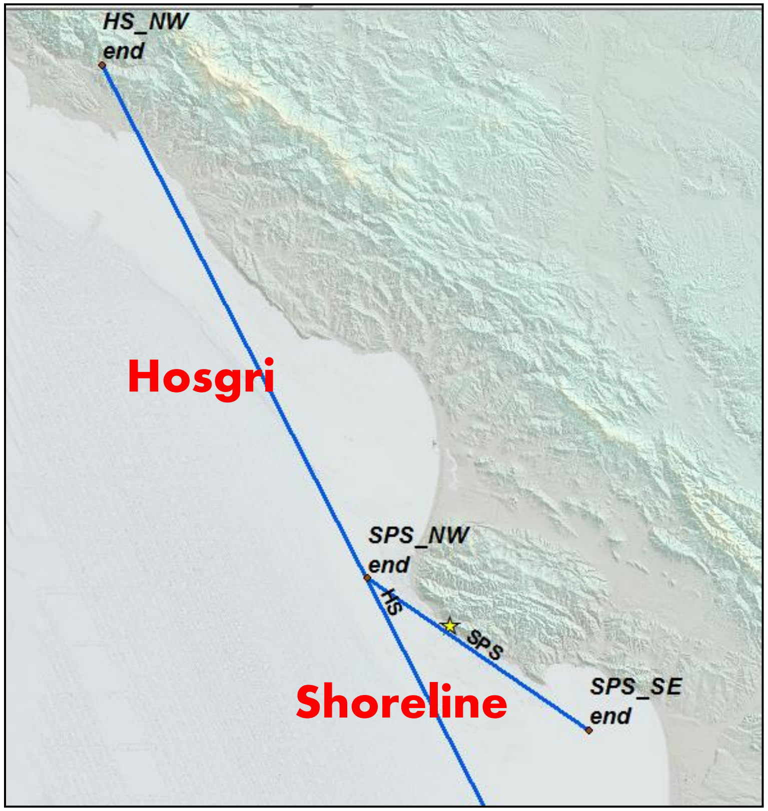
LINKING ASSUMPTIONS:
HOSGRI + SHORELINE COMPLEX



- Random hypocenter generated on Hosgri and rupture propagates along length of the Hosgri fault.
- As rupture passes the intersection with the Shoreline, a rupture is triggered on the Shoreline at the intersection point. Hypocenter is located at $\text{width}_{DD}/2$

Dynamic Rupture Modeling Informed Scenarios

OTHER ASSUMPTIONS:



- Hypocenter of Splay is always triggered at intersection point.
- Triggering is always at the time the Primary fault rupture passes the intersection point.
- There is always full rupture of the splay.

Dynamic Rupture Modeling Informed Scenarios

QUESTIONS DYNAMIC MODELING MAY HELP TO ANSWER:

- When should we trigger a second rupture vs. let a mature rupture plane pass onto a secondary fault?
- Should secondary ruptures always trigger at the intersection point? Should we consider a delayed trigger? What is the longest delay that should be considered?
- In the case of splay ruptures, how far down the splay will the rupture propagate before it dies out?
- How likely are the proposed scenarios? Is it possible that dynamic modeling just cannot make some of them occur?
- What have we failed to consider?

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Jeff Bayless (URS), Jennifer Donahue (GeoSyntech), Fabio Silva (SCEC), Doug Dreger (UC Berkeley), and Norm Abrahamson (PG&E)

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