

# Guidelines for the Selection, Modification and Scaling of Ground Motion Time Histories

Paul Somerville  
URS, SCEC

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# Criteria for Specification of Ground Motions

- UBC site-specific hazard has a probabilistic basis
- CBC hazard has a probabilistic basis, except in the near source region where it is deterministic, based on median + 1 sigma
- Multiple ground motion levels having different return periods are used in PBEE

## Selection of Scenario Earthquakes to Represent a Deterministic Response Spectrum

- Maximum magnitude of earthquake on controlling fault
- Closest distance to controlling fault
- Median + 1 sigma ground motion level (epsilon is +1) for IBC near fault MCE
- $e=1$  indicates presence of some amplifying effect such as rupture directivity or basin response

## Selection of Scenario Earthquakes to Represent a Probabilistic Response Spectrum

- Probabilistic response spectrum contains contributions from many earthquake magnitudes on many faults or sources
- Deaggregation of the hazard identifies the main contributors to the hazard
- This allows the identification of a scenario earthquake to approximate the probabilistic hazard

## Deaggregation of Probabilistic Seismic Hazard

- Magnitude of the earthquake  $M$
- Distance from the source to the site  $R$
- Epsilon  $e$

e.g.  $M$  6.5, distance 30 km, epsilon 0.5

Epsilon is the number of standard deviations by which the probabilistic response spectrum lies above or below the median ground motion for the Magnitude and Distance

# Dependence of Deaggregation Values on:

- Return period

Typically, longer return period ground motions are dominated by larger and closer earthquakes. Eventually these saturate and the only parameter that changes is epsilon

- Ground motion period

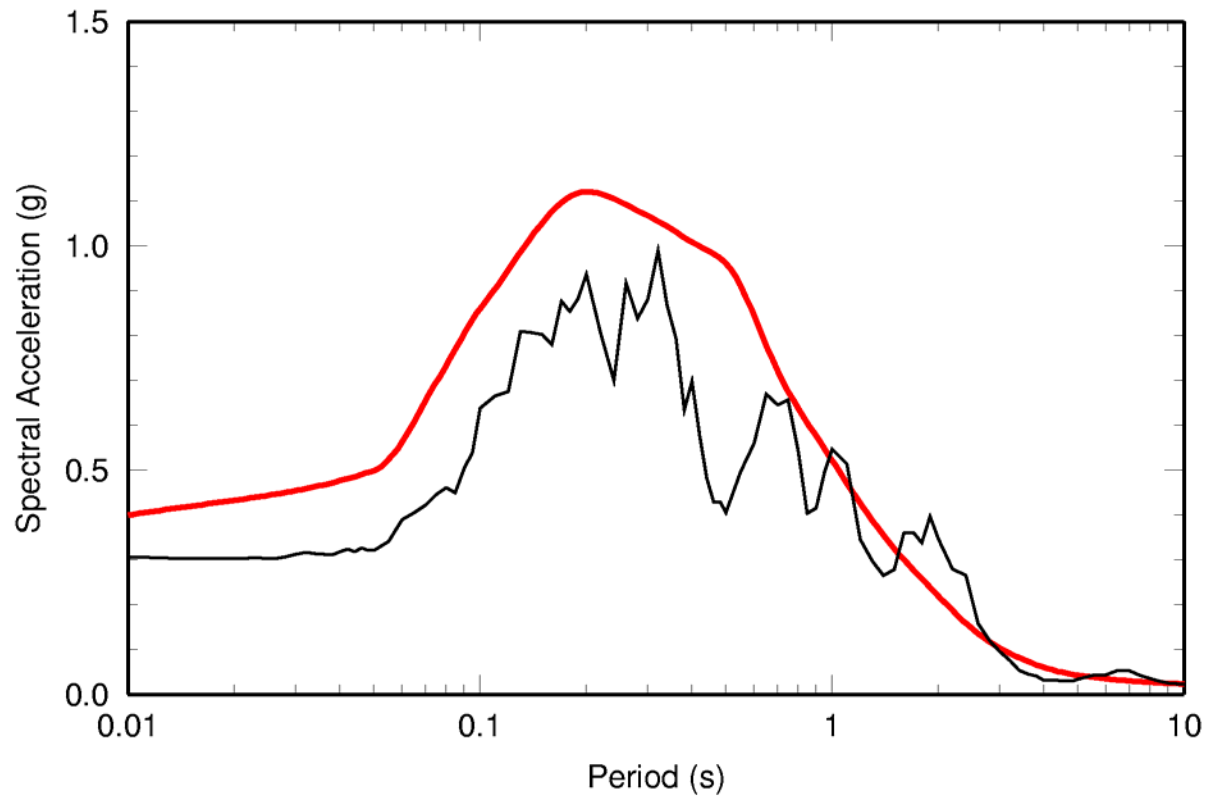
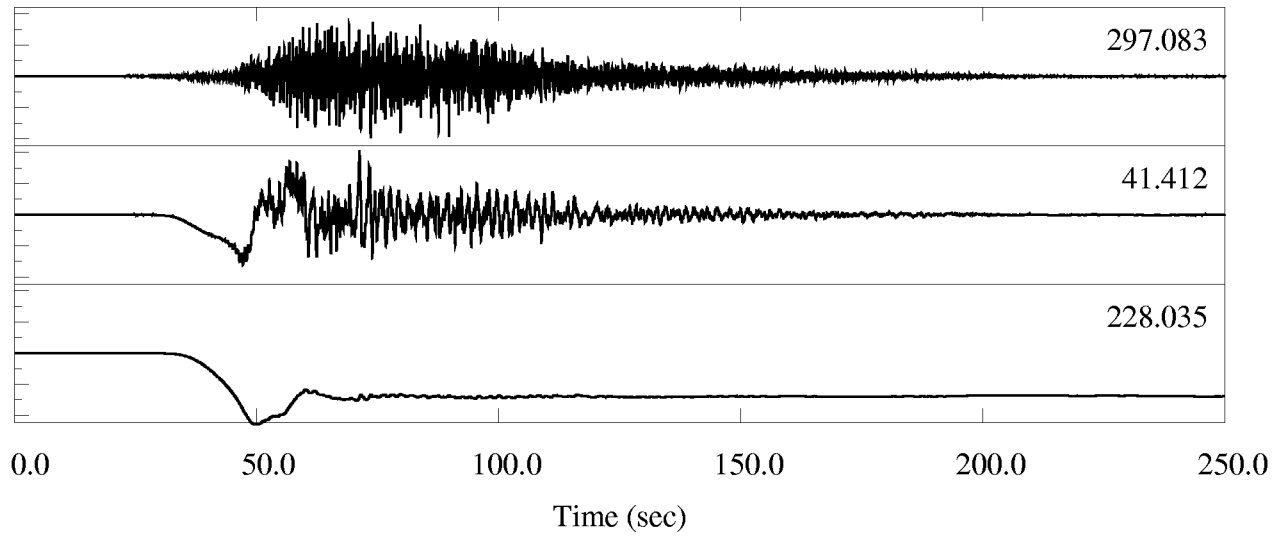
Typically, longer period ground motions are dominated by larger and more distant earthquakes

# Spectral Matching

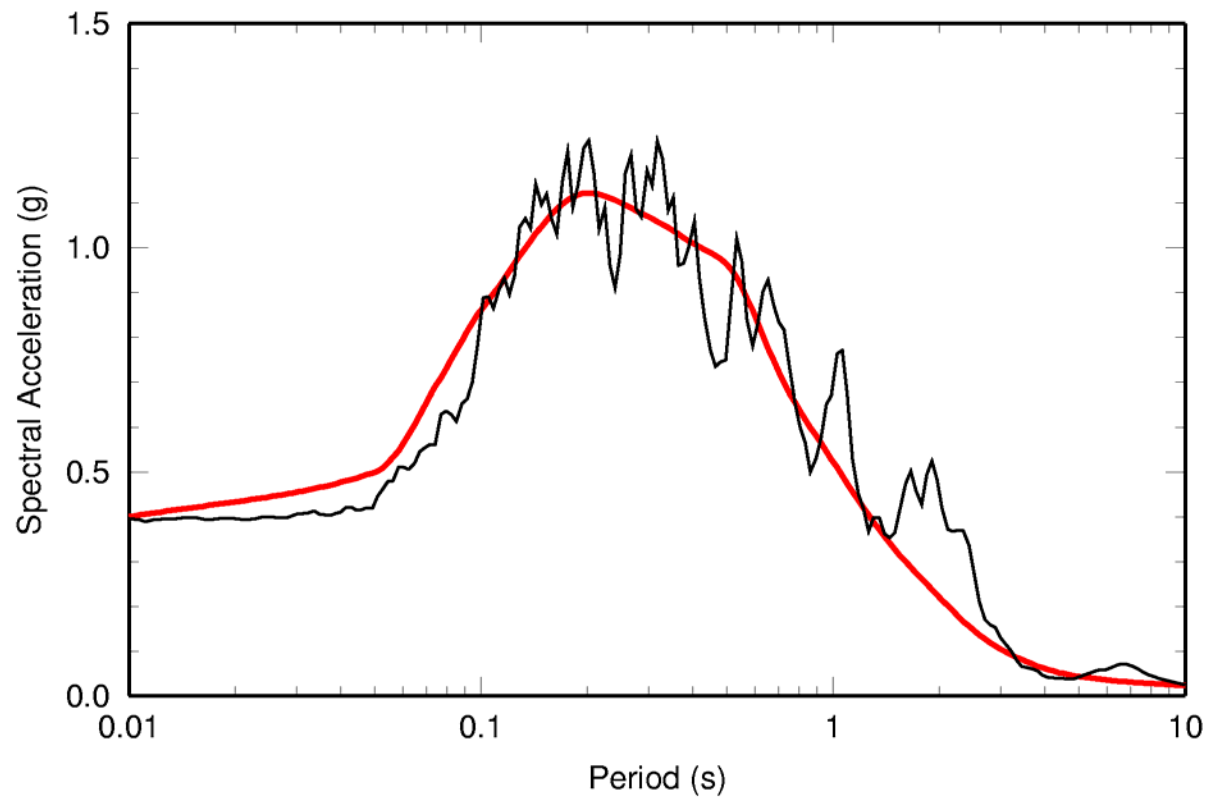
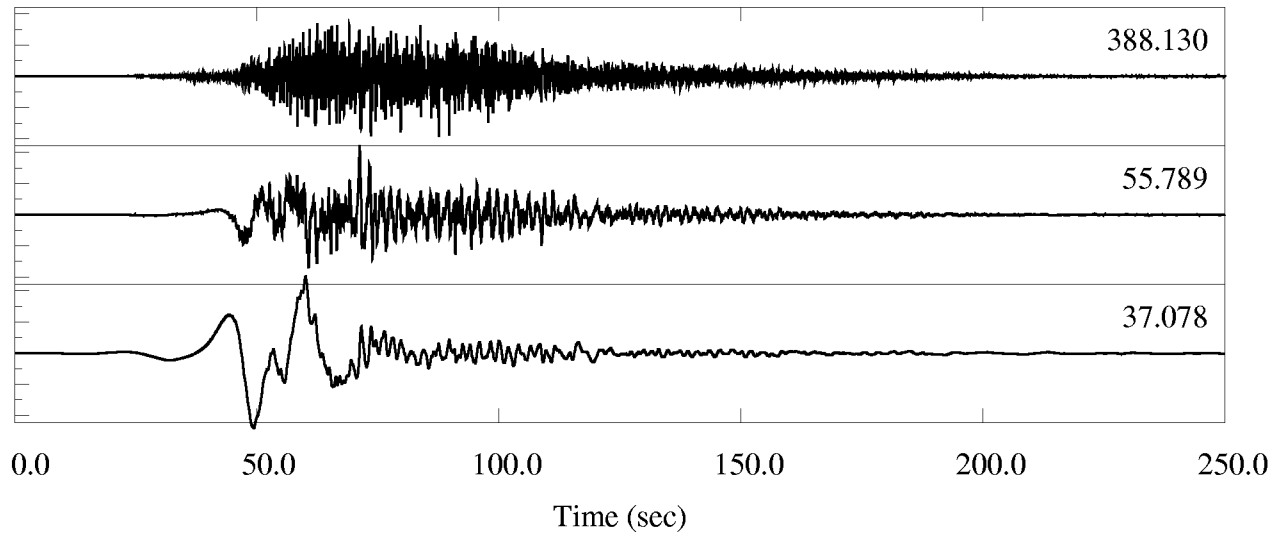
- Real strong motion records have response spectral peaks and troughs that impact the nonlinear response of a structure
- Ideally, we should use unmodified time histories to sample this behavior, but sampling requires numerous time histories
- Spectral matching reduces the number of time histories that we need to use, at the expense of using less realistic time histories

# Levels of Spectral Matching

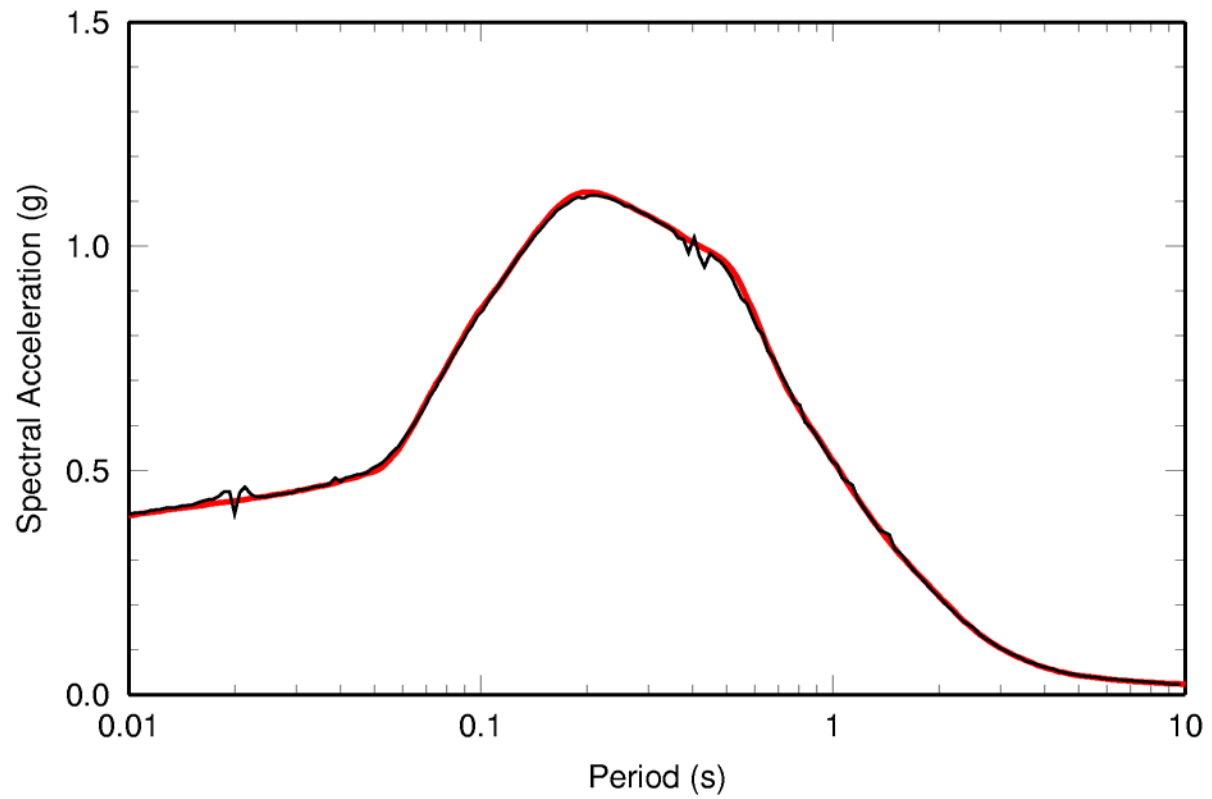
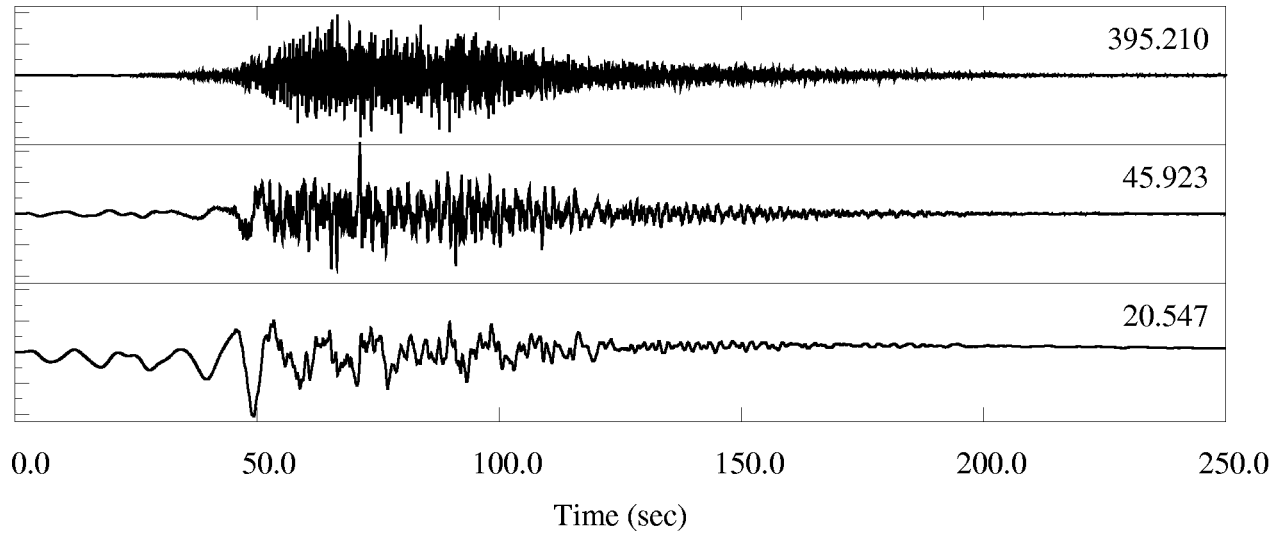
- No spectral matching, which may leave critical peaks and troughs that strongly determine nonlinear response – OK when using many records
- “Loose” spectral matching, which makes the response spectrum approximately follow a smooth target spectrum but leaving peaks and troughs – OK when using a few records
- “Tight” spectral matching, which makes a smooth response spectrum that lacks peaks and troughs but conforms to a smooth uniform hazard spectrum - OK when using 1 record - minimizes variability but may introduce bias



**No  
spectral  
matching**



**Loose  
spectral  
matching**



**Tight  
spectral  
matching**

# Analysis Using 4-10 Time Histories

- Deaggregate probabilistic hazard by M, R, e
- Consider other possible contributors not included in probabilistic hazard, e.g. directivity effects, basin effects
- Select records that represent M, R, e and other effects
- Scale (for 10 records) each record to match the probabilistic response spectrum over a period range that is significant for the structure; or loosely match (for 4 records)

# Analysis Using 1-3 Time Histories

- Deaggregate probabilistic hazard by M, R, e for that level
- Consider other possible contributors not included in probabilistic hazard, e.g. directivity effects, basin effects
- Select 3 records that represent M, R, e and other effects
- Spectrally match (loose for 3 records; tight for 1) each record to the probabilistic response spectrum

# Different Kinds of Records

- Large amplitude records
- Impulsive records e.g. caused by rupture directivity
- Short duration records
- Intermediate duration records
- Long duration records e.g. produced by large magnitudes or basin waves
- Broadband records
- Narrow band (e.g. soft soil) records
- Records with energy concentrated at short, intermediate or long periods

# Conditions that Produce High Epsilon Values

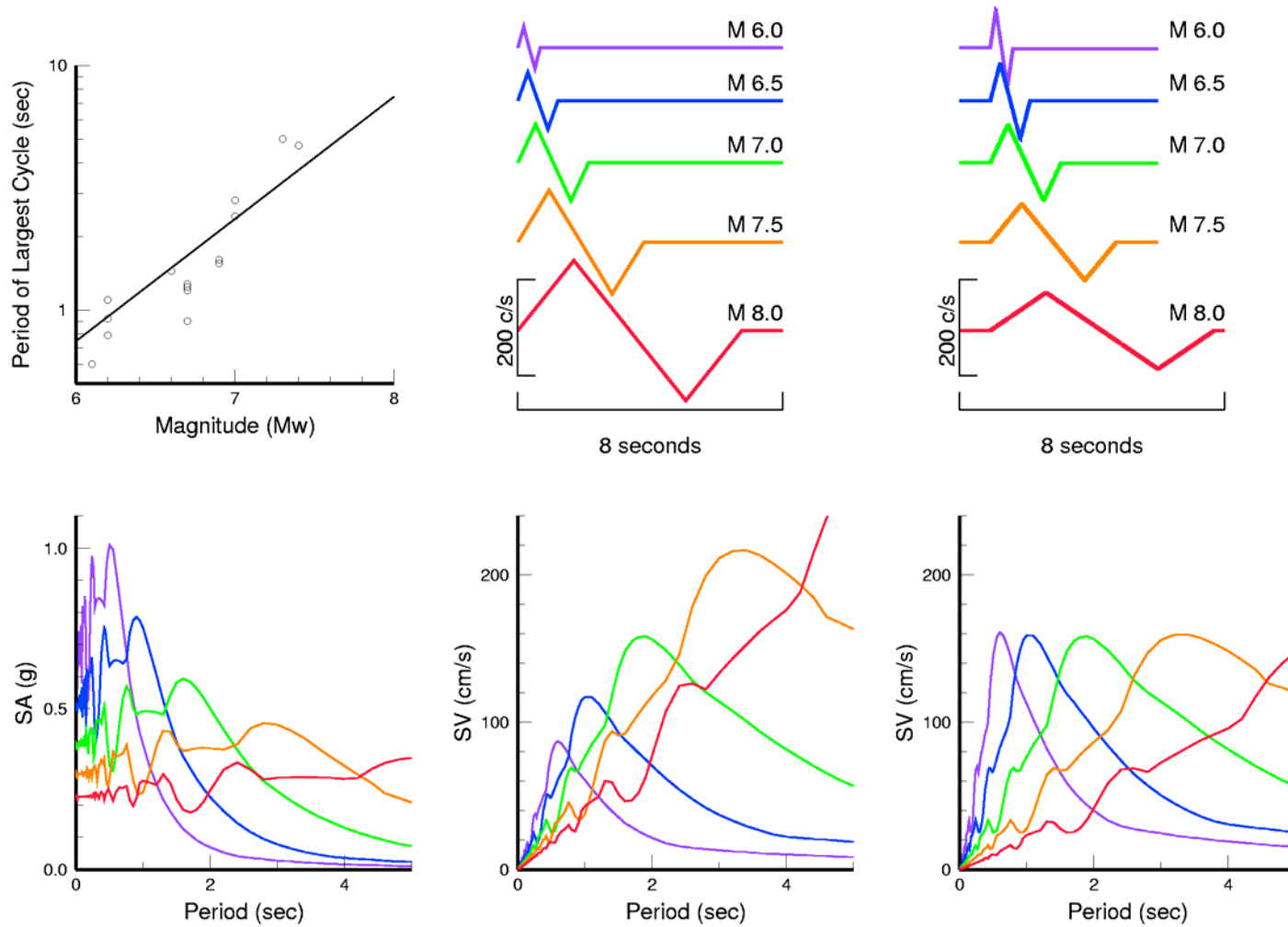
- Near-fault rupture directivity effects  
(brief pulse-like motion)
- Hanging wall effects  
(enhanced short period motion)
- Basin resonance effects  
(long duration long period waves)
- Unusual site conditions





# Magnitude Scaling of the Near Fault Rupture Directivity Pulse

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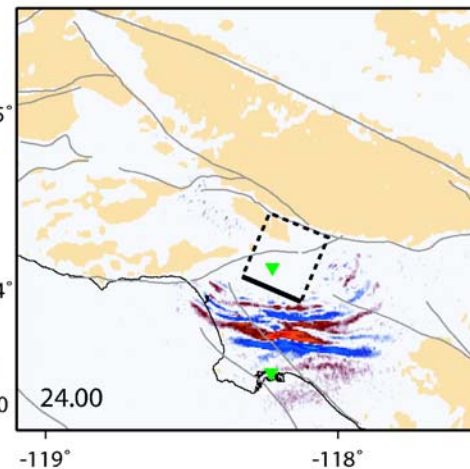
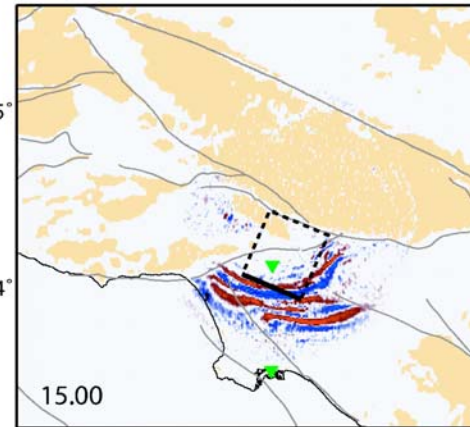
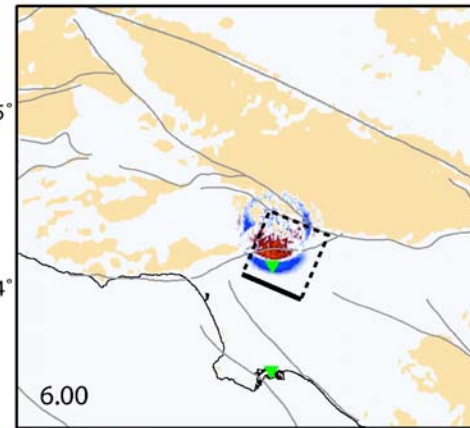
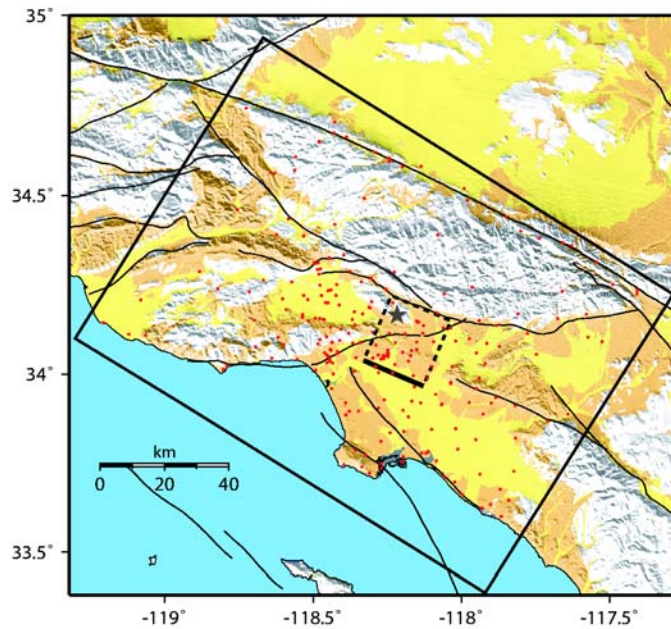


# Basin and Basin Edge Effects

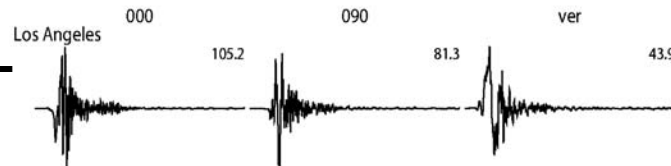
# Focusing of Energy by Rupture Directivity and Basin Effects

**Puente Hills  
Blind  
Thrust**

Puente Hills LA EQ: Broadband Simulation



**Los Angeles -  
Directivity**



**Long Beach -  
Basin Effect**

