NORTHRIDGE 20
SYMPOSIUM

Ground Motion Hazard, Site Response, & Ground Failure

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Overview

- Effects that caused large ground motions
- Broadband strong motion simulation
- Validation of Northridge simulations
- PSHA based on simulations (Cybershake)
- Outstanding issues – basin edge effects
- Next steps

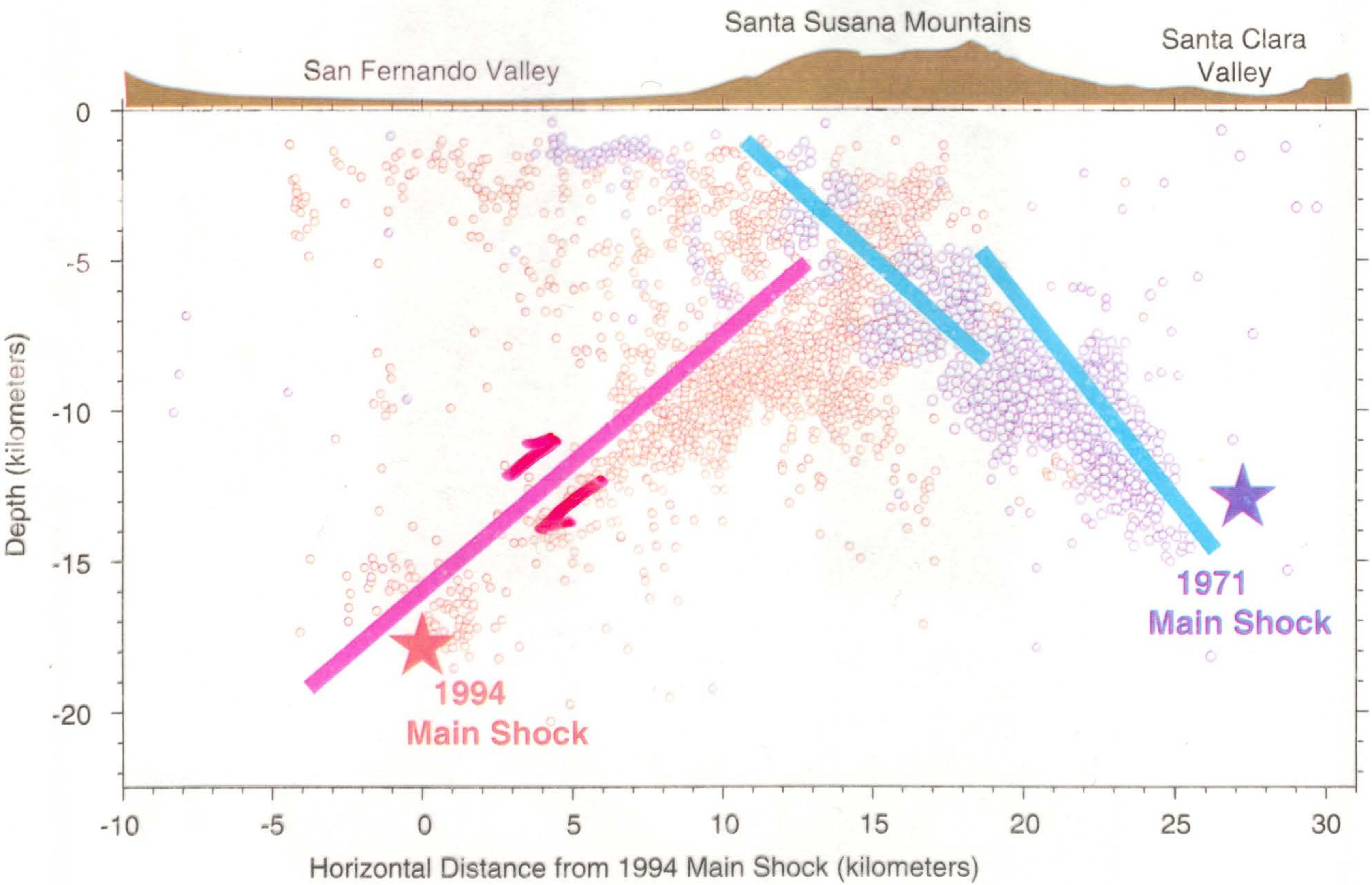
Large ground motions caused by:

- Blind thrust fault
  - Depth to top of rupture Dtor
- Rupture directivity effects
  - “Seismic boom” from near supersonic rupture
  - Amplified by radiation pattern
- Hanging wall effects
- Basin effects
- Basin edge effects
  - Multipathing
  - Focusing

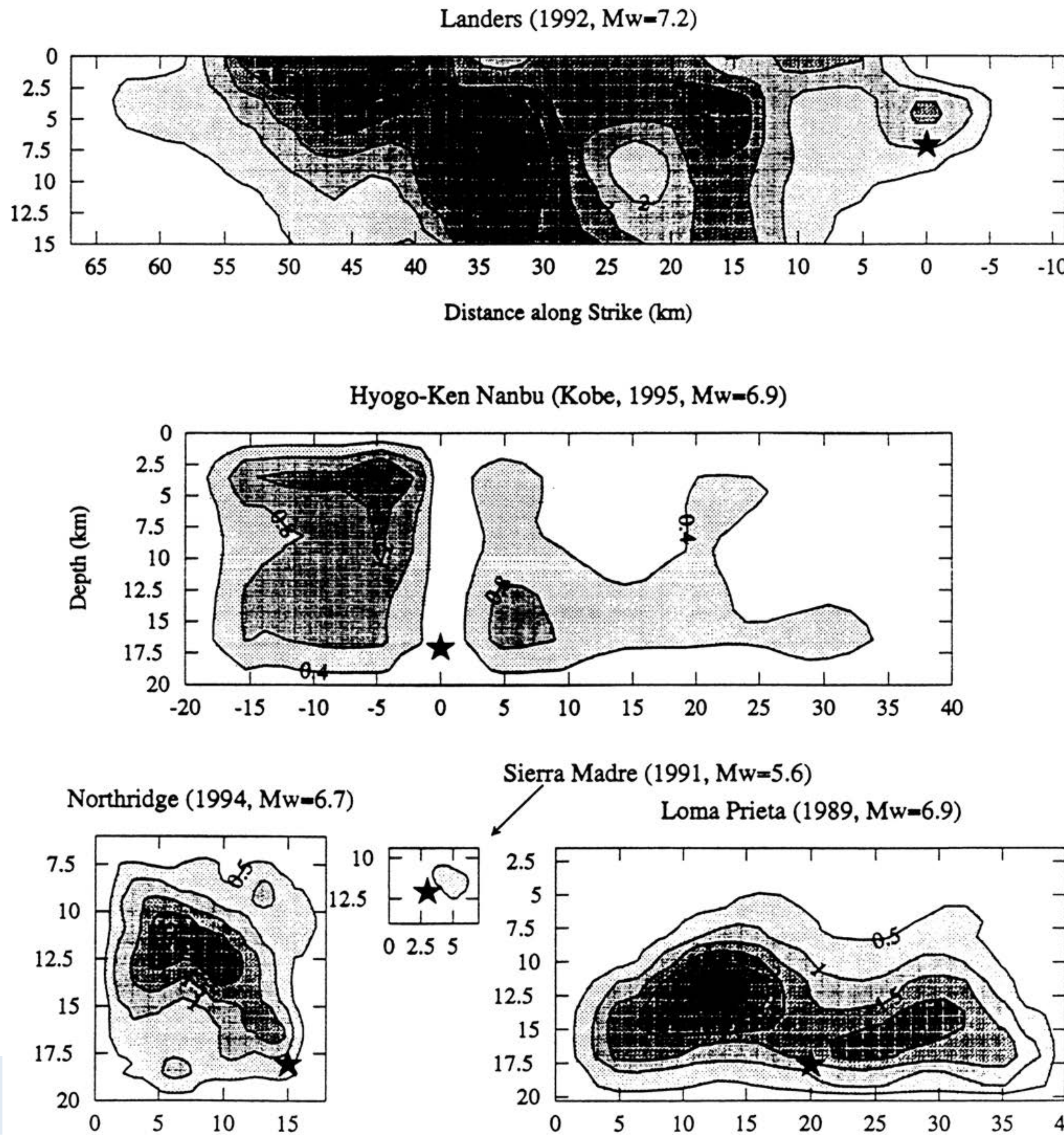
Accomplishments

- Ability to simulate strong motion effects:
  - Rupture directivity effects
  - Buried faulting effects (Dtor)
  - Hanging wall effects
  - Basin effects
  - Basin edge effects
- Development of basin amplification factors in PEER NGA Project
- Guidance on Dtor and HW effects in NGA
- SCEC Broadband Simulation Platform

Blind Thrust Fault, Dtor = 6 km



Surface vs. Buried Faulting



Wald

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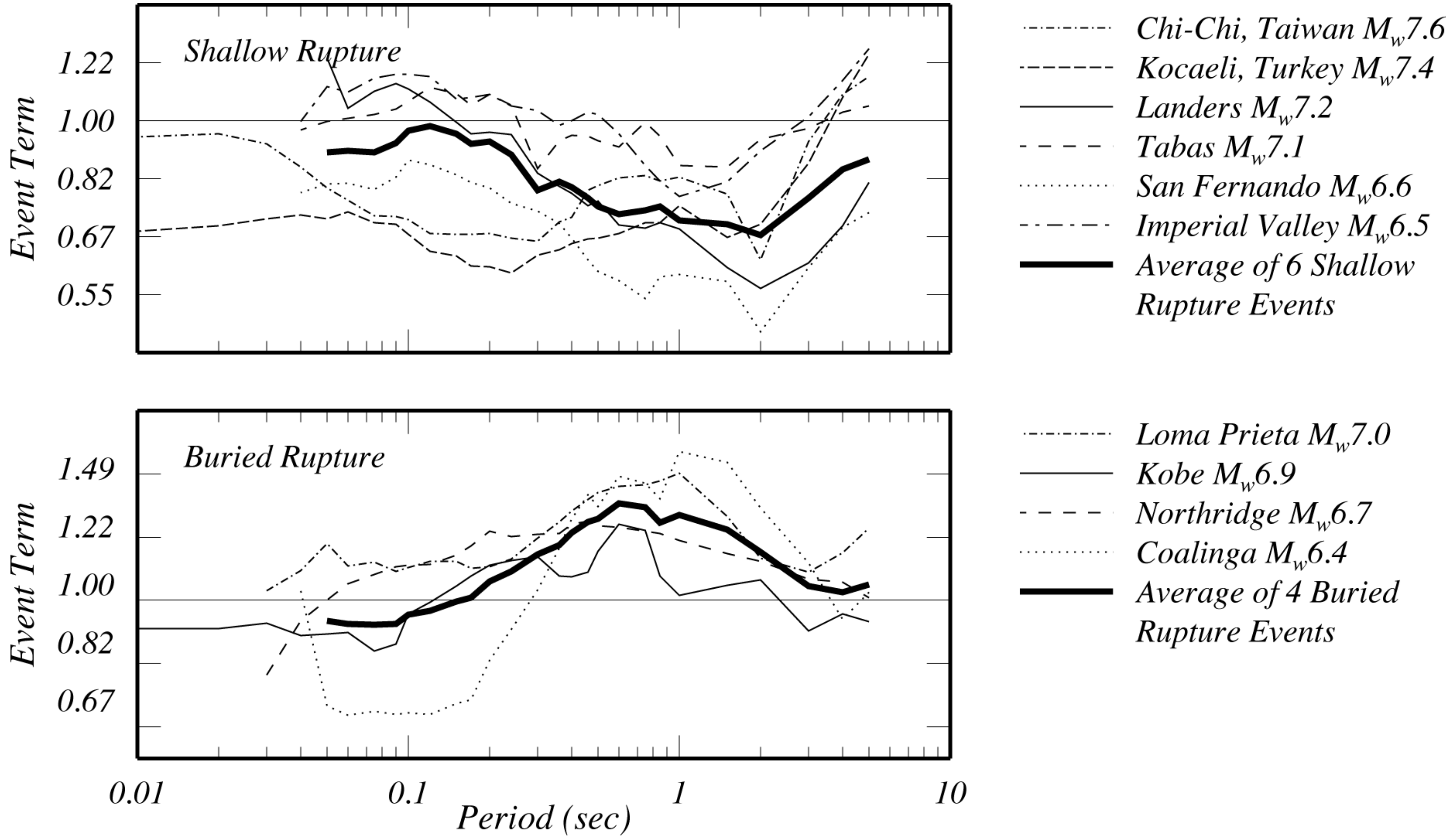
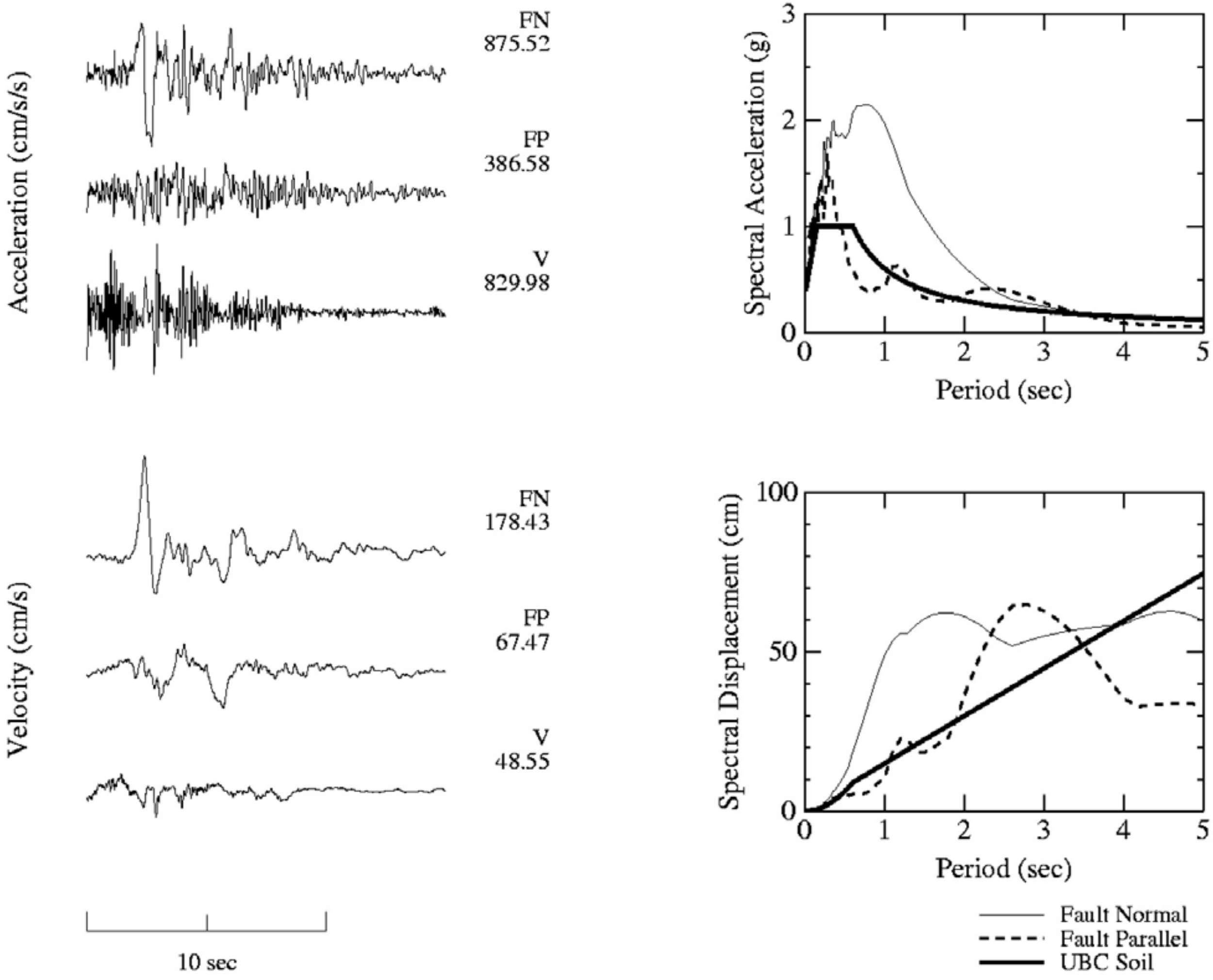
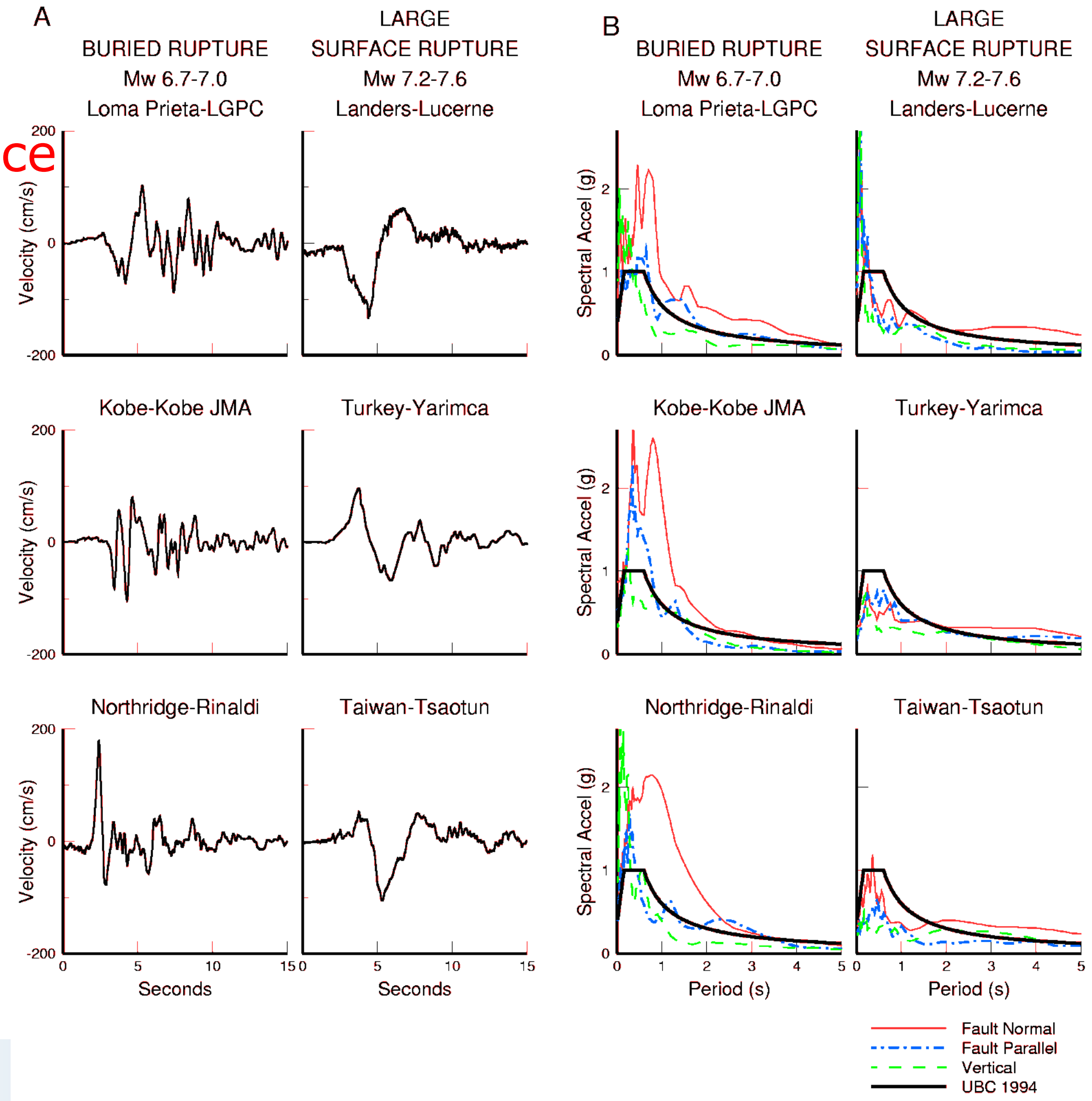
Surface vs. Buried Faulting Event Terms



Rupture Directivity, Rinaldi



M<7 vs M>7; Buried vs Surface



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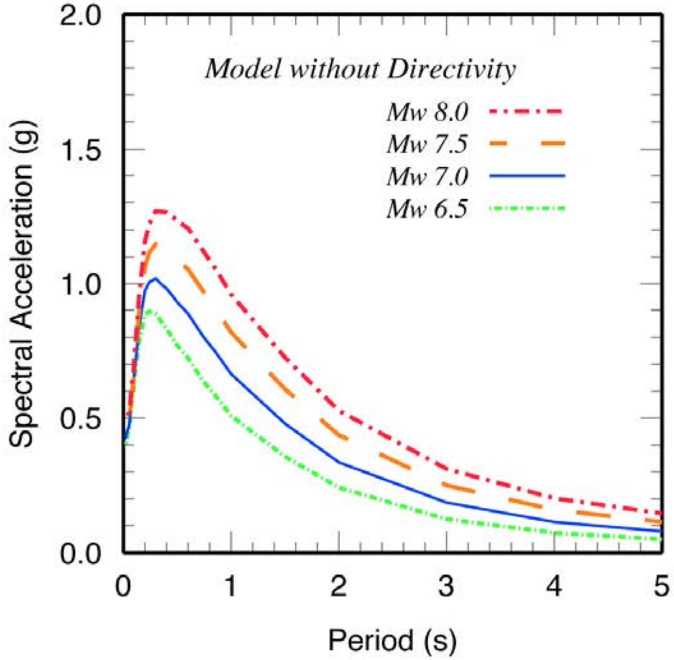
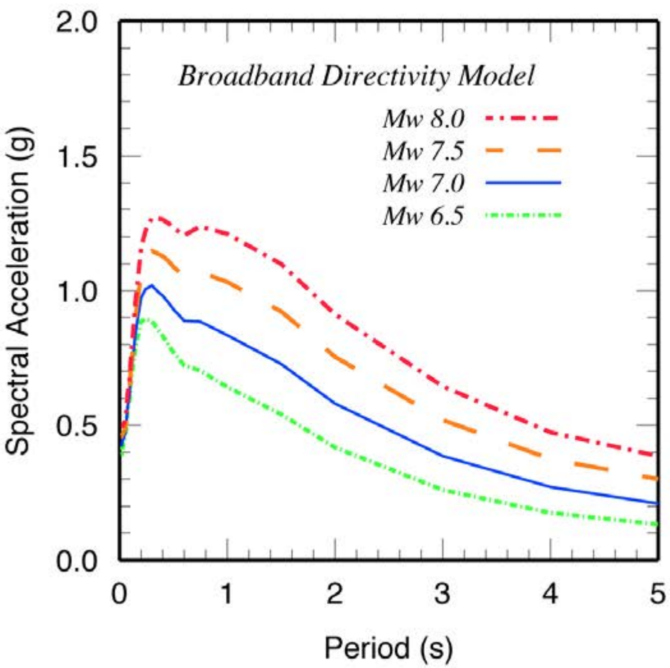
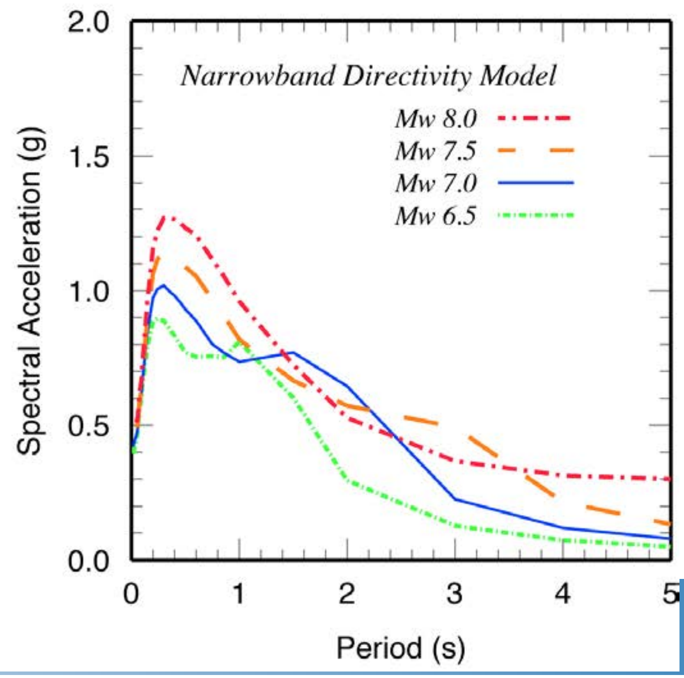
Broadband and Narrowband Directivity Models







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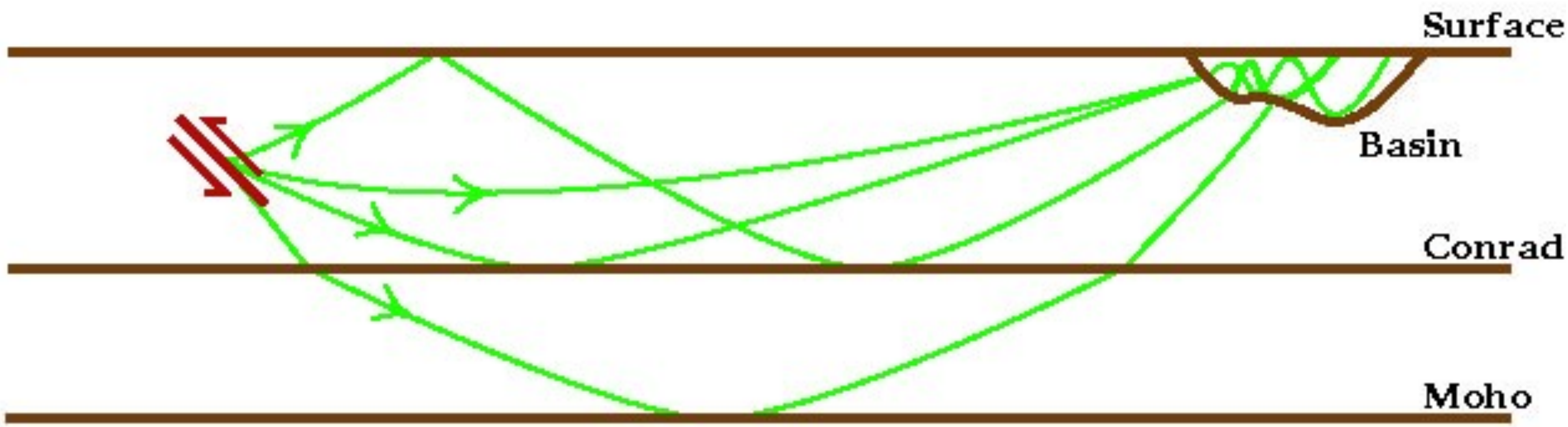
Simulation of Ground Motion Effects

- Blind thrust fault
  - Depth to top of rupture Dtor
- Rupture directivity effects
  - Seismic boom
  - Amplified by radiation pattern
- Hanging wall effects
- Basin effects
- Basin edge effects
  - Multipathing
  - Focusing

Strong Ground Motion Modeling

	Earthquake Source	Path	Site



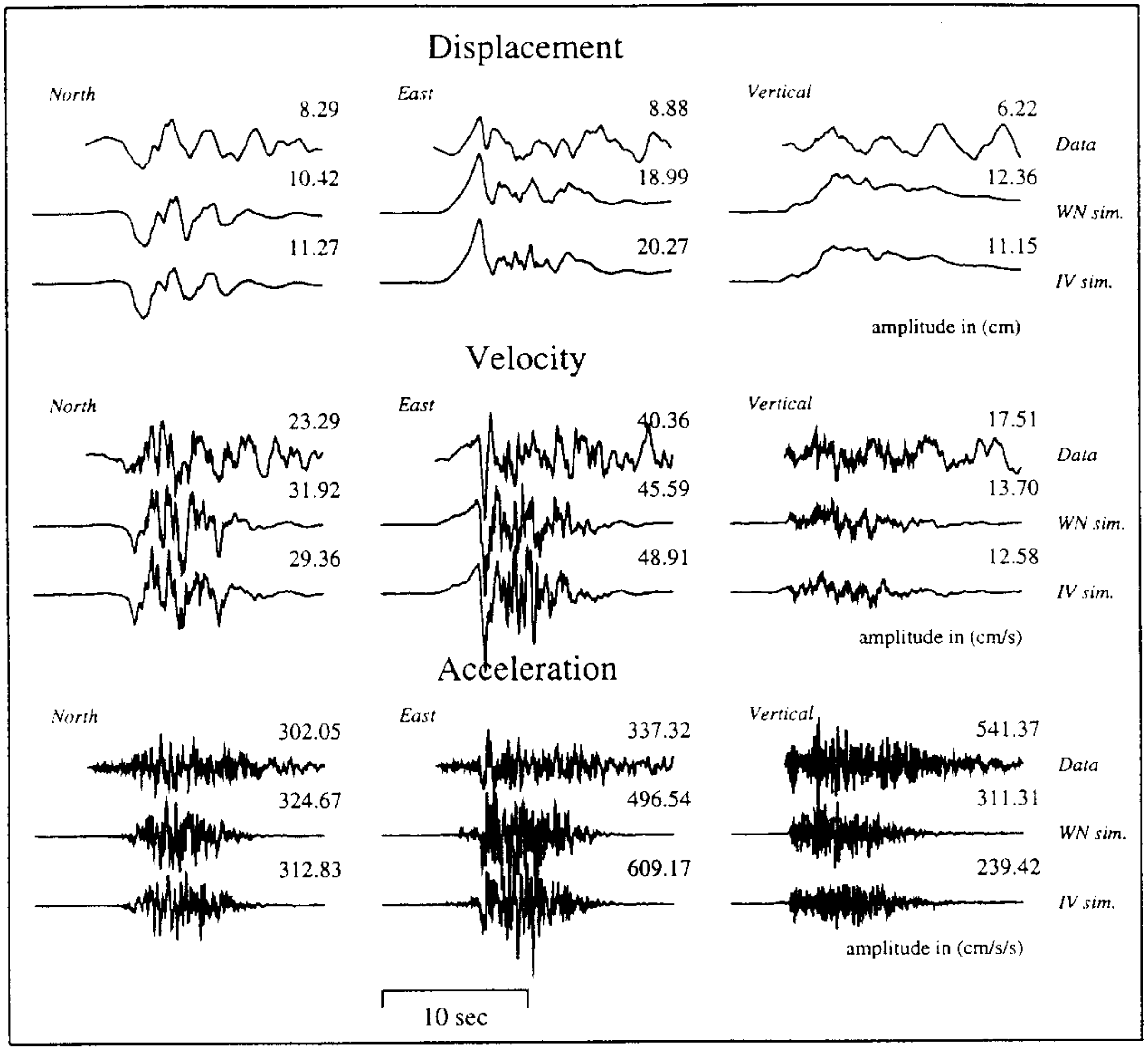
Empirical:	*Magnitude*	*Distance*	*Soil Category*
Seismological:	*Shear Dislocation*	*Crustal Waveguide*	*Complex 3D Structure*

Elastodynamic Representation Theorem

- Ground motion U(t) can be calculated from the convolution of the slip time function D(t) on the fault with the Green's function G(t) for the appropriate distance and depth, integrated over the fault rupture surface: $U(t) = \sum D(t) * G(t)$

- Combine long period deterministic and short period stochastic simulations to generate broadband time history

1D Strong Motion Simulation, SAC Steel Project



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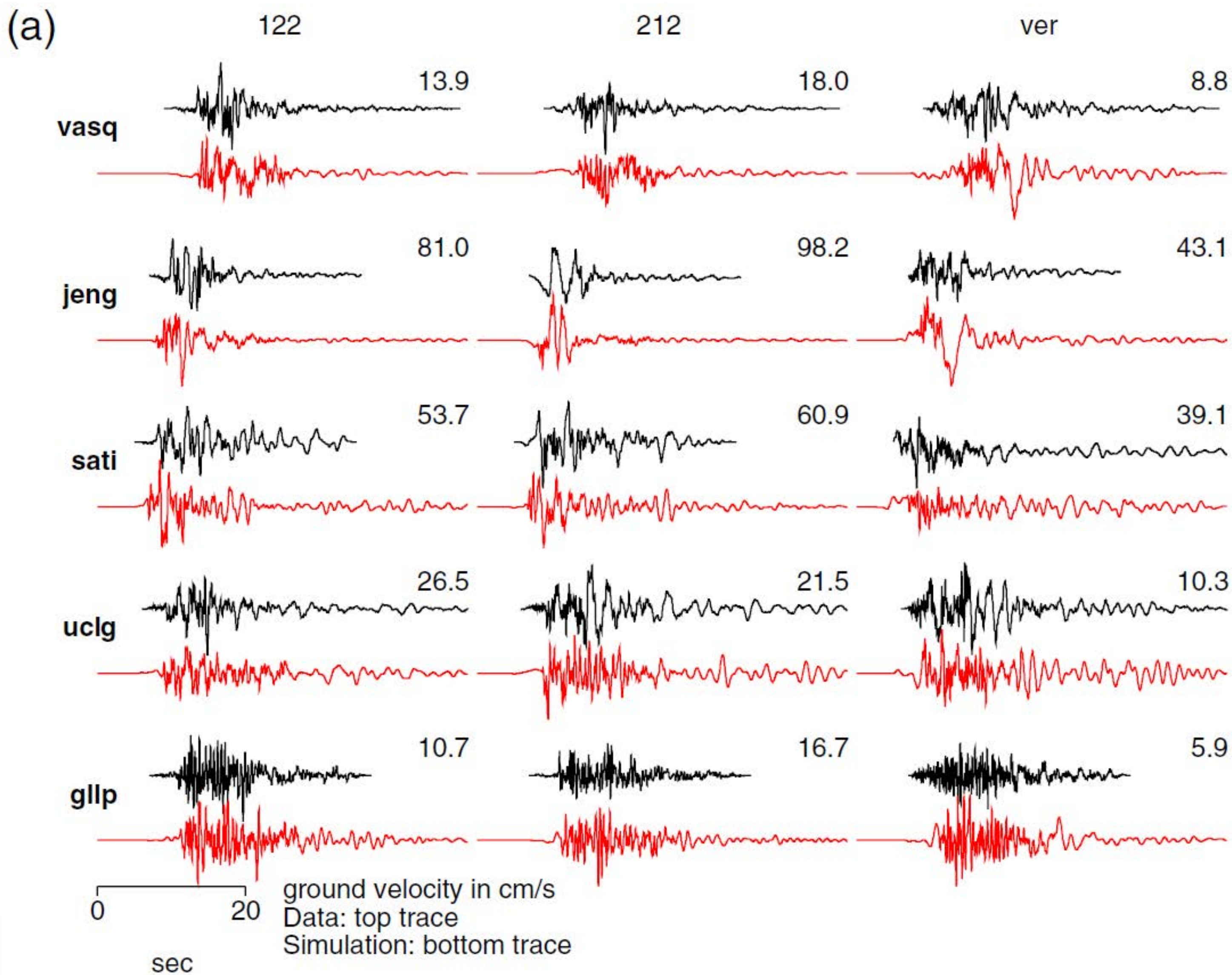
Validation of 3D Broadband Simulation



Graves & Pitarka, 2010

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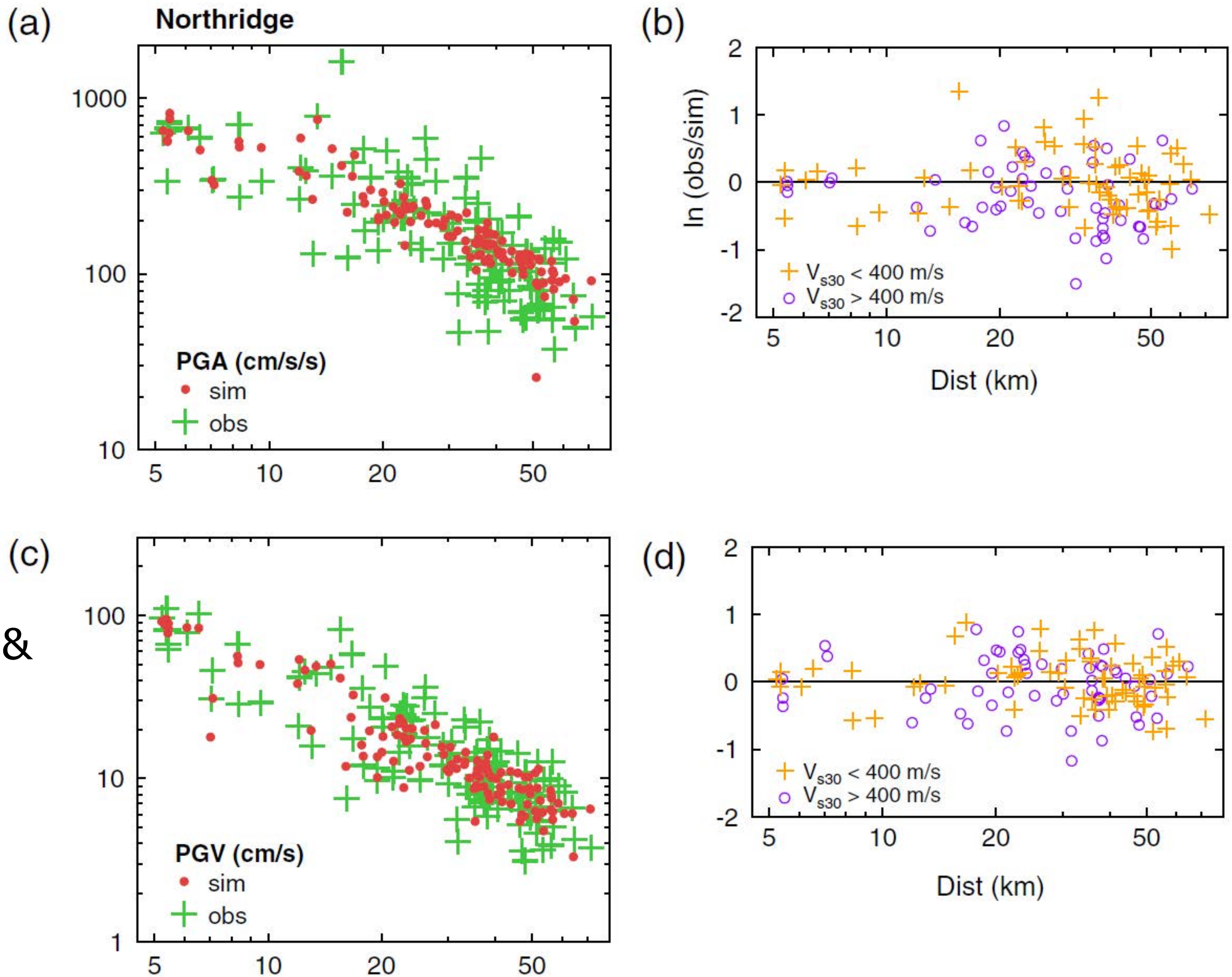

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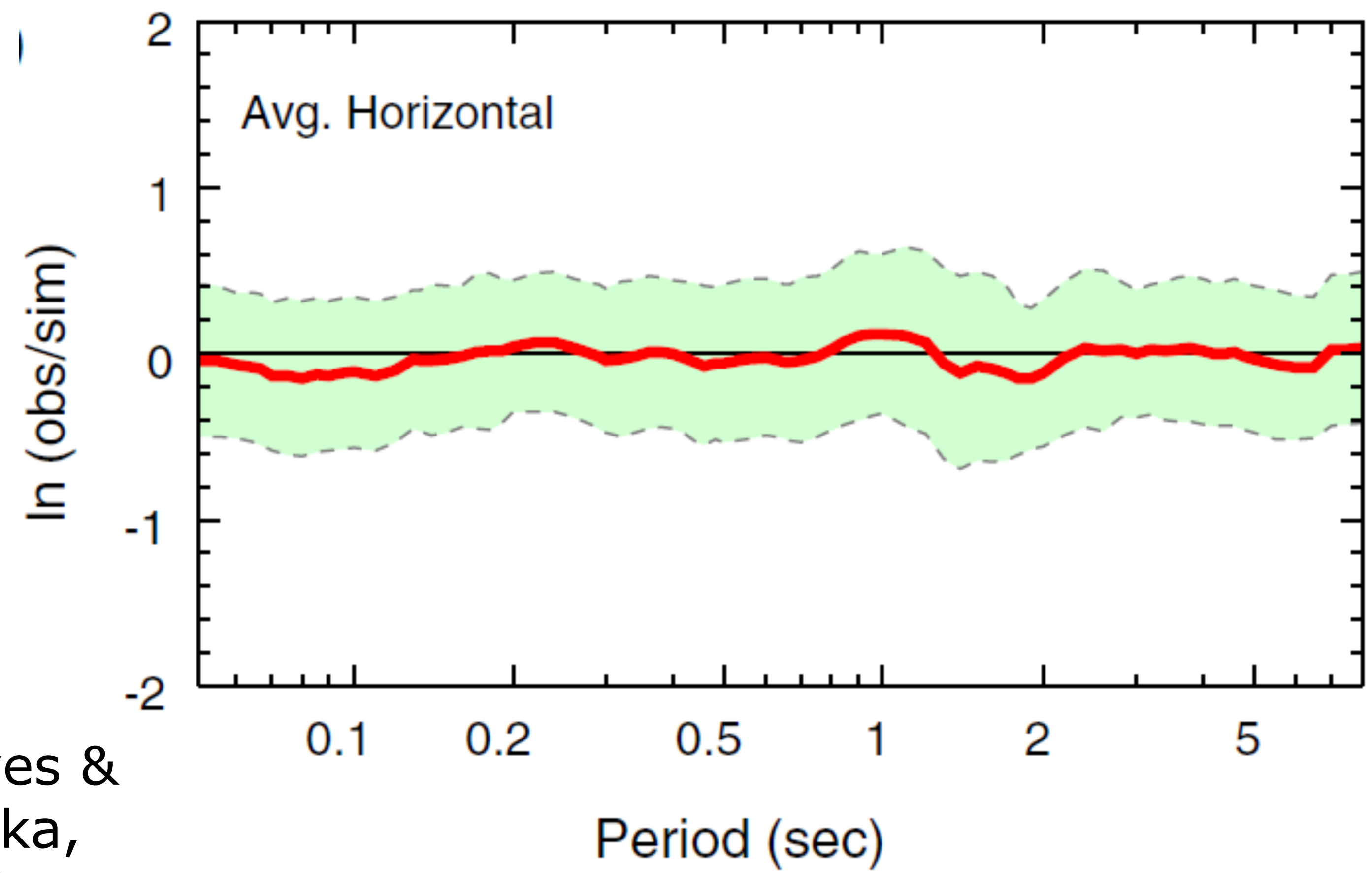
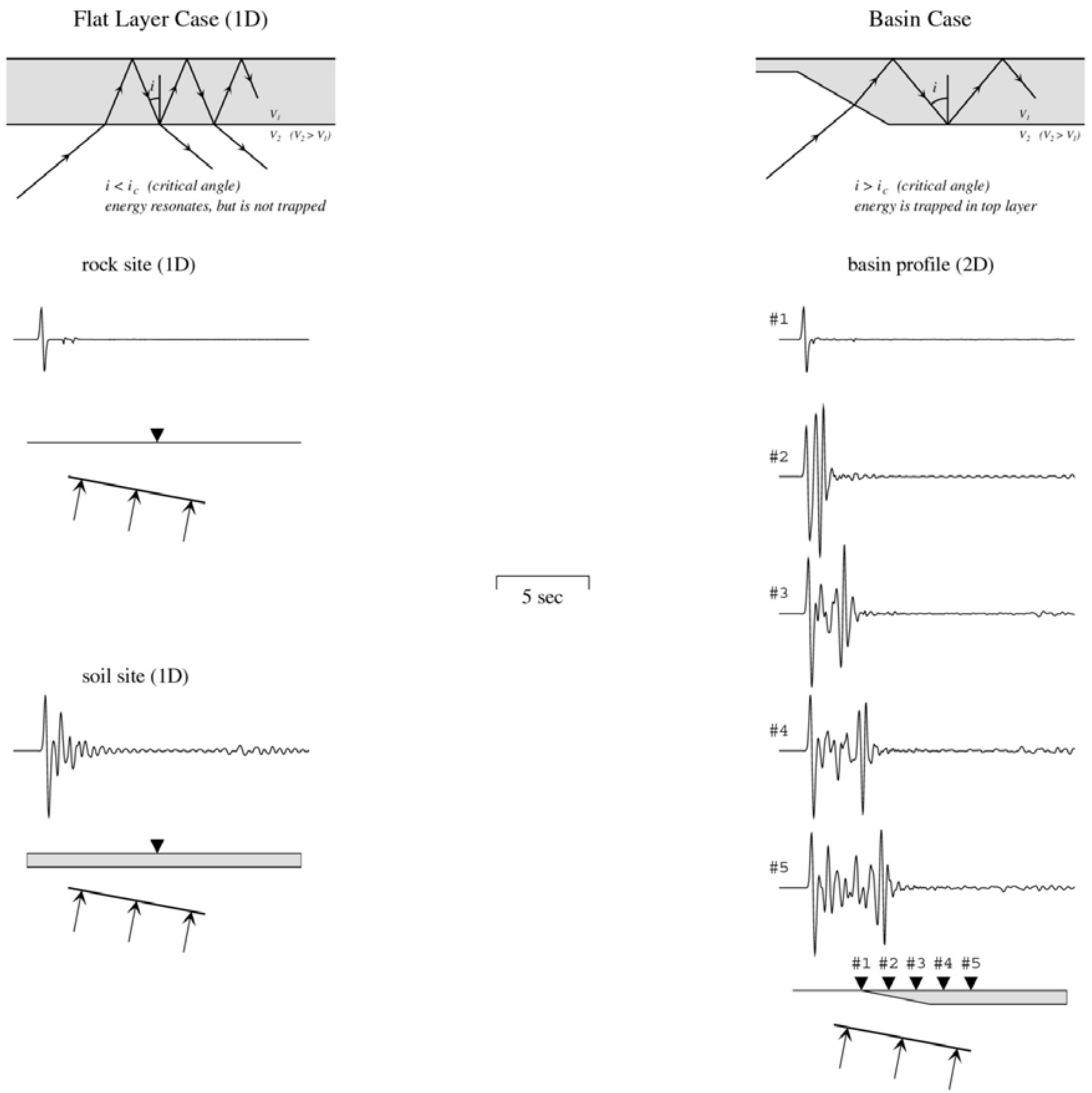


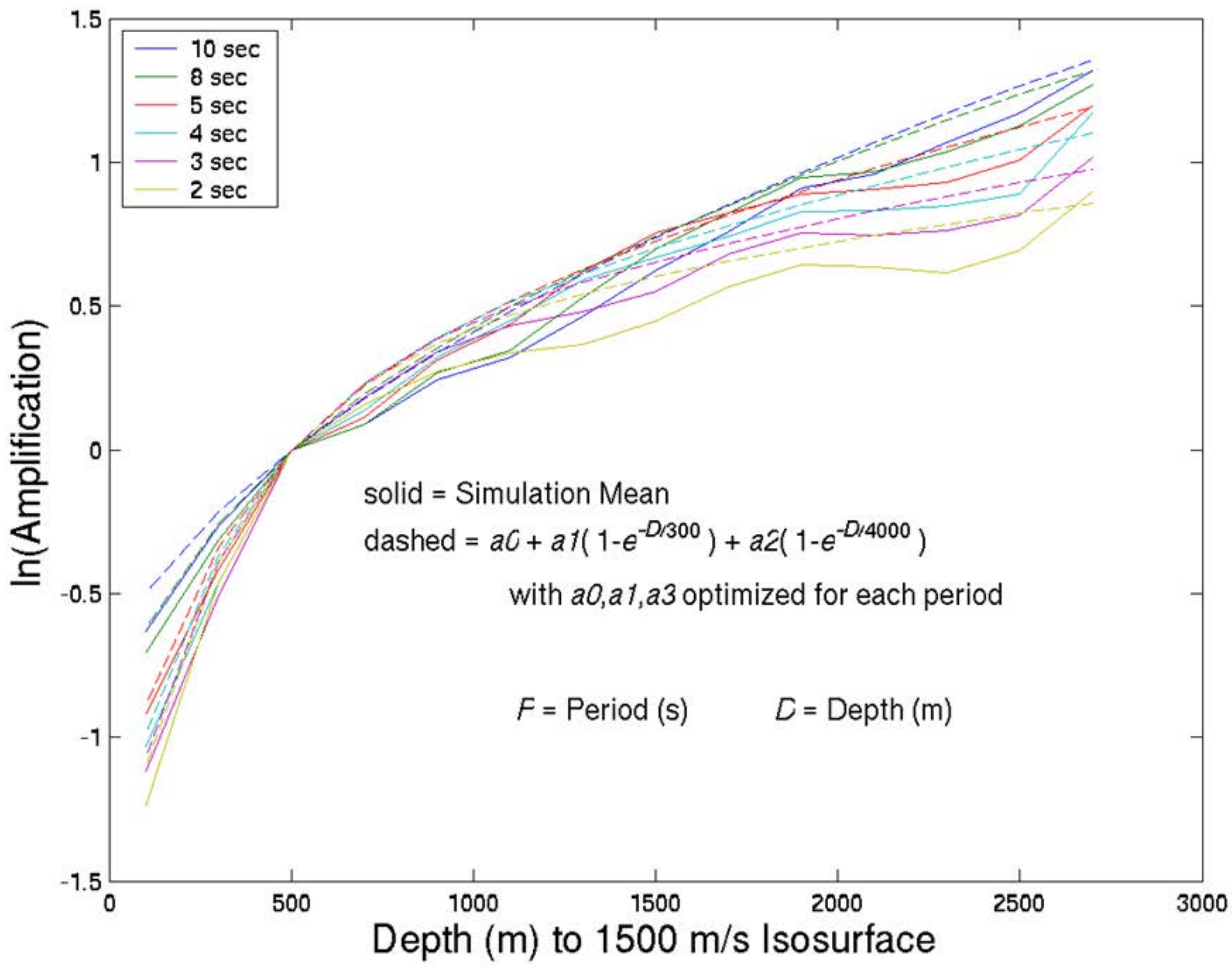
Graves & Pitarka, 2010

Basin Wave Trapping Mechanism



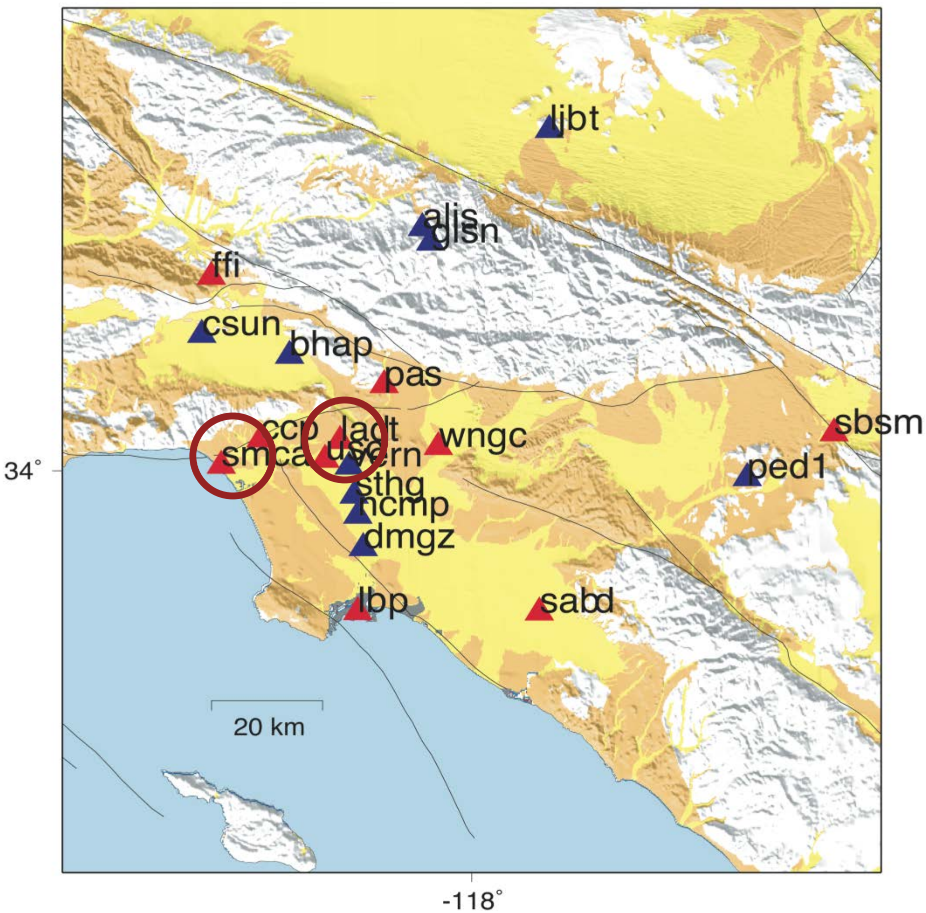
Graves

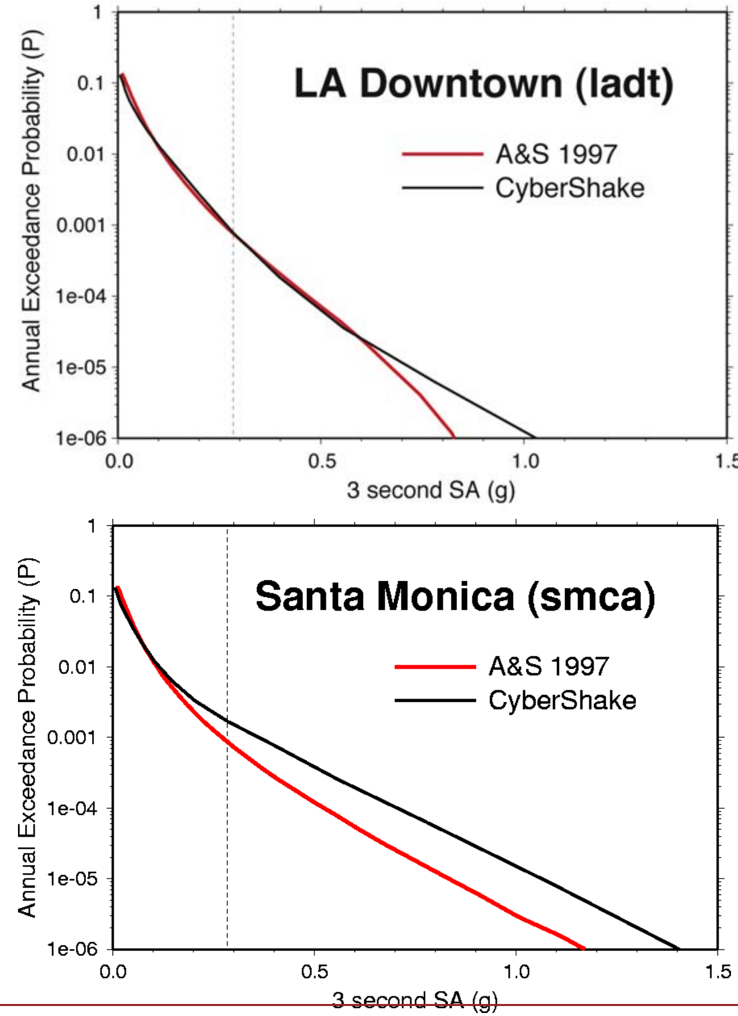
Basin Amplification



PEER/SCEC
NGA West 1

PSHA based on 3D simulations vs GMPE





Graves et al., SCEC Cybershake Platform

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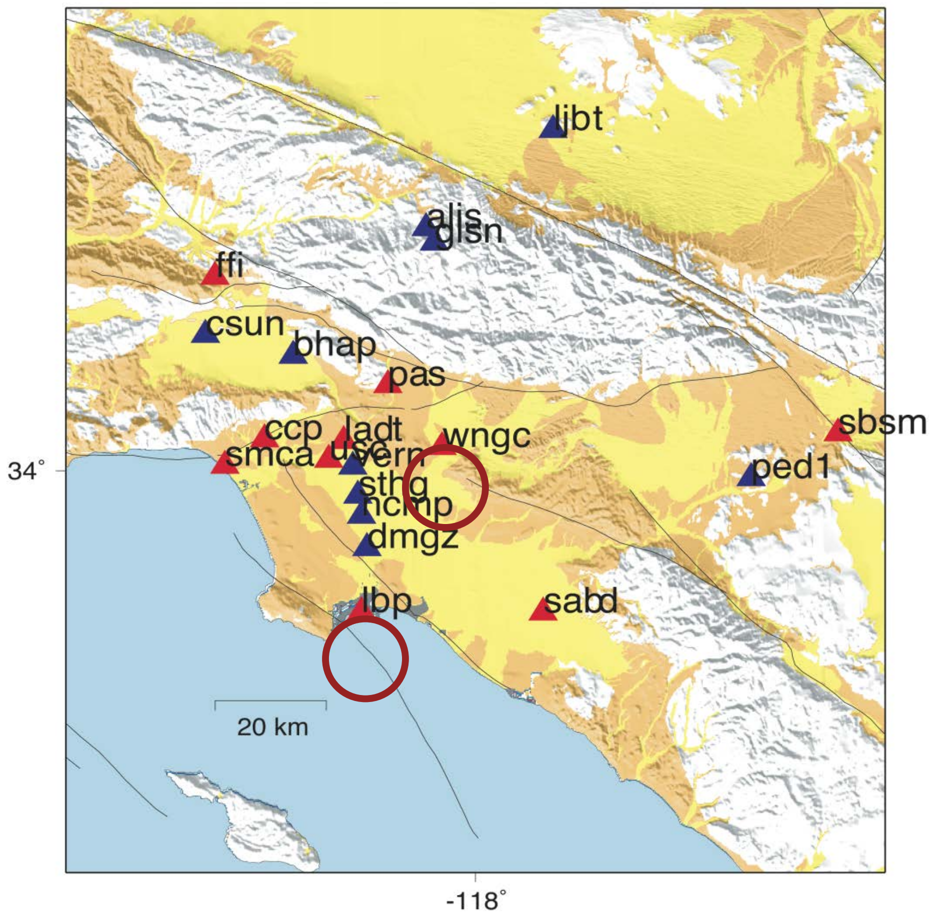
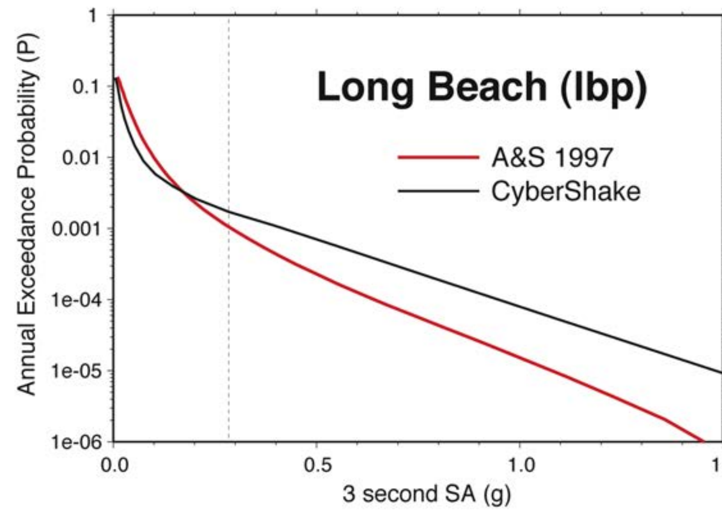
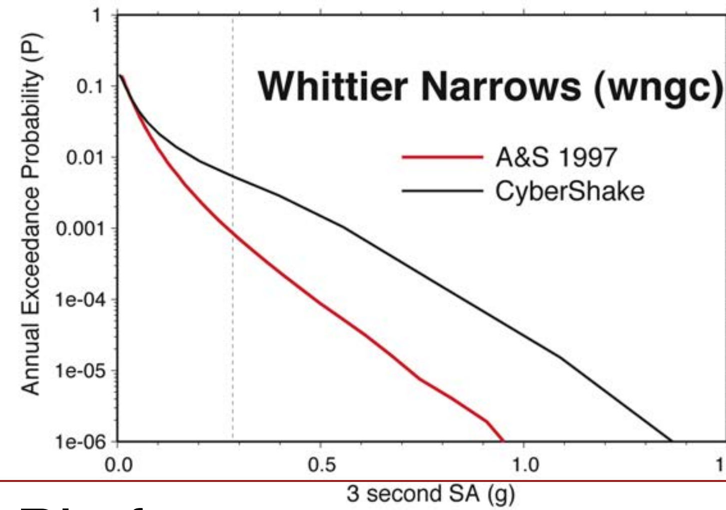
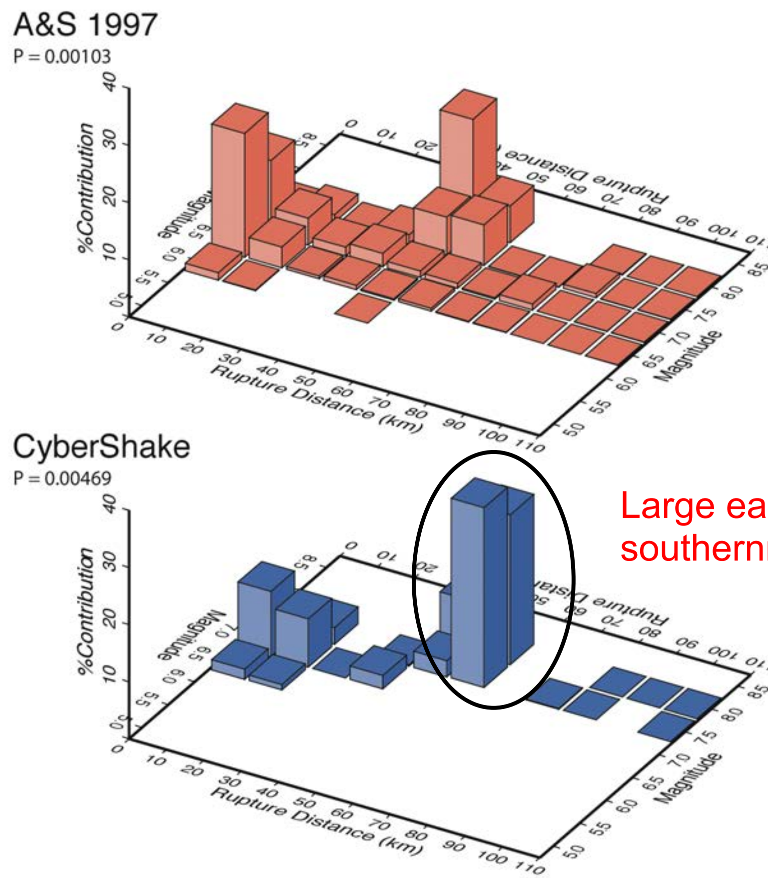






Graves et al., SCEC Cybershake Platform

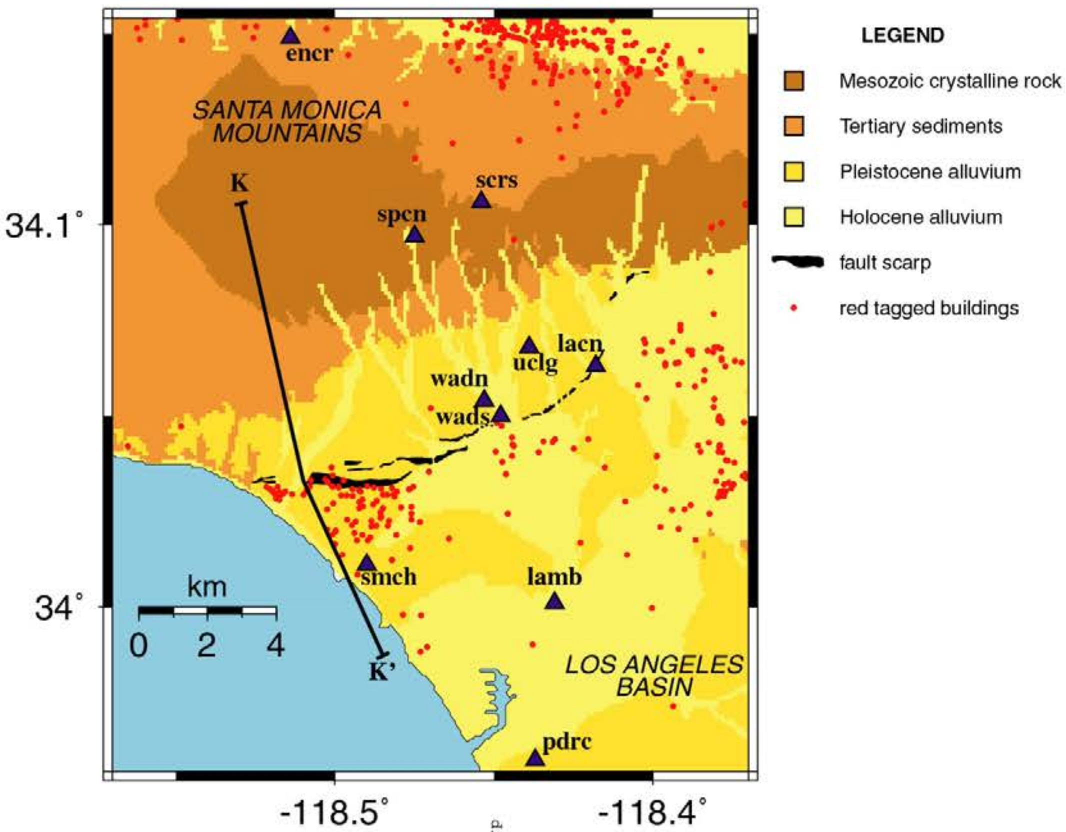
Cybershake vs. GMPE: Hazard Disaggregation at Whittier

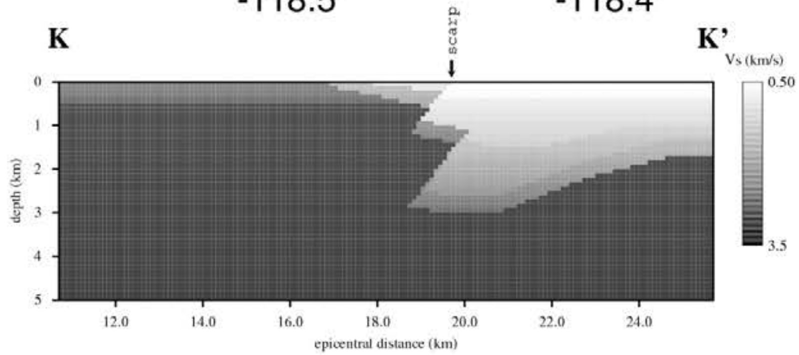


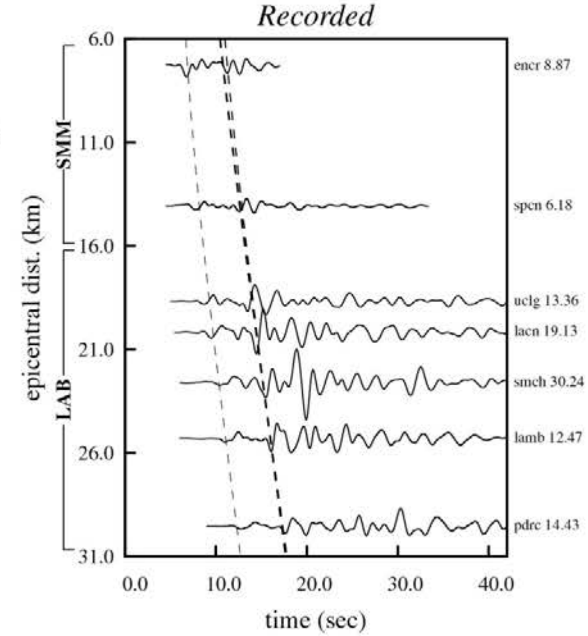
Large earthquakes on southernmost SAF

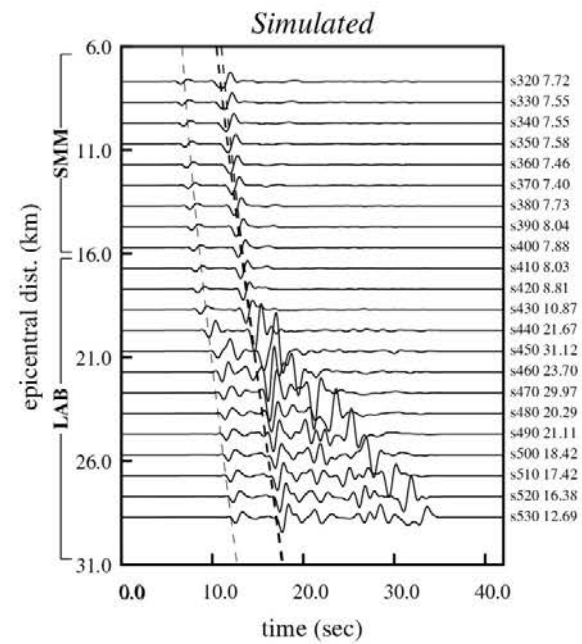
Graves et al., SCEC Cybershake Platform

Basin Edge Effects, Santa Monica Fault



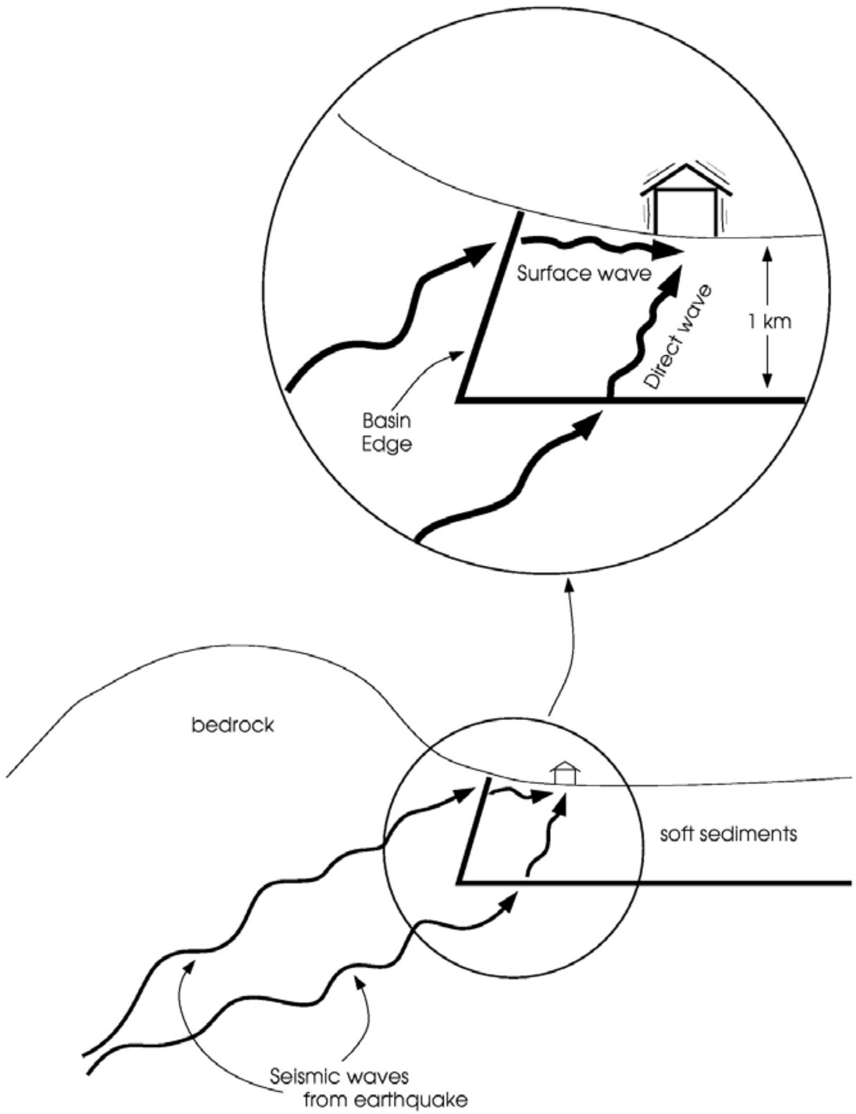






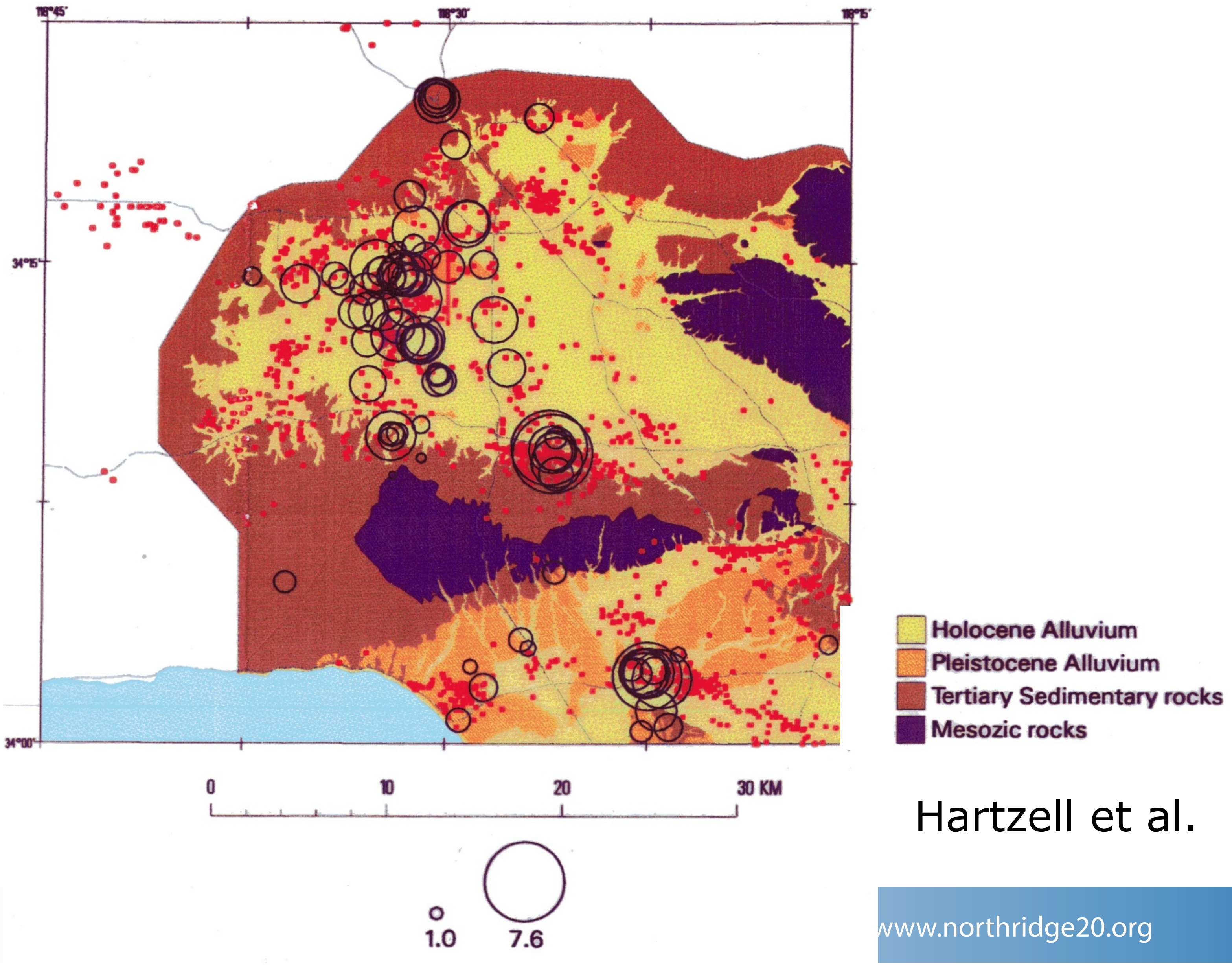
Graves

Multipathing Effect at Basin Edge



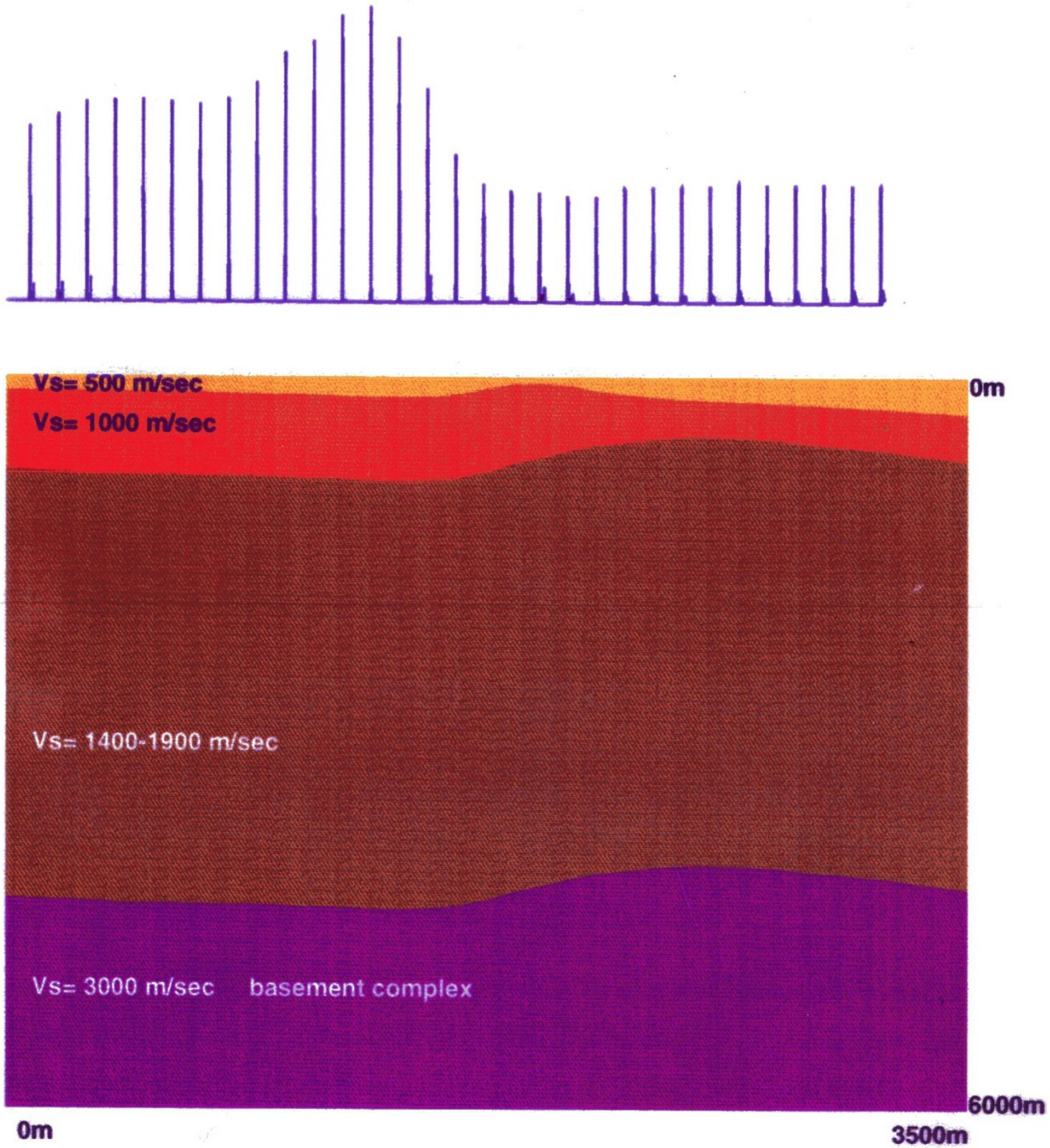
Graves

Amplification Measured in Aftershocks



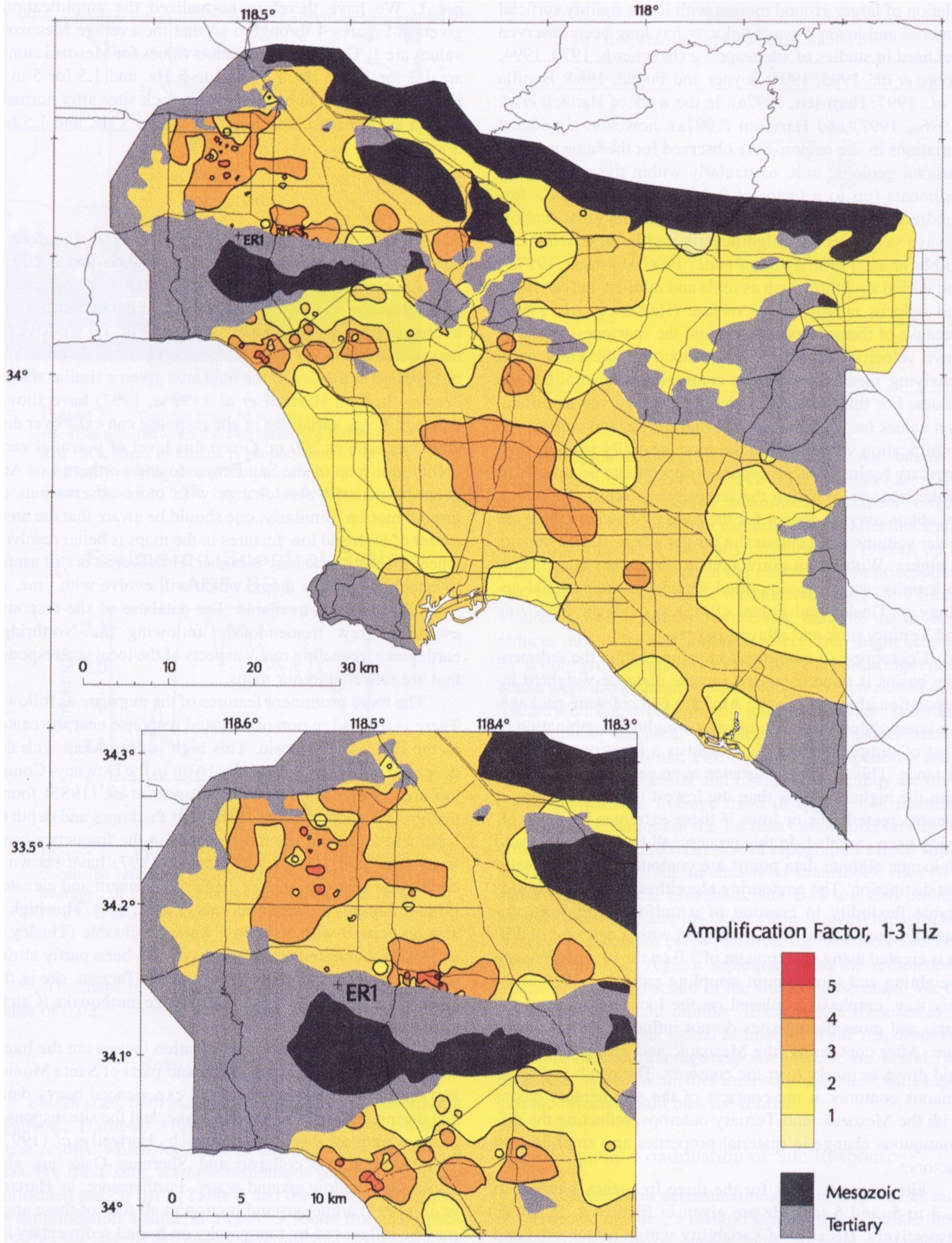
Hartzell et al.

Focusing from Topography on Subsurface Rock



Frankel

Empirical Amplification



Hartzell et al.

Next Steps

- Ongoing improvement and validation of broadband simulations on the SCEC Broadband Platform:
  - http://scec.usc.edu/scecpedia/Broadband_Platform
  - Open for anyone to use

- Improved narrowband rupture directivity model based on simulations

- Improved hanging wall model based on simulations

Next Steps

- Understand the effects of non planar 3D structure on ground motion amplification through waveform modeling of recorded ground motions
- Compare simulated amplifications with measurements by USGS (Hartzell et al.)
- Special focus is needed on basin edges, especially fault-bounded basin edges

Next Steps

- Use ground motion simulations (Cybershake) to map probabilistic long period ground motions for the next revision of the National Seismic Hazard Maps (SCEC/USGS/C.B. Crouse)

- Exploit the capacity of simulations to provide ground motion time histories as well as response spectra in earthquake engineering research and practice