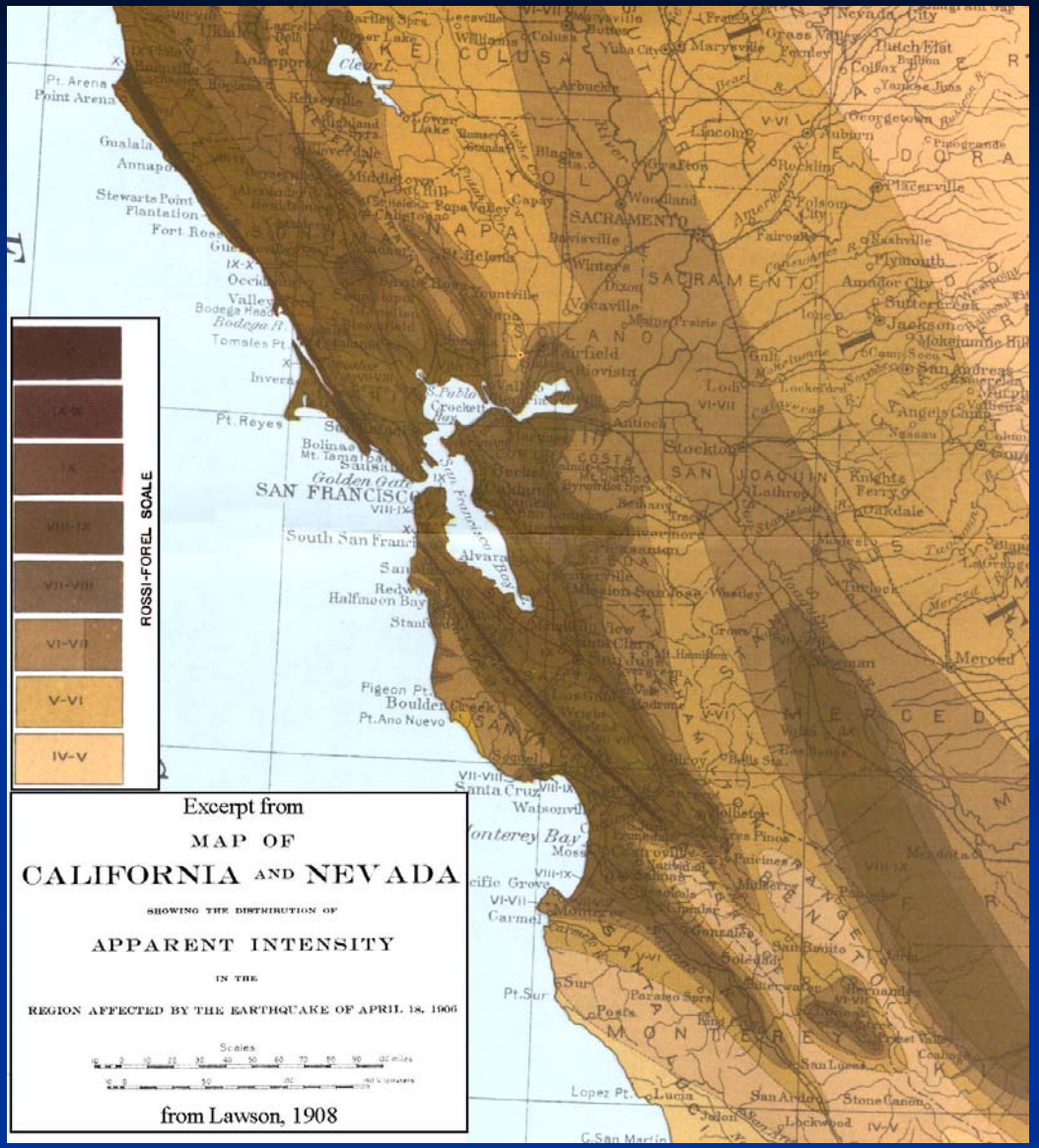
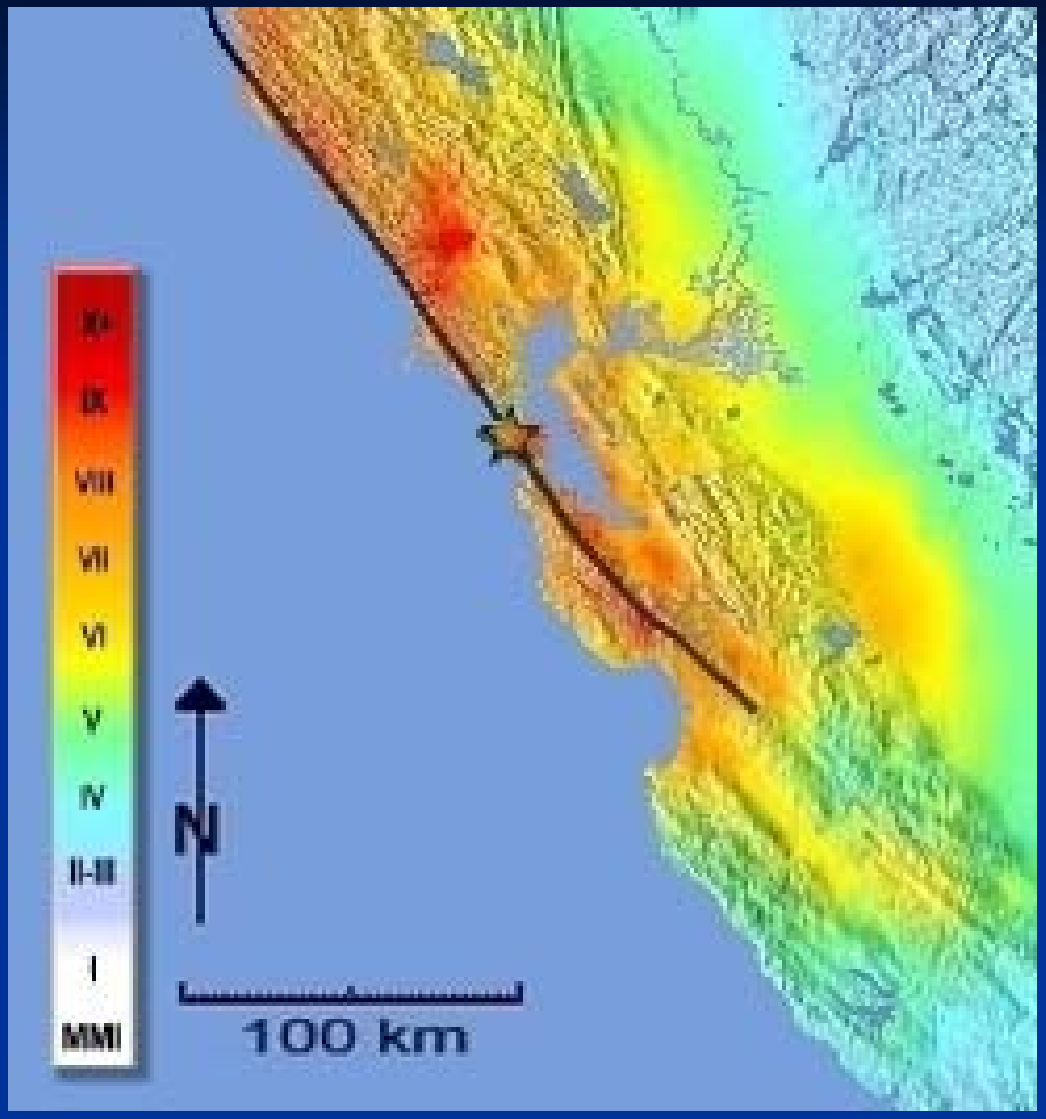
Ground shaking attenuation relations



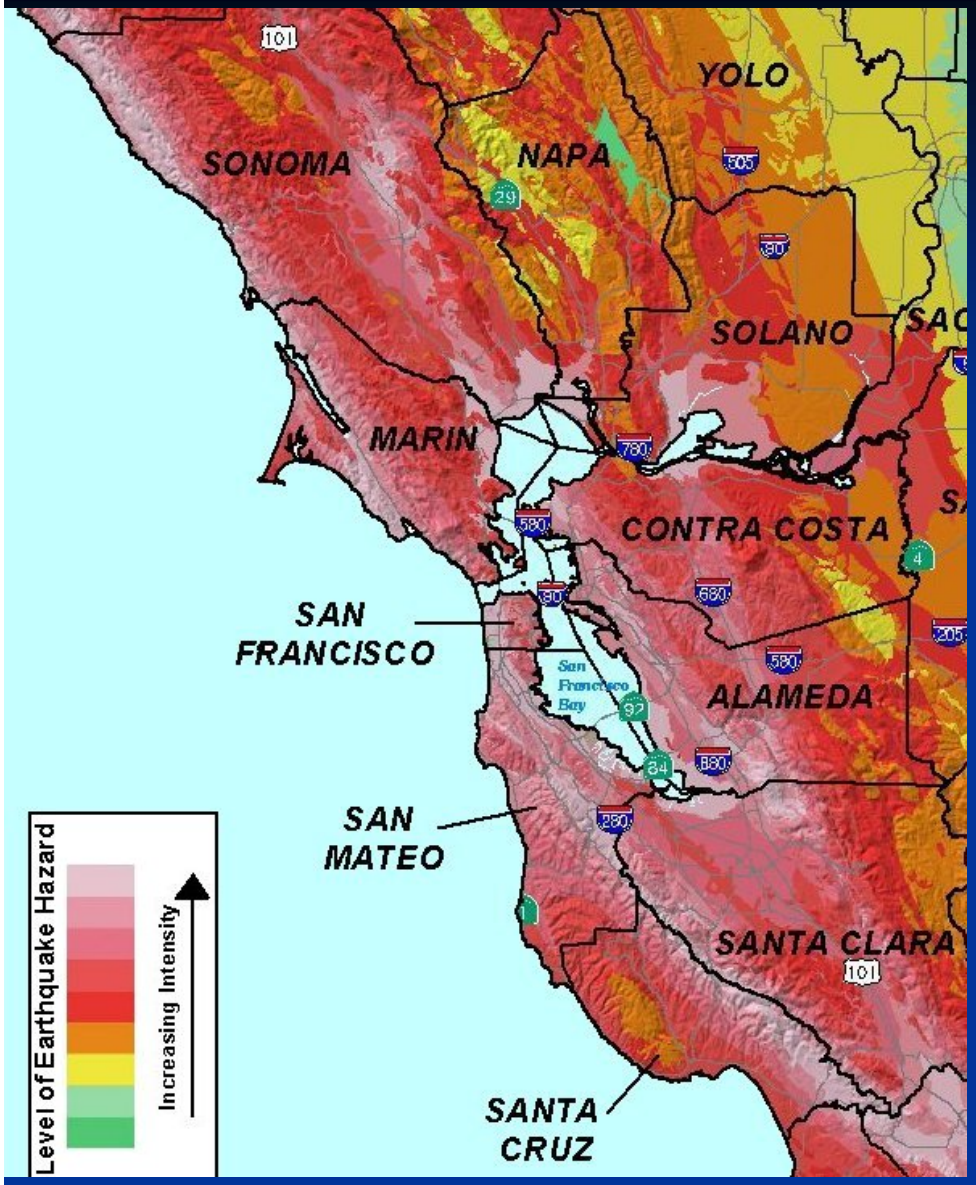
Felt Reports from the Lawson, 1908 report

- Learned that ground shaking function of distance from fault source.
- Learned that soft soils amplified ground shaking.



- Ground motions can be simulated using complex finite fault rupture models and shallow site conditions.
- Simulations are used in the Eastern U.S.
- These ground motions can be converted to intensity but the uncertainties are high.

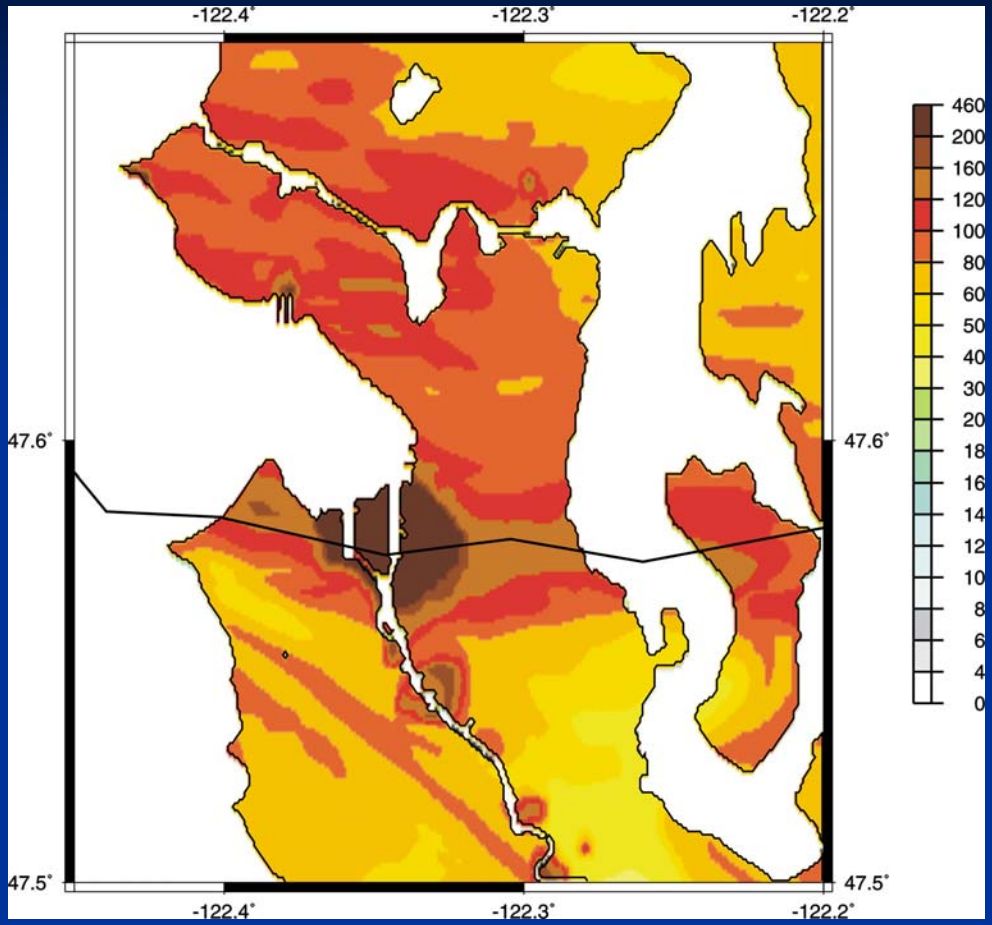
Predicted ground motions for the 1906 earthquake (Boatwright and Bundock, 2005)



- Maps for public use.
- Soils considered, but we used the 1hz ground motion that would show amplification in soft soils.

Seismic hazard map for 2% probability of exceedance in 50 years including site conditions.

1 Hz spectral acceleration with 2% probability of exceedance in 50 years



- Includes rupture directivity, basin response, shallow soils.
- Issues with high frequency ground motion; basin edge effect (focussing), hanging wall effects.

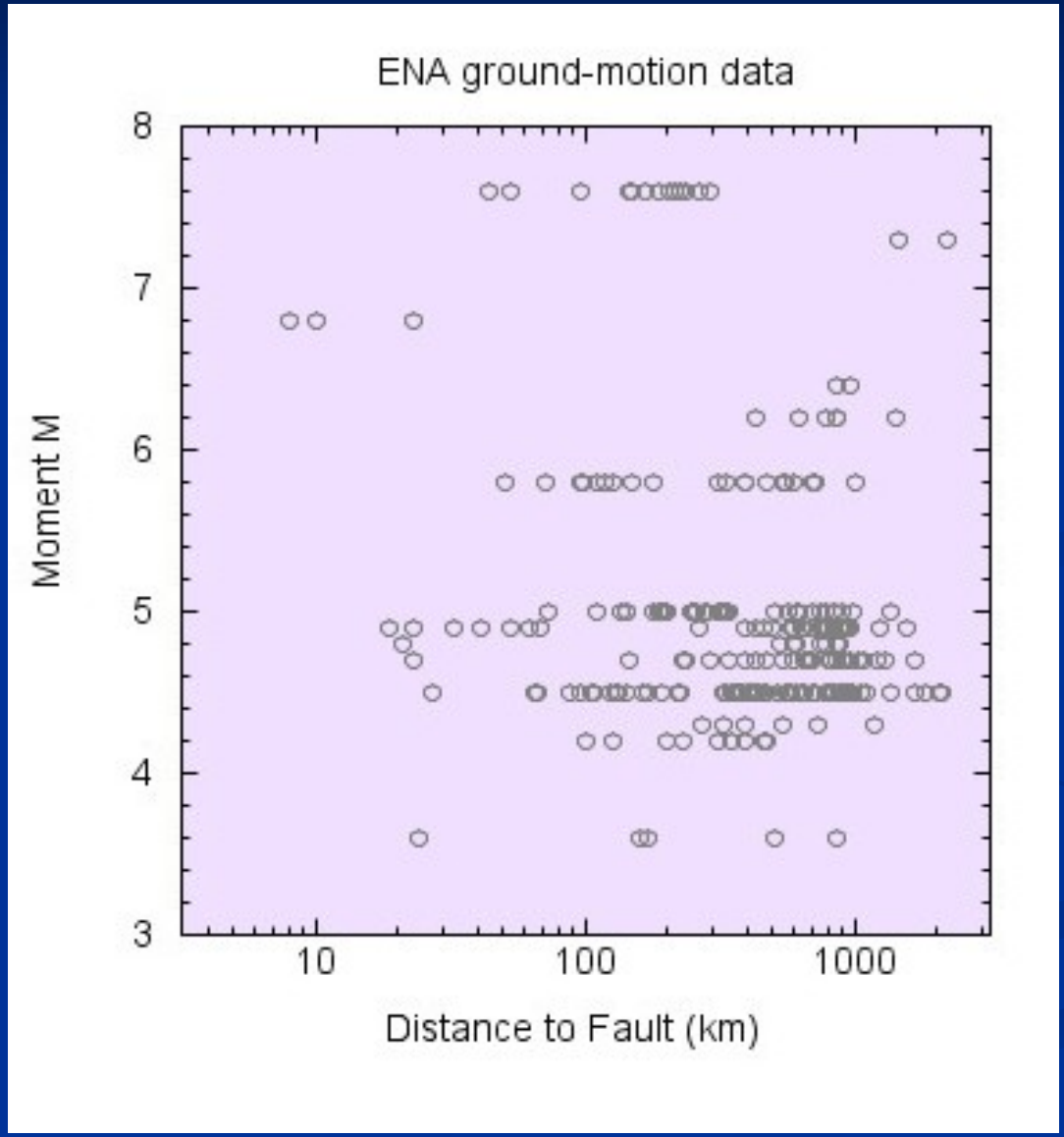
including 3-d basin effects
linear amplification
factors for fill and
Holocene alluvium

USGS science for a changing world

Two types of Attenuation Relations

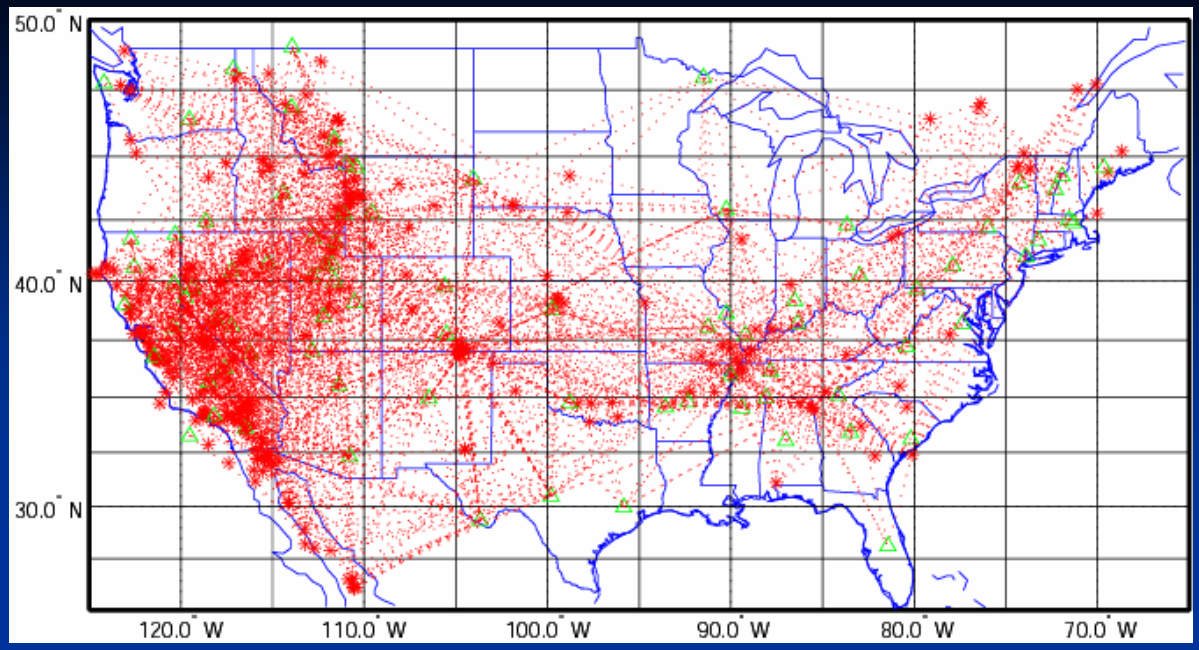
- High Q (inside the plate)
- Low Q (Next to plate boundary)

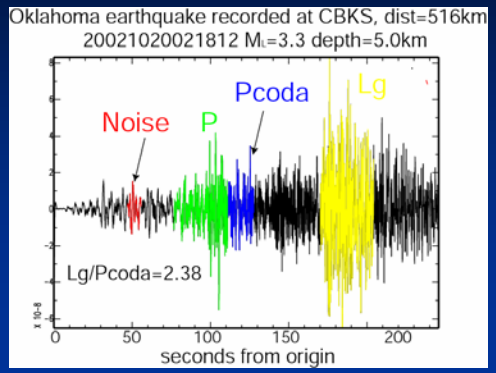
Ground Motion Data (High Q)

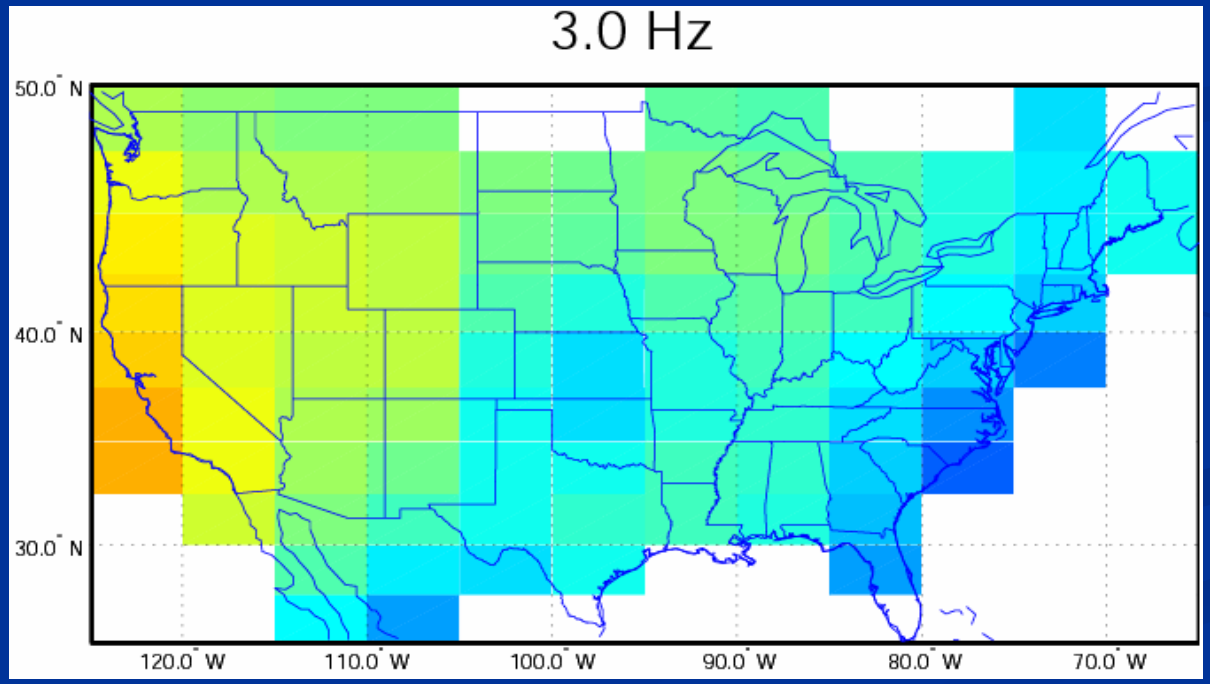


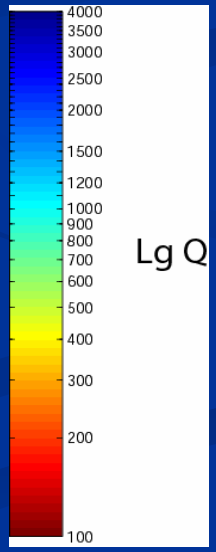
Types of models used in development of High Q ground motion relations

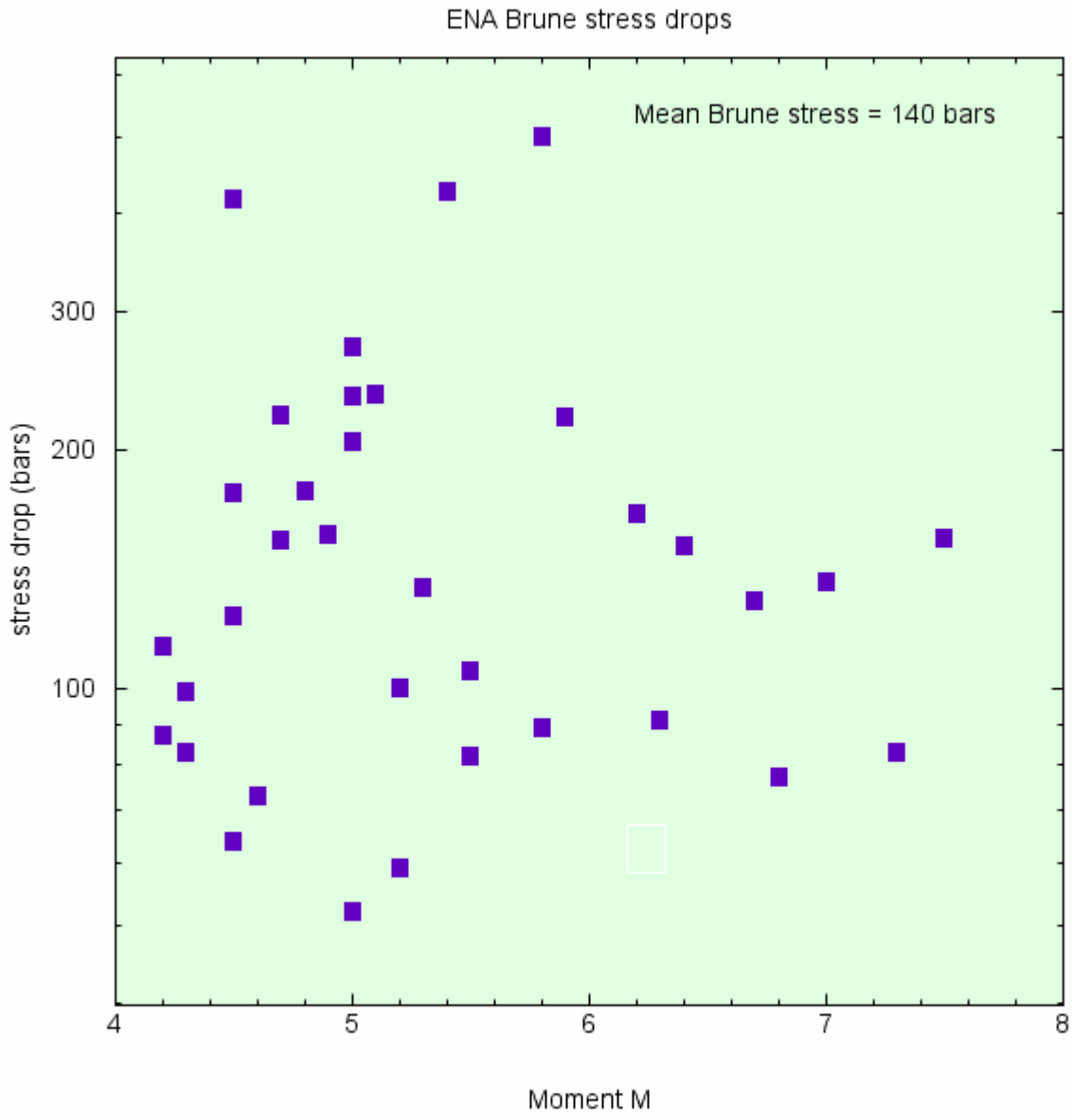
- Simulated
- Hybrid – Use empirical and simulated


50.0° N
40.0° N
30.0° N
120.0° W
110.0° W
100.0° W
90.0° W
80.0° W
70.0° W


Oklahoma earthquake recorded at CBKS, dist=516km
20021020021812 ML=3.3 depth=5.0km
Noise
P
Pcoda
Lg
Lg/Pcoda=2.38
0
50
100
150
200
seconds from origin


3.0 Hz
50.0° N
40.0° N
30.0° N
120.0° W
110.0° W
100.0° W
90.0° W
80.0° W
70.0° W


4000
3500
3000
2500
2000
1500
1200
1000
900
800
700
600
500
400
300
200
100
Lg Q



ENA stress drops, based on high-frequency spectral level. Mean = 140 bars.

High-frequency spectral level depends on stress drop (as in point-source model)

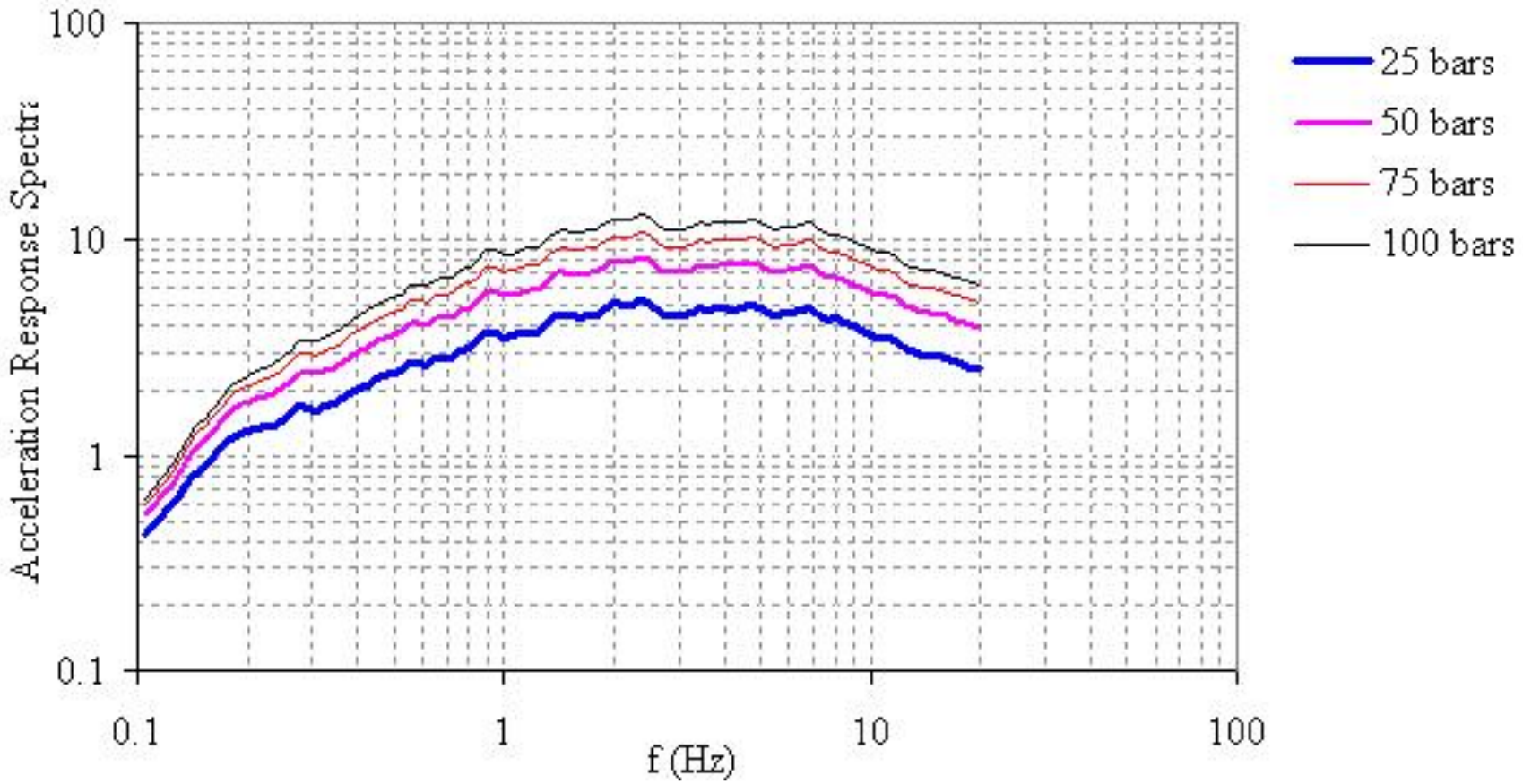
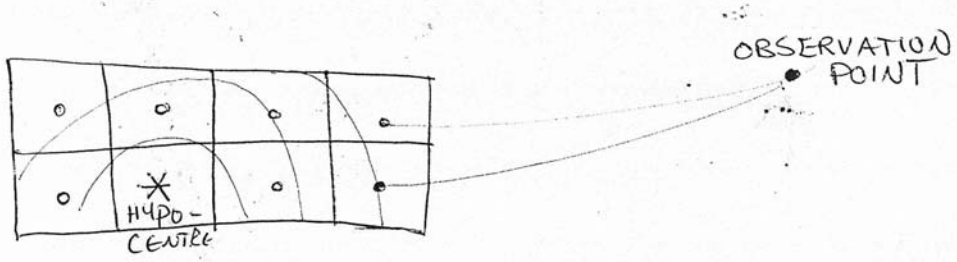


Fig 6. 5% damped pseudo-acceleration for event of M7.0 at R=333 km (25% pulsing area) for different stress parameter , using dynamic corner frequency. In EXSIM, variation of stress parameter can be used to adjust the relative amplitudes of high-frequency motion. By increasing the stress parameter, the amplitude of high frequencies increases.

Stochastic finite fault model (Silva; Beresnev and Atkinson; *Motazedian and Atkinson, 2005*)

STOCHASTIC FINITE-FAULT MODEL
(Beresnev and Atkinson, 1997, 1998)

TREAT FINITE FAULT PLANE AS AN ARRAY OF SUBFAULTS



MODEL EACH SUBFAULT AS A STOCHASTIC POINT SOURCE, WITH A BRUNE (ω^2) SOURCE SPECTRUM

RUPTURE STARTS AT A SPECIFIED SUBFAULT (HYPOCENTRE), AND PROPAGATES IN ALL DIRECTIONS WITH SPECIFIED RUPTURE PROPAGATION VELOCITY (SAY 0.8 TIMES SHEAR WAVE VELOCITY).

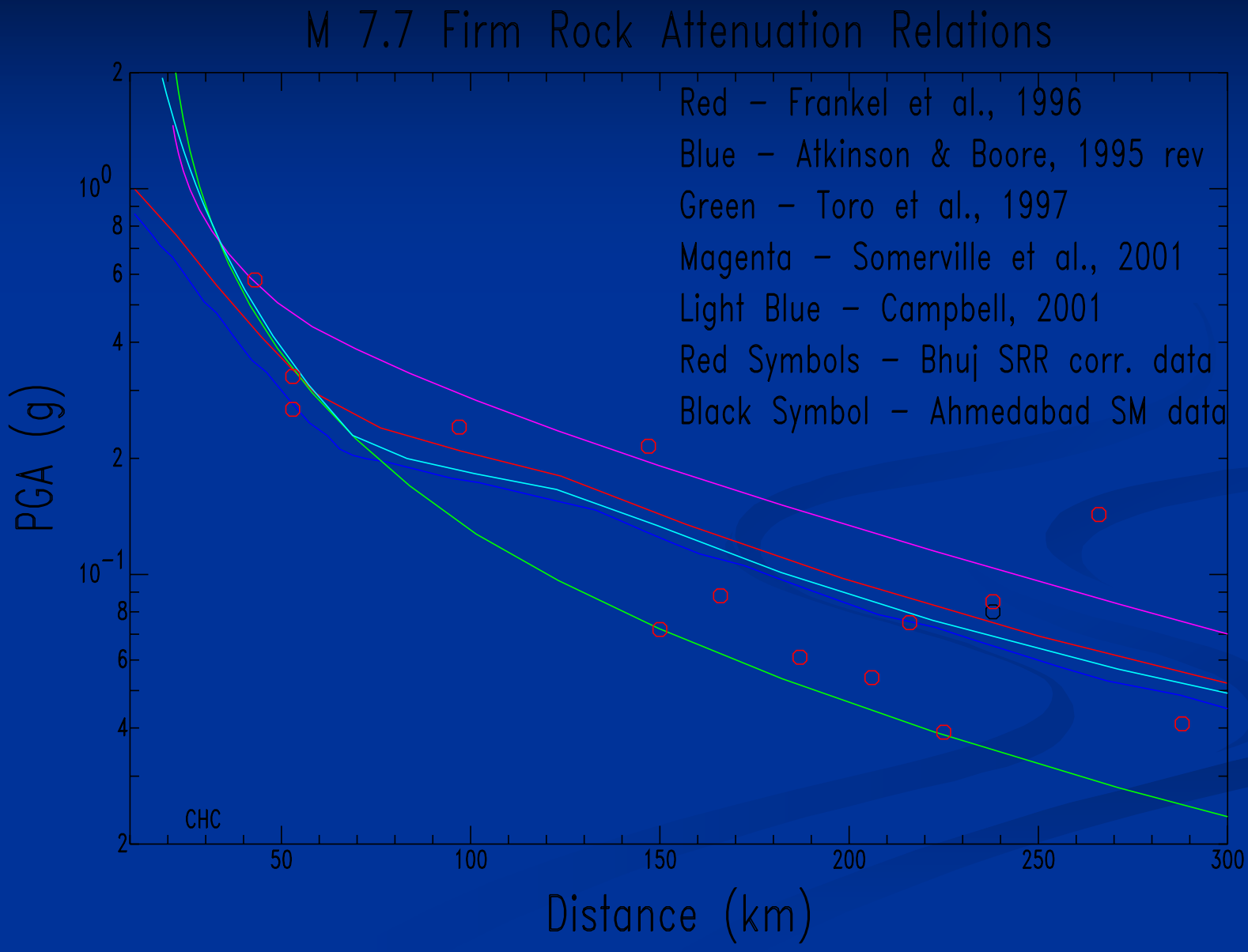
SUBFAULT RADIATION IS 'TRIGGERED' WHEN RUPTURE REACHES THE CENTRE OF THE SUBFAULT

CONTRIBUTIONS TO RADIATION AT OBSERVATION POINT ARE SUMMED OVER ALL SUBFAULTS.

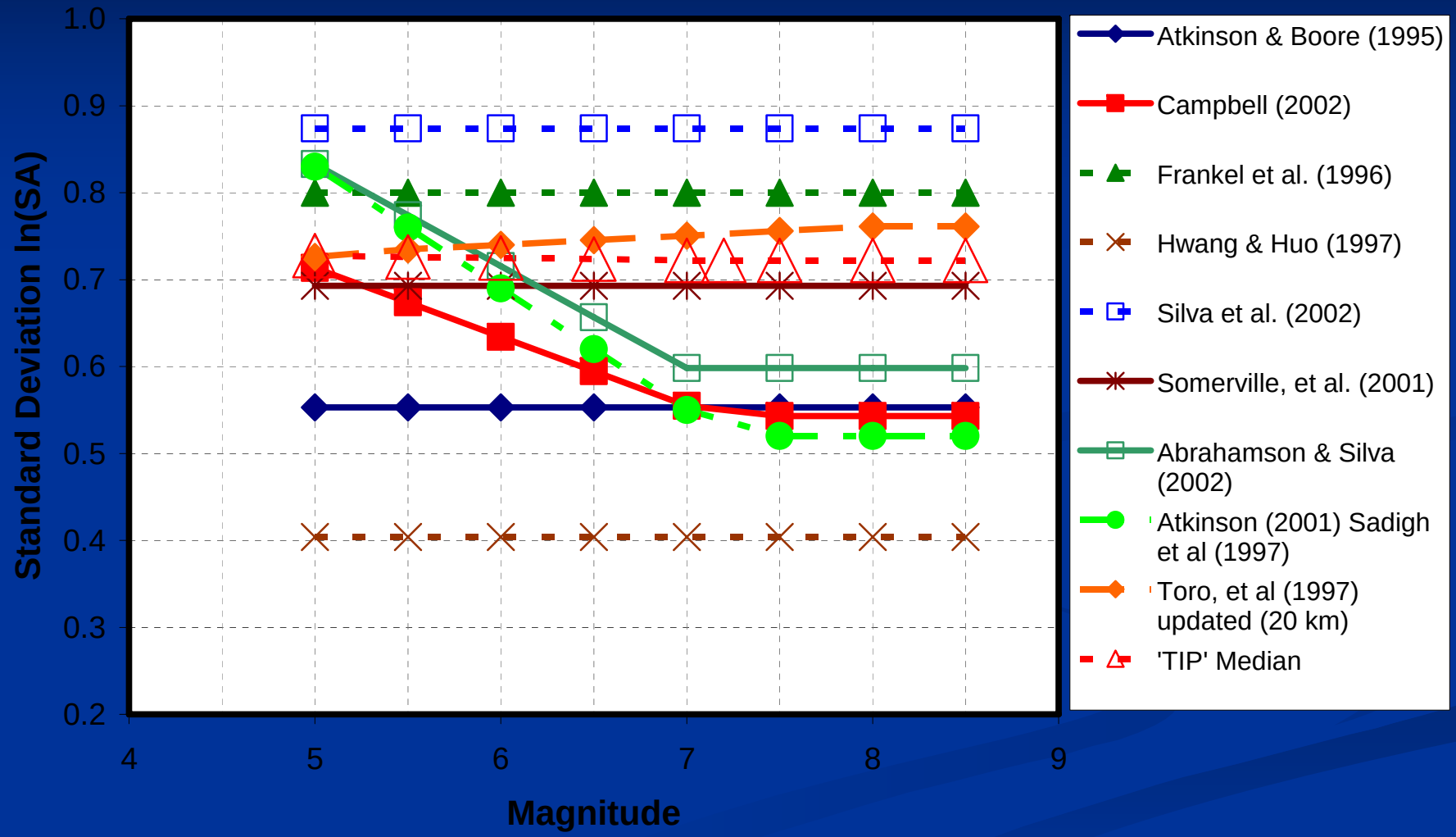
The Hybrid Empirical Method (HEM)

- Applied by adjusting empirical ground motion relations from one region (Host) to represent ground motion characteristics in another region (Target)

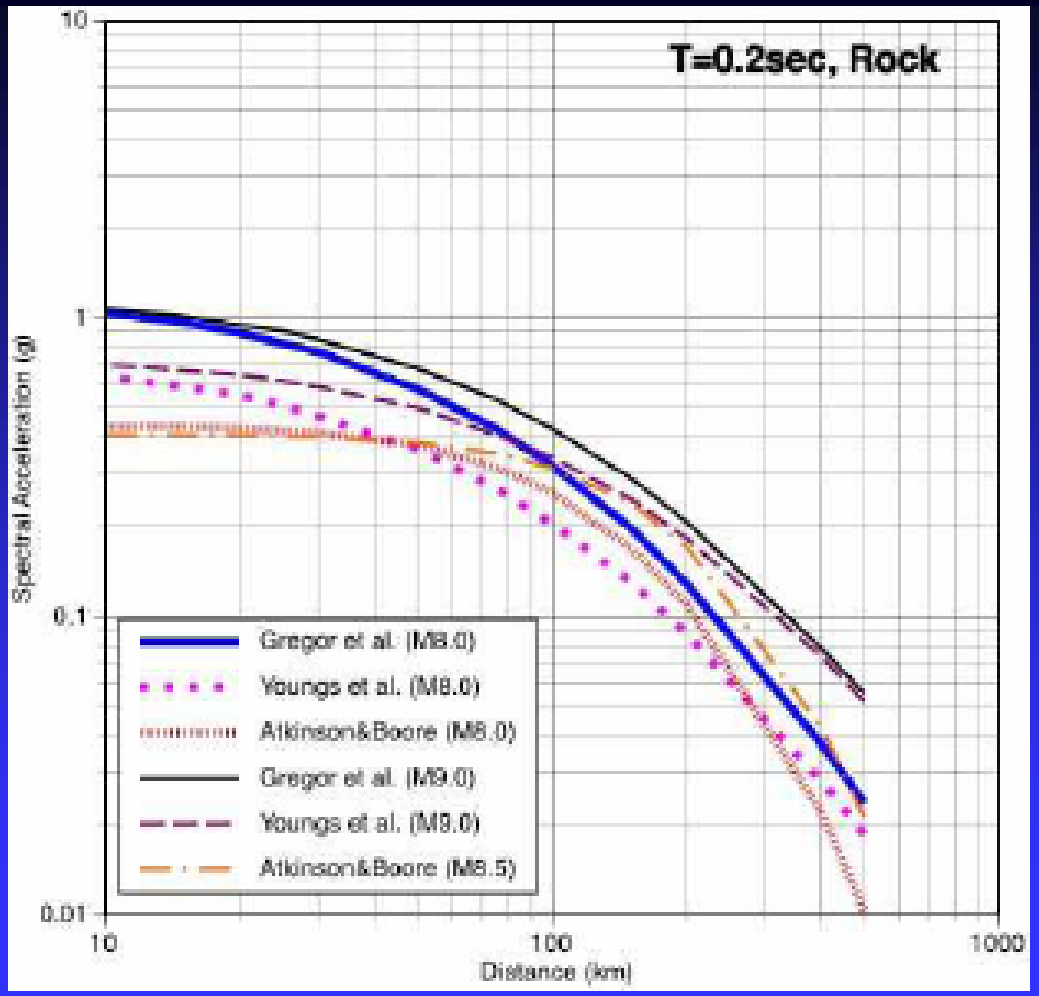
2002 Equations

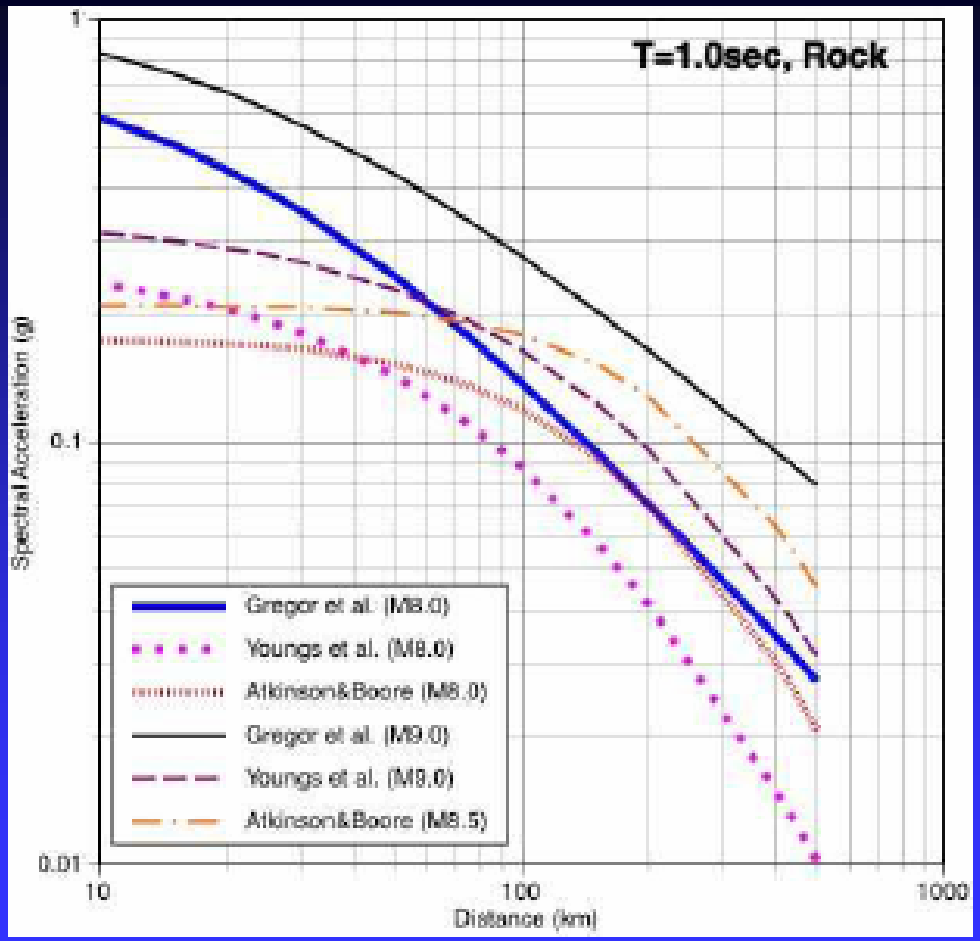


Aleatory Variability - 1 Hz SA



Subduction zones


T=0.2sec, Rock
Spectral Acceleration (g)
10
1
0.1
0.01
10
100
1000
Distance (km)
Gregor et al. (M8.0)
Youngs et al. (M8.0)
Atkinson&Boore (M8.0)
Gregor et al. (M9.0)
Youngs et al. (M9.0)
Atkinson&Boore (M8.5)


T=1.0sec, Rock
Spectral Acceleration (g)
1
0.1
0.01
10
100
1000
Distance (km)
Gregor et al. (M8.0)
Youngs et al. (M8.0)
Atkinson&Boore (M8.0)
Gregor et al. (M9.0)
Youngs et al. (M8.0)
Atkinson&Boore (M8.5)

Low Q (highly attenuating)

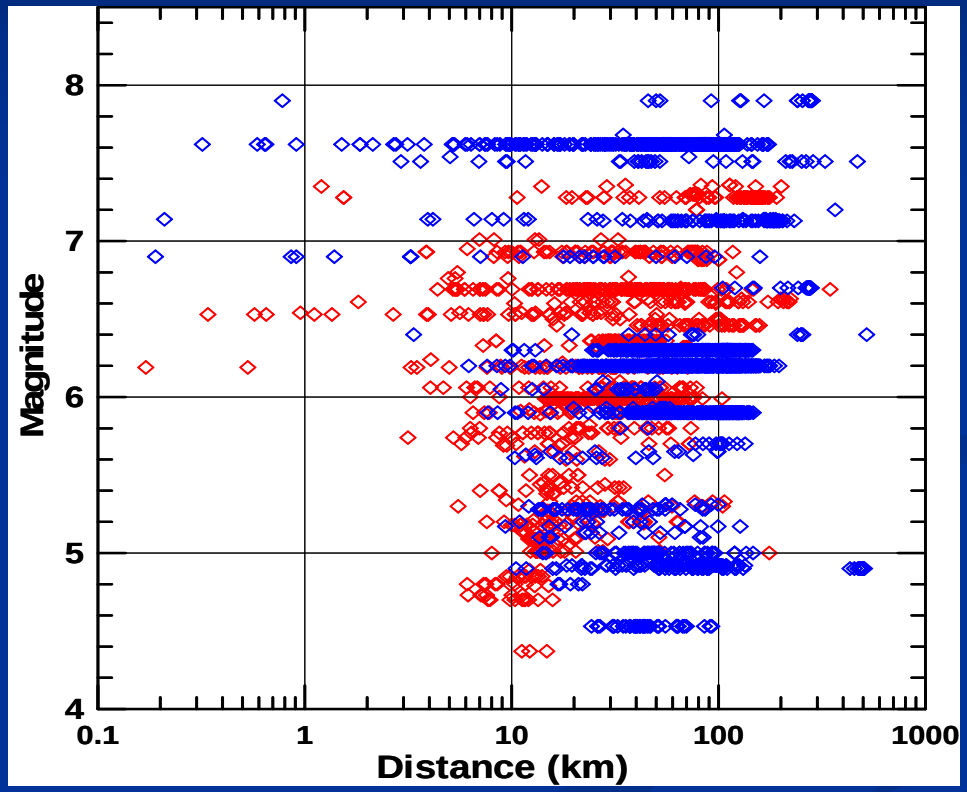
New Ground motion models for Low Q regions

- Ground motion model
  - Provide a model for median ground motion
  - Provide a model for aleatory uncertainty
- Ground motion parameters
  - Horizontal components (Geometric mean, FN, FP)
  - PGA, PGV, PGD (optional)
  - Spectral acceleration (minimum of 20 periods from 0 –10 s)
- Applicable magnitude range
  - Use moment magnitude
  - 5.0 – 8.5 (strike-slip faulting)
  - 5.0 – 8.0 (reverse faulting)

- Applicable distance range
  - Select preferred distance measure
  - 0 – 200 km
- Style of faulting (fault mechanism)
  - Strike slip
  - Reverse
  - Normal
- Site classification
  - Select preferred site classification scheme
  - Need not include “very soft soil” (NEHRP E)
  - Provide translation to NEHRP site categories

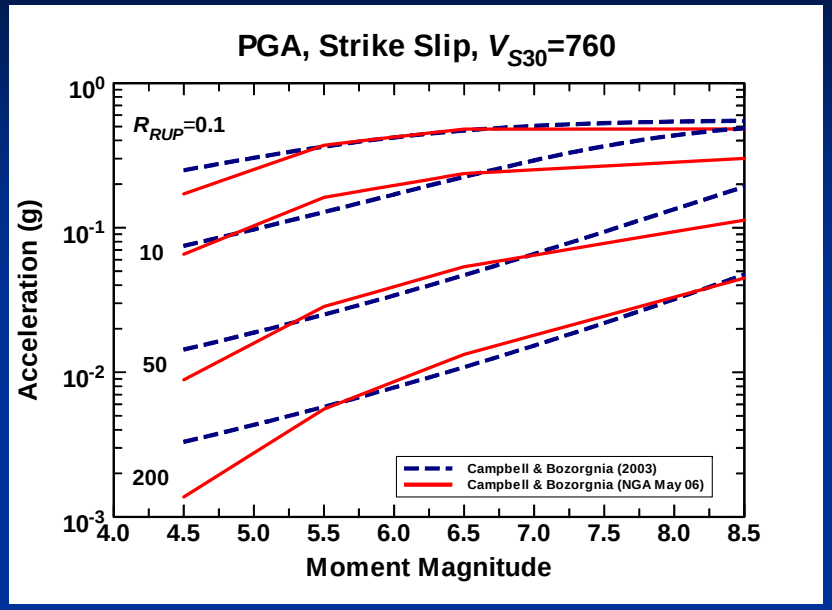
NGA Project Database

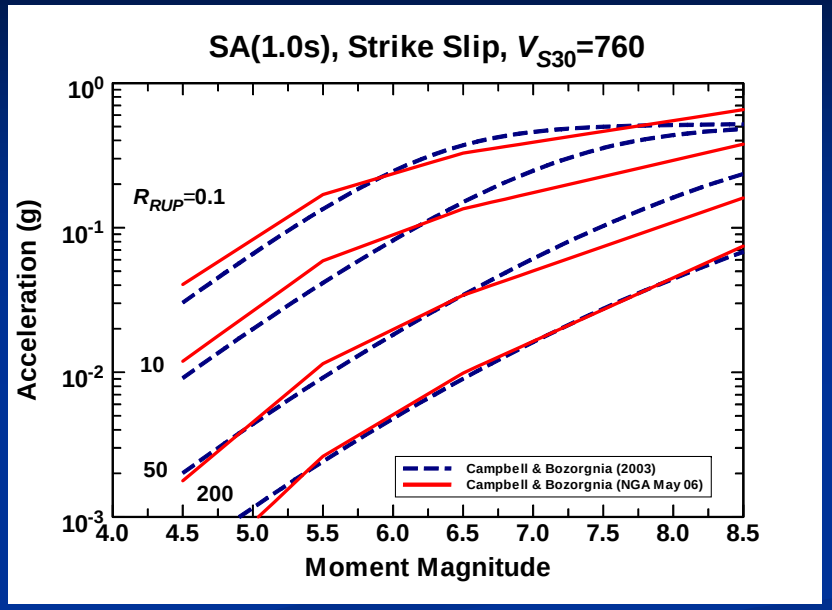
- NGA strong-motion database:
  - **172** worldwide earthquakes
  - **1,400** recording stations
  - **3,500** multi-component strong-motion recordings
  - **Over 100** parameters describing source, path, and site conditions

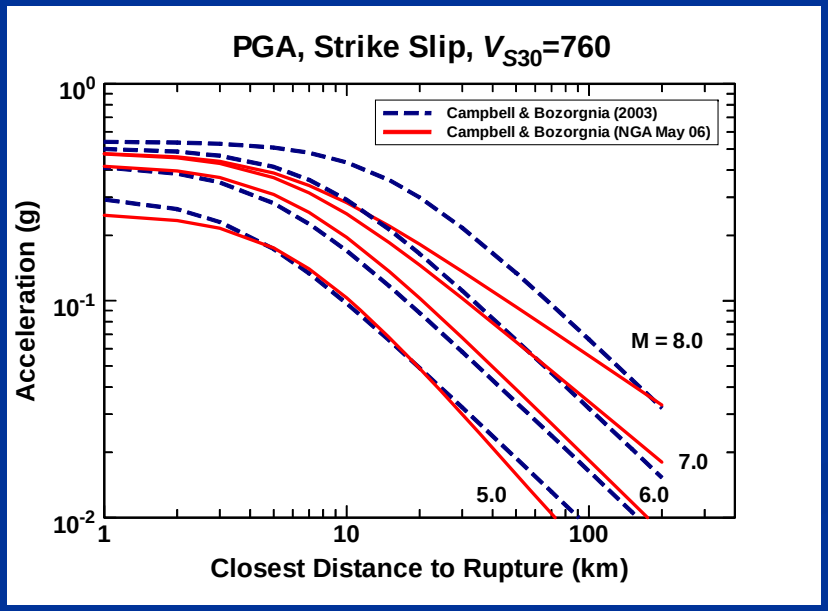


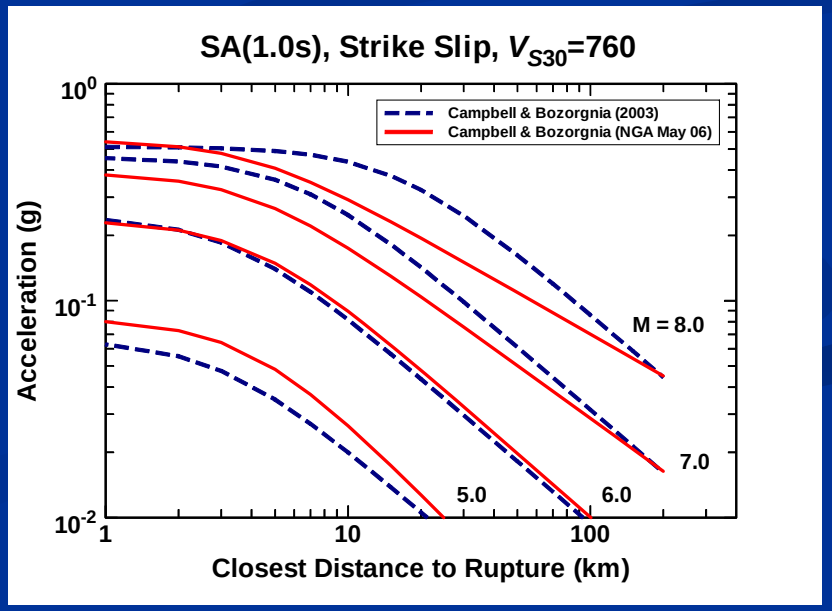
Previous Data **New Data**

C&B06 vs. C&B03 – SS, NEHRP B-C









C&B06 Intra-event Residuals by Region