Characterization of Ground Motion Hazard

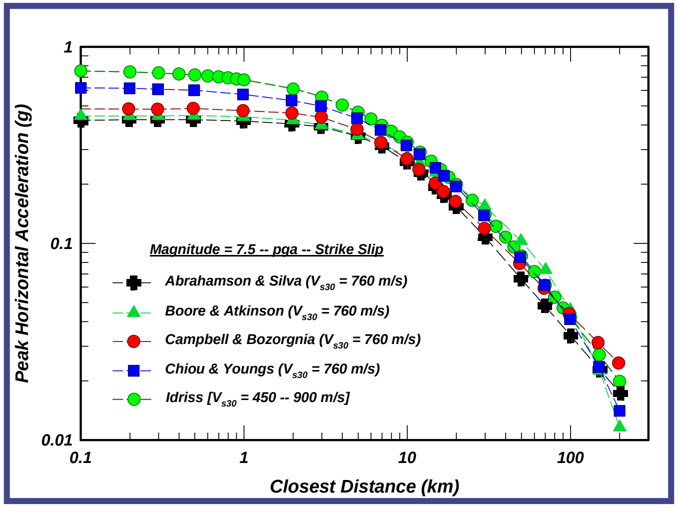
Yousef Bozorgnia

PEER Associate Director

PEER Summative Meeting - June 13, 2007

Numerous Research Projects on Characterization of Ground Motion Hazard

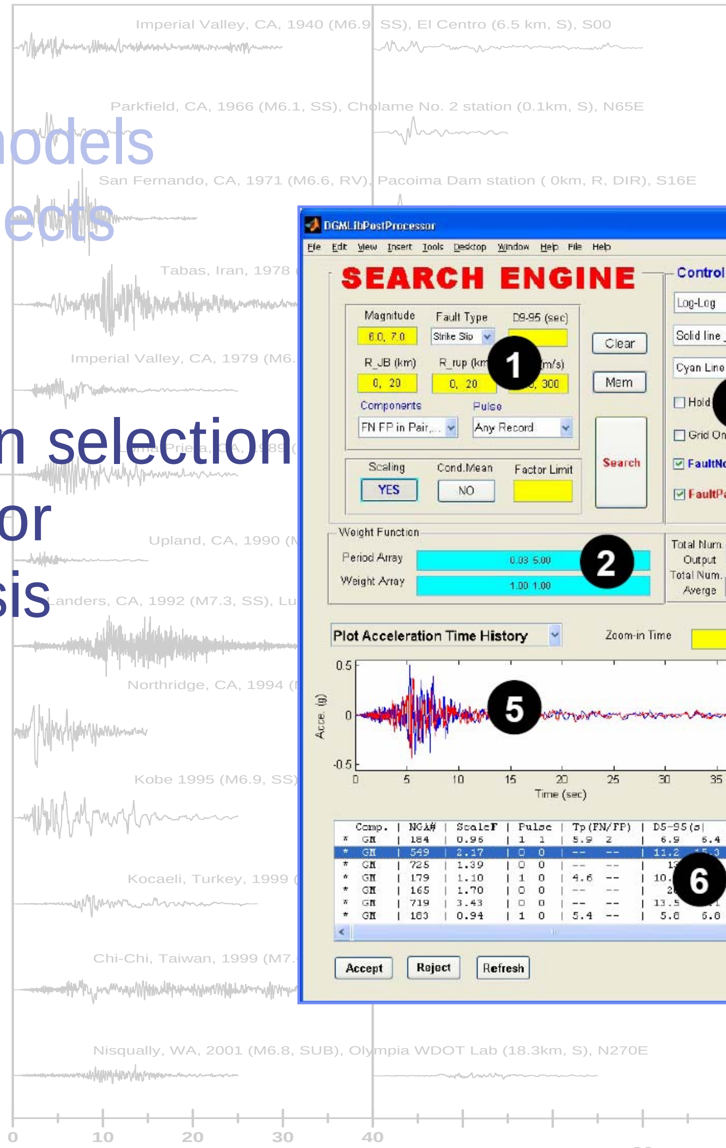
- ❖Attenuation models and related projects

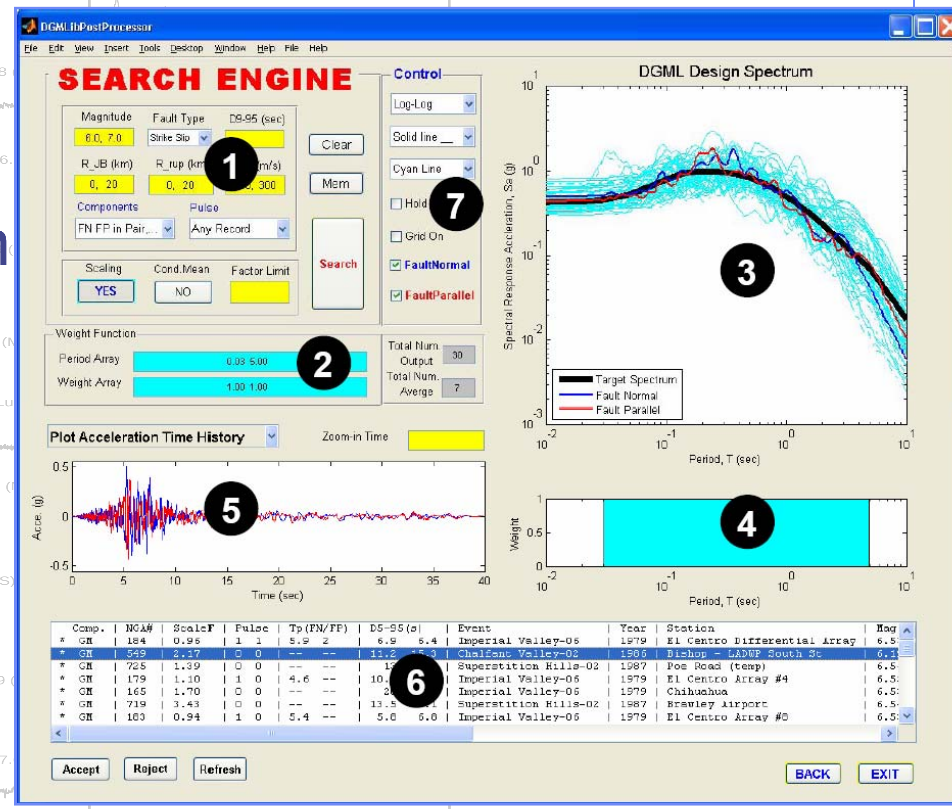


Numerous Research Projects on Characterization of Ground Motion Hazard

❖Attenuation models and related projects

❖Ground motion selection & modification for nonlinear analysis

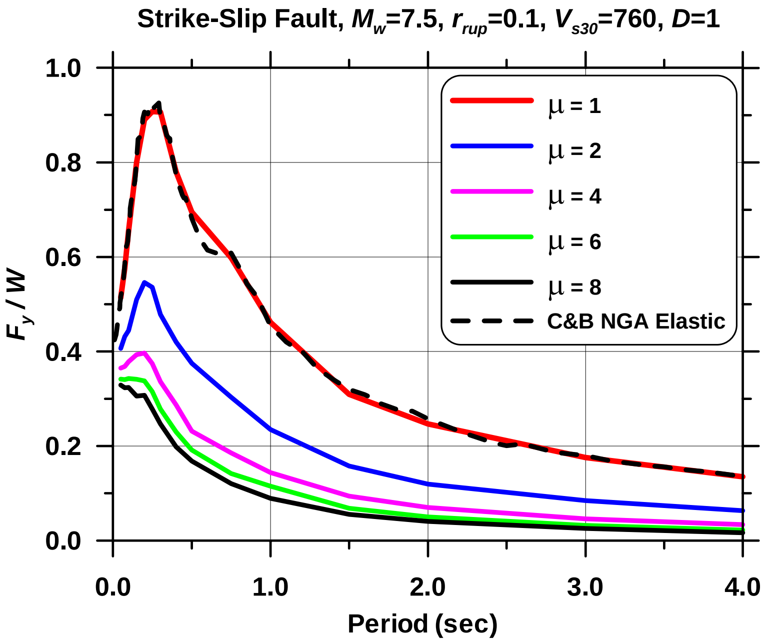




PEER

Numerous Research Projects on Characterization of Ground Motion Hazard

- Attenuation models and related projects
- Ground motion selection & modification for nonlinear analysis
- Investigation of various IMs



Inelastic Spectra

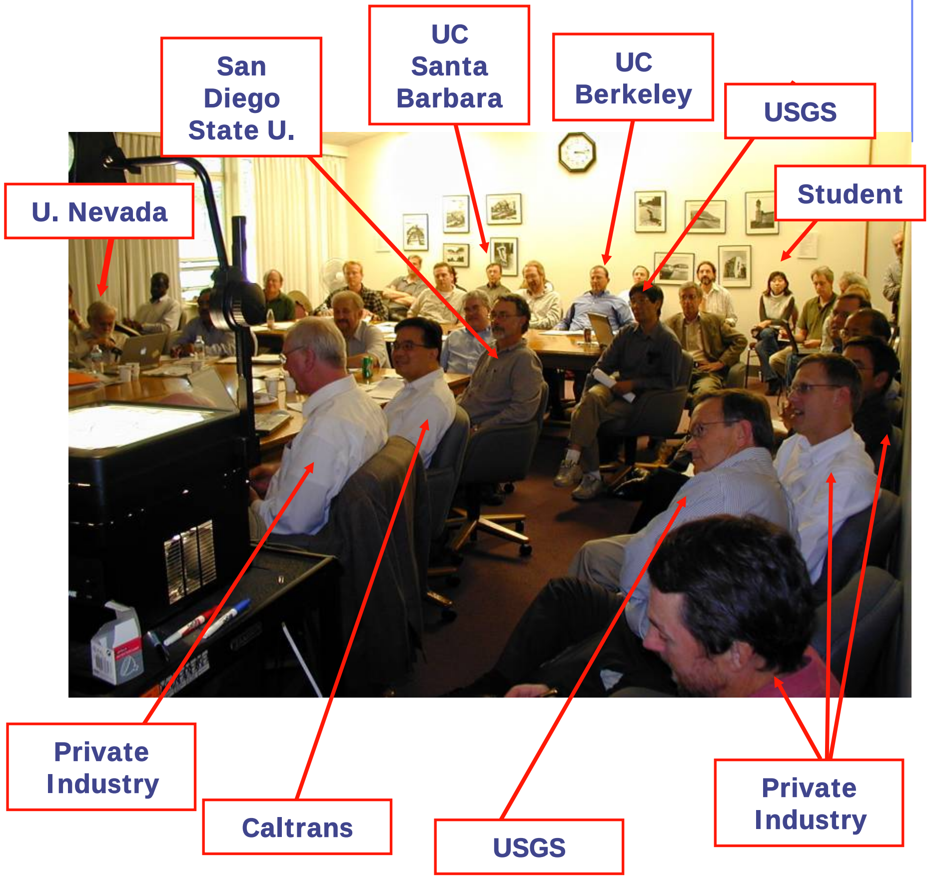
Numerous Research Projects on Characterization of Ground Motion Hazard

- ❖Attenuation models and related projects
- ❖Ground motion selection & modification for nonlinear analysis
- ❖Investigation of various IMs
- ❖Input motion for tall buildings with large embedded structures

Next Generation Attenuation (**NGA**) Models

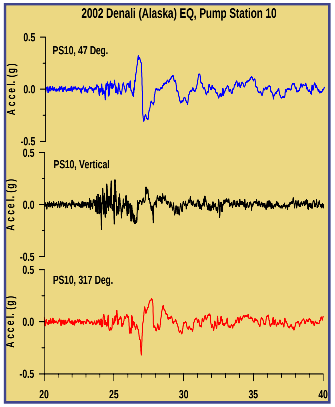
Next Generation “Attenuation” (NGA) Is a Multidisciplinary “Program”

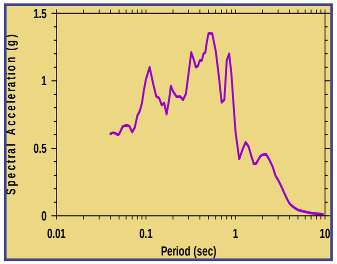
- Coordinated by PEER over the last four years
- Bringing together: ***geologists, seismologists, geotechnical engineers, structural engineers***, and ***users*** of ground motion models
- And Researchers, practitioners

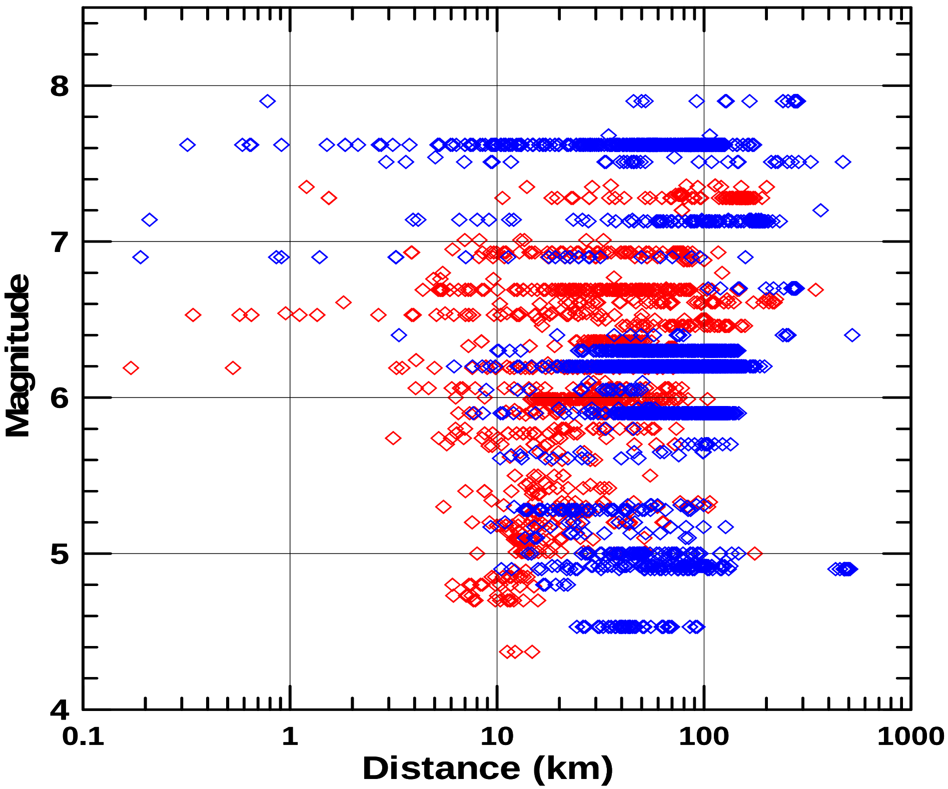


PEER Compiled One of the Largest Uniformly-Processed Strong-Motion Databases in the World

- 173 worldwide earthquakes
- > 10,500 uniformly processed records







Previous Data New Data

PEER

PEER Strong-Motion Database

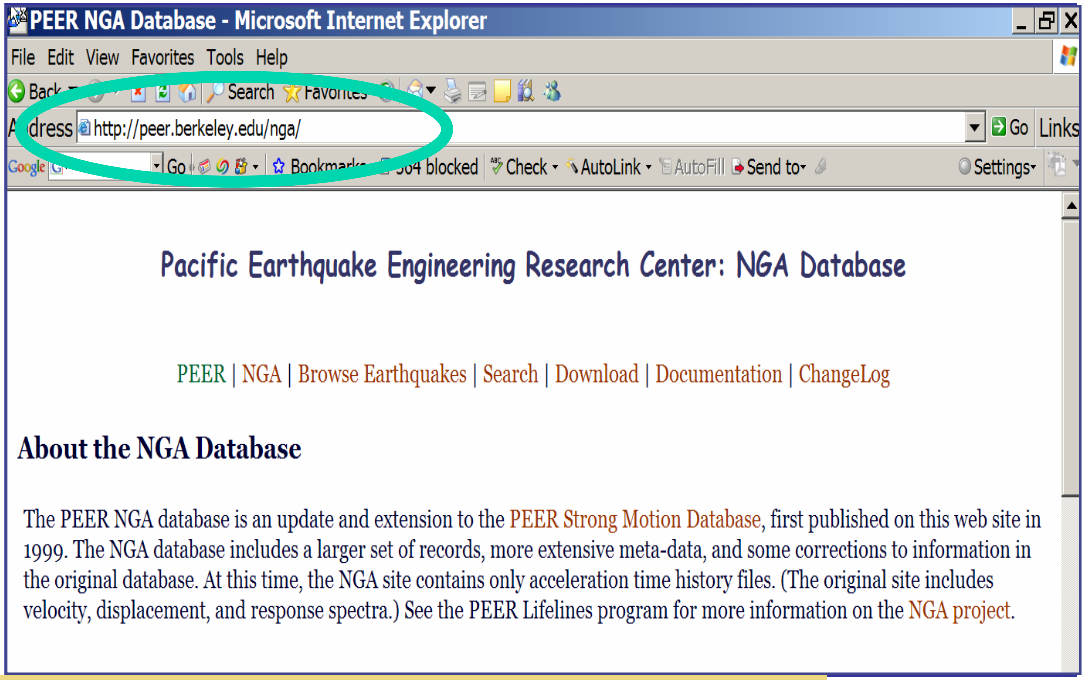
- There are more than 100 variables describing source/path/site conditions of a record:

✓ *6 types of distance measures*

✓ *4 site classification schemes*

✓ *Estimated V_{S30} for most of recording sites*

✓ *HW/FW classes*



The database is fully available to the public

NGA Model Developer Teams

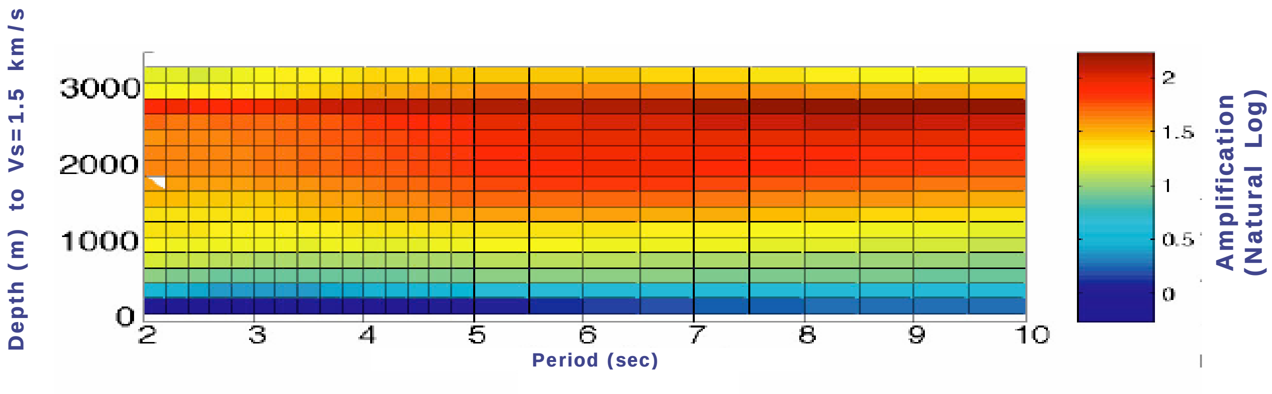
- NGA empirical ground motion model developers
  - **Abrahamson & Silva** (updating their 1997 model)
  - **Boore & Atkinson** (updating Boore et al., 1997 model)
  - **Campbell & Bozorgnia** (updating their 1997, 2003 models)
  - **Chiou & Youngs** (updating Sadigh et al., 1997 model)
  - **Idriss** (updating his 1993 & 1996 models)
- All model developers started with a common database

NGA Attenuation Models

- **Ground motion parameters**:
  - Horizontal components
  - PGA, PGV, PGD
  - Pseudo spectral acceleration at 5% damping
  - Period: 0 - 10 sec

- Magnitude range:
  - 5.0 - 8.0+
- Distance range:
  - 0 – 200 km
- Fault Mechanism:
  - Strike-Slip
  - Reverse
  - Normal
- Site Effects
  - V_{s30}

NGA Models Were Constrained by Simulation

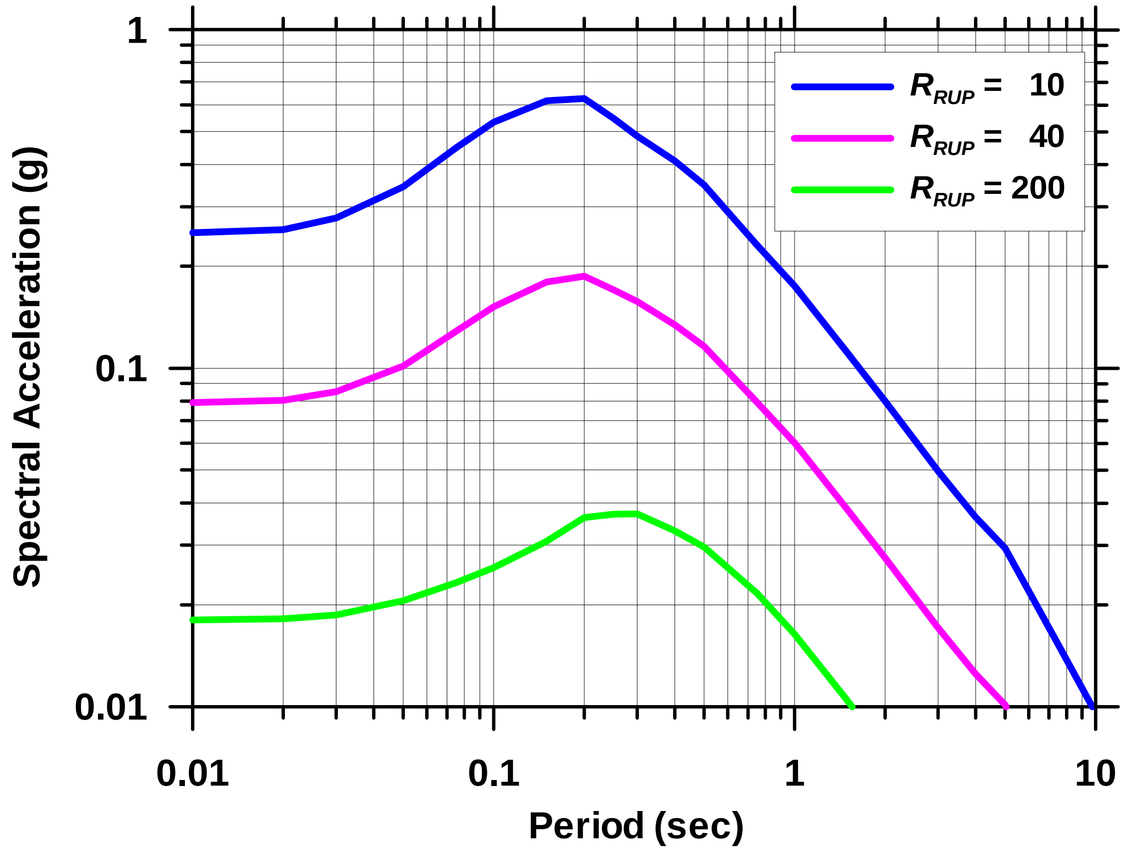


- *To fill the gaps in data*

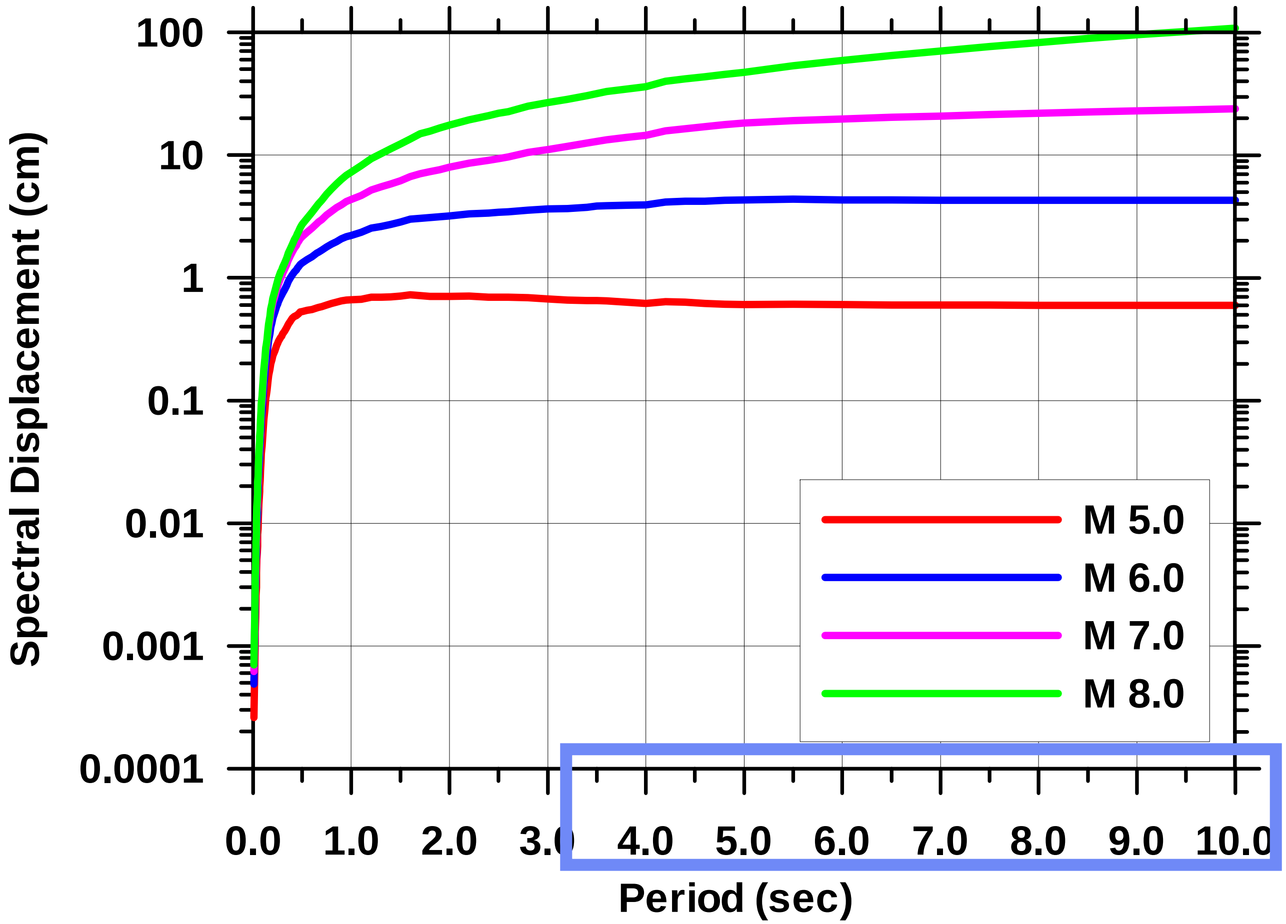
- *Simulations of 3-D basin and 1-D rock motions*
  - *To model amplification due to sediment-depth*
  - *To constrain attenuation models*

- *Nonlinear soil response analysis*
  - *Amplification factors for different soil profiles subjected to a wide range of input motions*

Example Result: C&B NGA Predicted Acceleration Spectra
Strike Slip, **M** = 7.0, V_{S30} = 760 m/s

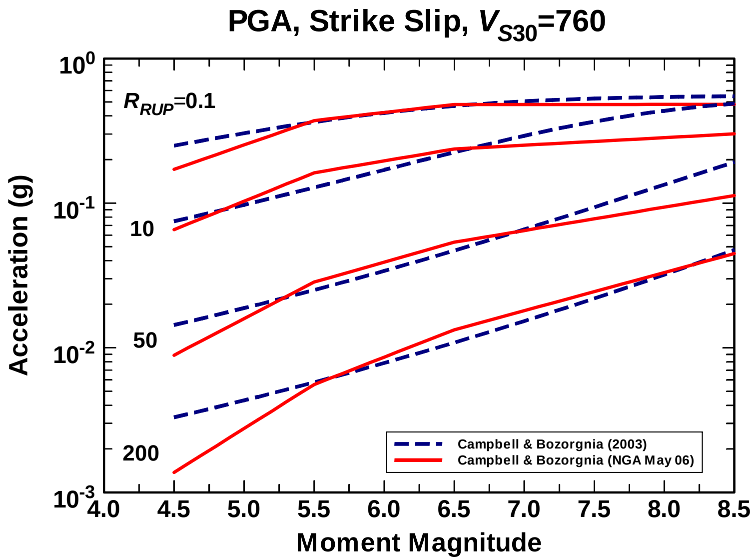


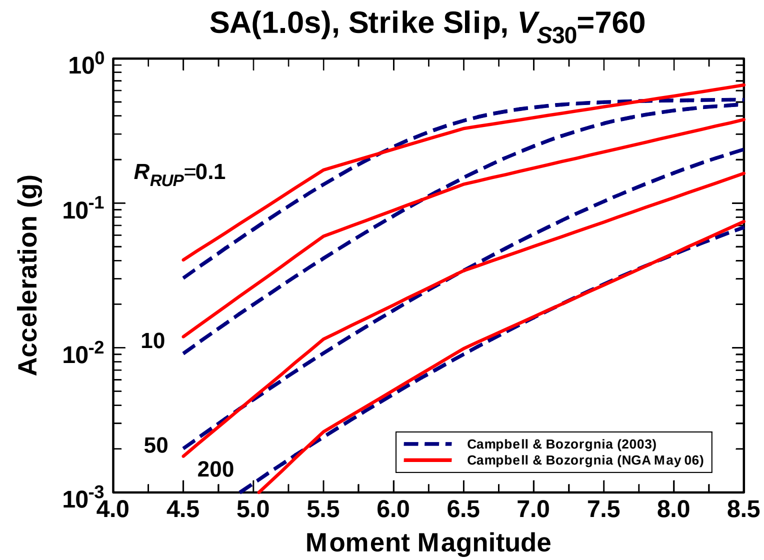
Behavior at Long Periods
C&B NGA Predicted Spectral Displacement
Strike Slip, R_{RUP} = 10 km, V_{S30} = 760 m/s

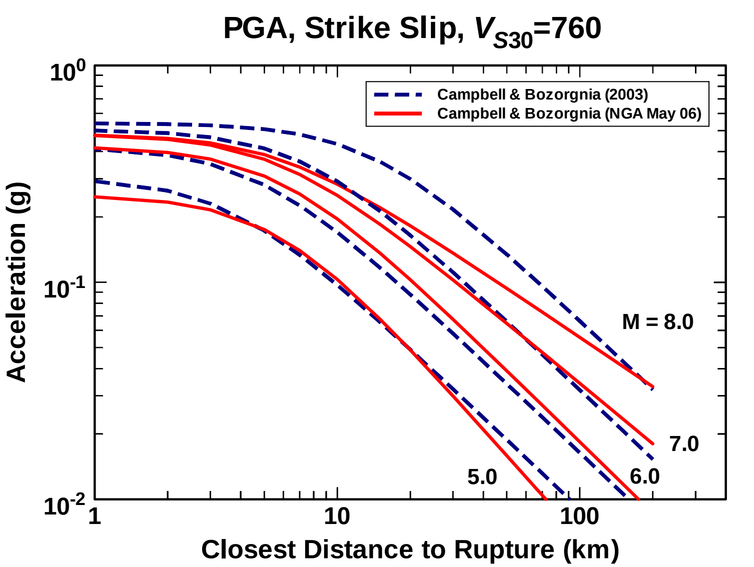


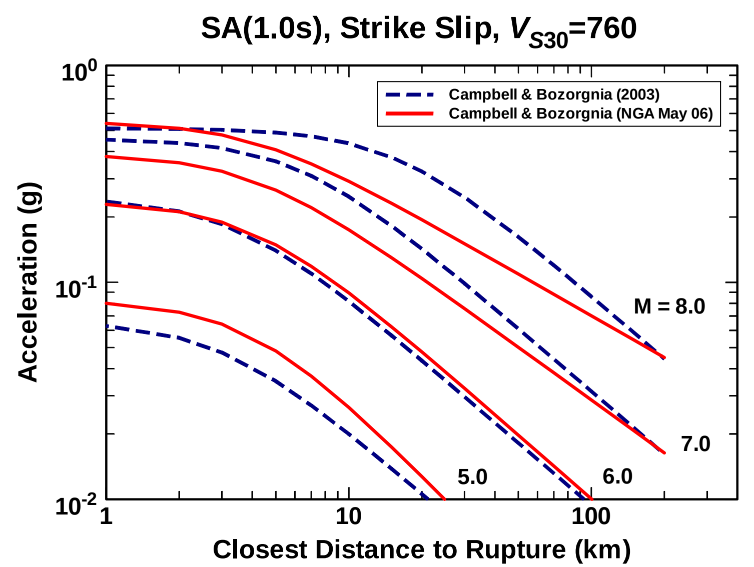
Examples of Comparison of NGA Models

Campbell & Bozorgnia (C&B) NGA vs. C&B 2003 Strike-Slip Fault, NEHRP **B-C**

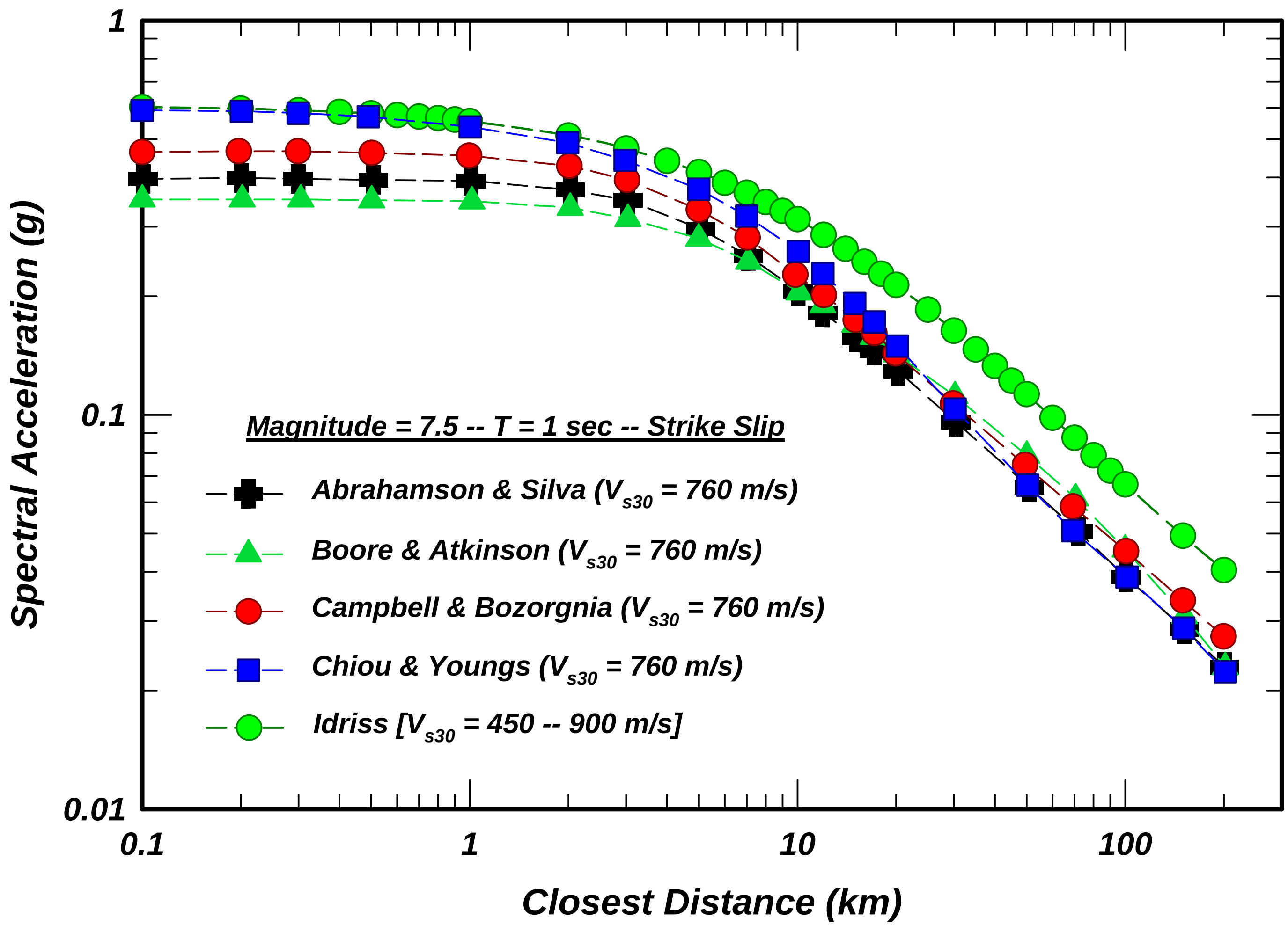






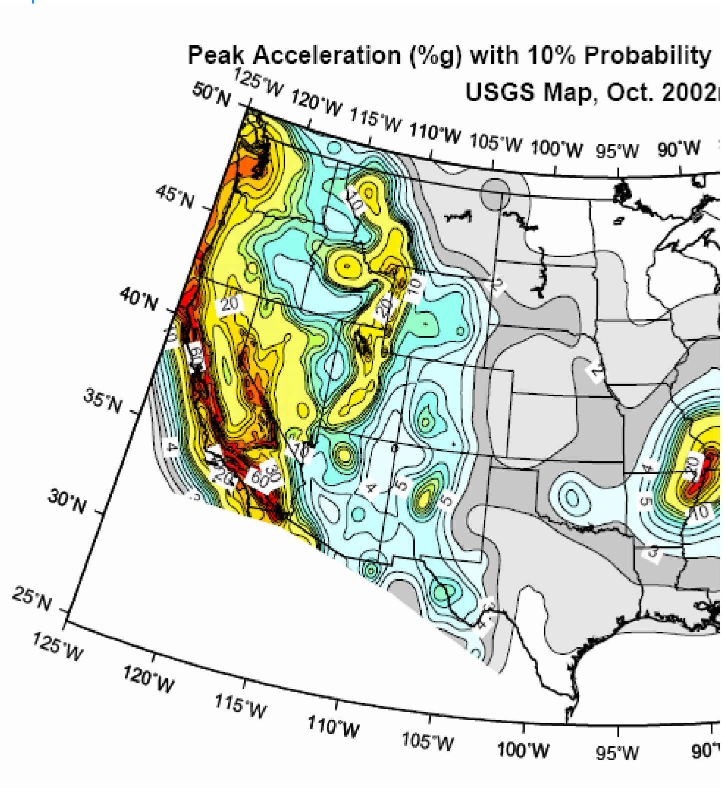


$S_a(T=1.0s)$ – Strike-Slip, M 7.5, NEHRP B-C



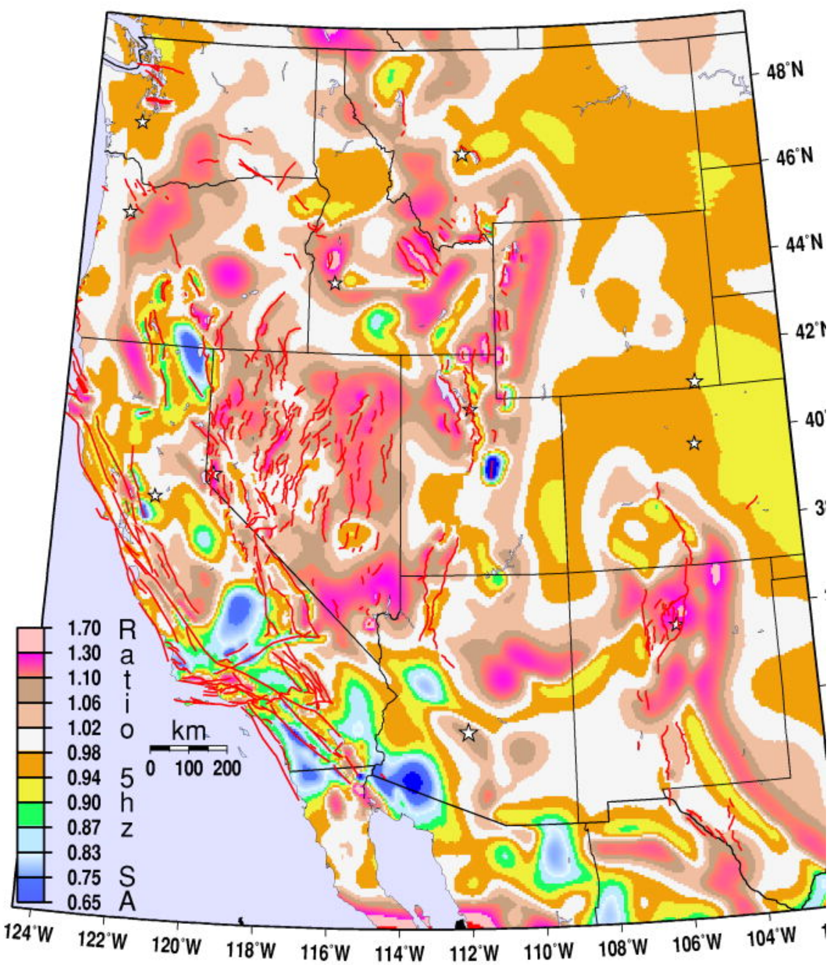
NGA &
US National Seismic Hazard Maps

Impact of NGA Models on Seismic Design



- USGS has extensively reviewed NGA, and is adopting the NGA models for the US National Seismic Hazard Maps
- Design spectra based on either deterministic or probabilistic approach will be affected by NGA models

WUS 2007/2002 ratio 5-Hz SA w/2%PE50YR



GMT Apr 4 08:17 SA, 2007 model over 2002 model. Site 760ms. 5 Hz 2%50 yr PE. denom is 2002 official 5hz sa

Preliminary Map

Period=0.2 sec Spectral Acceleration 2% P.E. in 50 years

Ratio of New/Old:

Using 3 NGA relations
Versus:
2002 Hazard Maps
Abrahamson and Silva (1997), Sadigh et al. (1997), Boore et al. (1997), Campbell and Bozorgnia (2003), Spudich et al. (1999) for extensional areas

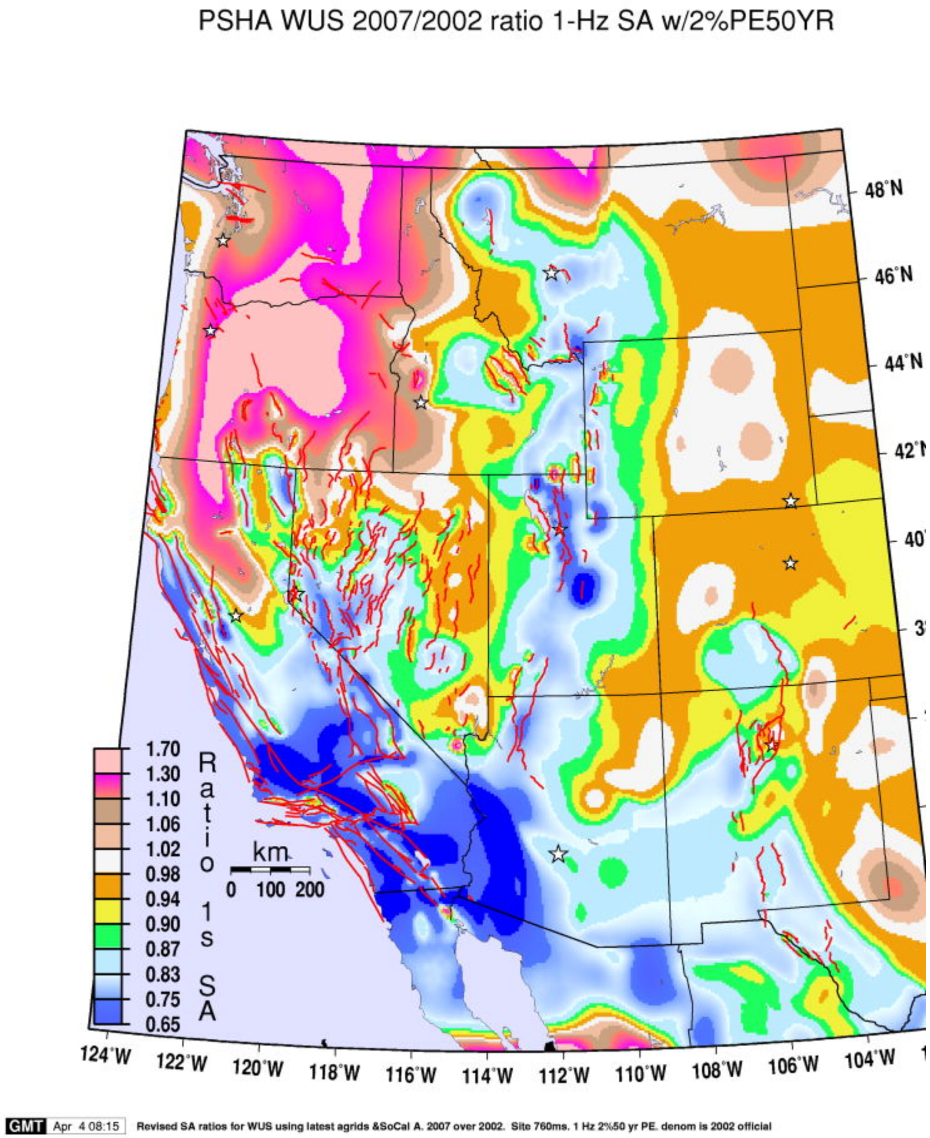
Using same set of fault sources as 2002 maps; Subduction zone and deep earthquakes are not included

Rock site condition

Period=1.0 sec Spectral Acceleration
2% P.E. in 50 years

Ratio of New/Old:

Using 3 NGA relations
Versus:
2002 Hazard Maps
Abrahamson and Silva (1997),
Sadigh et al. (1997),
Boore et al. (1997),
Campbell and Bozorgnia (2003),
Spudich et al. (1999) for extensional areas



Preliminary Map

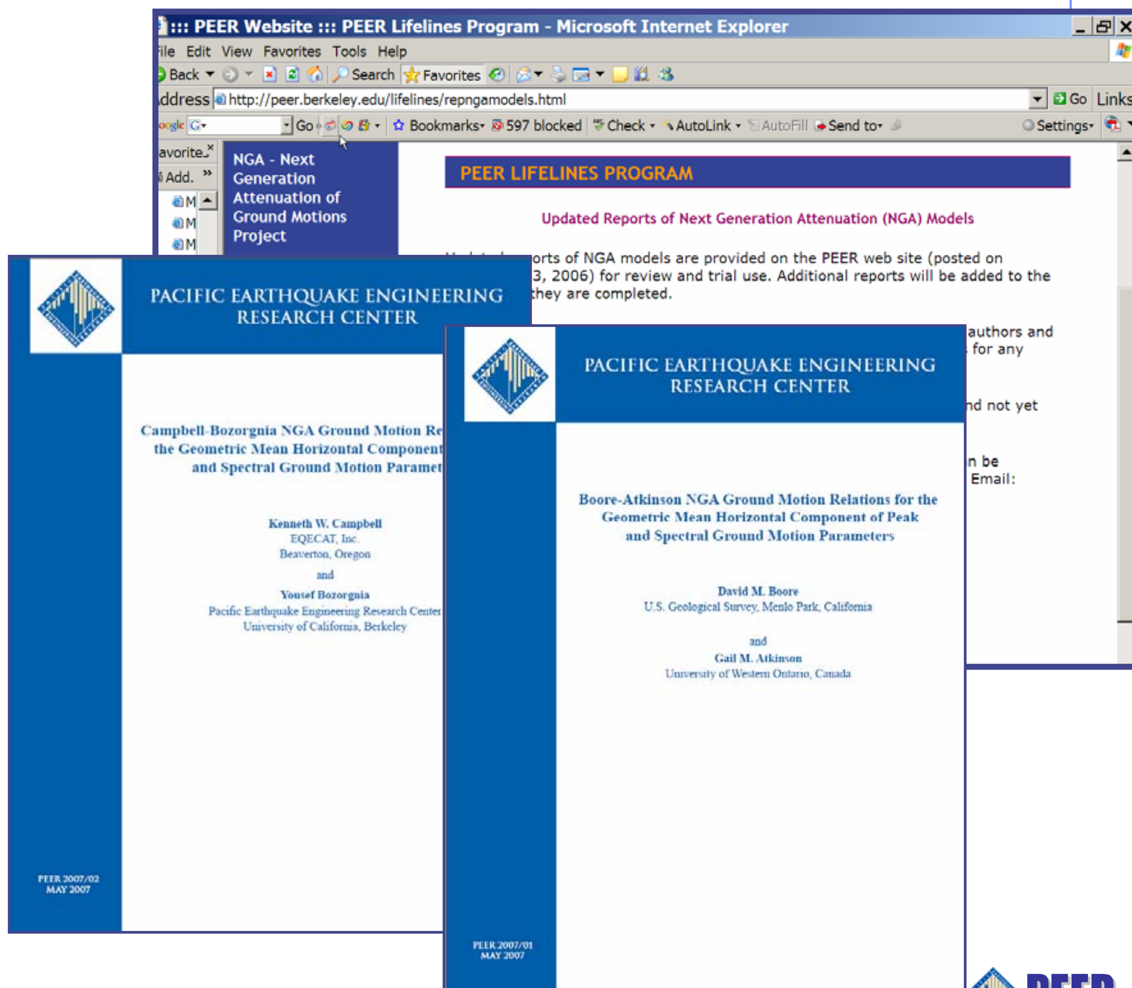
Reasons...

- “Some of the decrease of 1 sec S_a from the 2002 maps is caused by:
  - Difference in the Vs30 assigned for “rock” sites in the 2002 maps and the average V_{s30} for rock sites reported in NGA (shouldn’t be a factor in the Campbell-Bozorgnia and Boore-Atkinson NGA relations)”
- “Most of the decrease is from having additional data from moderate and large earthquakes and improved functional forms to fit the data”

Courtesy: Art Frankel

NGA Reports & Papers

- Draft final reports are available at PEER web site
- Including computer files of the models
- PEER reports are being printed
- Journal papers will be published in special issue of **EERI Spectra**, March 2008



NGA Models Are More Robust Than Old Models Because...

- **Quantity and quality of data**
- **Amount of time the developers spent on models**
- **Interactions among model developers**
- Number of independent variables
- Availability of supporting ground motion simulations
- Public participation via workshops and conferences
- Formal peer review commissioned by USGS

Finally…It would have been much more difficult to accomplish NGA without a framework of a national earthquake engineering center

- Example: For NGA, PEER coordinated efforts, and has had research contracts with:
  - USGS (different researchers)
  - California Geological Survey
  - SCEC (various contracts)
  - Various universities
  - Several firms and practitioners

Special Thanks To:

Caltrans

STATE OF CALIFORNIA
ENERGY COMMISSION

PG&E

PACIFIC EARTHQUAKE ENGINEERING RESEARCH