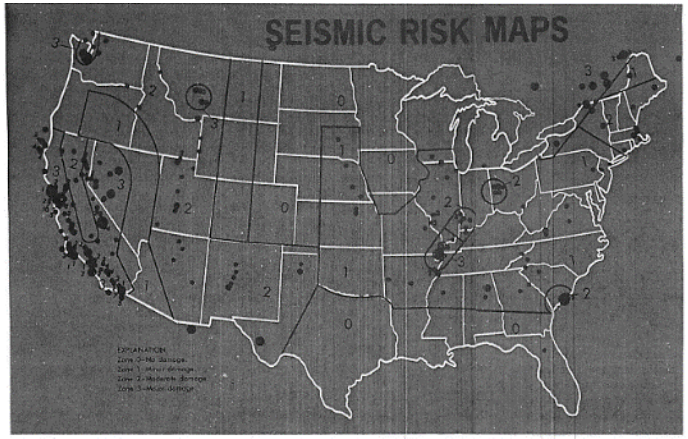
INTRODUCTION

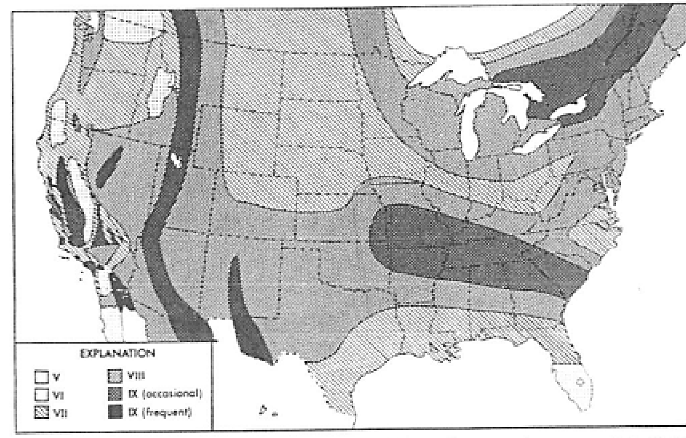
- Why do we update the National Seismic Hazard Maps?
- What have we learned recently that influences the maps?
- What is the uncertainty in the maps?
- What products will help us communicate risk?

Early versions of U.S. hazard maps

U.S. Coast and Geodetic Survey, 1948

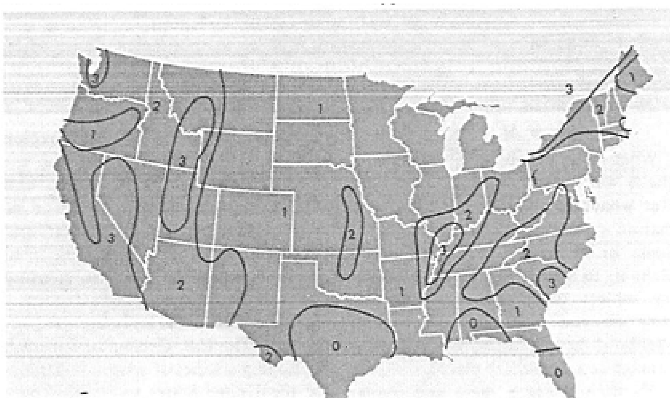


Richter, 1958



Seismic risk map, developed in 1958 by Charles Richter, shows maximum expected seismic intensities (redrawn).

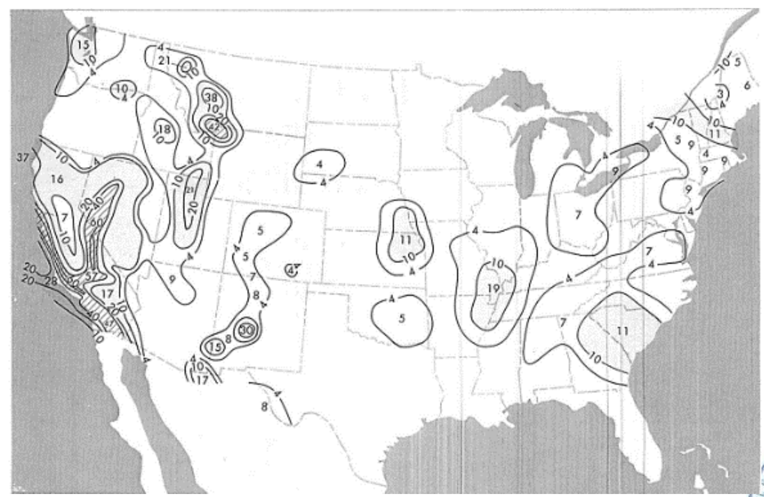
Algermissen, 1969



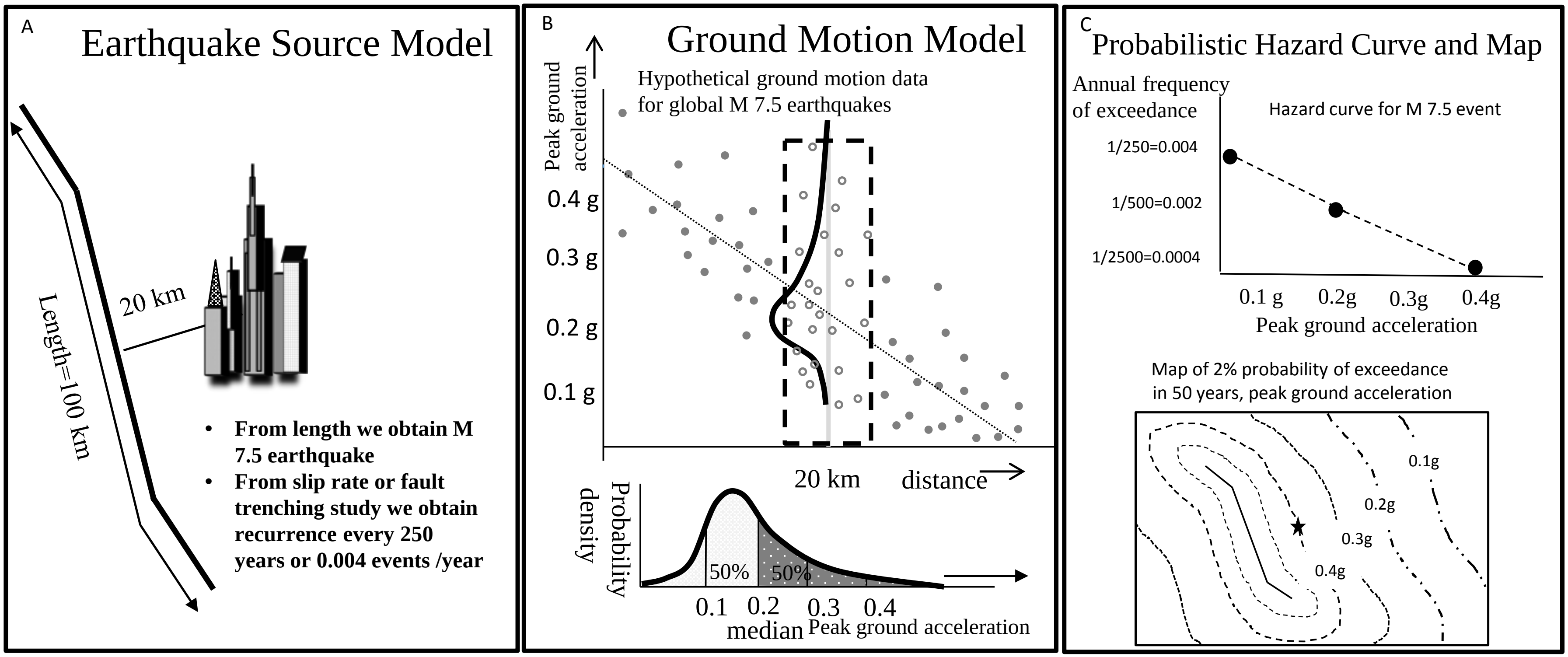
Zone 0—No damage.
Zone 1—Minor damage; distant earthquakes may cause damage to structures with fundamental periods greater than 1.0 seconds; corresponds to intensities V and VI of M. M.*Scale.
Zone 2—Moderate damage; corresponds to intensity VII of the M. M. *Scale.
Zone 3—Major damage; corresponds to intensity VIII and higher of the M. M. *Scale.
*Modified Mercalli Intensity Scale of 1931.

Seismic risk map of the United States, redrawn from map issued in 1969 by S. T. Algermissen of the U.S. Coast and Geodetic Survey (now with U.S. Geological Survey).

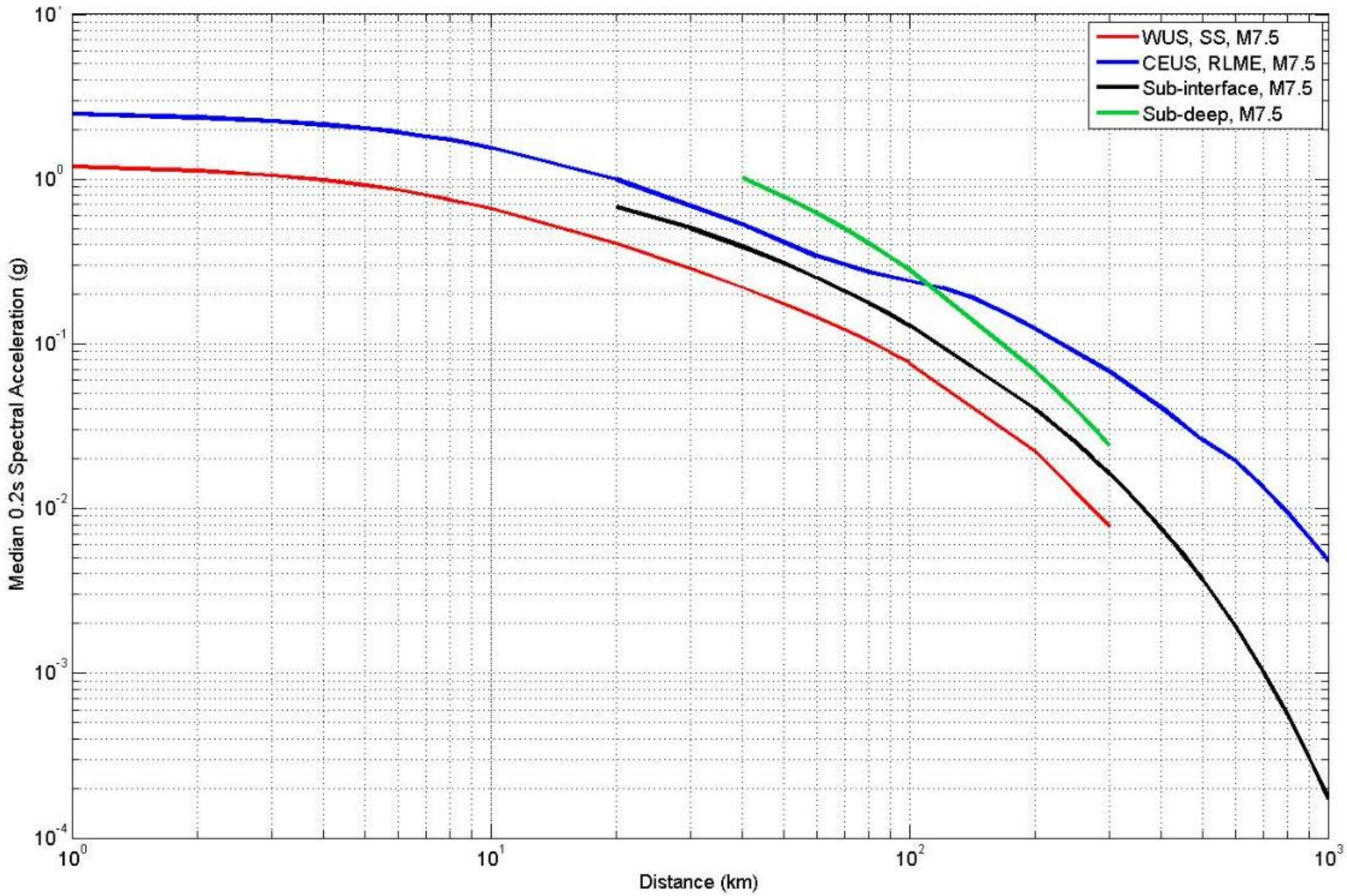
Algermissen and Perkins, 1976



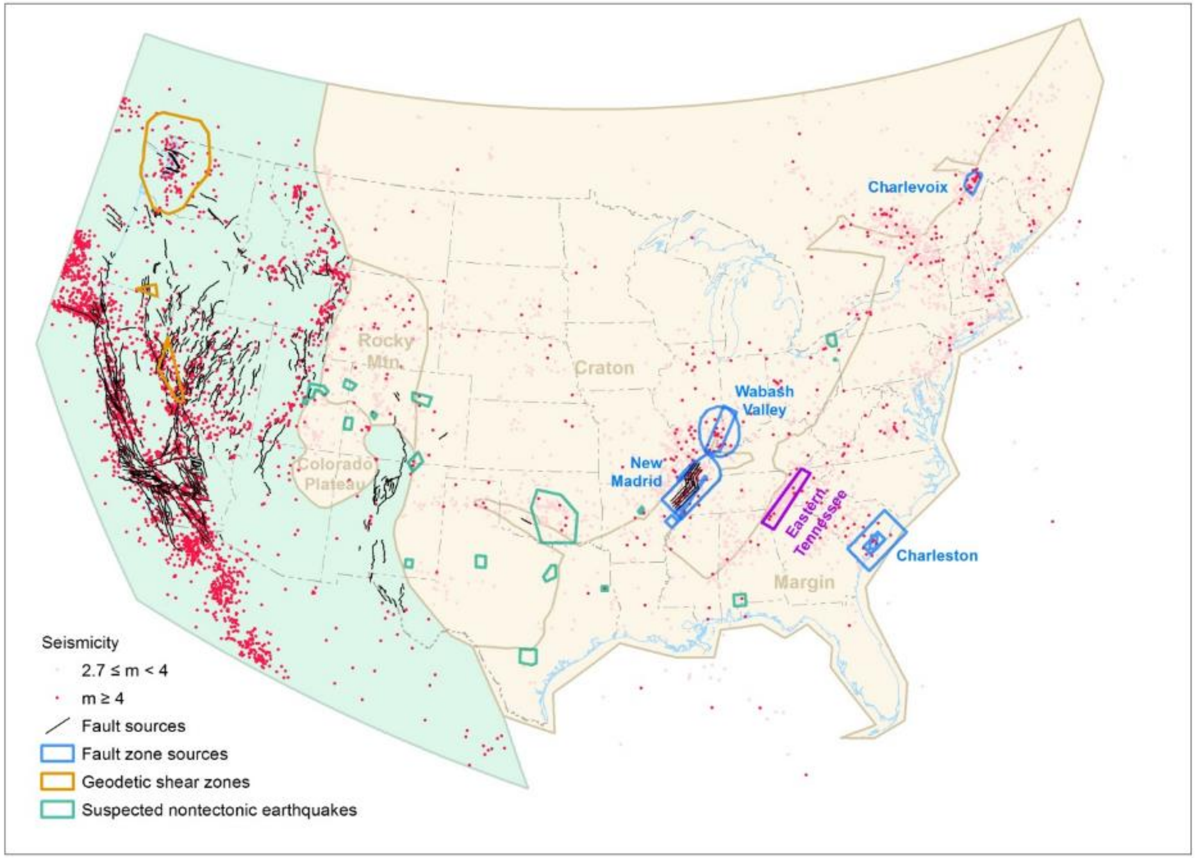
Methodology



Comparison of ground motion models

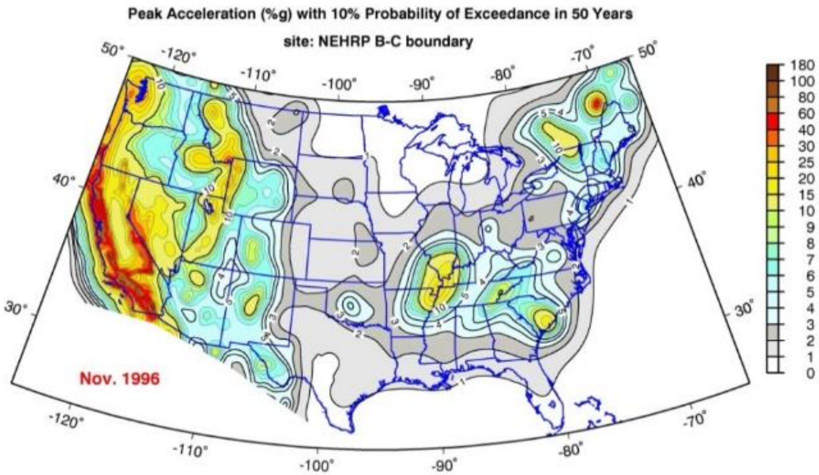


Earthquake Sources

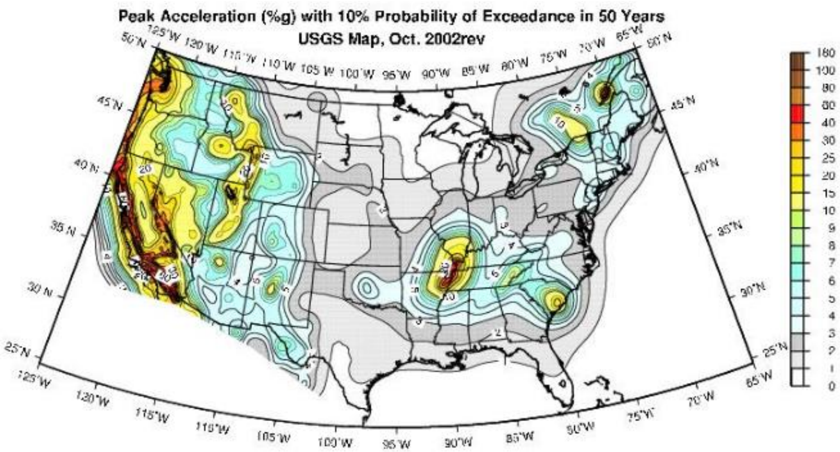


Later versions of the U.S. hazard maps

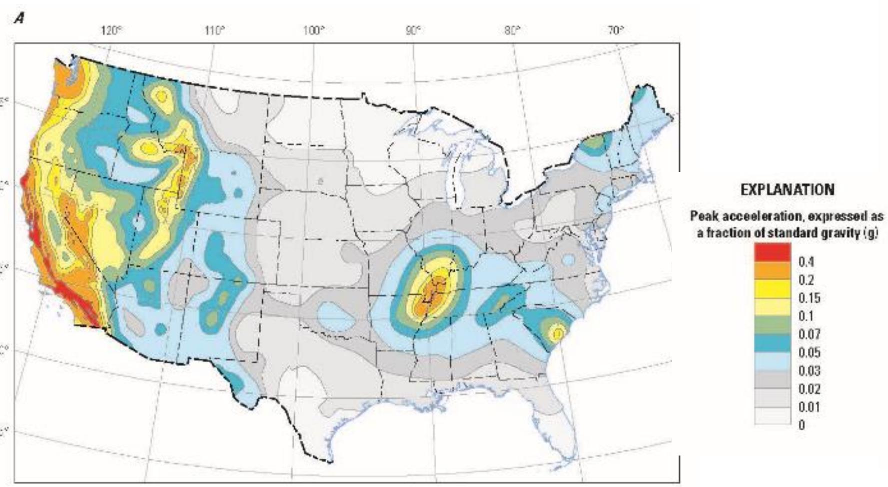
Frankel et al., 1996



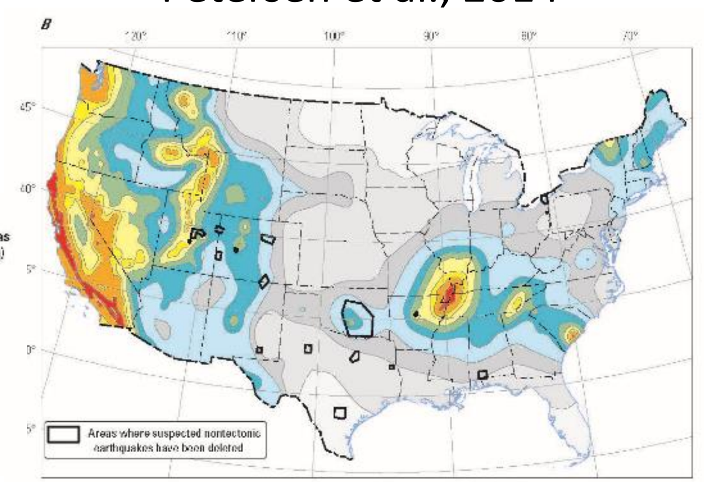
Frankel et al., 2002



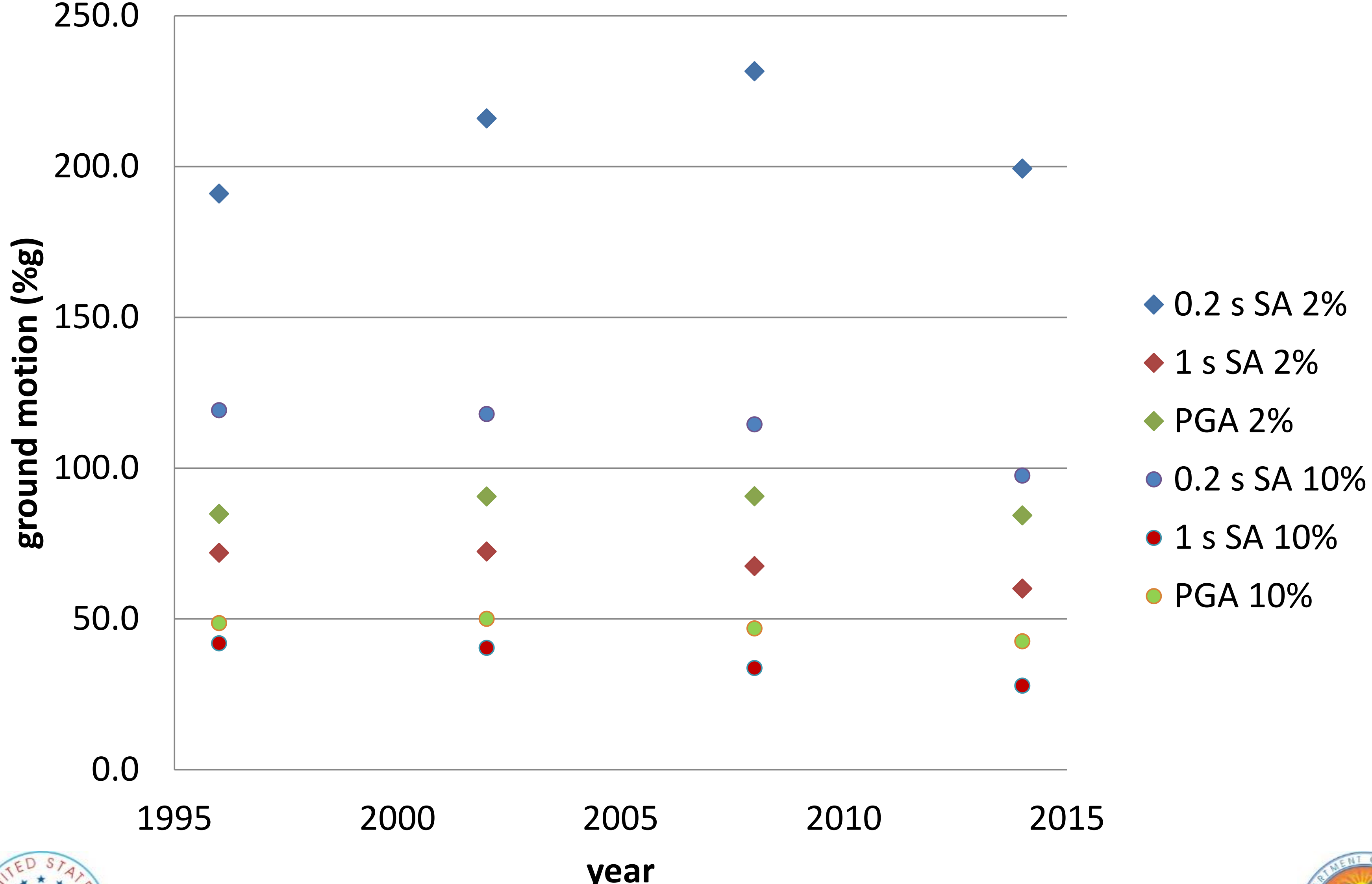
Petersen et al., 2008



Petersen et al., 2014



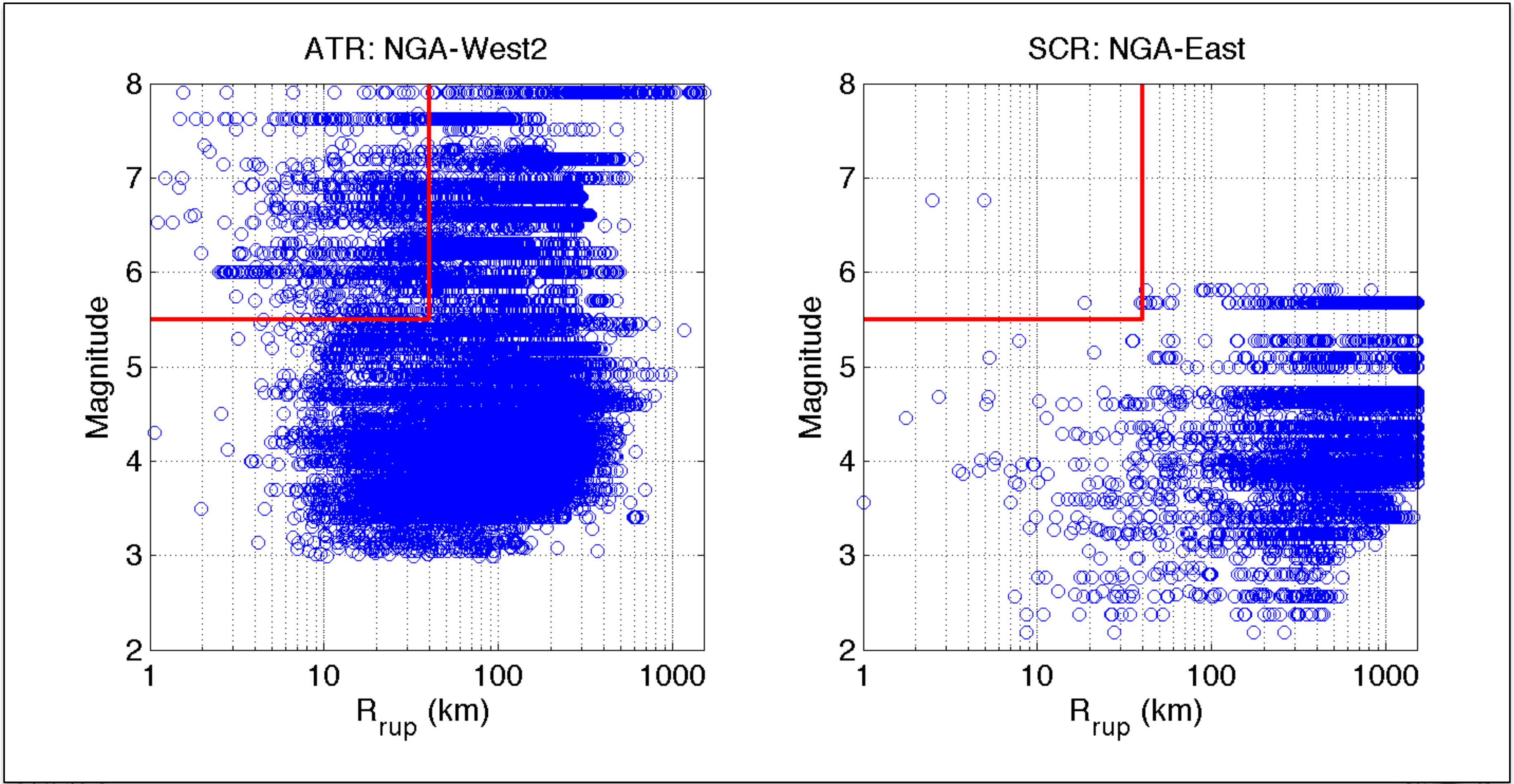
Los Angeles


250.0
200.0
150.0
100.0
50.0
0.0
ground motion (%g)
1995
2000
2005
2010
2015
year
0.2 s SA 2%
1 s SA 2%
PGA 2%
0.2 s SA 10%
1 s SA 10%
PGA 10%

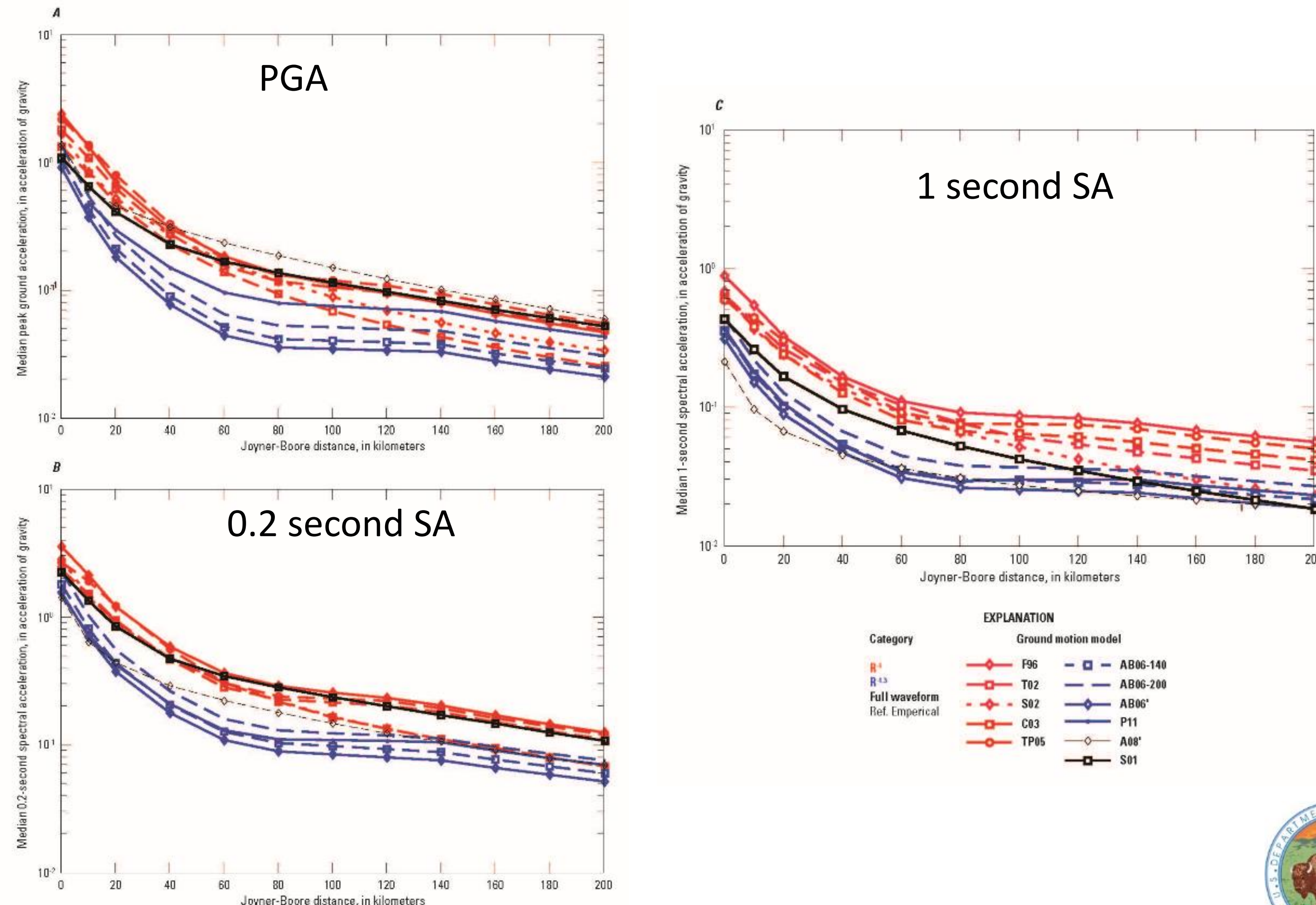
What changed in 2014?

- Ground motion models (NGA-West2, CEUS ground motion models)
- UCERF3 (longer complex sources, regional seismicity rate constraints, new faults, smoothing M 2.5)
- Cascadia subduction zone (new characterization of M 8-8.8 earthquakes)
- Intermountain West/Pacific NW faults (Wasatch Fault, Eglington Fault, geodetic data)
- CEUS SSC Source Characterization (catalog, smoothing)
- Induced Seismicity

Ground Motion Characterization

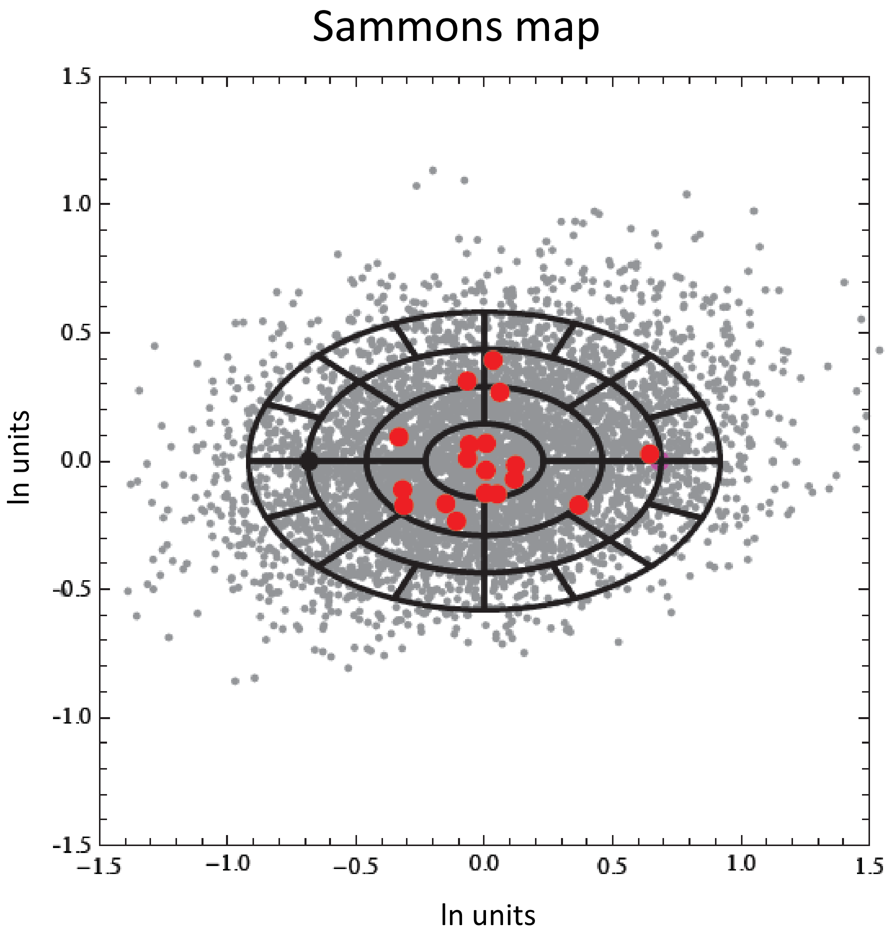


2014 CEUS Ground motion models

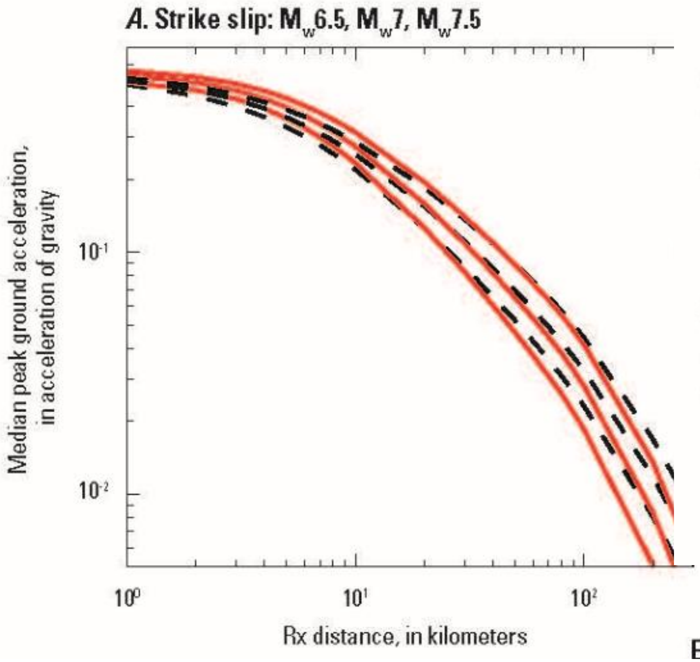


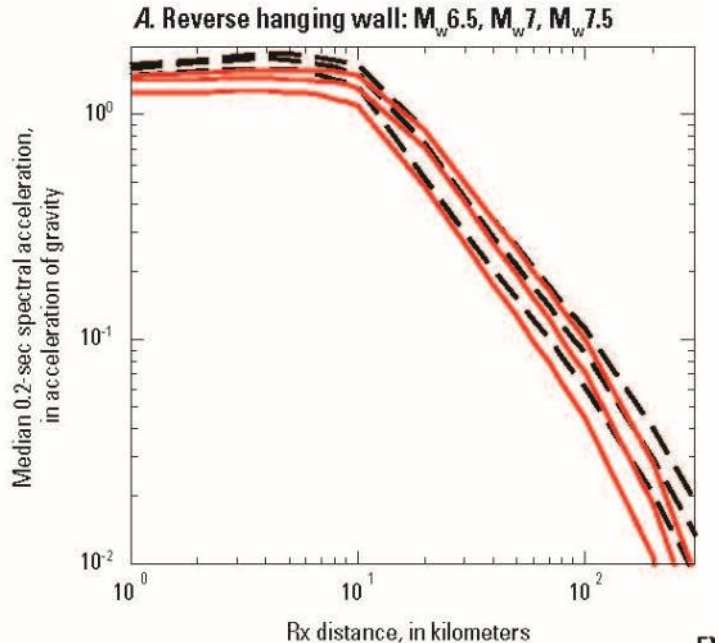
Ground Motion Characterization: *NGA-East*

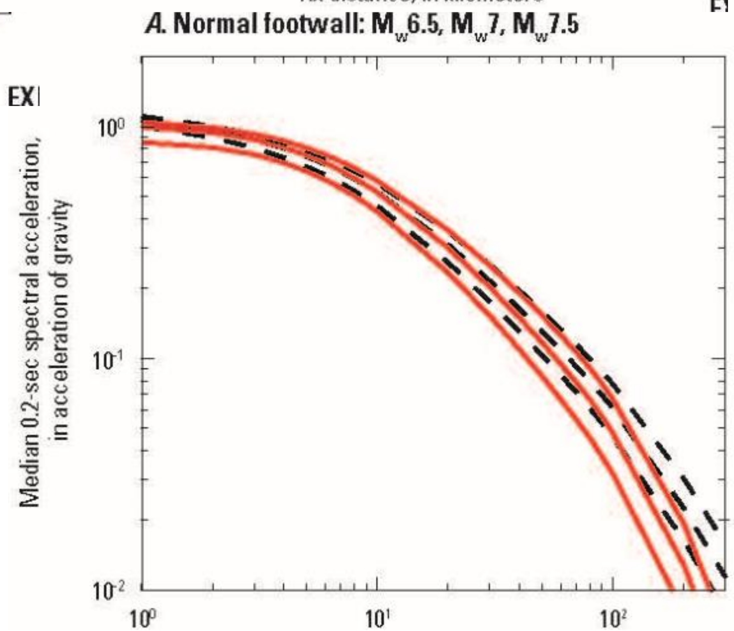
- About 22 Seed models
- NGA-East parameters
  - Average horizontal ground motions (5%-damped PSA for *f*=0.1-100Hz), for
  - Hard rock sites (V_S=3000 m/s, κ=0.006 s) located up to 1,500 km from
  - Future earthquakes in CENA **M**4.0-8.2
- Deliver 29 table-based models derived from Sammons Map
- Adjustment parameters for the Gulf Coast region.



Ground motion models

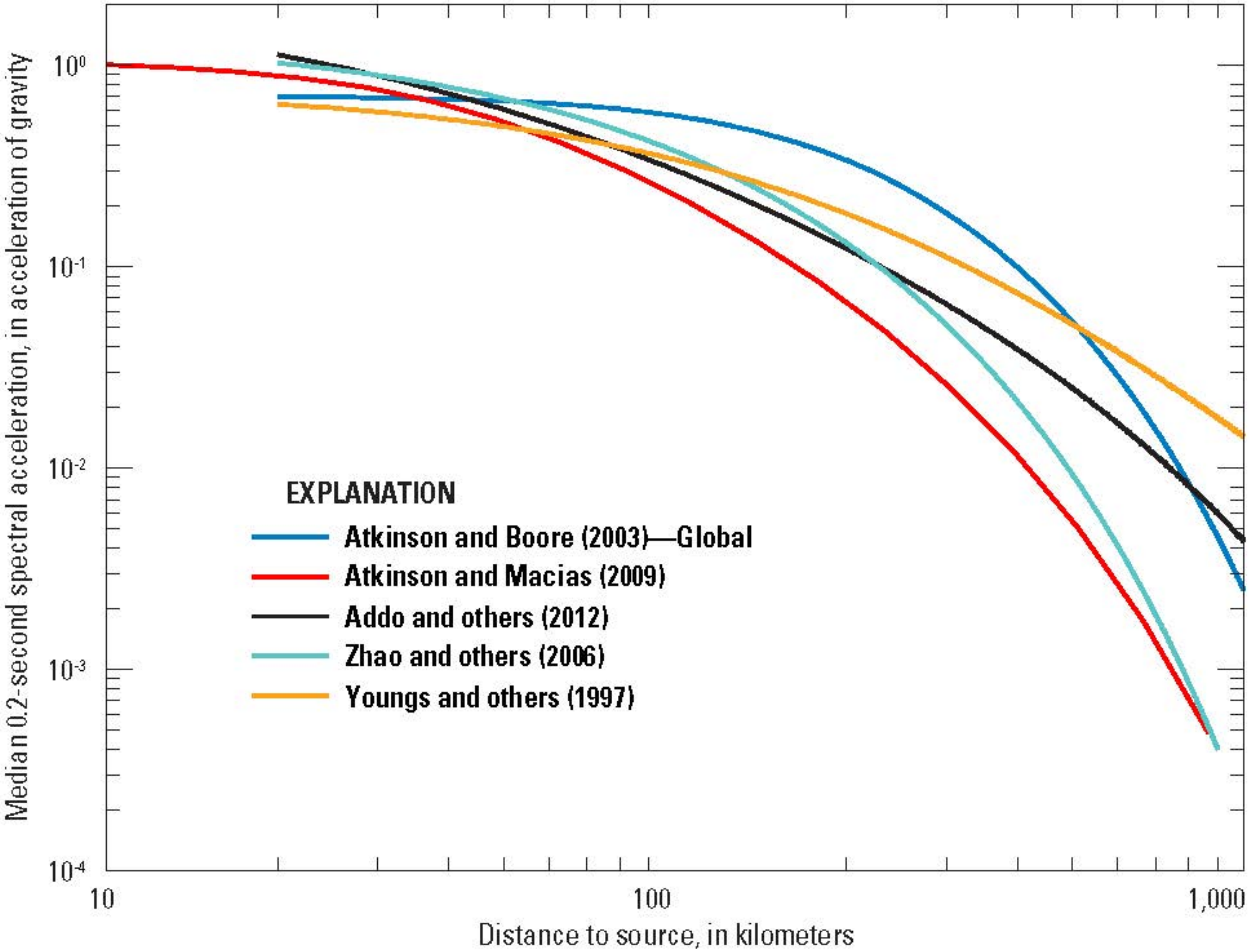






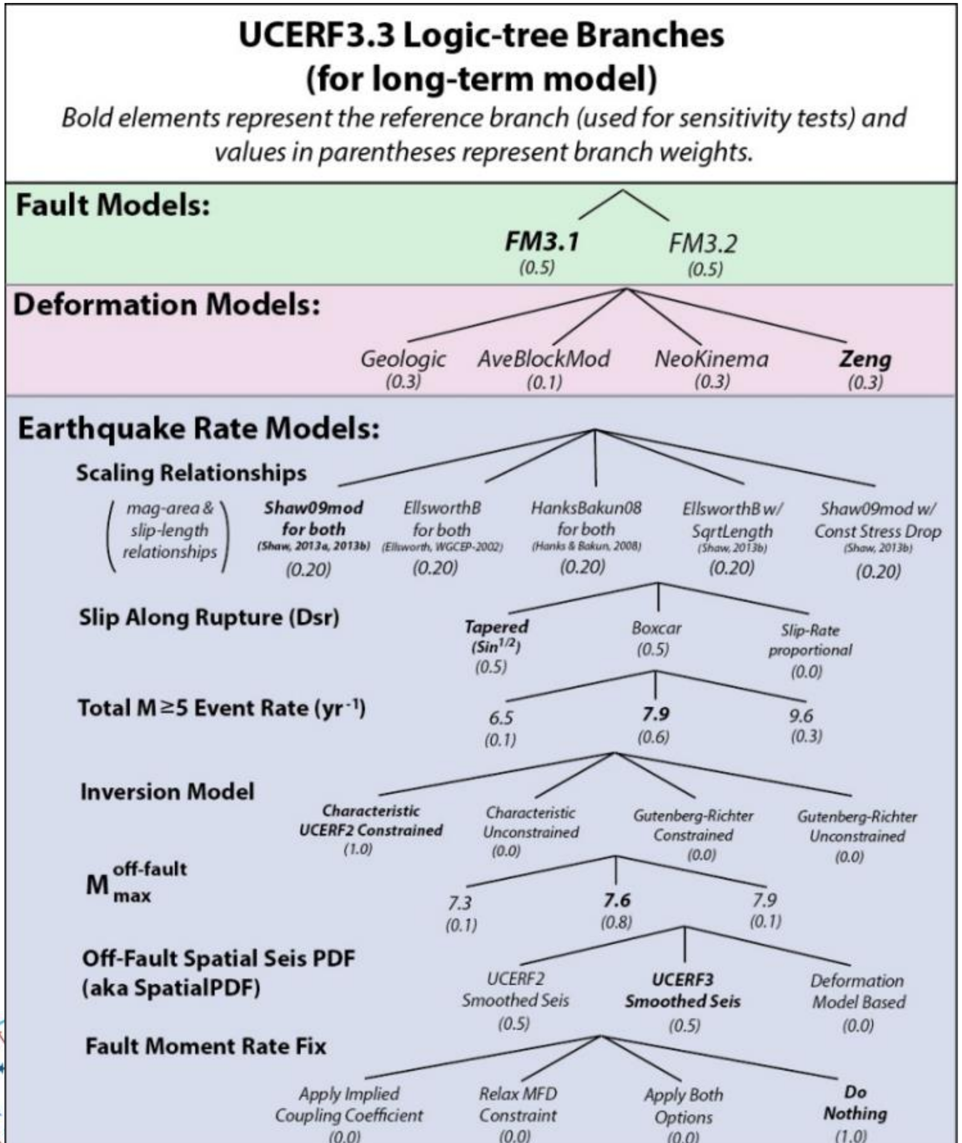
1. 2014 Median higher for Strike-slip (near) and lower for reverse and normal faulting near) all fall off faster with distance
2. Standard deviation higher

Ground motion models (subduction)



CALIFORNIA: UCERF3

2014 CA NSHM Logic-tree

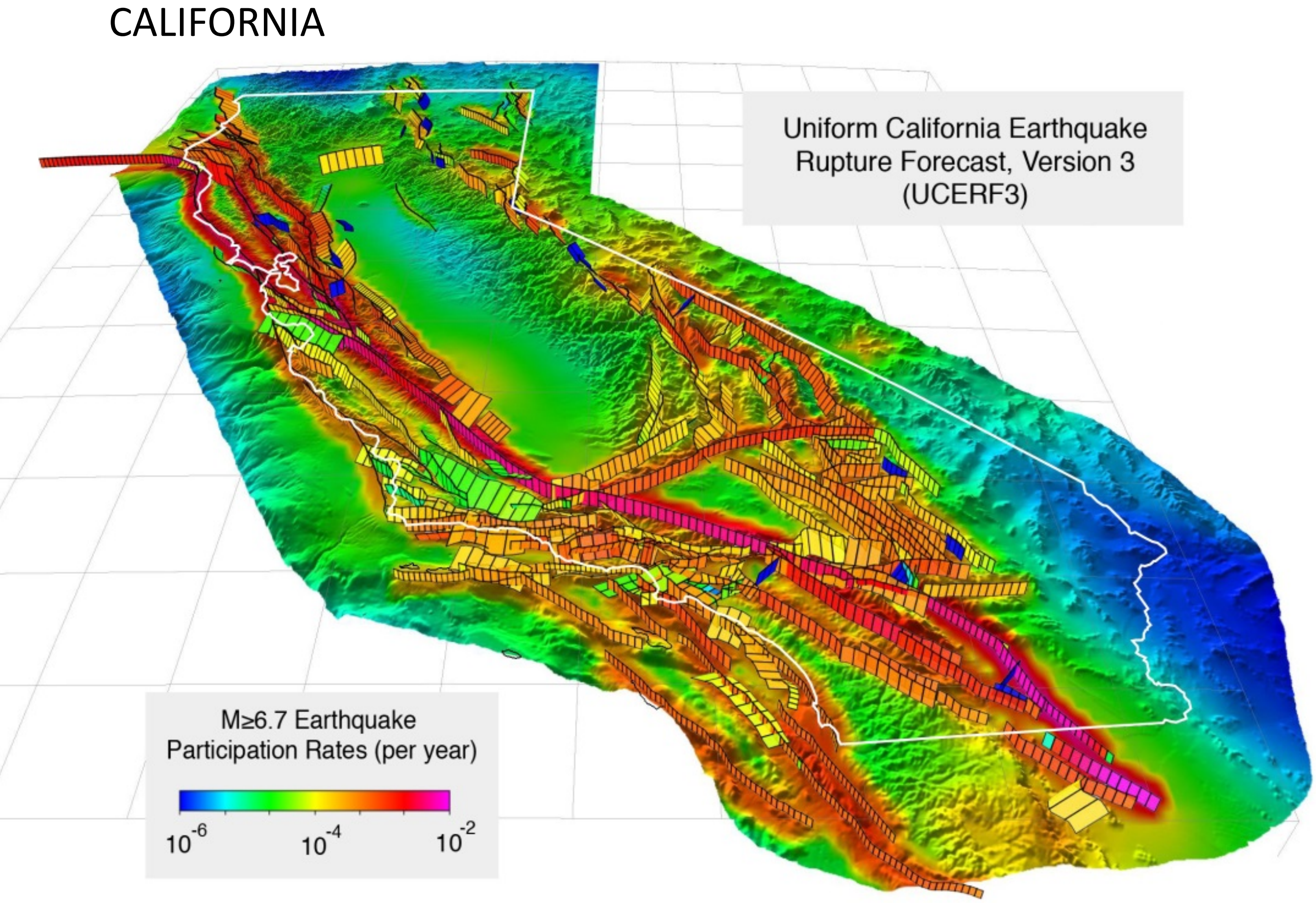


Ground motion models: NGAW2

- Abrahamson et al. (0.22)
- Boore et al. (0.22)
- Campbell & Bozorgnia (0.22)
- Chiou & Youngs (0.22)
- Idriss (0.12)

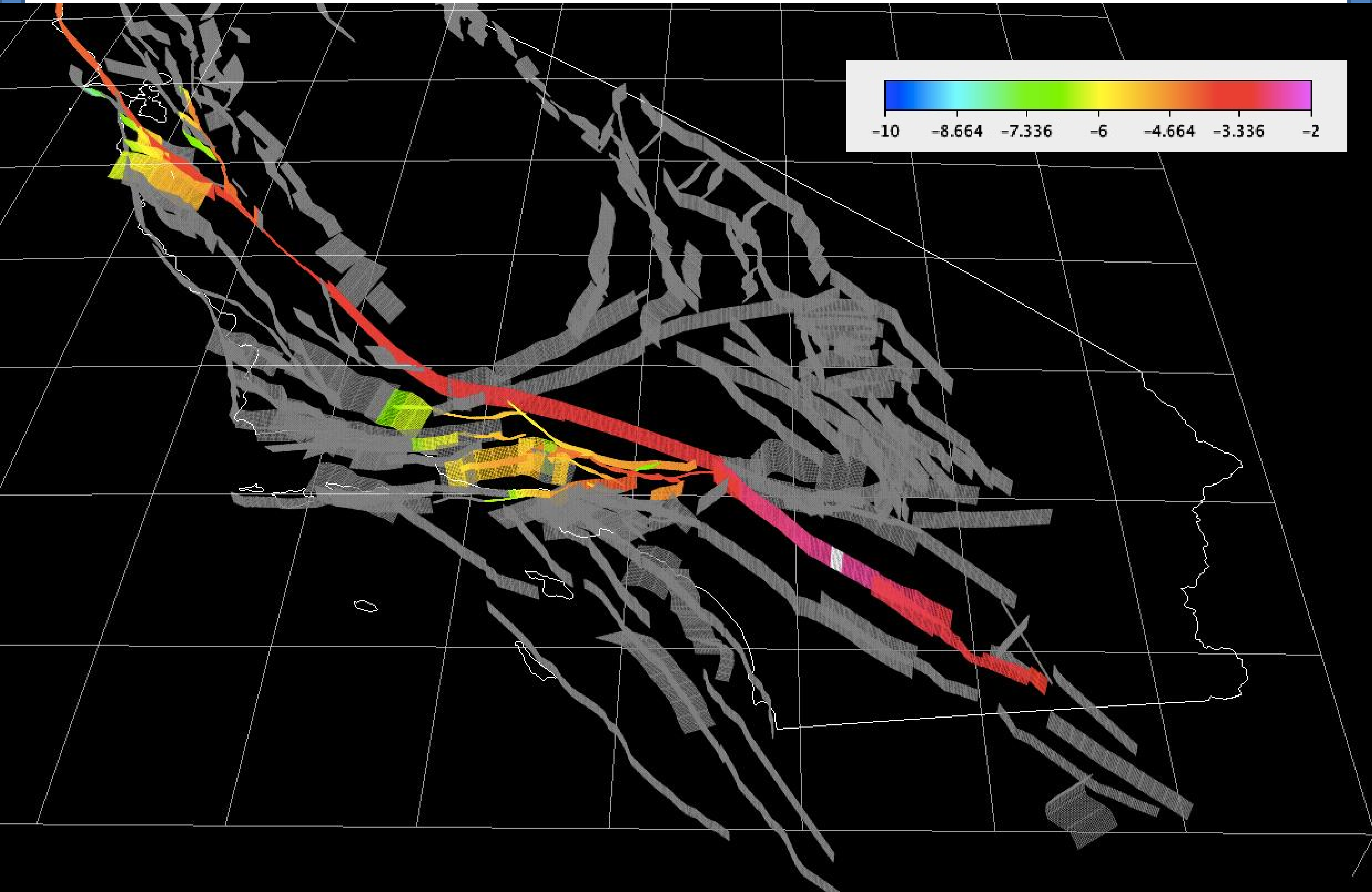
21,600 branches

Uniform California Earthquake Rupture Forecast Model (UCERF3)

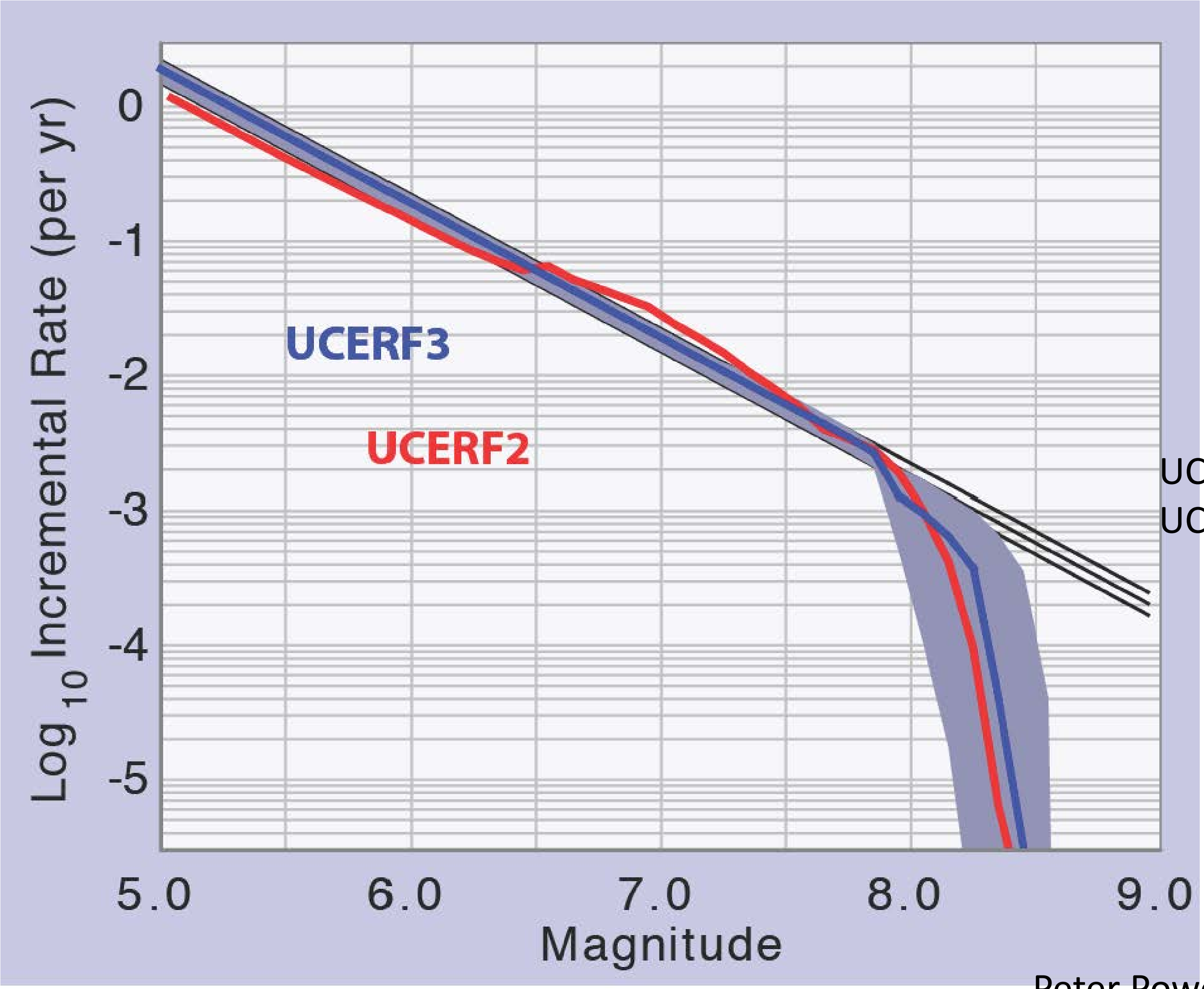


UCERF3 San Jacinto Rupture Participation

Ned Field
Peter Powers



Alternative rupture models/rates

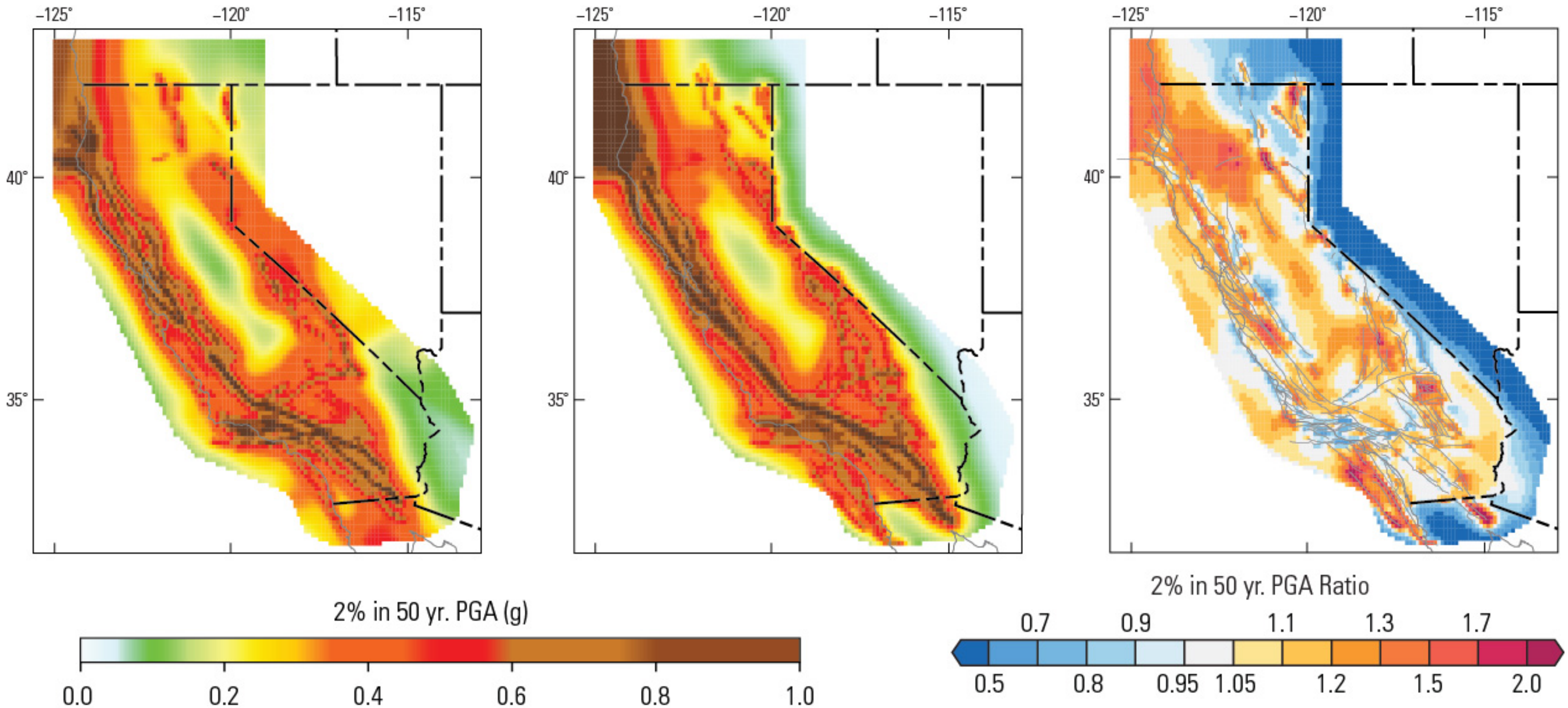


UCERF2 - 2008
UCERF3 - 2014

Peter Powers

2008 to 2014 Hazard Change; PGA 2% in 50-yr

2008 2014 2014 / 2008

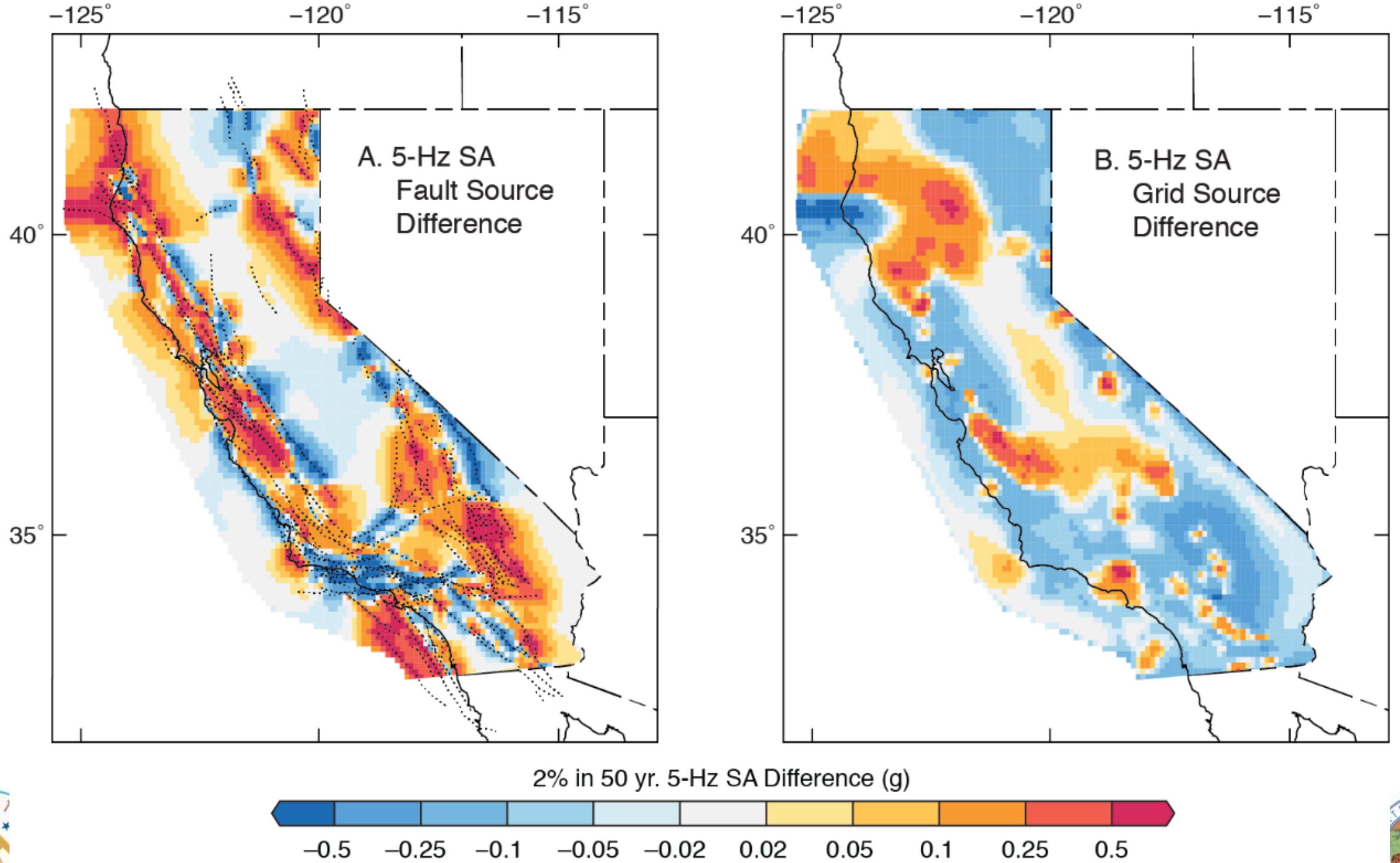


Peter Powers

Hazard Change: Decomposed

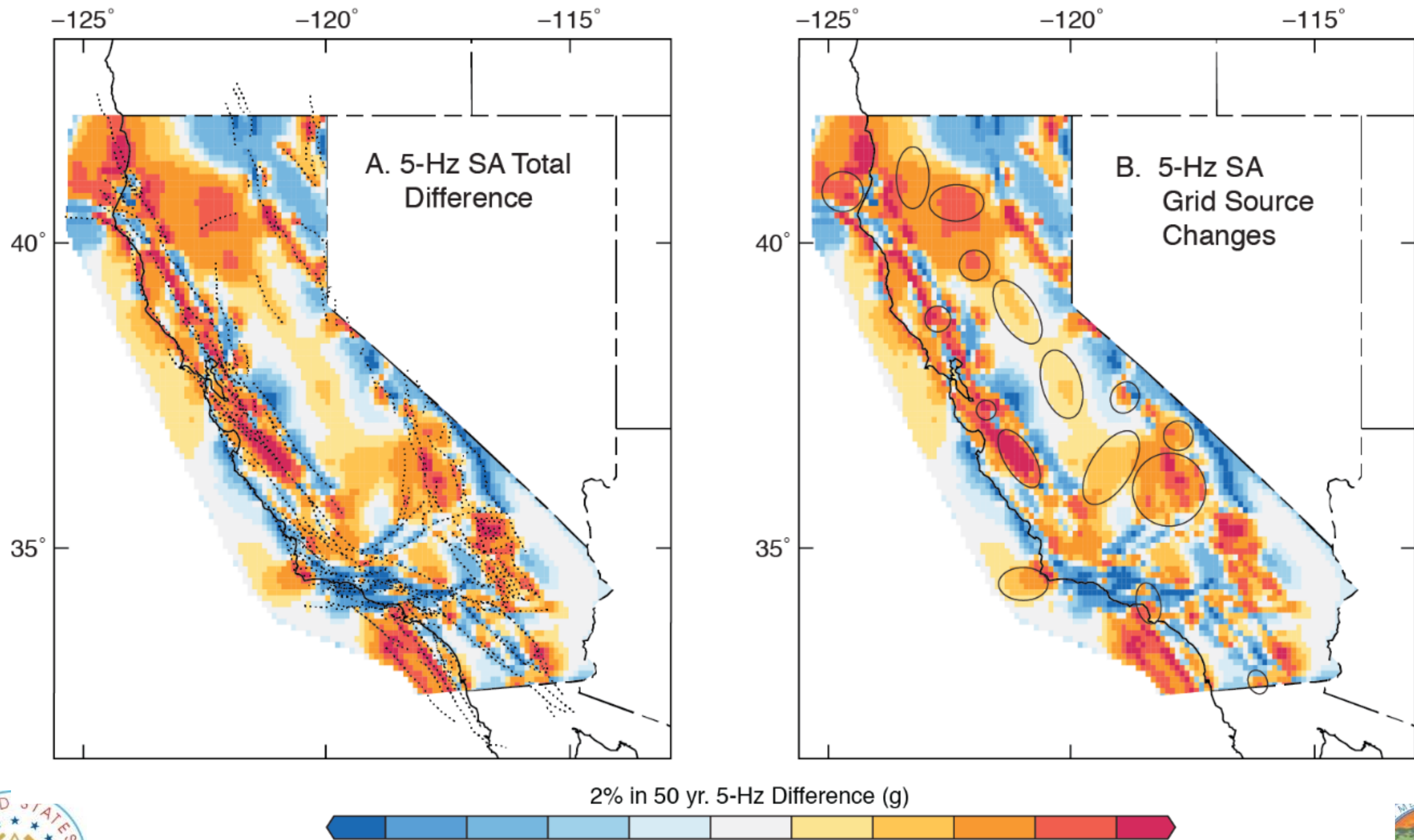
2014 minus 2008 Faults Model only

2014 minus 2008 Grid Sources only

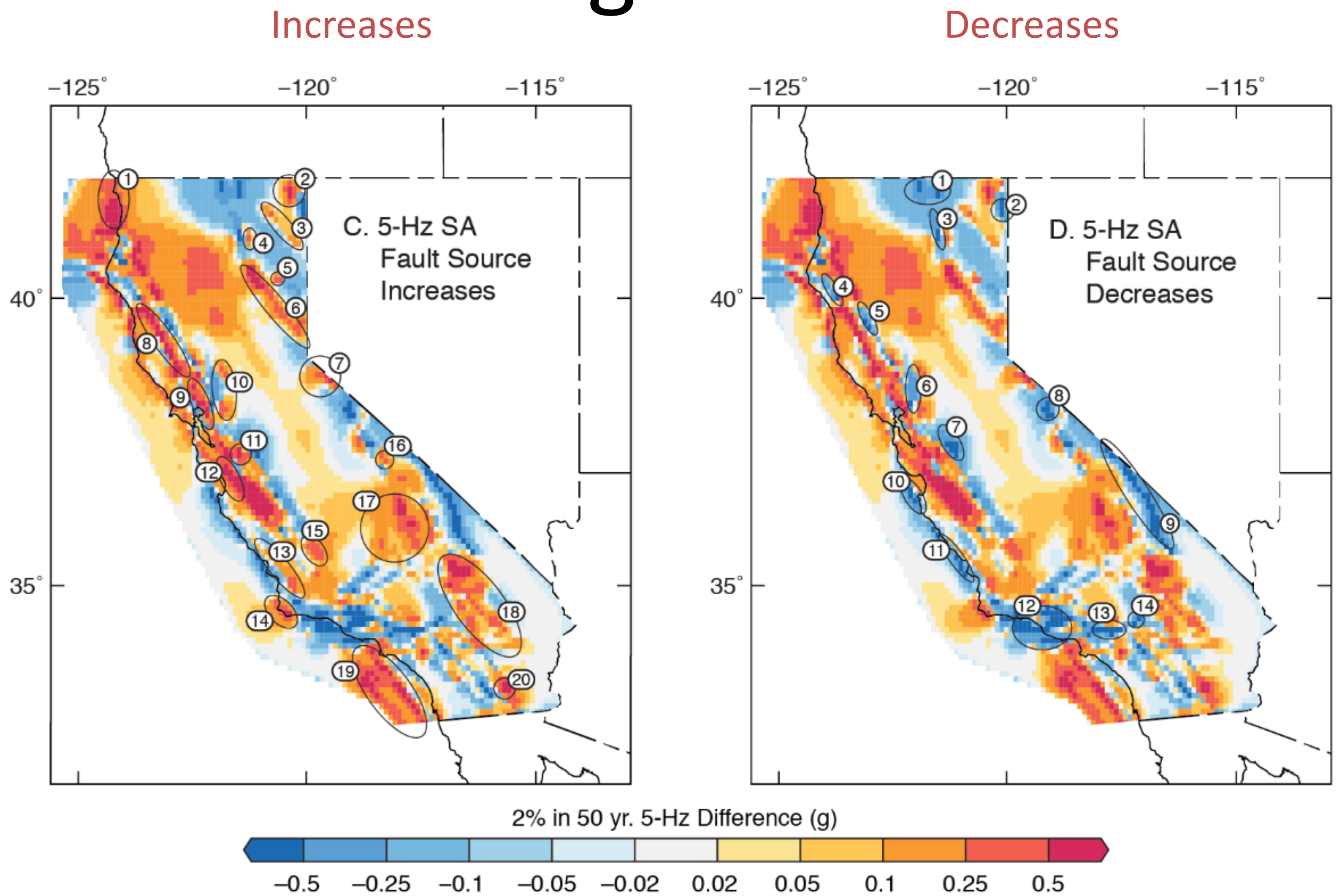


Hazard Change: Grid Sources

Total Model

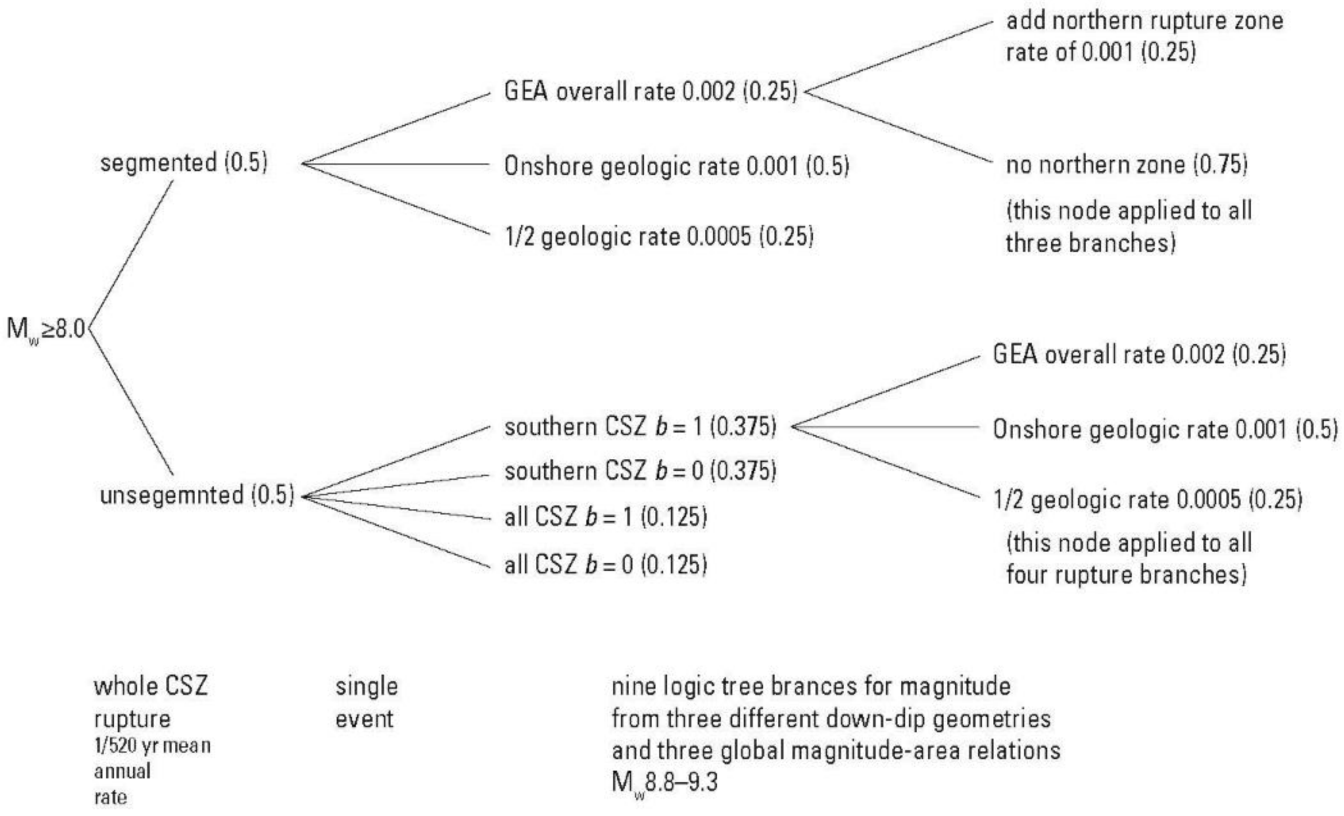


Hazard Change: Fault Sources

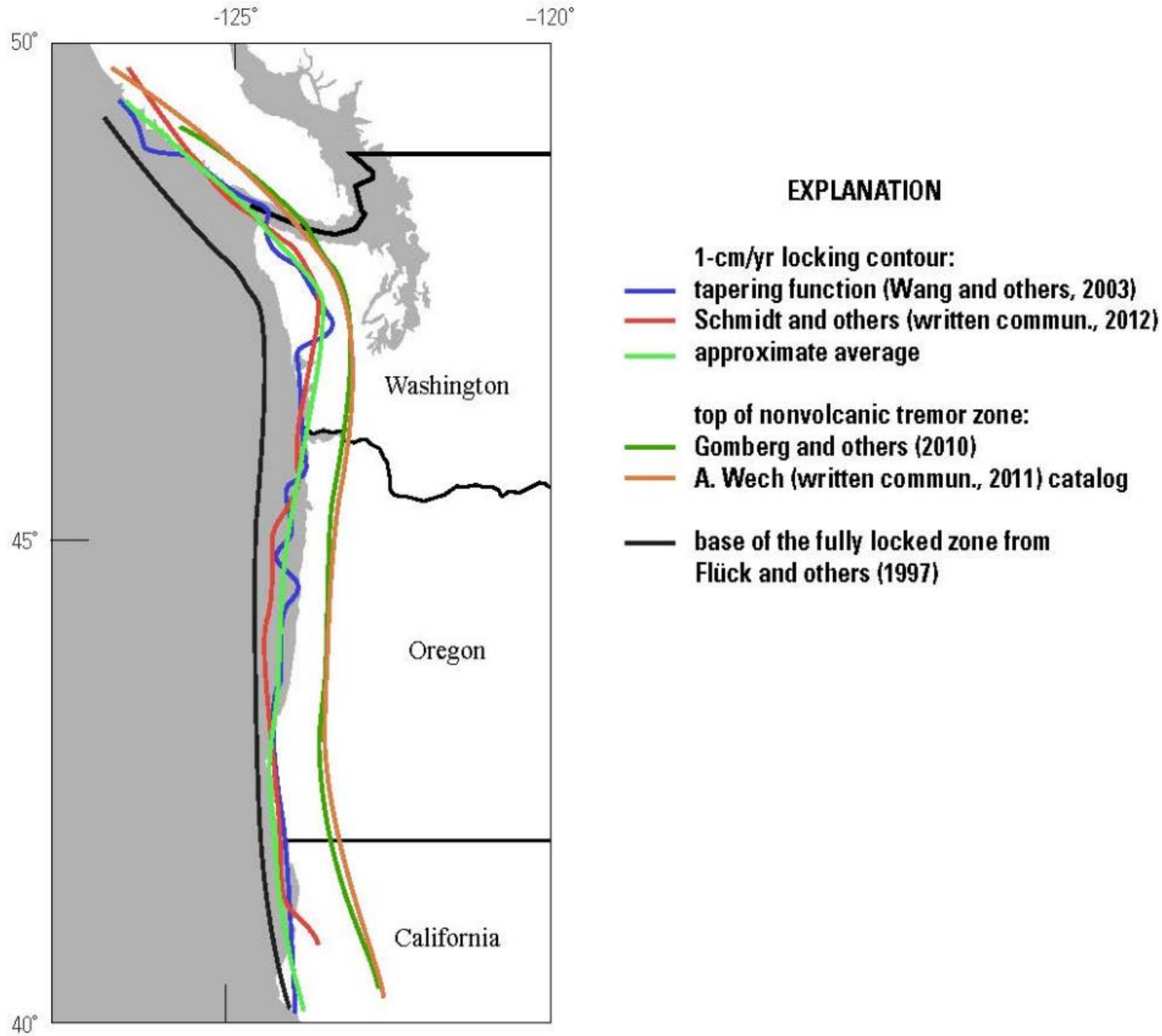


Changes due to: 1) New Faults 2) Slip/Moment Rate Changes 3) Methodology

Cascadia Subduction Zone Logic Tree

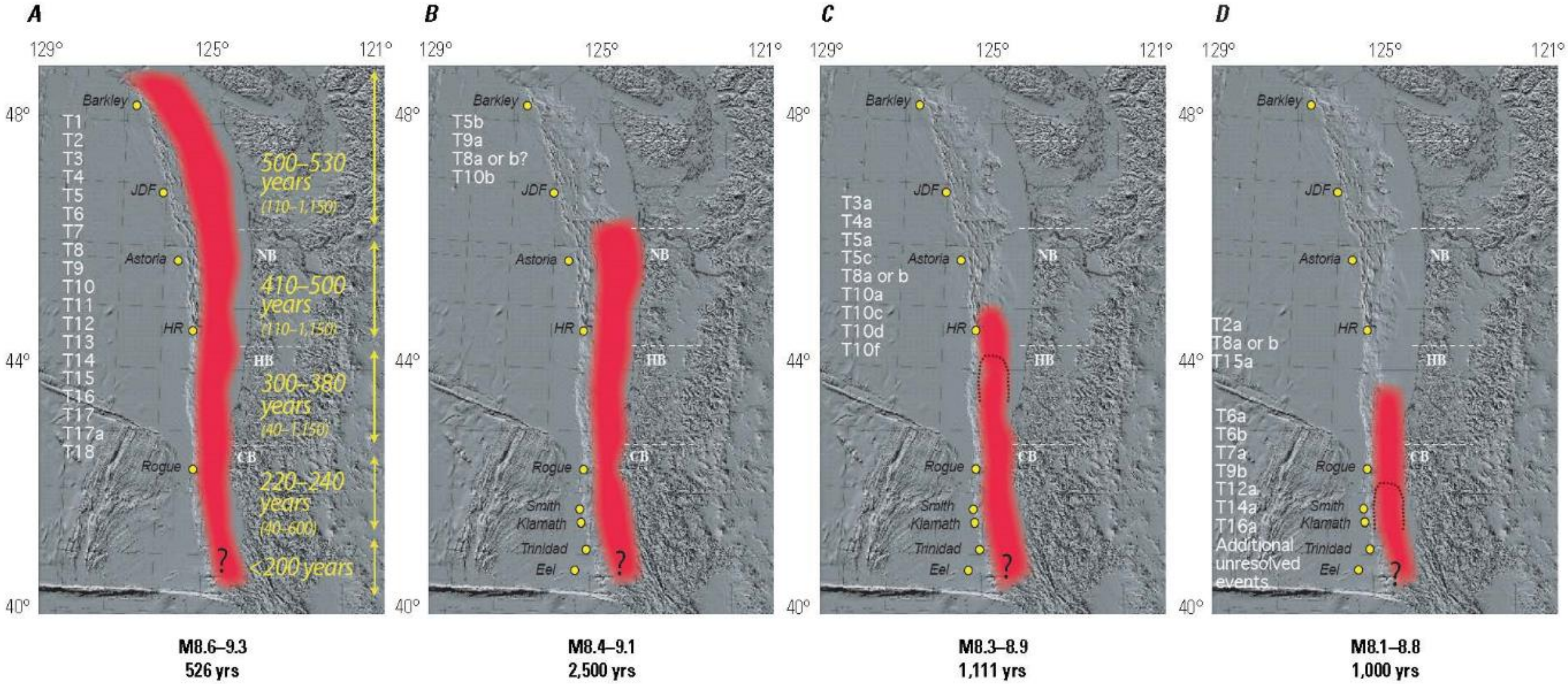


Cascadia Subduction Zone

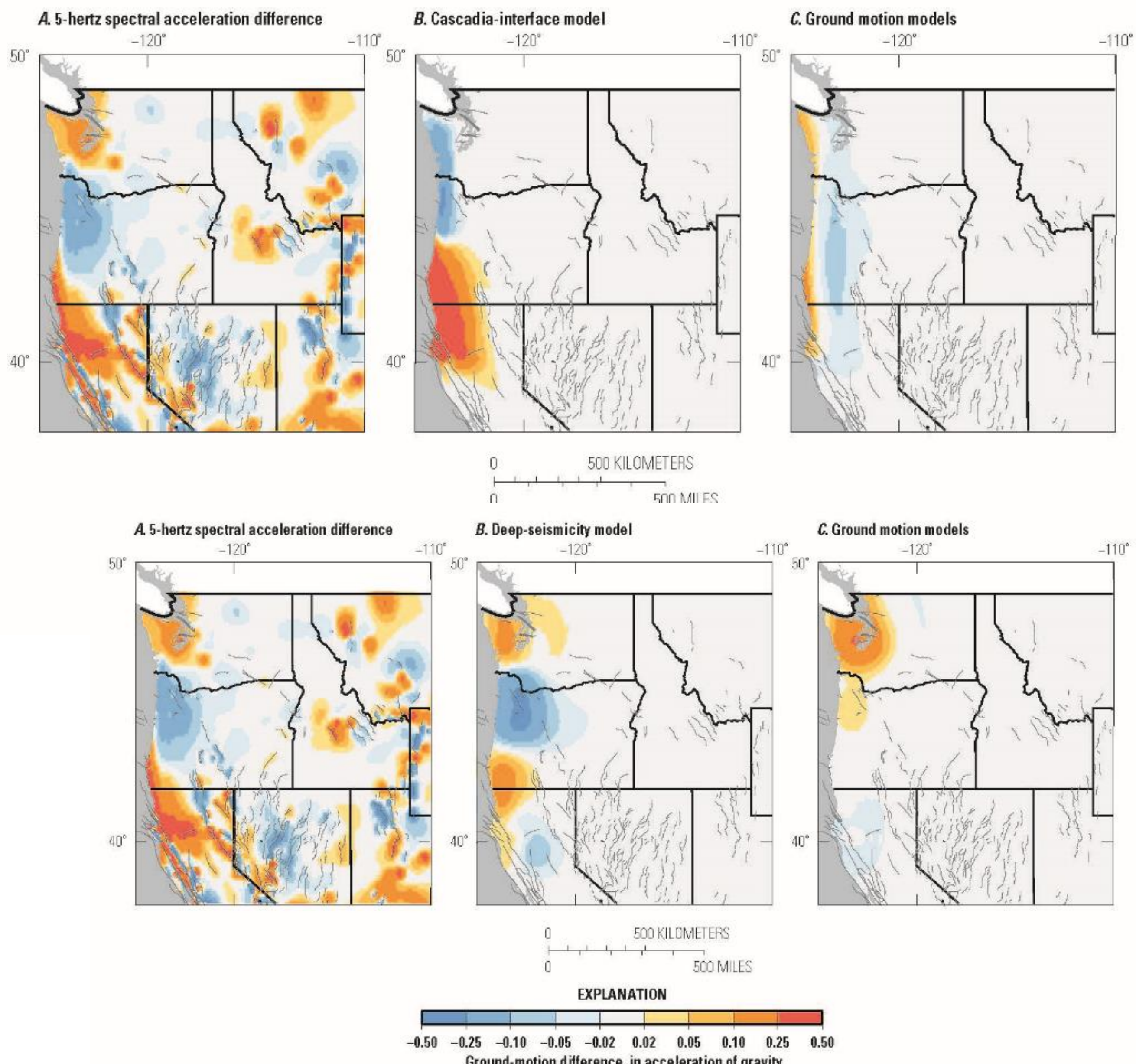


Cascadia Subduction Zone

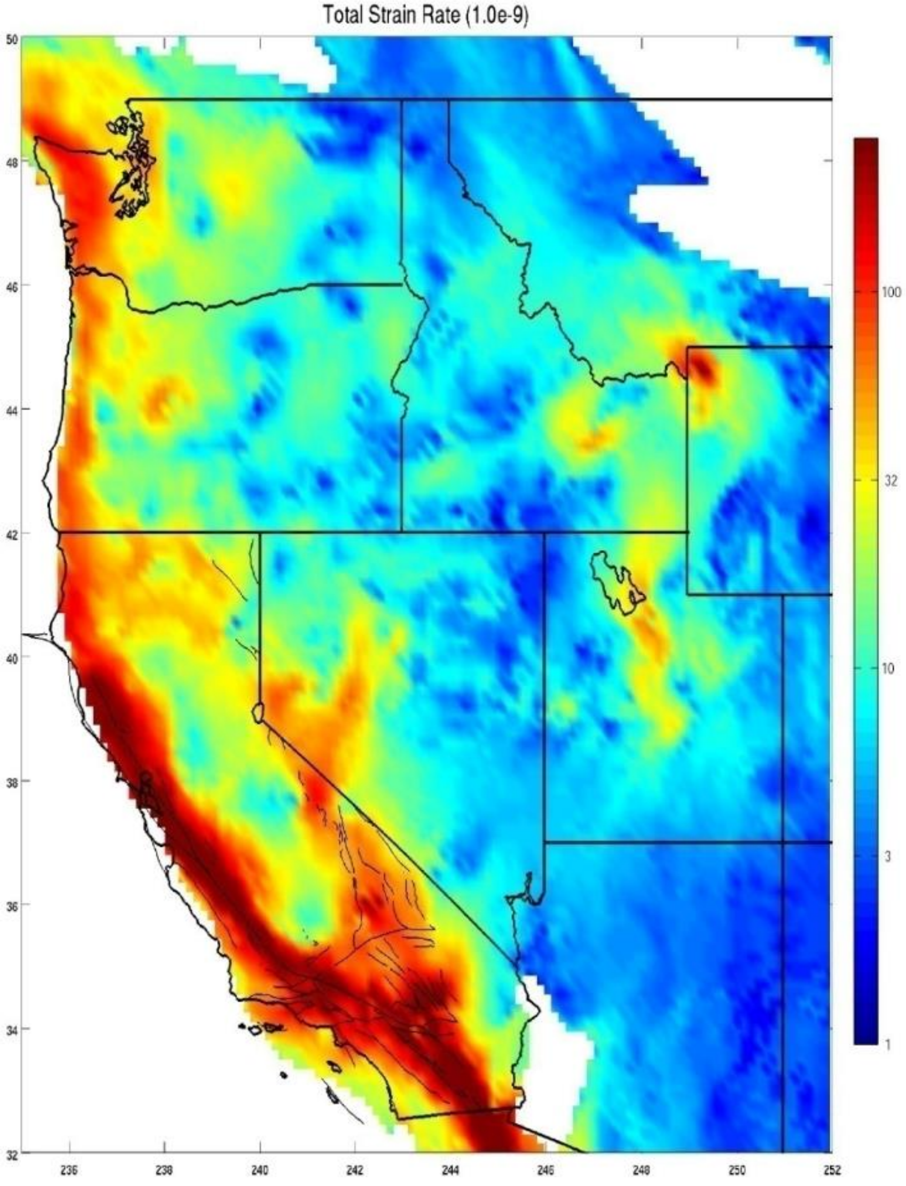
CASCADIA



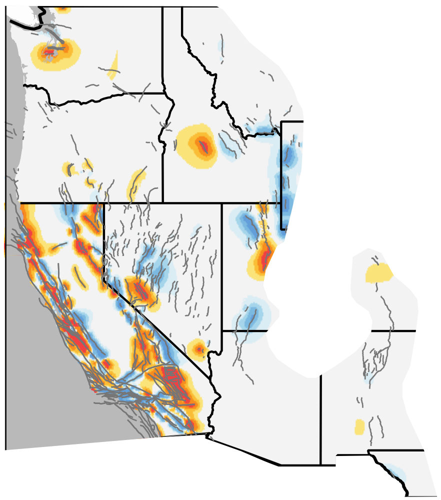
Pacific NW changes due to faults, seismicity, ground motions



Inclusion of geodetic data

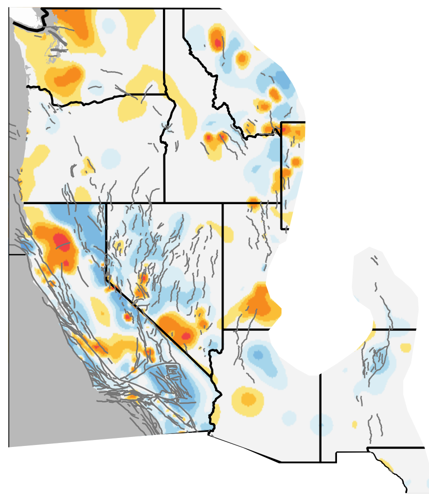


WUS changes due to faults, seismicity, ground motions



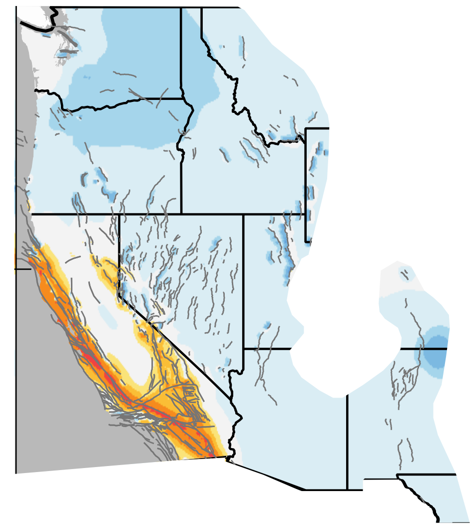
EXPLANATION

gravity



EXPLANATION

ation of gravity

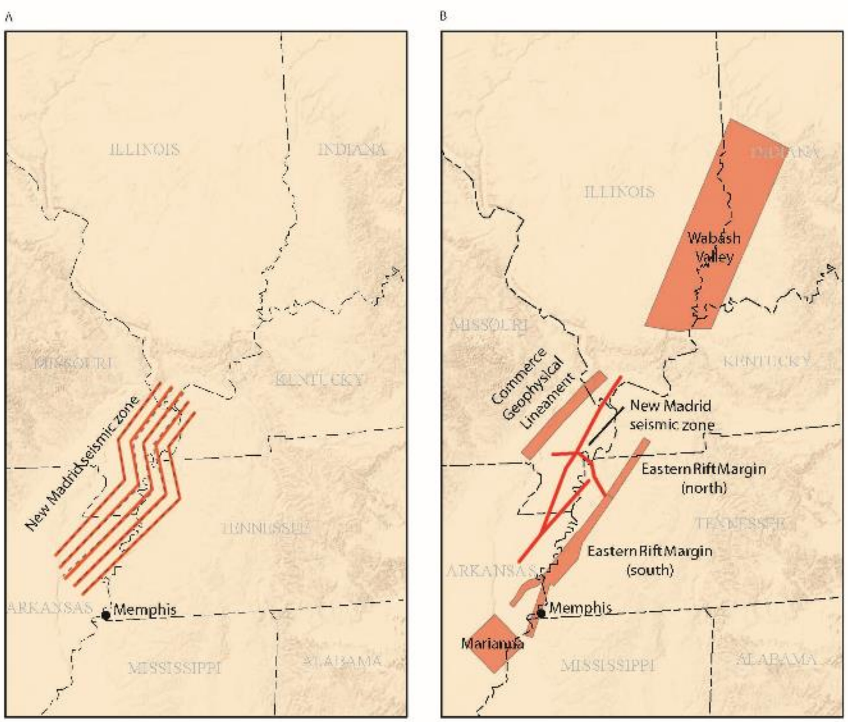


EXPLANATION

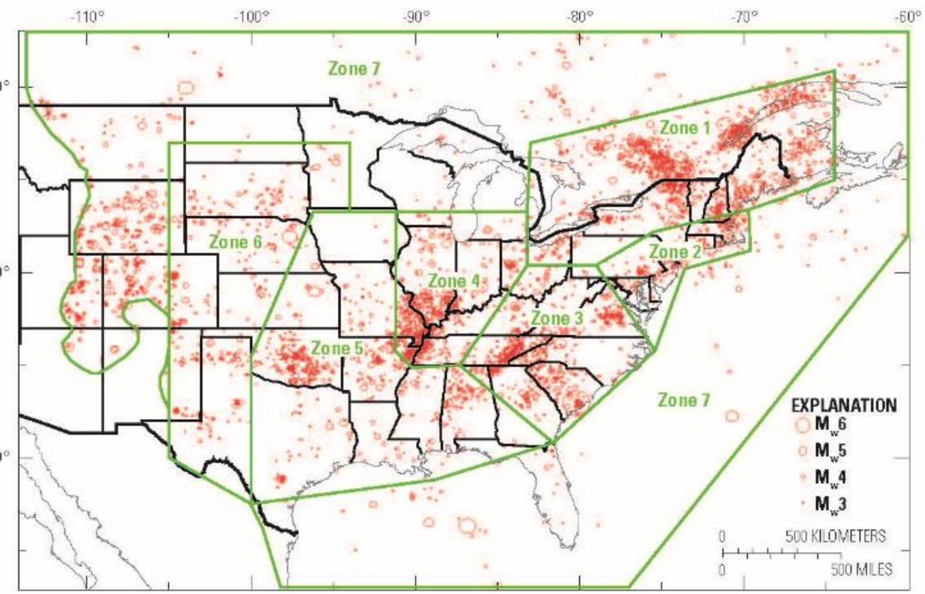
n of gravity

Central and Eastern U.S.

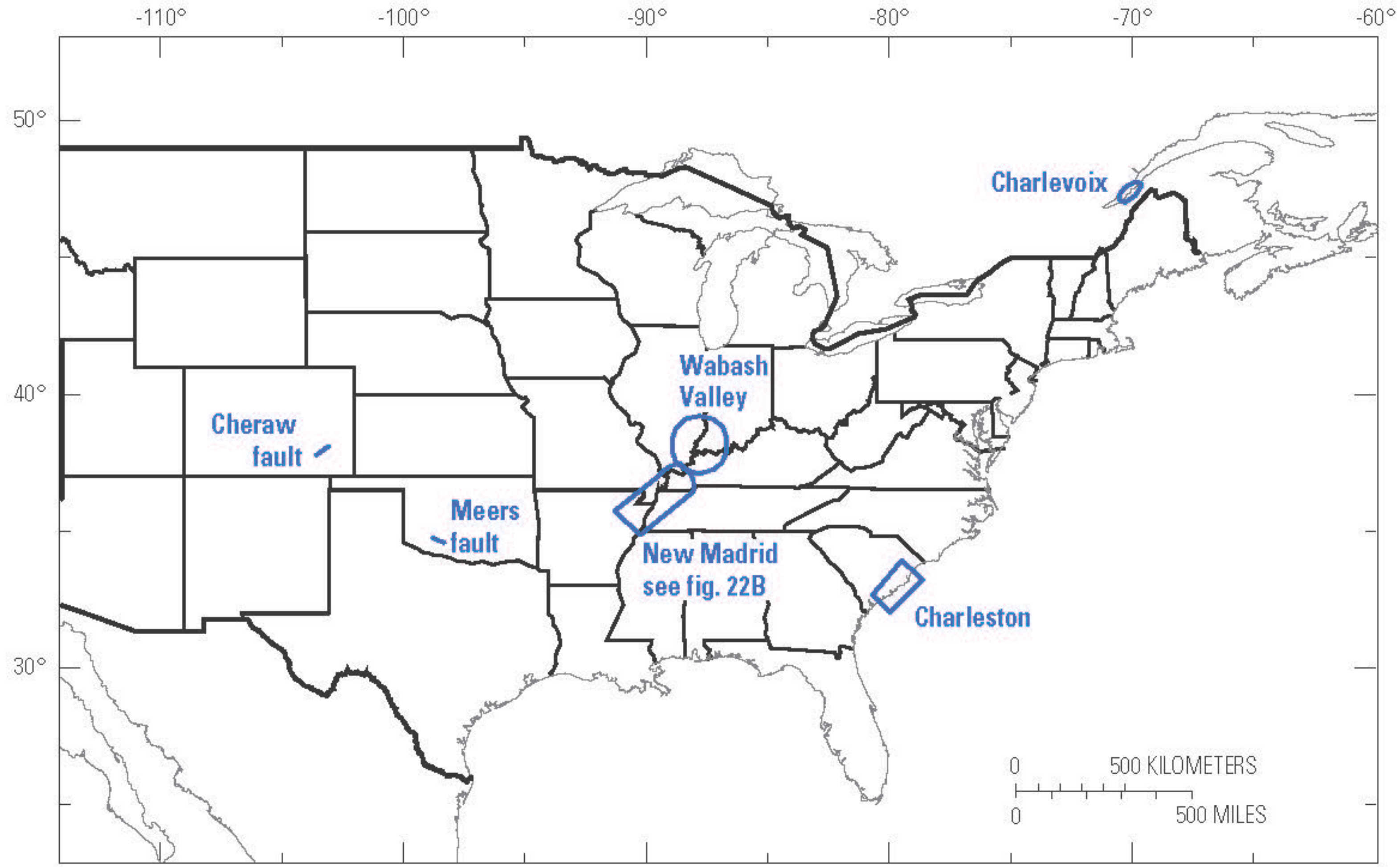
New Madrid



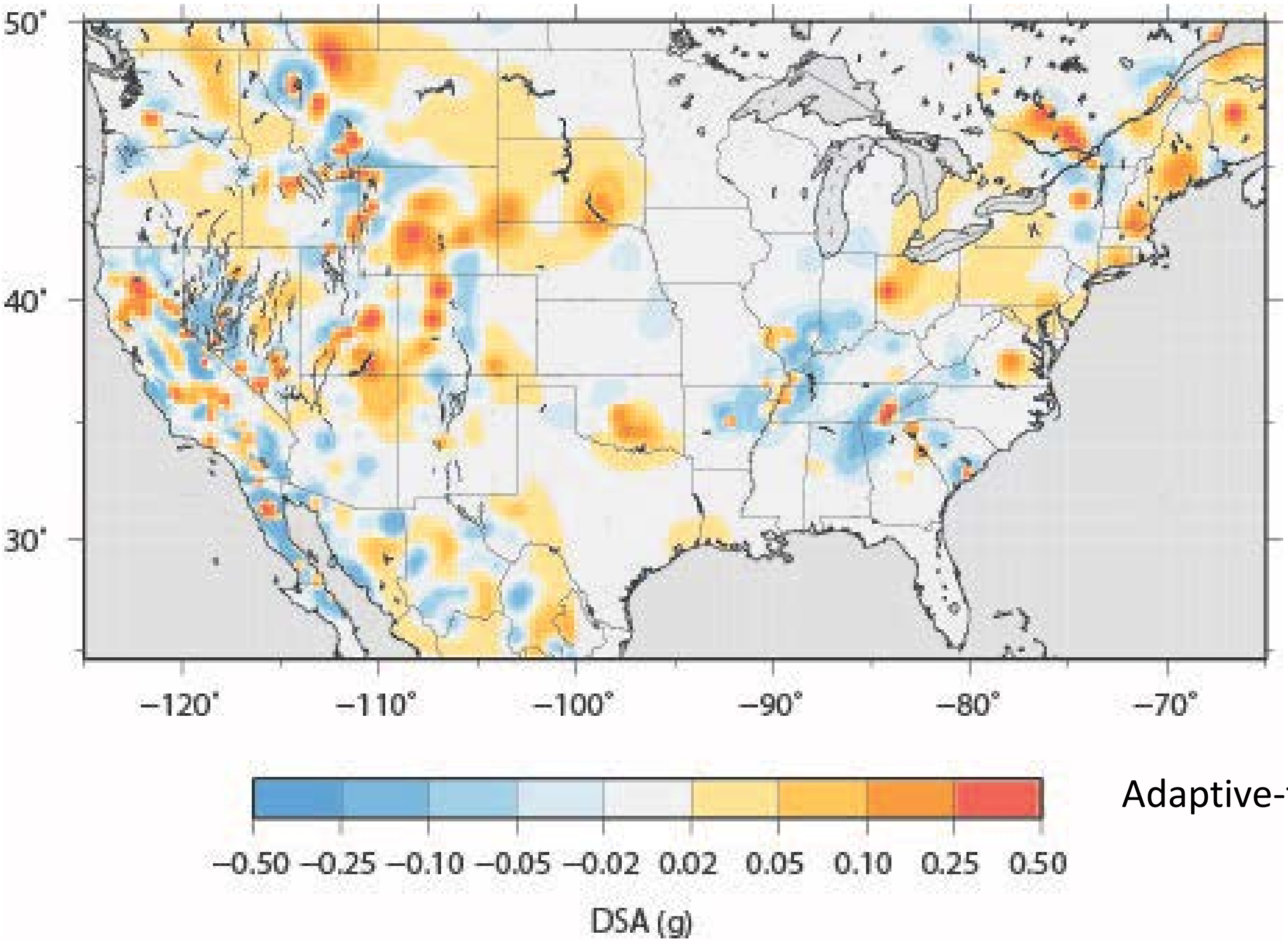
New catalog, completeness times



Faults


-110°
-100°
-90°
-80°
-70°
-60°
50°
40°
30°
Charlevoix
Wabash
Valley
Cheraw
fault
Meers
fault
New Madrid
see fig. 22B
Charleston
0
500 KILOMETERS
0
500 MILES

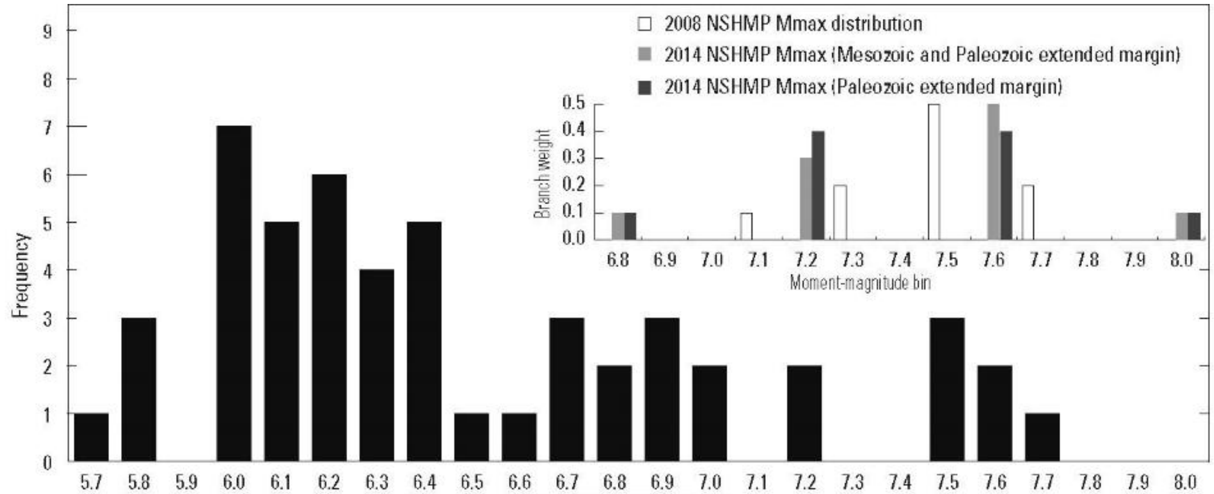
Hazard difference of Alternative gridded models



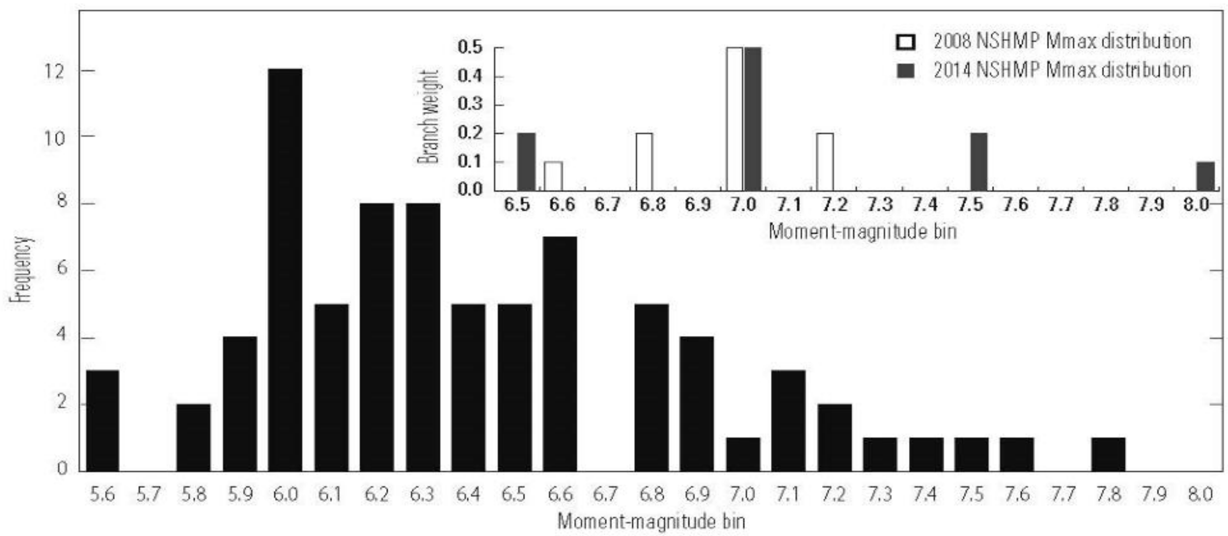
Adaptive-fixed

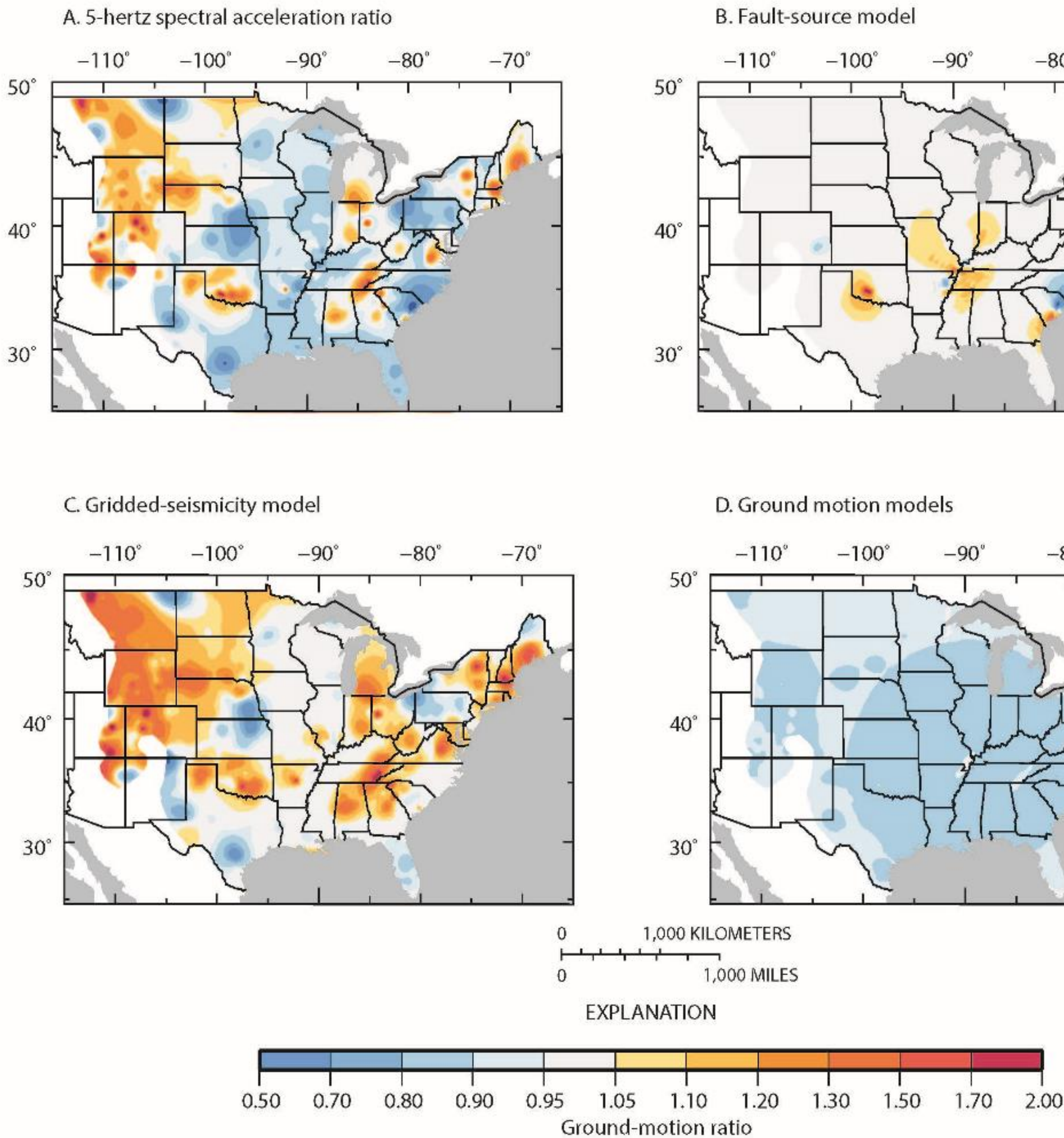
Maximum Magnitude

Extended Margin

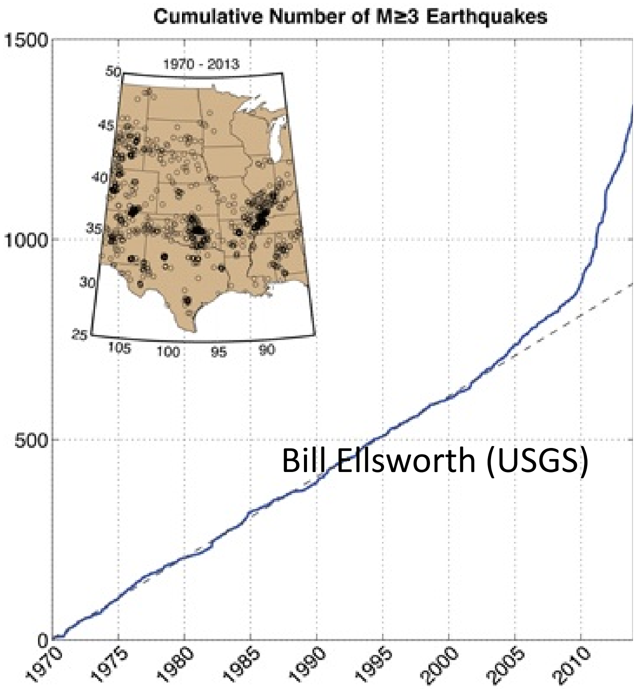


Stable Craton

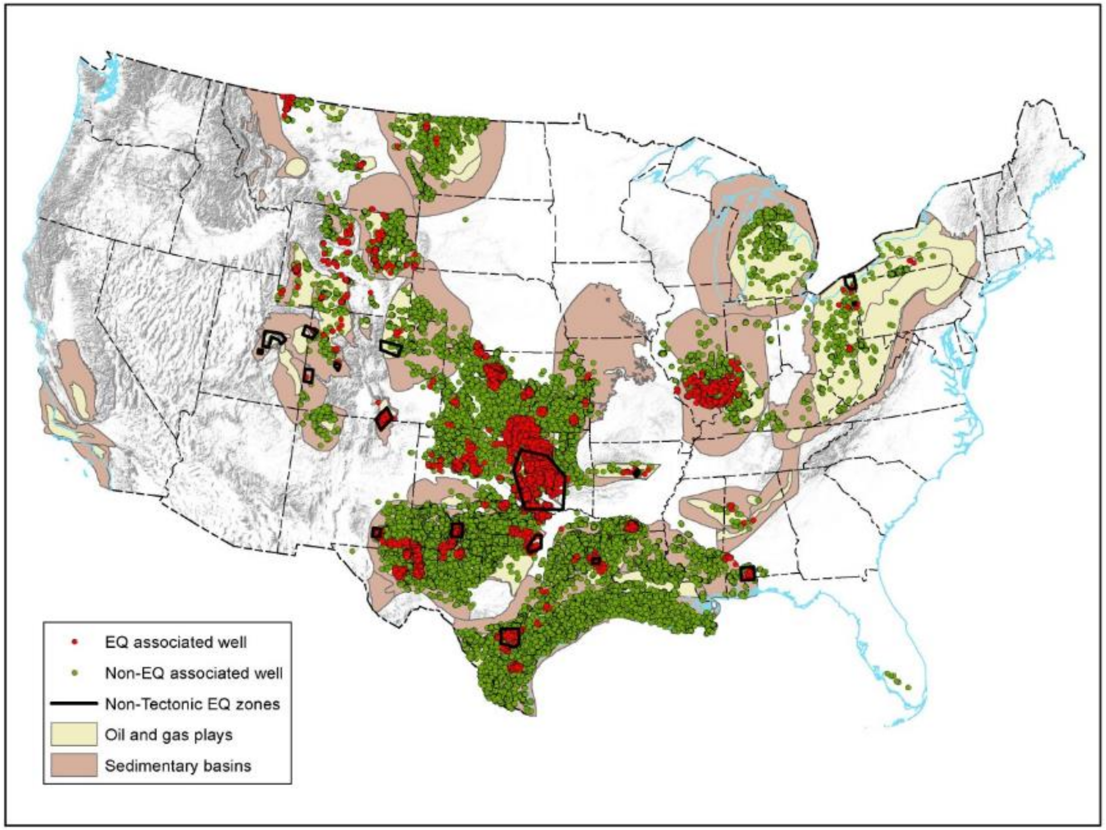



A. 5-hertz spectral acceleration ratio
B. Fault-source model
C. Gridded-seismicity model
D. Ground motion models
−110°
−100°
−90°
−80°
−70°
50°
40°
30°
0
1,000 KILOMETERS
0
1,000 MILES
EXPLANATION
0.50
0.70
0.80
0.90
0.95
1.05
1.10
1.20
1.30
1.50
1.70
2.00
Ground-motion ratio

Induced Seismicity

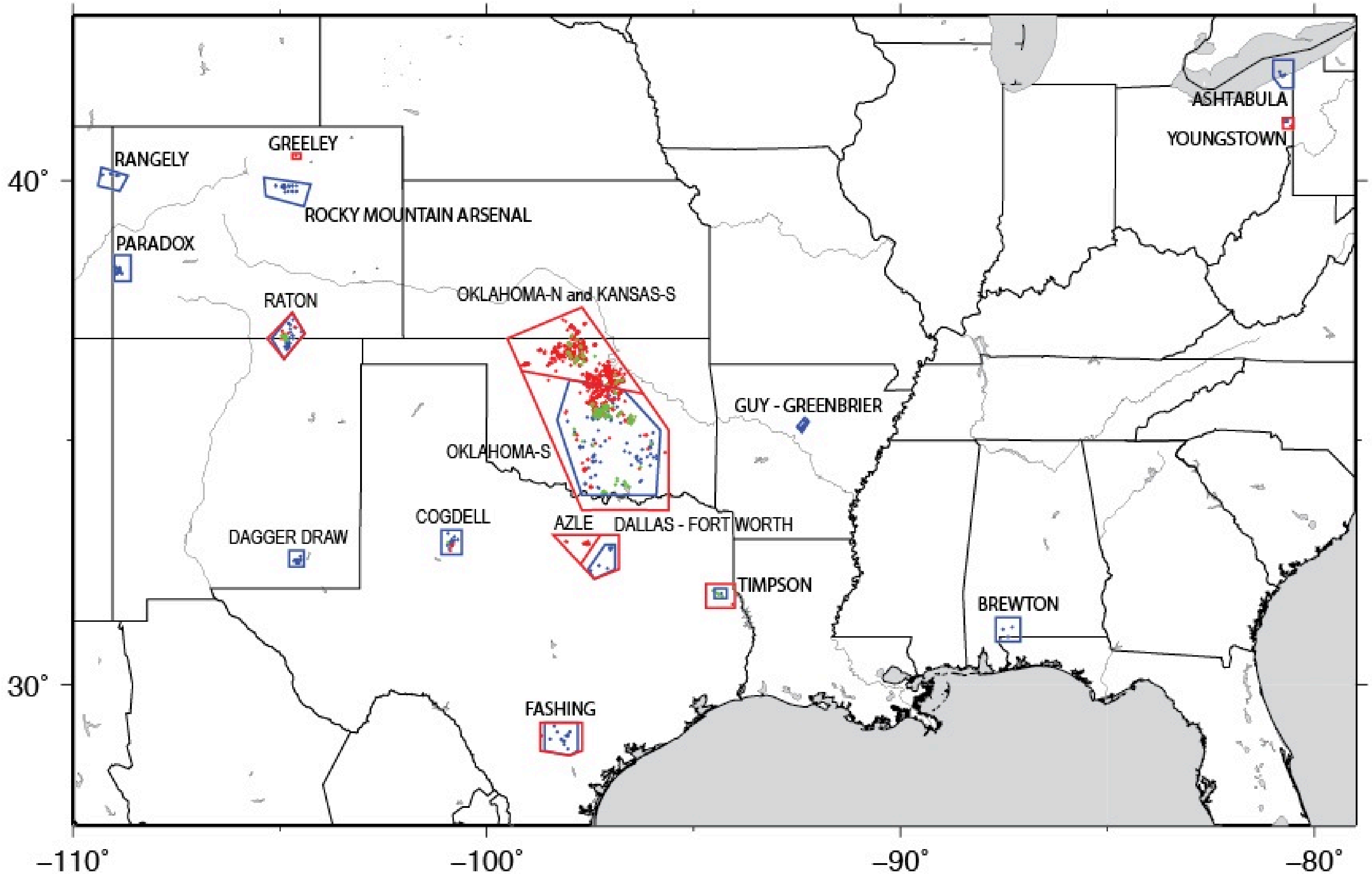


Bill Ellsworth (USGS)

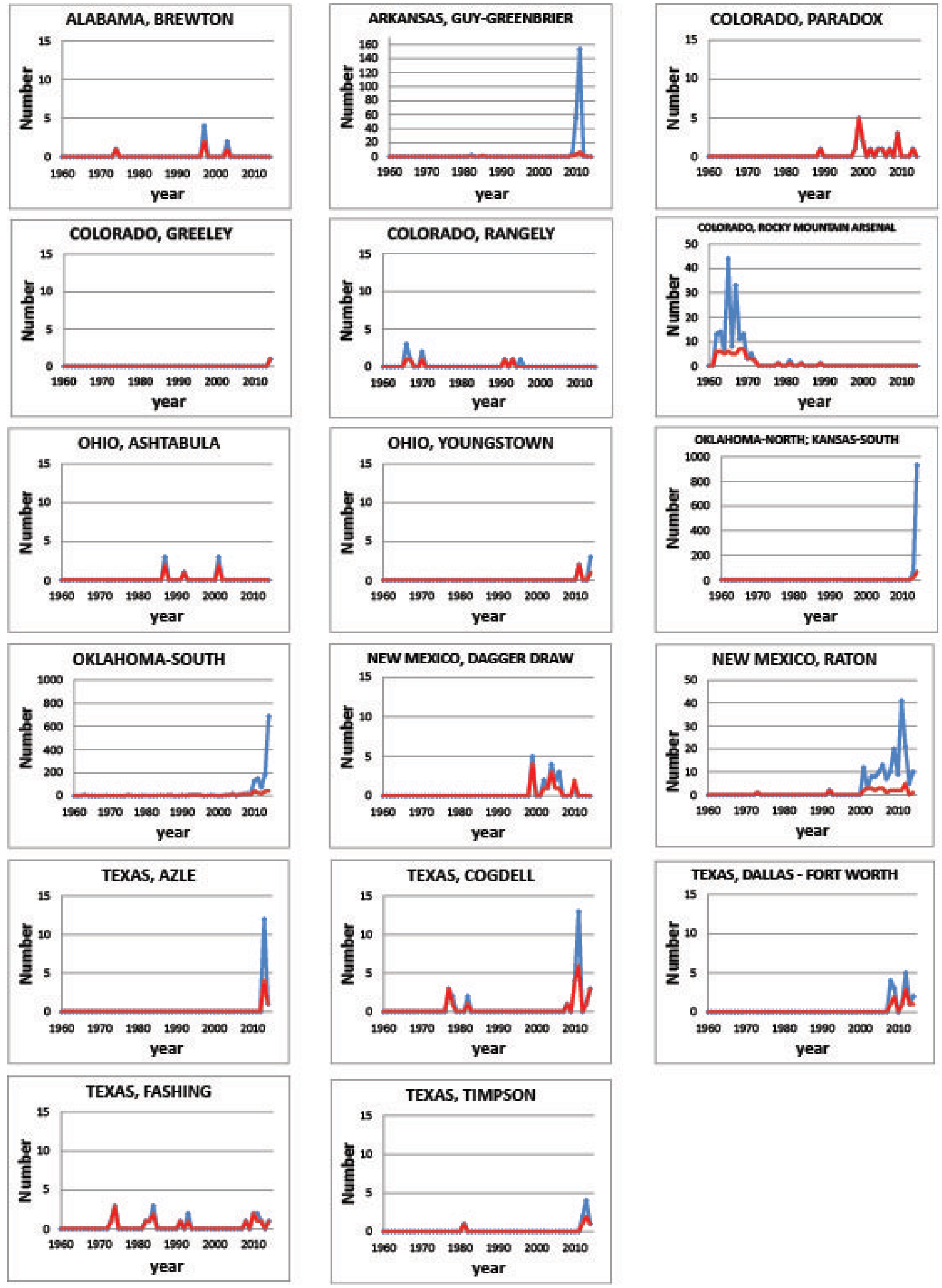


From Jonathan Godt (USGS)

Locations of Potential Induced Earthquakes



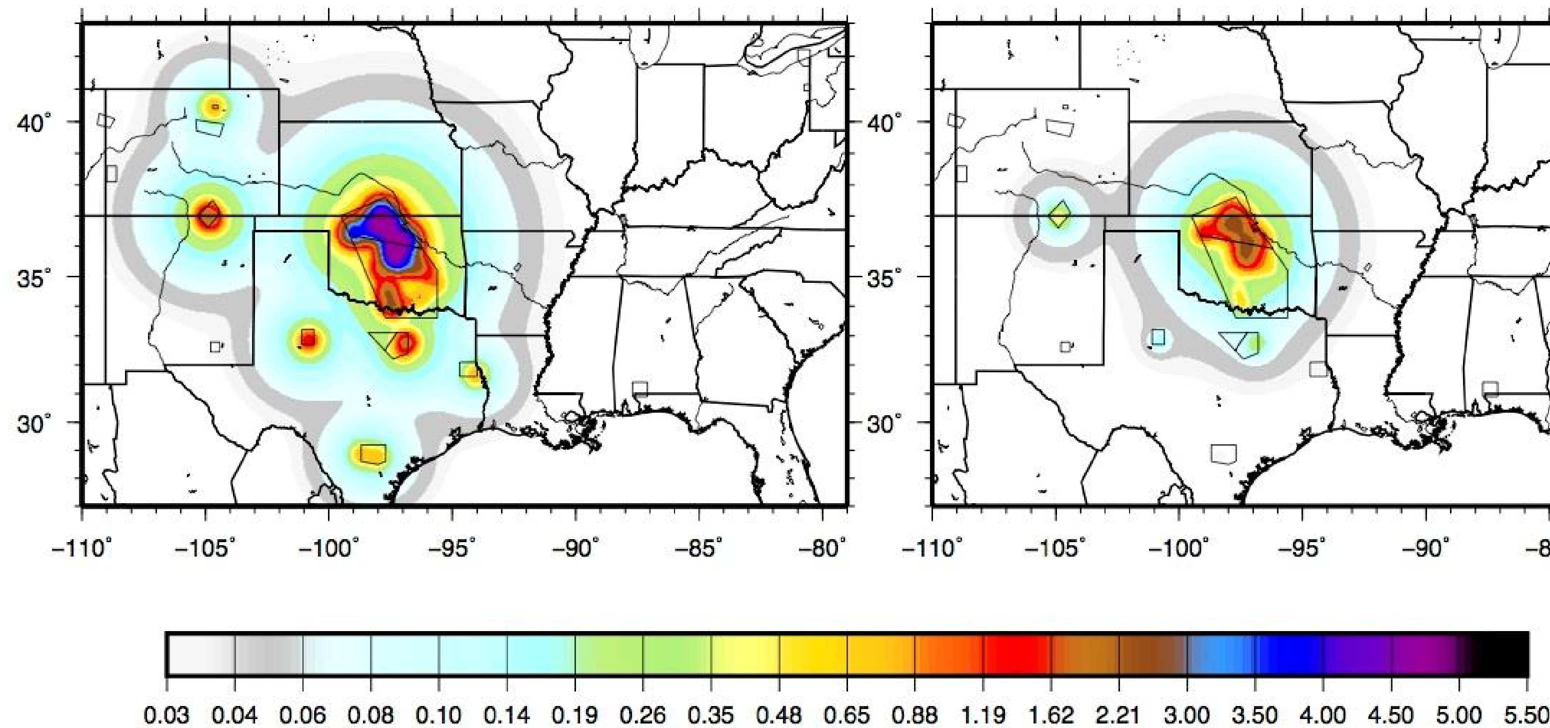
M>2.5 Earthquakes within 17 areas of suspected Induced seismicity



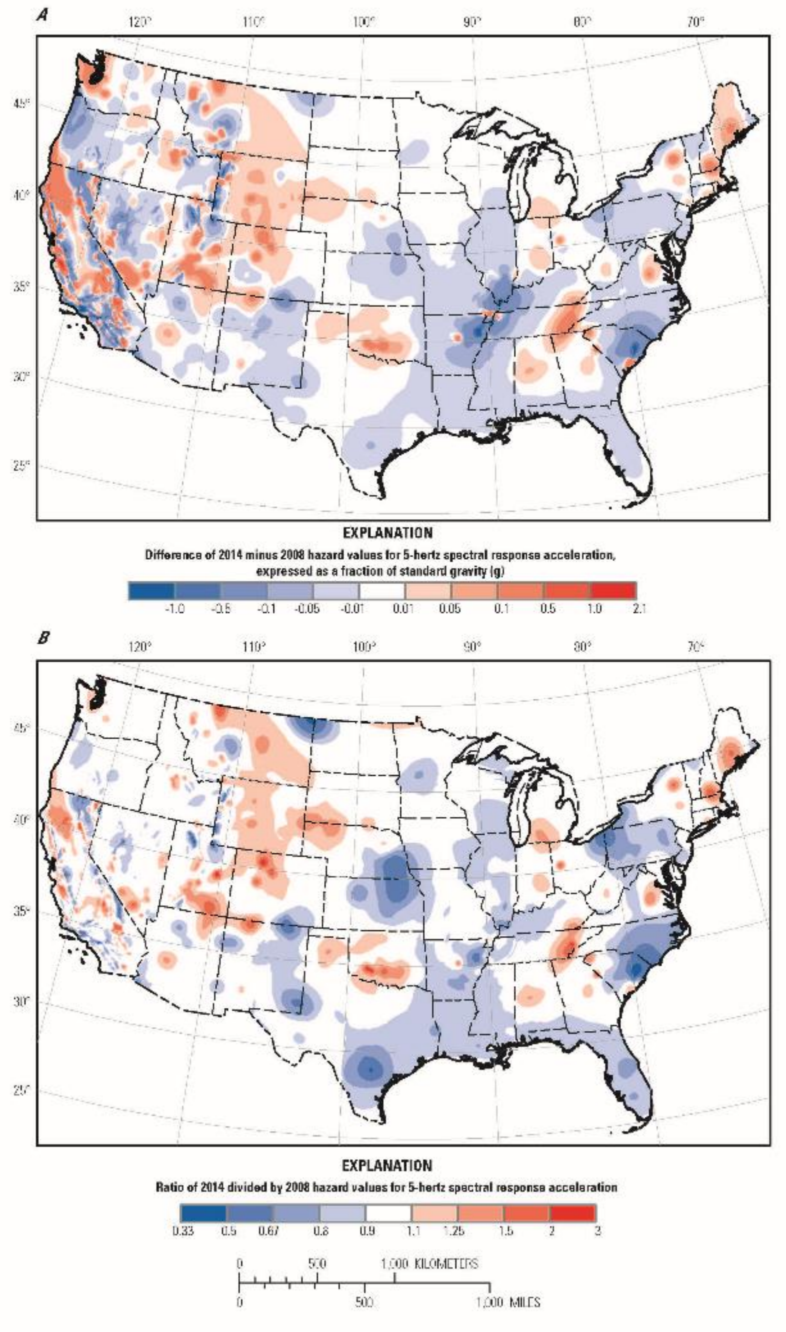
Base Case, 5-Hertz

0.04% chance of exceedance per year
(2% in 50-years)

1.39% chance of exceedance per year
(50% in 50-years)

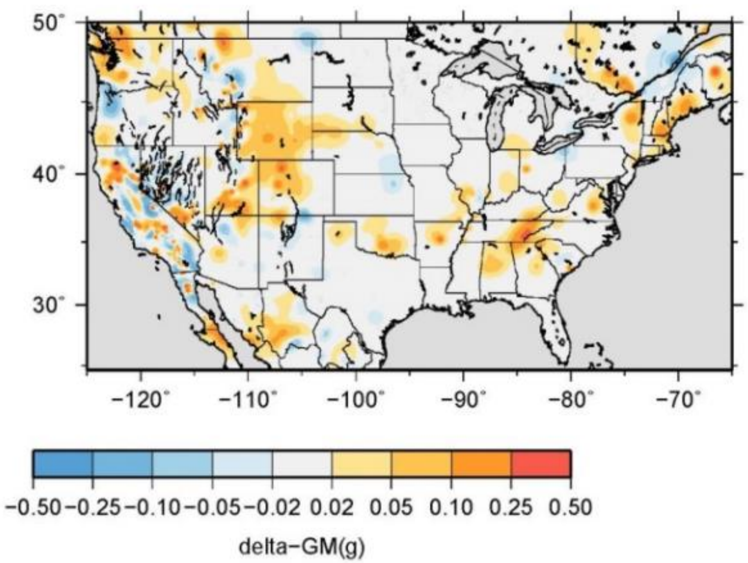


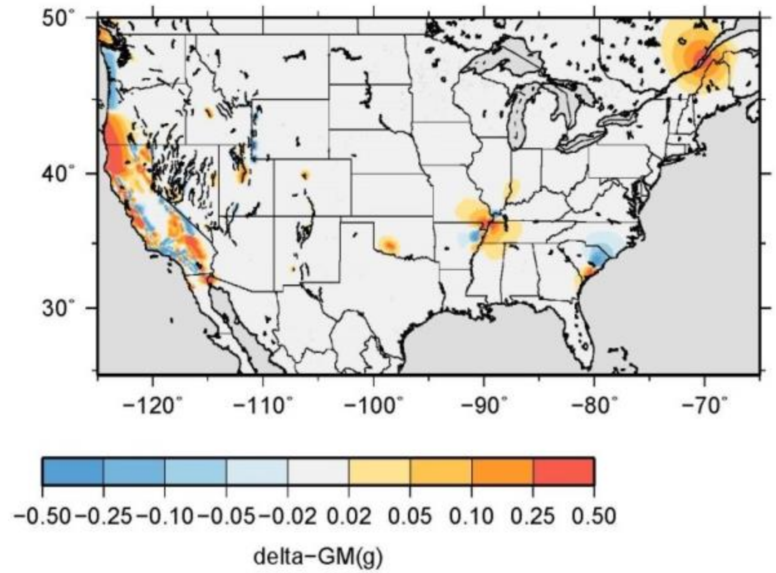
acceleration of gravity

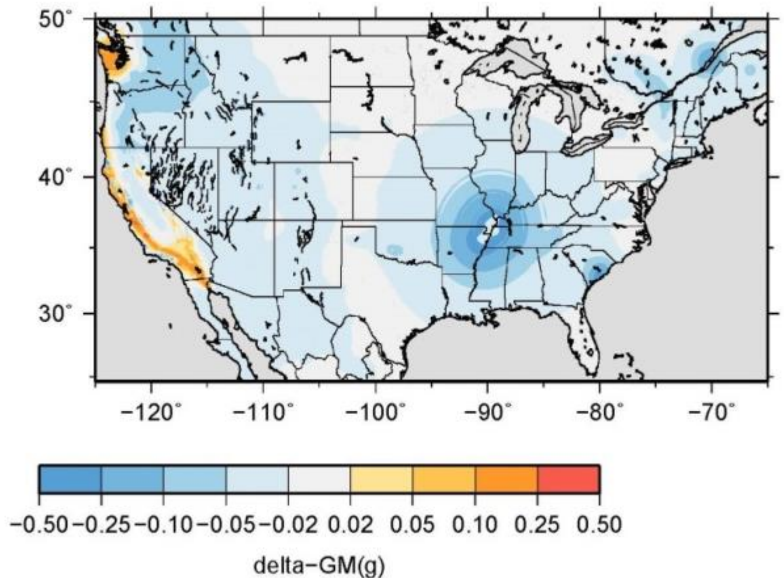


Comparison of 2014 model with 2008 model (2014-2008 or 2014/2008 5Hz- 2% in 50)

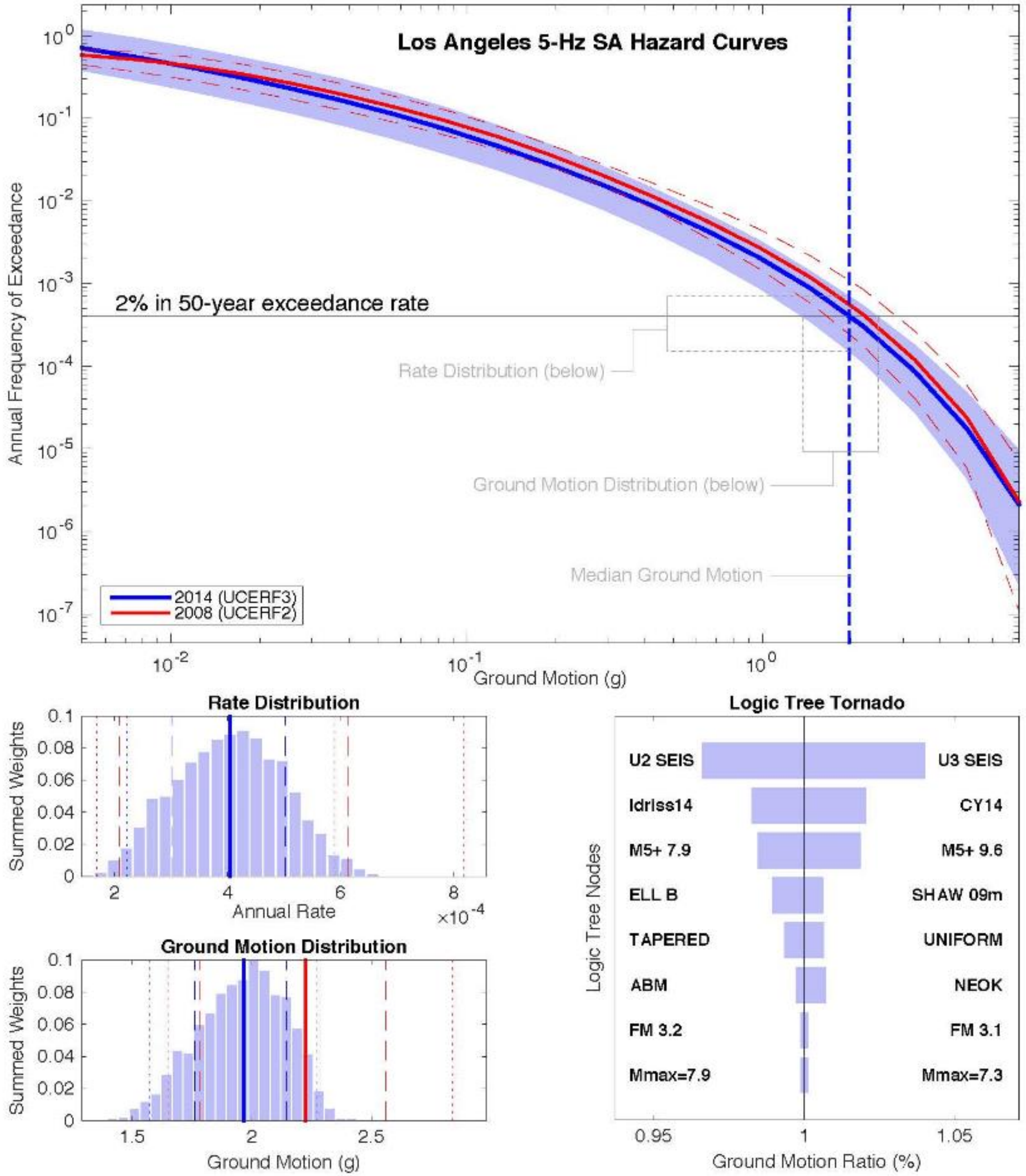
5-Hz maps showing differences from 2008 (A- seismicity; B- faults; C-GMMs)







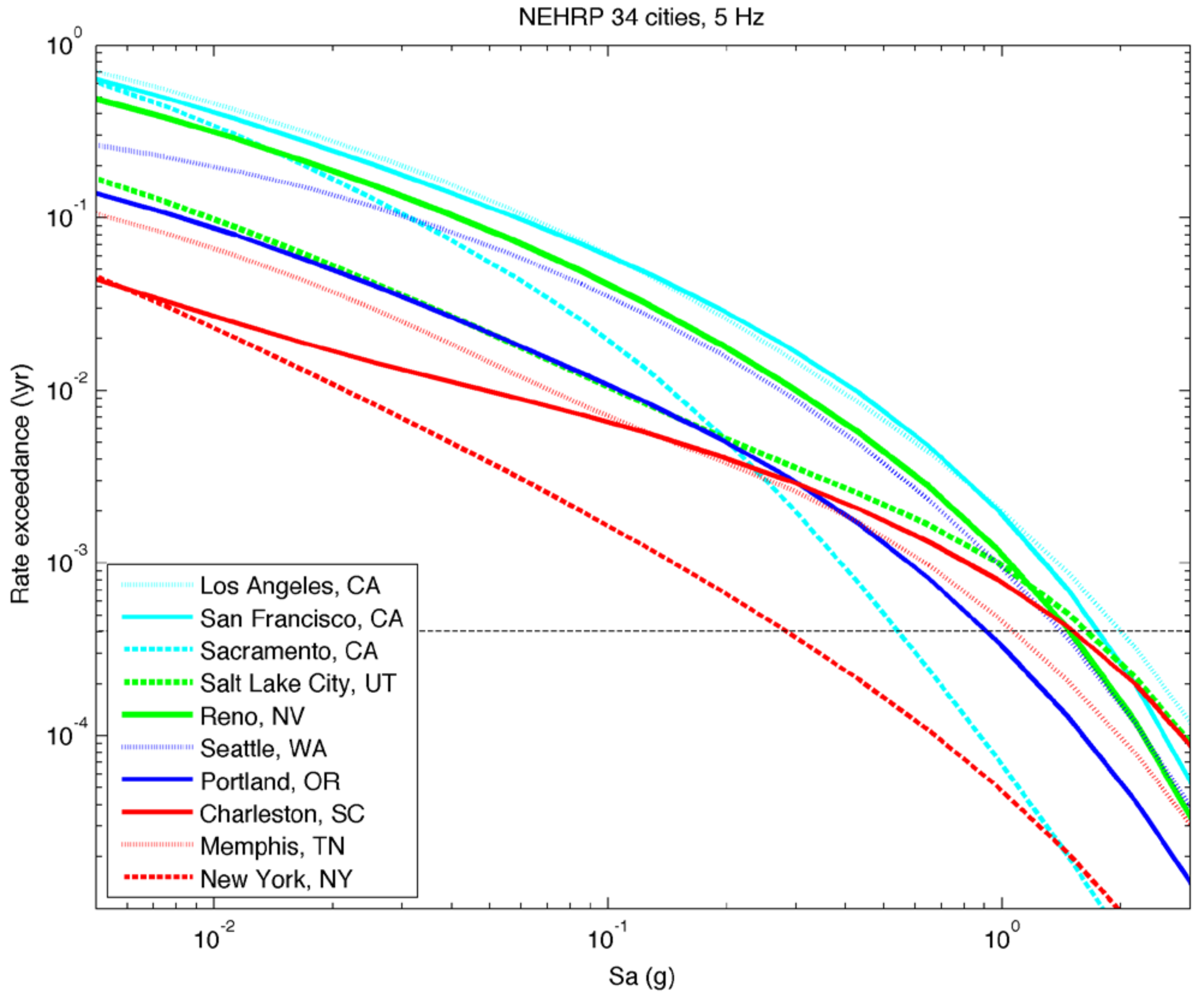
Los Angeles Uncertainty Analysis



Challenges

- How can we develop better hazard estimates in the future?
- What products can USGS develop to help people understand the seismic hazard information?
- How can we better assess and communicate uncertainty?
- How can we test the hazard products?

Hazard curves for cities across U.S.

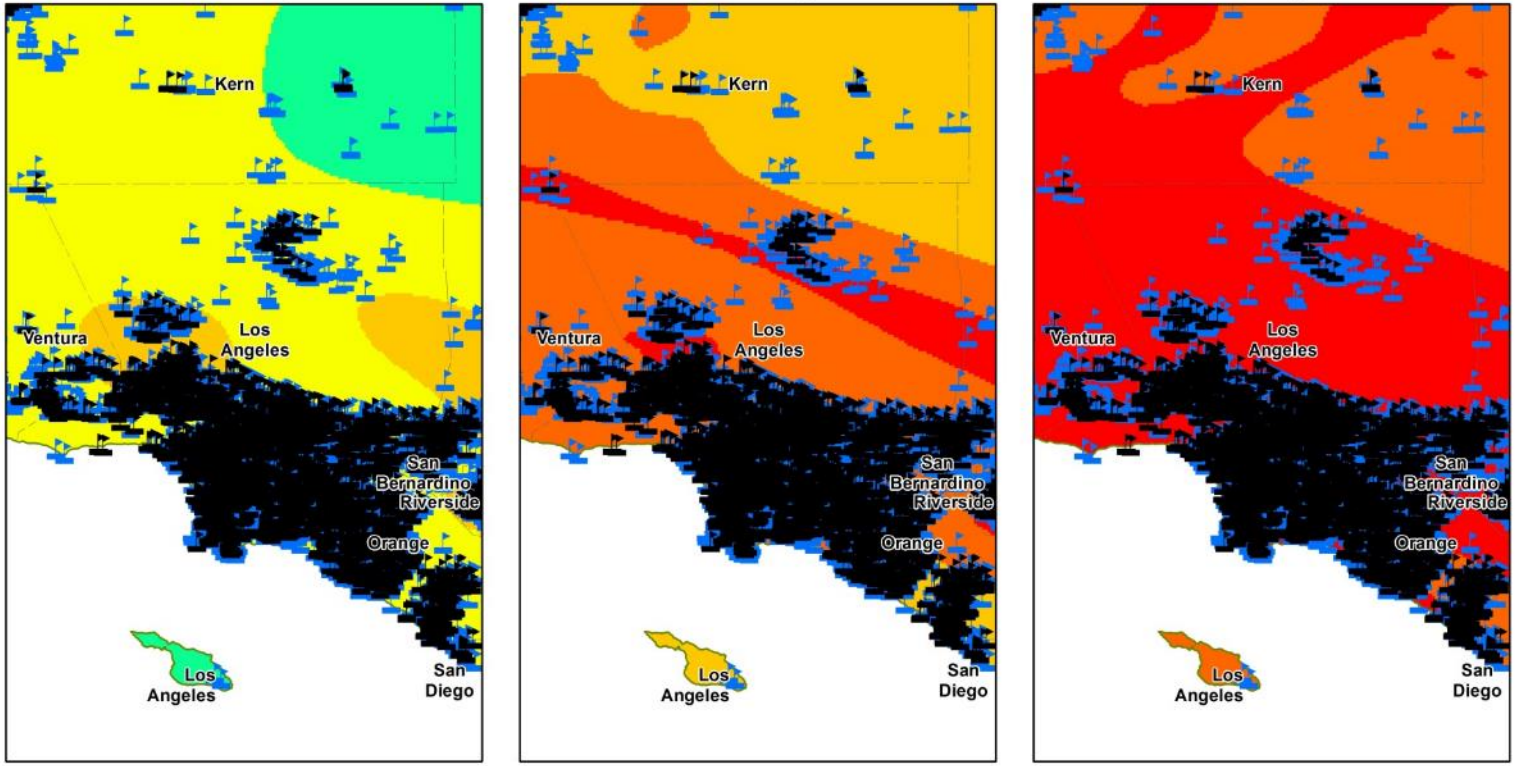


Los Angeles

likely
50% in 50 years

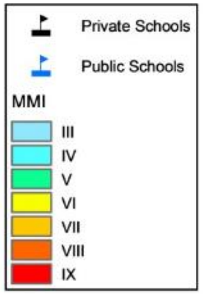
possible
10% in 50 years

rare
2% in 50 years



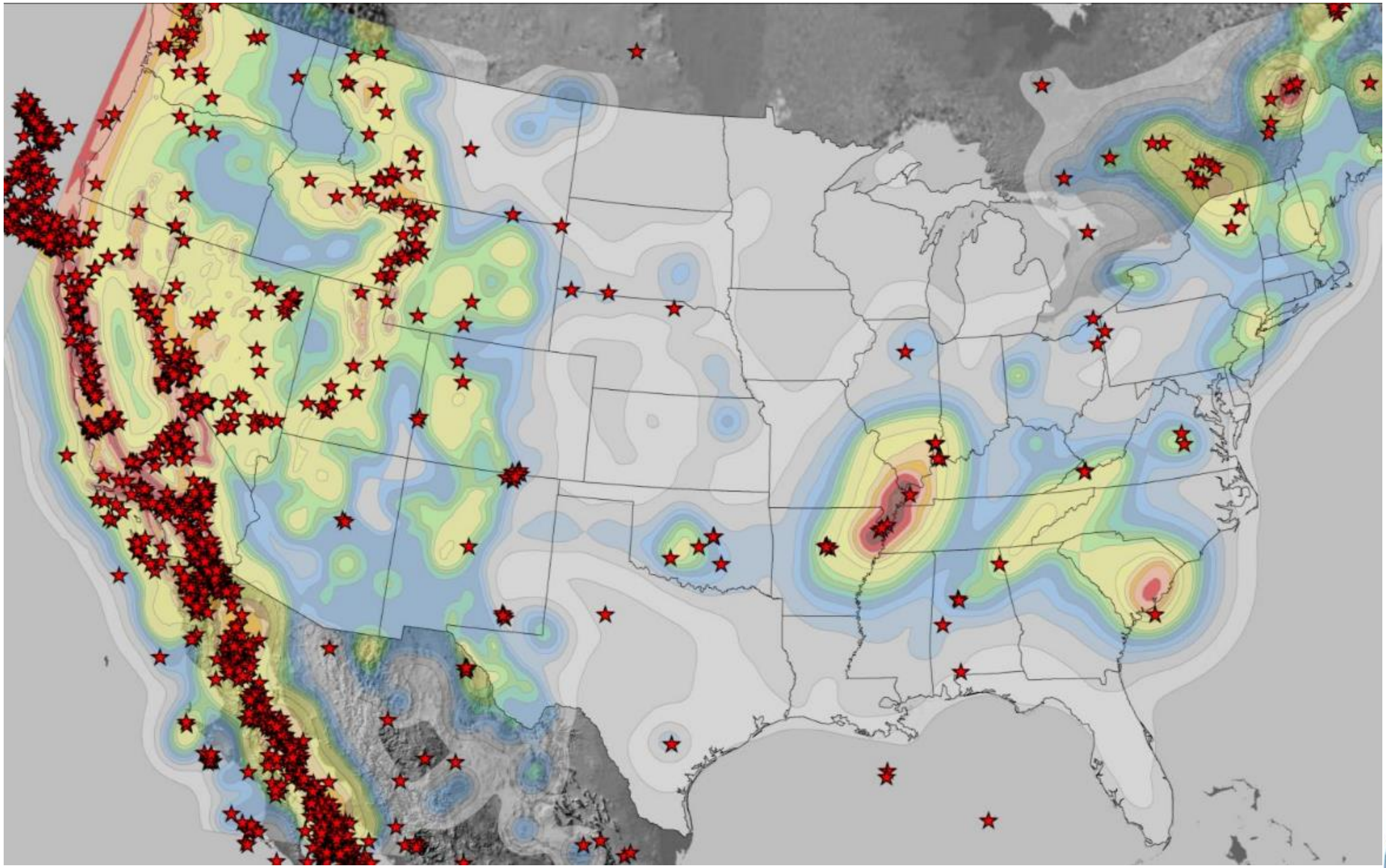
Number of schools in MMI zones

MMI	50% in 50 years	10% in 50 years	2% in 50 years
V	24		
VI	4000		
VII	619	502	
VIII		4006	4479
IX		135	164



Comparison of 1996 hazard and seismicity

1996 USGS PGA 2% in 50; ★M4.0 and greater since 1997



Conclusions

- Seismic hazard varies within each cycle based on new data, models, and methods.
- Uncertainties are large for source and ground motion models.
- Earthquake Spectra special issue is planned for release in the next few months.
- USGS will continue to develop hazard products that will be useful for end-user communities.

Hazard Change: Decomposed

Sources GMMs Total