Progress on the 2018 USGS National Seismic Hazard Model (2018 NSHM)

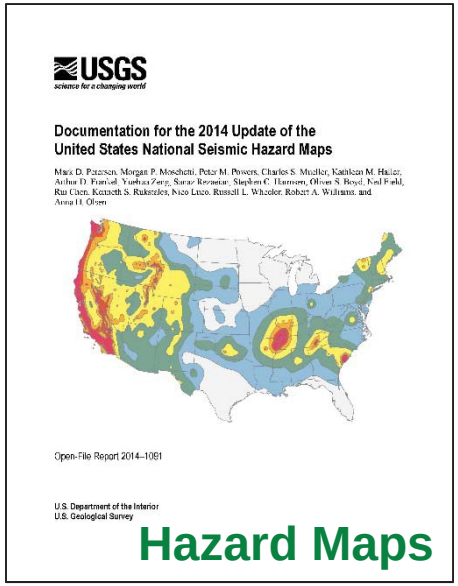
Building Seismic Safety Council (BSSC) Provisions Update Committee (PUC) Meeting

Sanaz Rezaeian
Research Structural Engineer
U.S. Geological Survey, Golden, CO

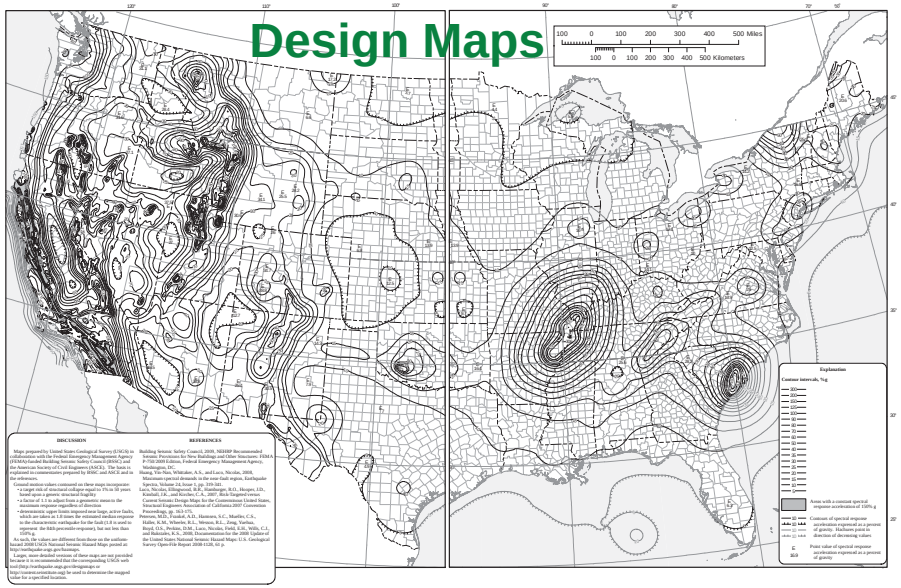
USGS
science for a changing world

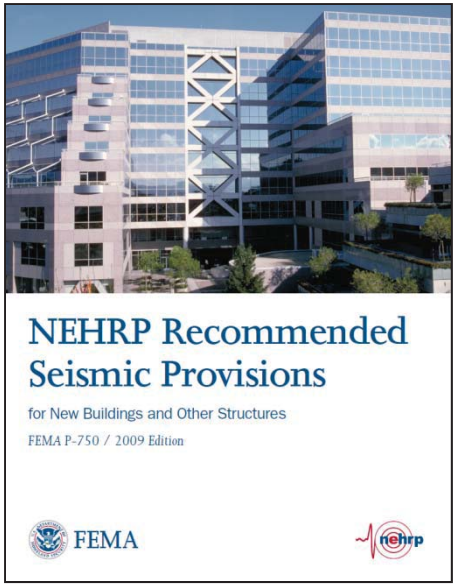
Bases of Design Ground Motion Maps

USGS National Seismic Hazard Model (NSHM) ← **This presentation** → **Project '17** → **Site-Specific Ground Motion Procedures of …**



Hazard Maps





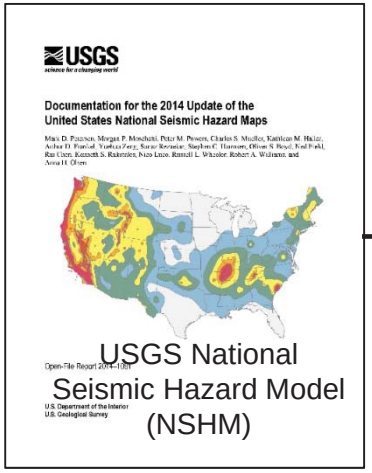
Risk-Targeted Maximum Considered Earthquake (MCE_R) Ground Motion Maps

Building Seismic Safety Council (BSSC) Provisions Update Committee (PUC) Meeting

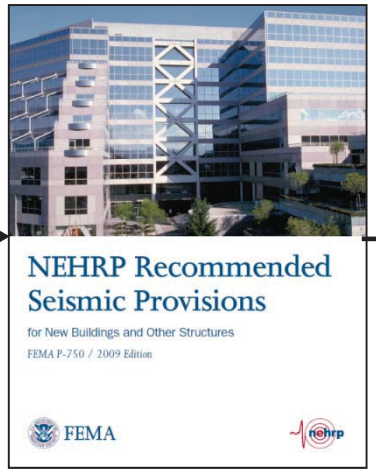
Past USGS NSHM Updates

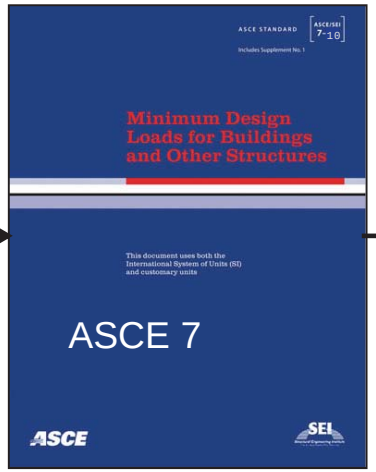
USGS NSHM	*NEHRP Provisions*	*ASCE 7 Standard*	*IBC*
1996	1997, 2000	1998, 2002	2000, 20003
2002	2003	2005	2006, 2009
2008	2009	2010	2012, 2015
2014	2015	2016	2018

2018 → 2020 → 2022 → 2024



USGS National Seismic Hazard Model (NSHM)

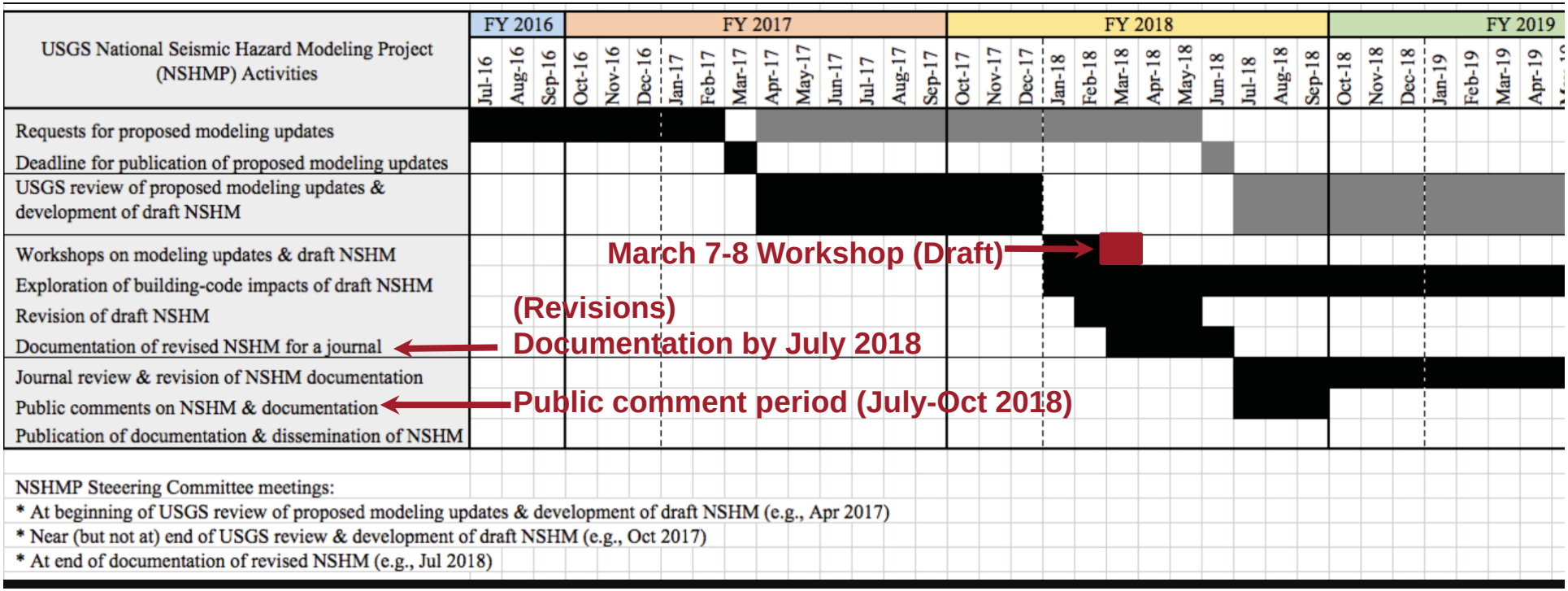




2017 Structural Engineers Association of California (SEAOC) Convention – Building Seismic Safety Council (BSSC) Session

Schedule of Upcoming NSHM Updates

2018 Schedule in Black



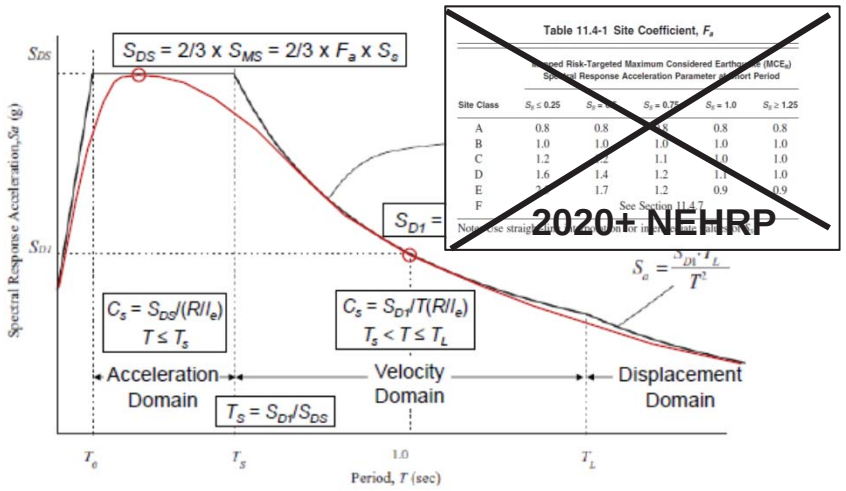
After 2018, next update will be in 2020 (2020 possible for ASCE7-22?)

Building Seismic Safety Council (BSSC) Provisions Update Committee (PUC) Meeting

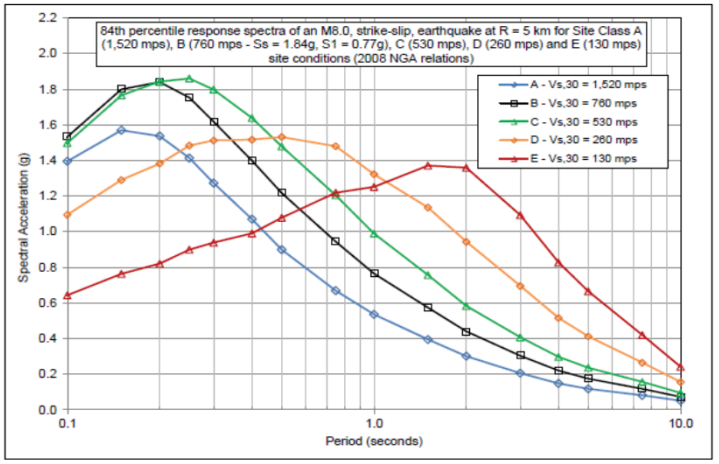
Multi-Period Response Spectrum

A Project ‘17 issue that will influence 2018+ USGS NSHMs

Current Design Spectrum (based on Ss & S1 for BC):



Multi-T Multi-Vs30 Spectrum:
(Fig from Charlie Kircher)



Future USGS Deliverables:

1. Provide more periods
2. Directly implement Vs30 into GMPEs

Multi-Period Response Spectrum

Provide hazard curves for 21 periods and 8 site classes:

Period T (s)	Site Class							
	A	B	BC	C	CD	D	DE	E
PGA			PGA					
0.010								
0.020								
0.030								
0.050								
0.075								
0.10								
0.15								
0.20			S_S					
0.25								
0.30								
0.40								
0.50								
0.75								
1.0			S_1					
1.5								
2.0								
3.0								
4.0								
5.0								
7.5								
10.0								

Challenges (Current GMPE Shortcomings for long T & soft soil):

1. **CEUS**:

   2014 GMPEs only applicable up to 2sec, and site classes A & BC (new NGA-East or Seed models)

2. **WUS & Subduction:**
   - Remove GMPEs not applicable for soft sites (Idriss14) & long periods (Atkinson&Boore03) and re-weight
   - Basin effects for long T and soft sites

Updates for 2018 NSHM

(Discussed in the March Workshop)

Ground Motion Characterization:

Central & Eastern U.S.:

1. NGA-East

- NGA-East GMPEs
- Other updated "seed" GMPEs

Western U.S. Crustal:

- Re-weighting GMPEs (no Idriss14)
- Basin effects for L.A., S.F., S.L.C., Seattle

Cascadia Subduction:

- Re-weighting GMPEs (no AB03)
- Basin effects for Seattle

2. Re-weighting & Basin Effects
(for multi-period multi-Vs30 spectrum)

Source / Fault Characterization:

California:

3. Seismicity Catalog

- Minor (no UCERF4)

Intermountain West:

- Working Group on Utah Earthquake Probabilities, 2016

Pacific Northwest:

- None/minor

Central & Eastern U.S.:

- Catalog of past earthquakes
- Induced seismicity exclusions

1. NGA-East

Hard Rock Sites, Site Class A (Vs30=3000m/s):

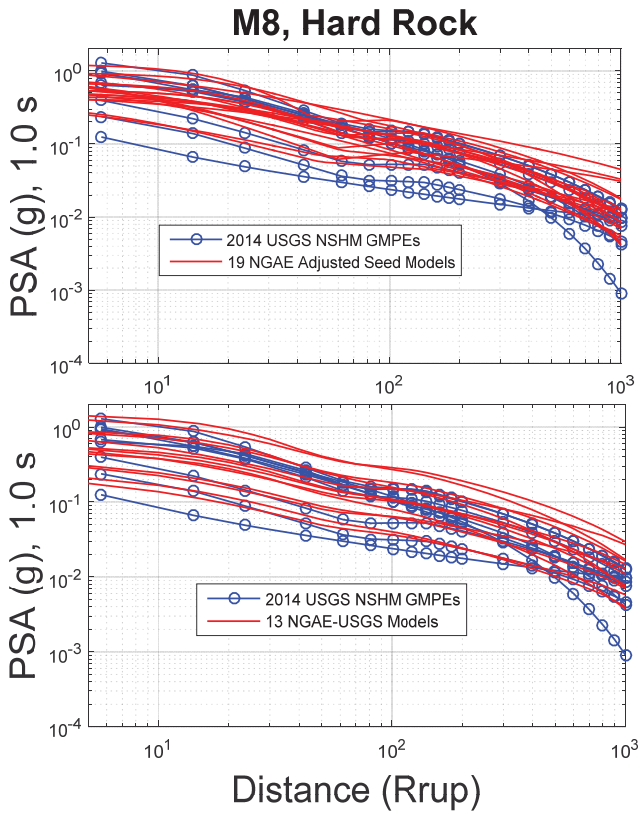
- ❑ 2014 NSHMs: 9 GMPEs

- ❑ 2018 NSHMs:

  A. 19+2 Updated "Seed" GMPEs
  - 19 physical GMPEs (update to the previous 9) used as seed models to develop NGA-East, 2 additional models published later
  - No weights or standard deviations

  B. 13 NGA-East (2017v) GMPEs
  - 13 independent models from Sammon's mapping
  - Assigned weights & standard deviations

  C. A combination of A & B
  - 50% A + 50% B (presented at workshop)
  - 1/3 A + 2/3 B (currently being explored)
  - …

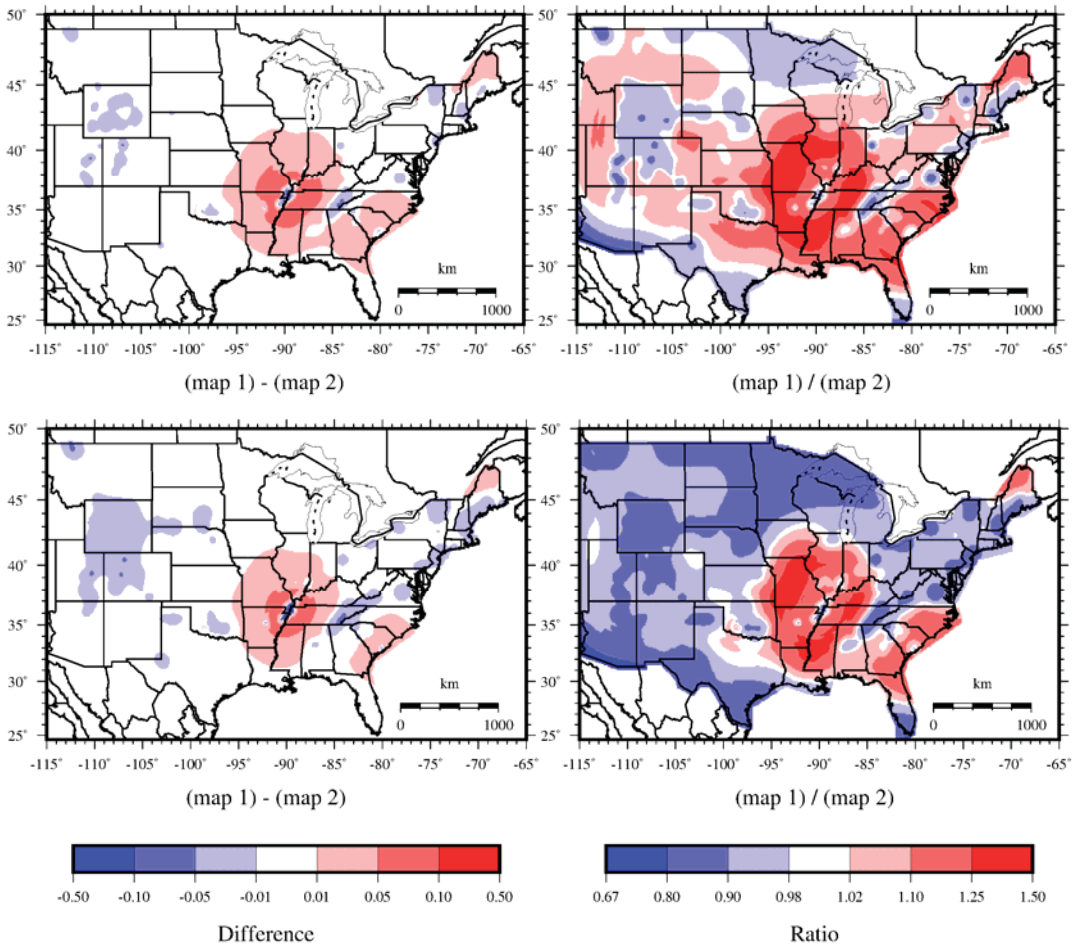


1. NGA-East

0.2 Sec, 2% PE in 50 years, uniform site class A

map 1: Option A (Seeds, LT #2)
map 2: 2014 NSHM

map 1: Option B (NGA-East, 2017v)
map 2: 2014 NSHM

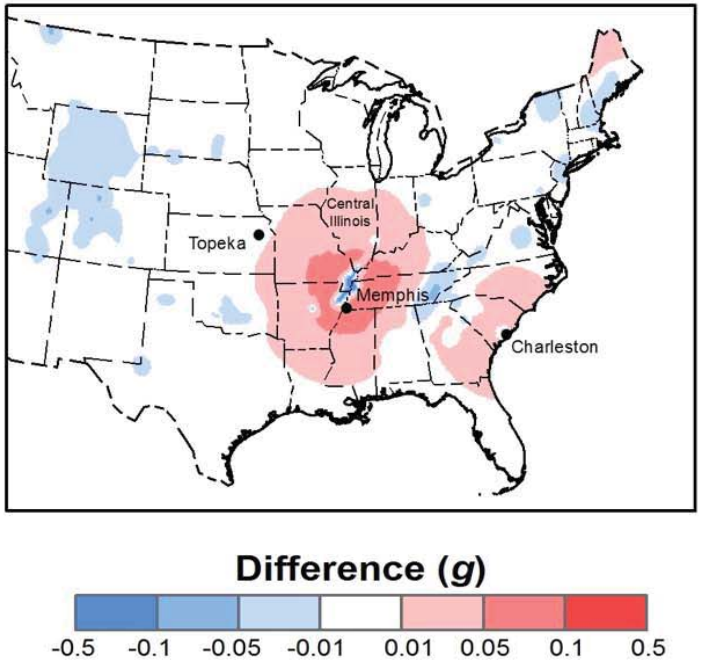


1. NGA-East

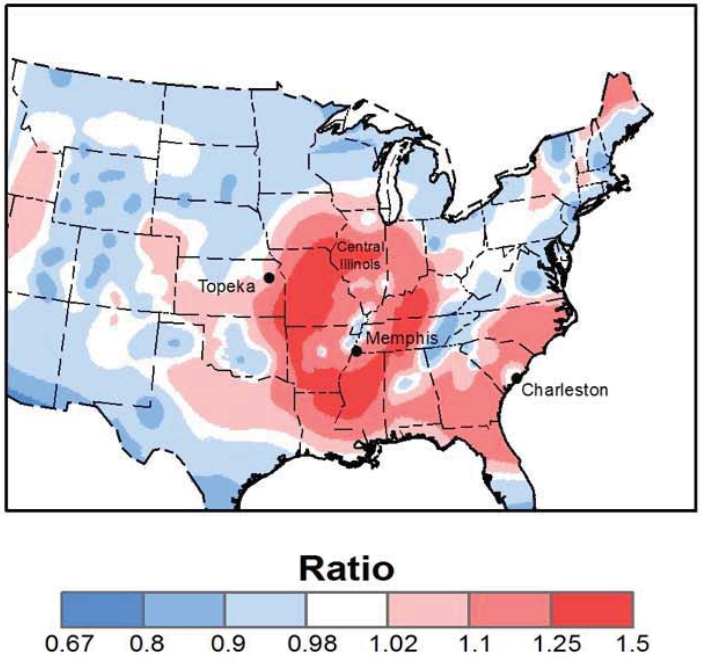
0.2 Sec, 2% PE in 50 years, uniform site class A

Option C: 50%A+50%B
(as proposed at the workshop)

Option C – (2014 NSHM)



Option C / (2014 NSHM)

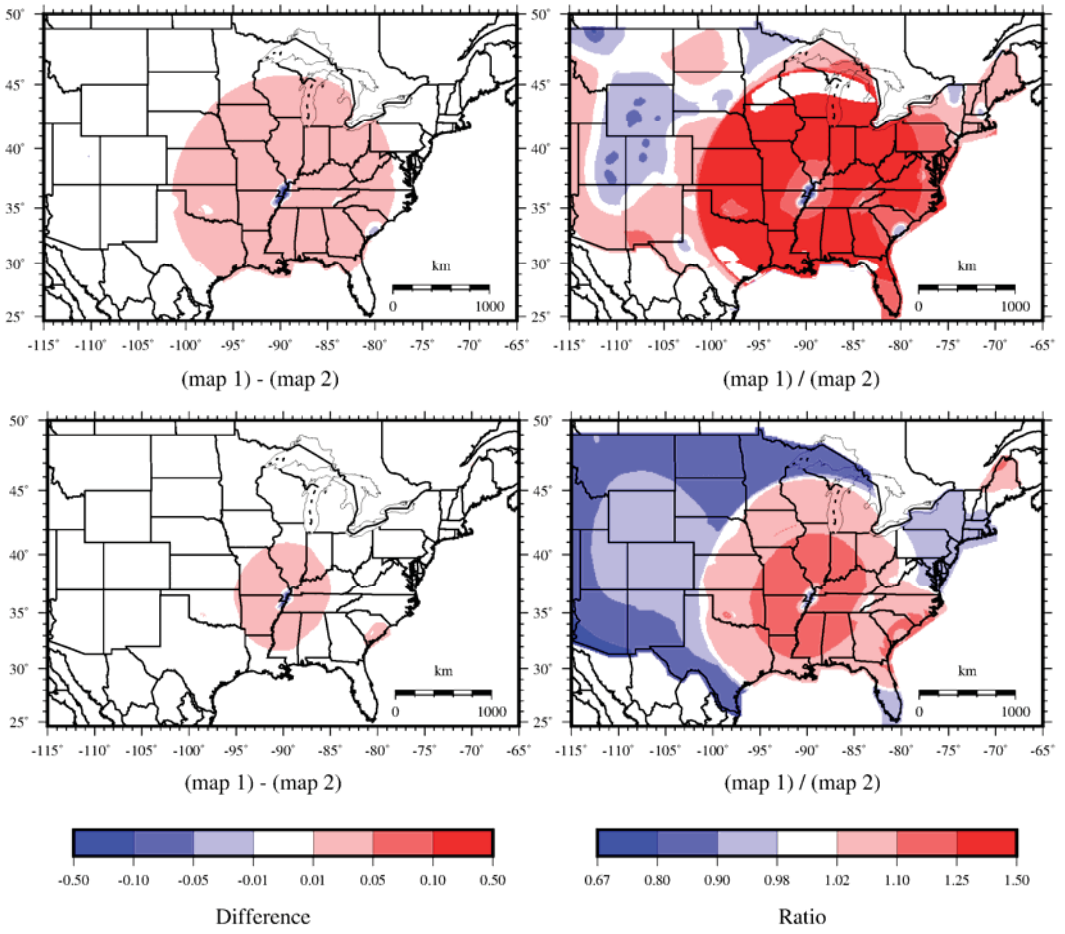


1. NGA-East

1 Sec, 2% PE in 50 years, uniform site class A

map 1: Option A (Seeds, LT #2)
map 2: 2014 NSHM

map 1: Option B (NGA-East, 2017v)
map 2: 2014 NSHM



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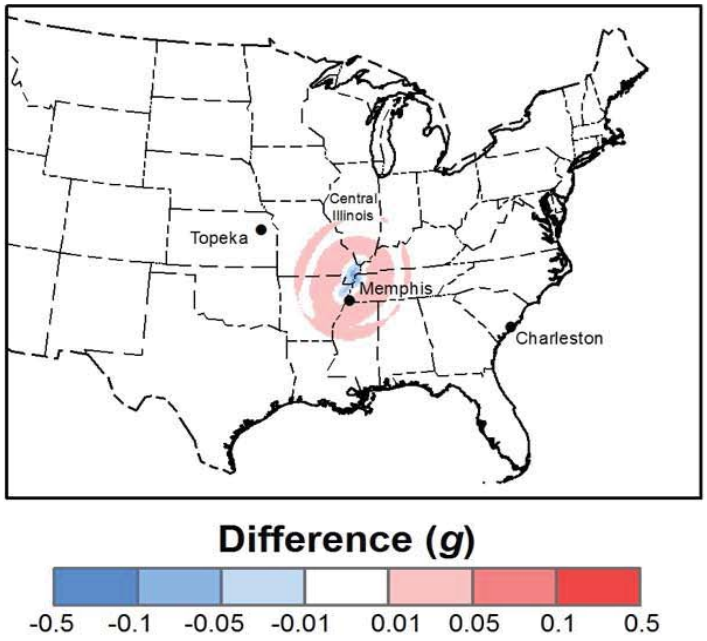
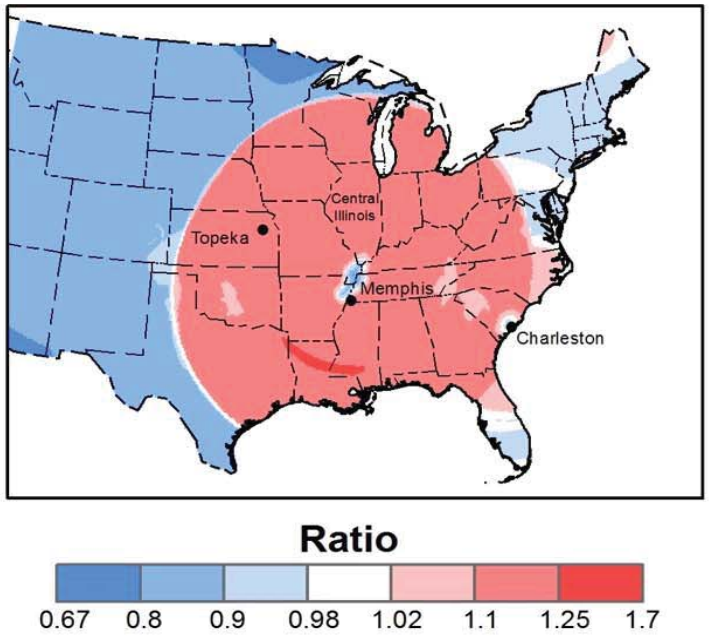
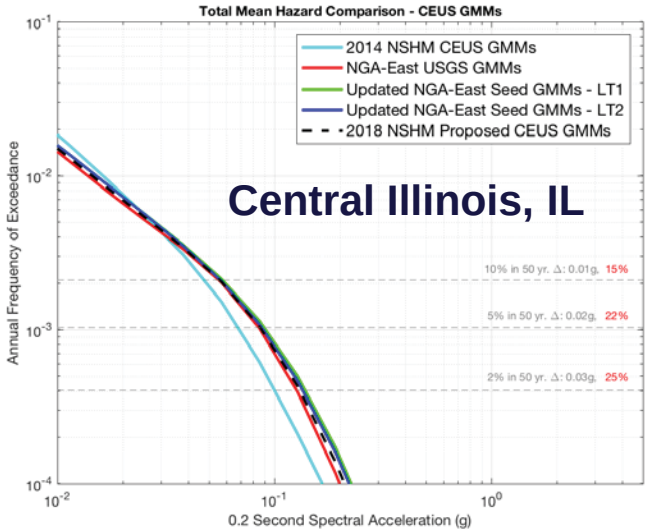


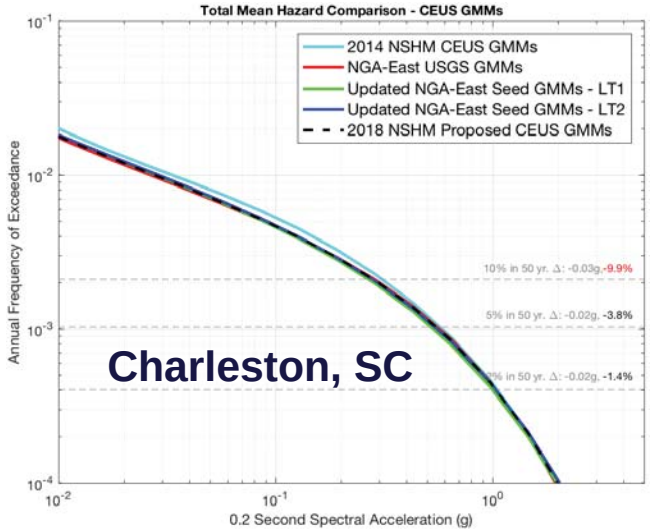
Option C / (2014 NSHM)

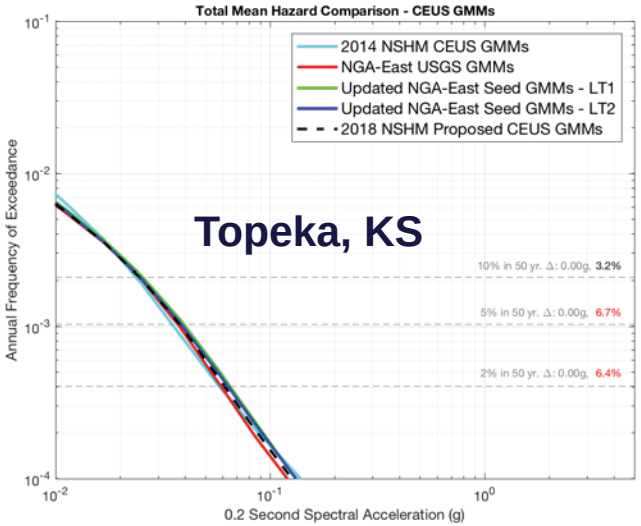


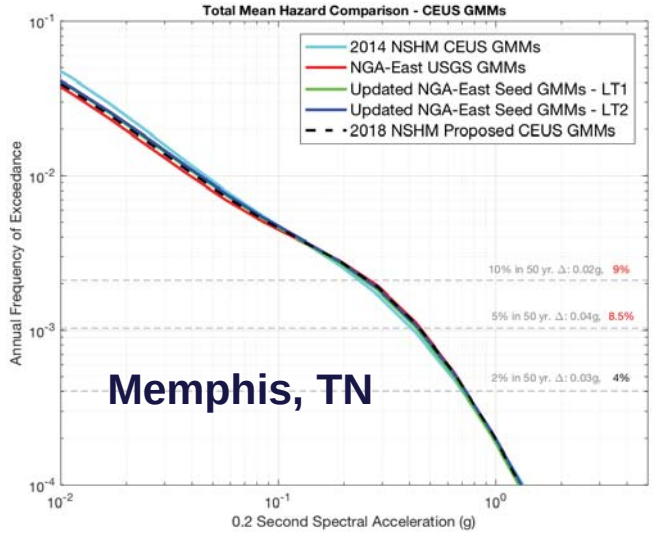
1. NGA-East

0.2s Hazard Curves:



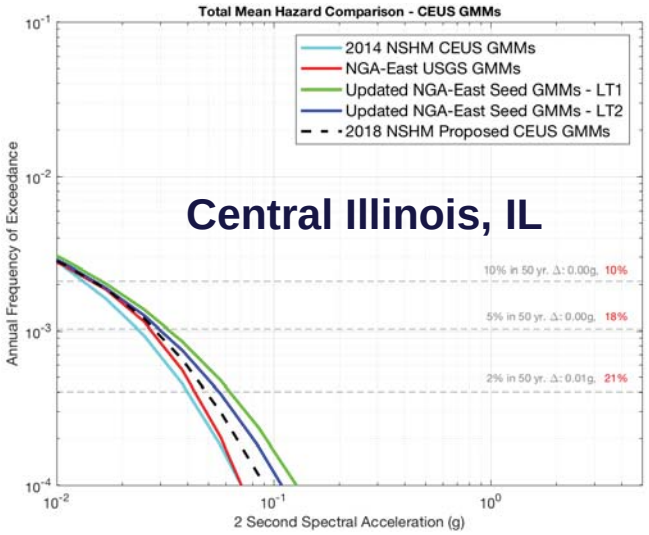


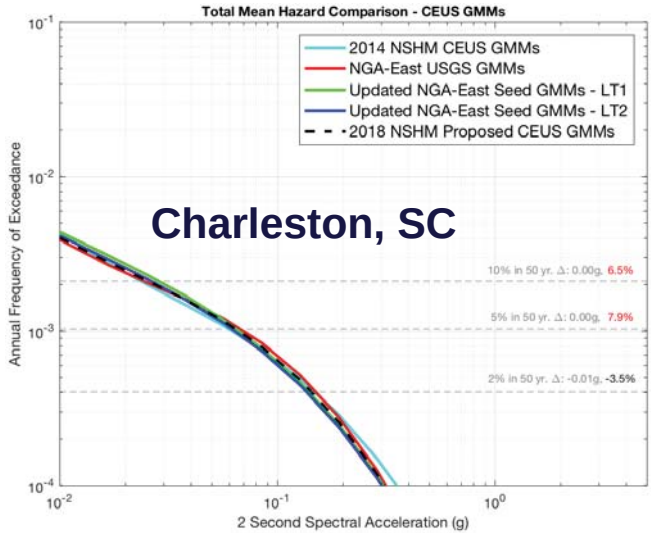


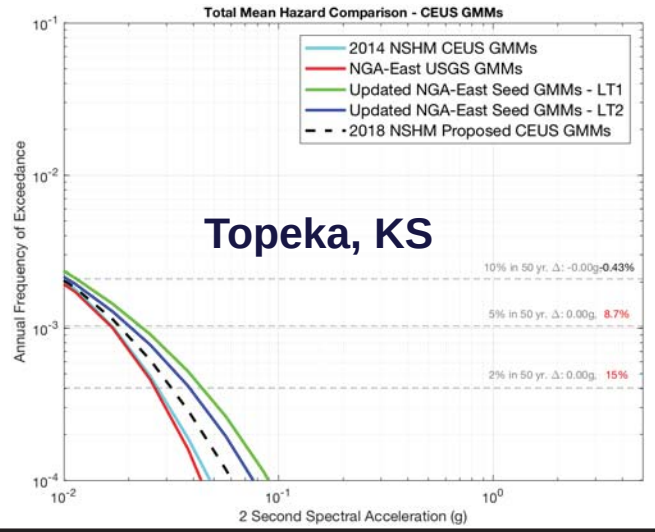


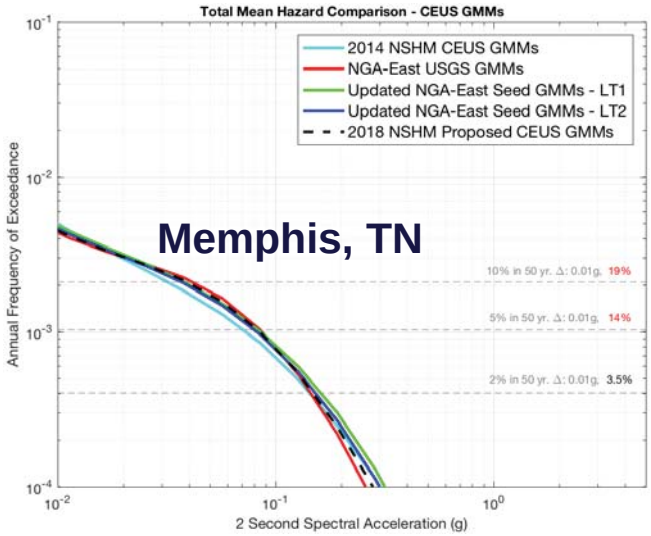
1. NGA-East

2s Hazard Curves:









1. NGA-East

Site classes other than A:

- Stewart et al. site amplification model (linear & nonlinear) for CEUS

PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER

Expert Panel Recommendations for Ergodic Site Amplification in Central and Eastern North America

Principal Investigator and Panel Chair:
Jonathan P. Stewart
University of California, Los Angeles

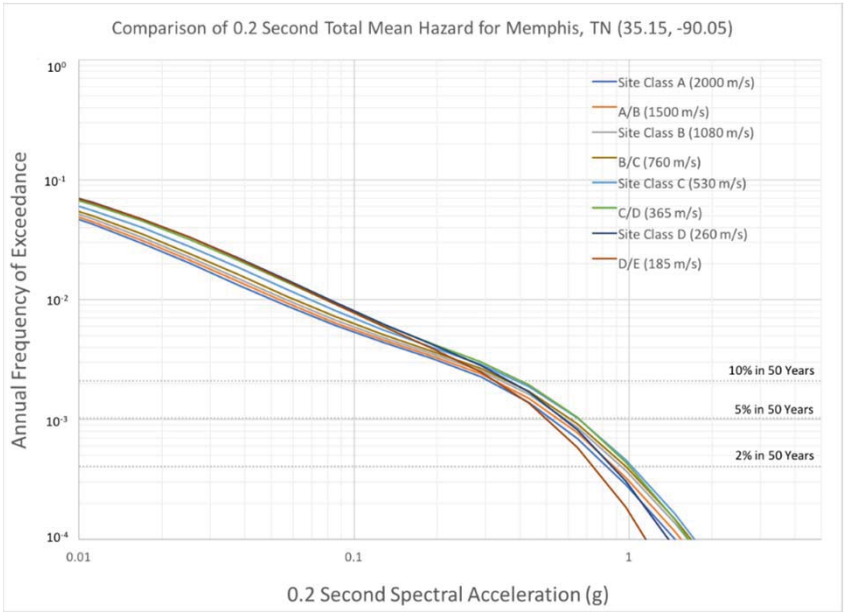
Graduate Students:
Grace A. Parker
University of California, Los Angeles
Joseph A. Harmon
University of Illinois at Urbana-Champaign

Authoring Panel Members:
Gail M. Atkinson
Western University
David M. Boore
U.S. Geological Survey
Robert B. Darragh and Walter J. Silva
Pacific Engineering and Analysis
Youssef M.A. Hashash
University of Illinois at Urbana-Champaign

PEER Report No. 2017/04
Pacific Earthquake Engineering Research Center
Headquarters at the University of California, Berkeley

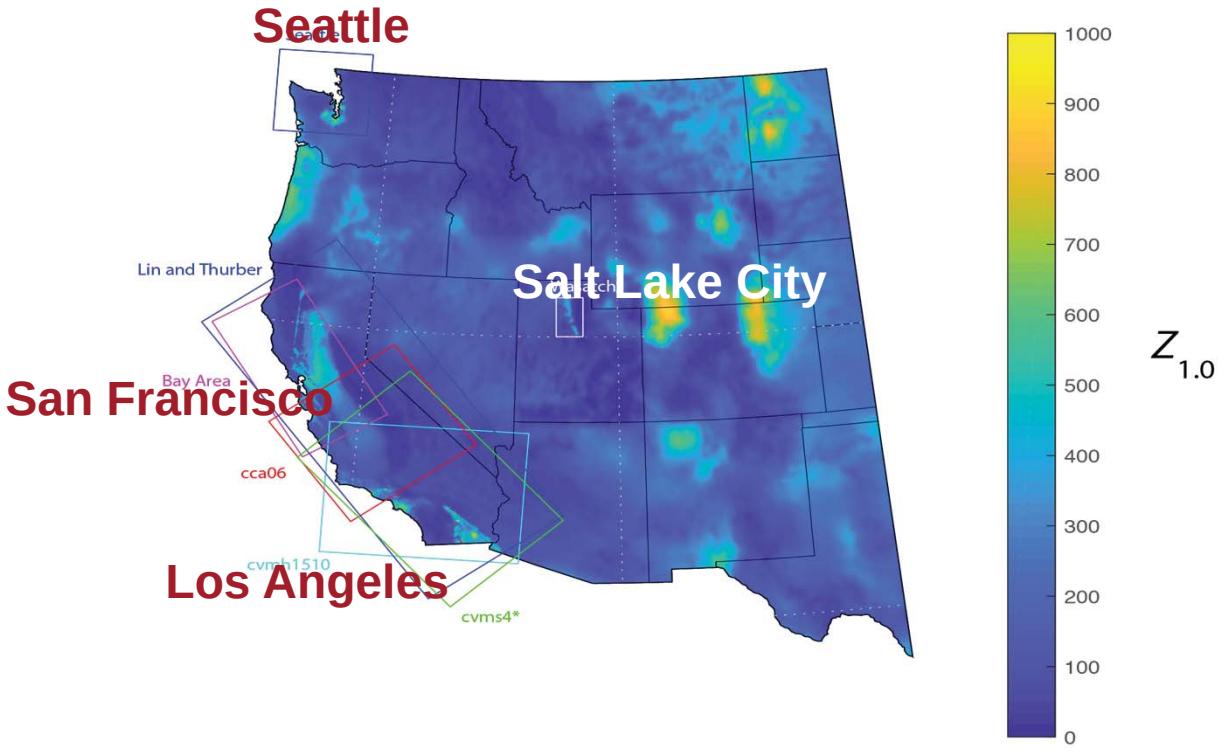
March 2017

PEER 2017/04
March 2017



2. Basin Effects

Basin Effects: Characterized by Z1 & Z2.5 in NGA-West2 GMPEs
Not characterized in subduction GMPEs (use CB Z2.5 term)
Long T & soft soils: sensitive to the values of Zx



Four Regions w/ local models where we have better estimates of Zx (3D basin models)

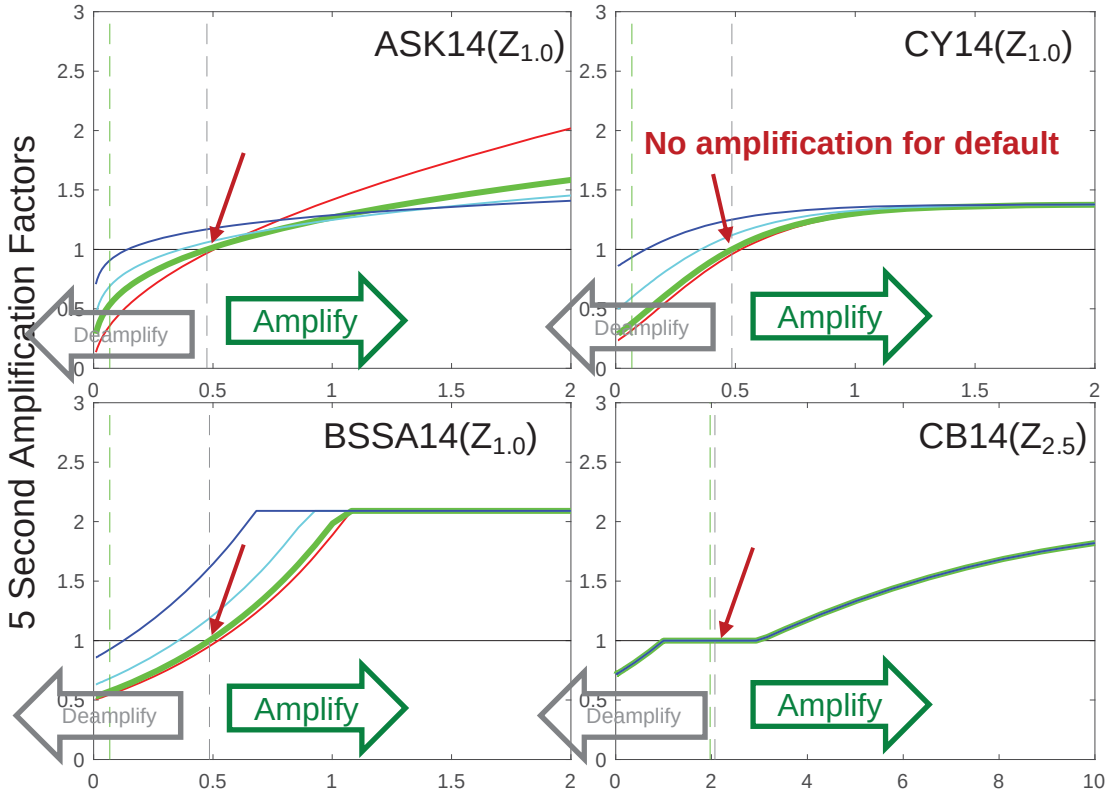
2. Basin Effects

In the absence of a local model for Zx, default basin depth is used in GMPEs Zx = f(Vs30)

Basin Depths

Default for site class D
V_{s30} =260 m/s
$Z_{1.0}$ (ASK14) = 0.475 km
$Z_{1.0}$ (BSSA14) = 0.486 km
$Z_{1.0}$ (CY14) = 0.485 km
$Z_{2.5}$ (CB15) = 2.07 km

Local (cvm S4.26m01)
V_{s30} = 353 m/s
$Z_{1.0}$ = 0.068 km
$Z_{2.5}$ = 1.97 km



Vs30
100 m/s
260 m/s
400 m/s
600 m/s

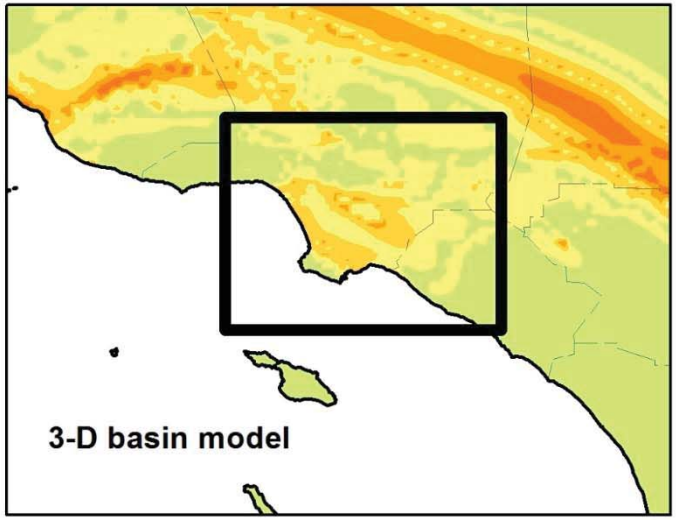
Basin Depth
Default
Local

2. Basin Effects

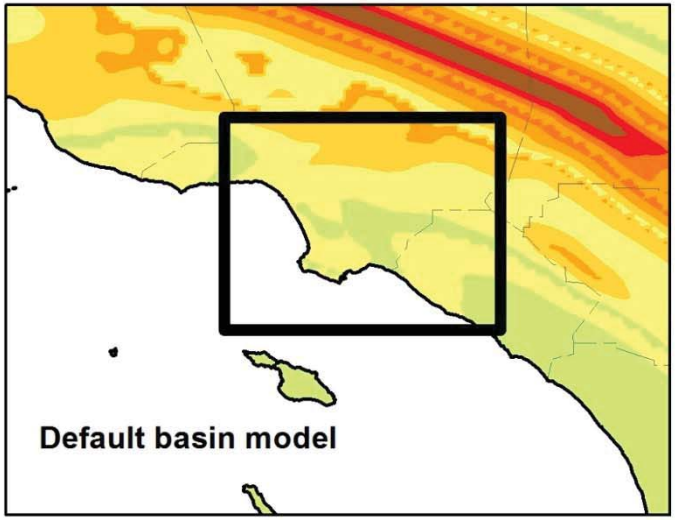
5 Sec, 2% PE in 50 years, Variable Vs30 (WA map)

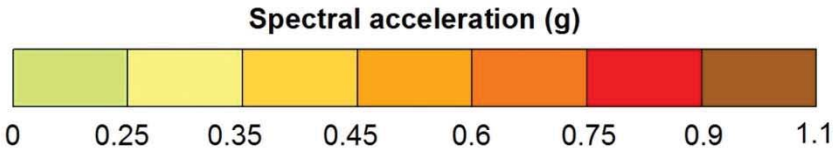
,

Local Basin Model:



Default Basin Model:



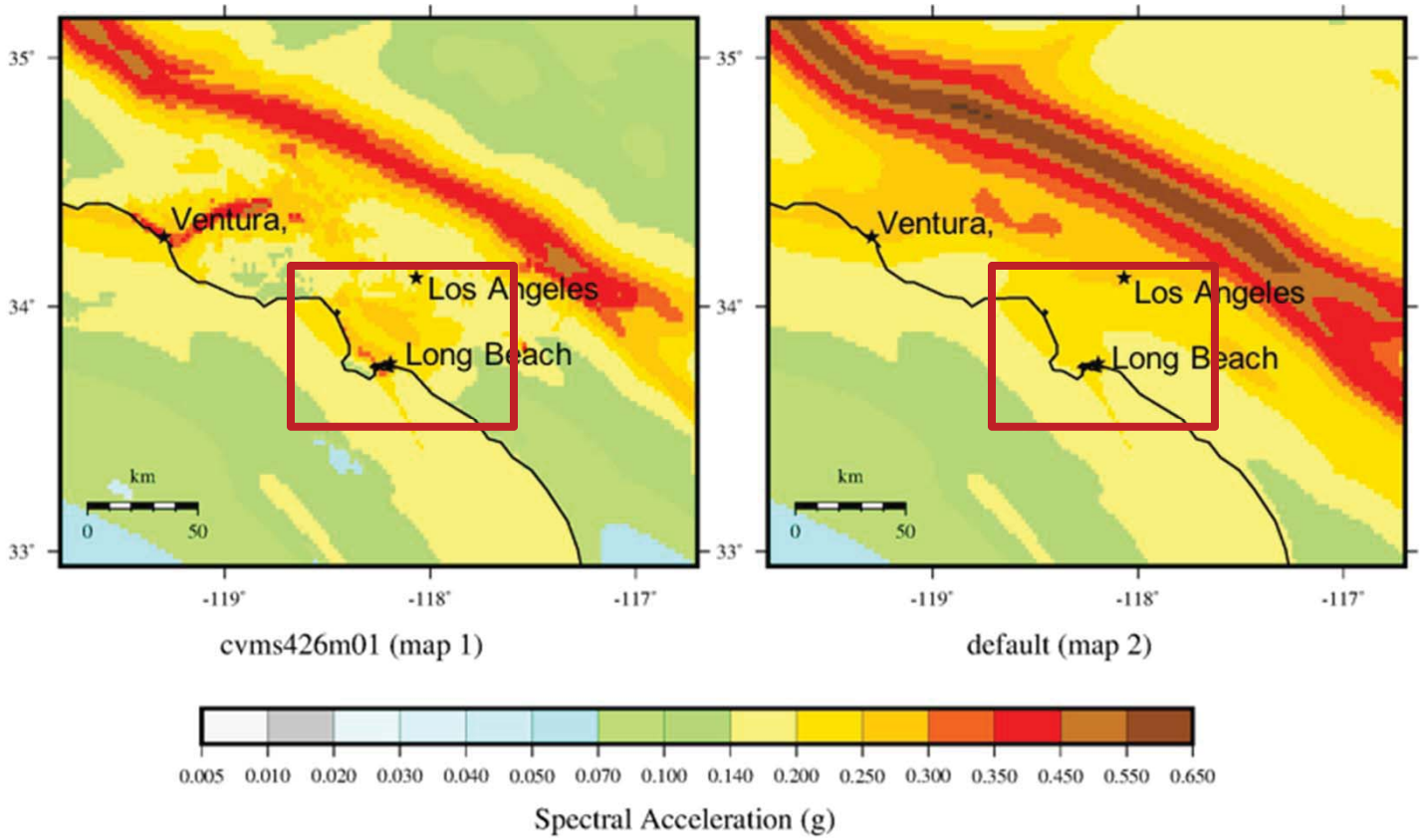


2. Basin Effects

5 Sec, 2% PE in 50 years, Site Class D

Local Basin Model:

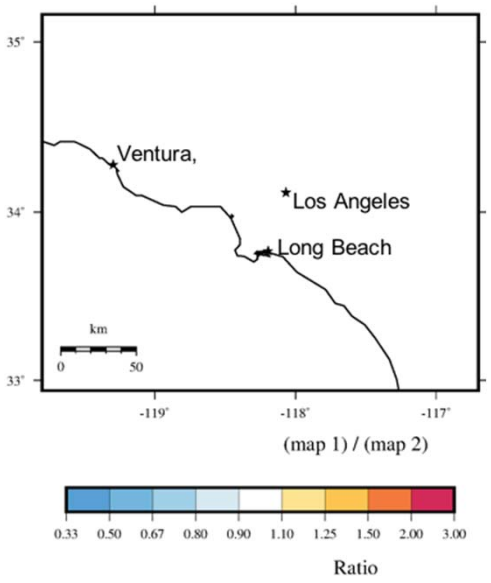
Default Basin Model:



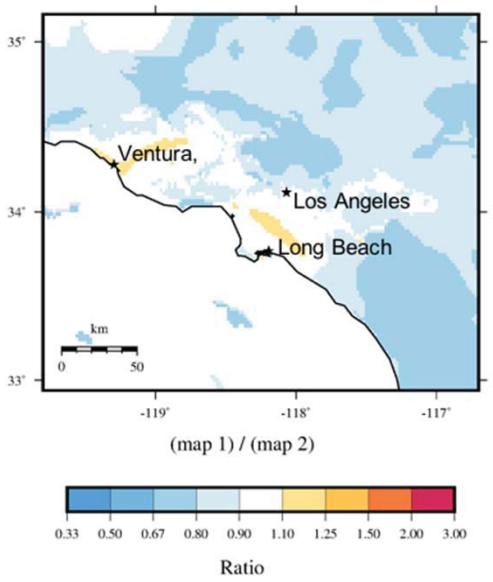
2. Basin Effects

Site Class D
2% probability of exceedance in 50 years,

Local/Default
0.2 sec



Local/Default
1 sec



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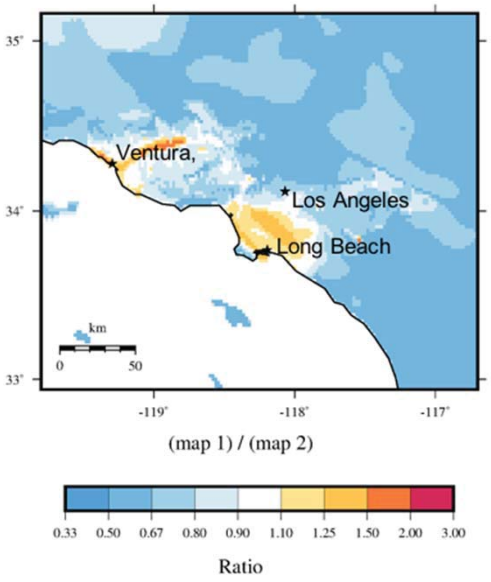
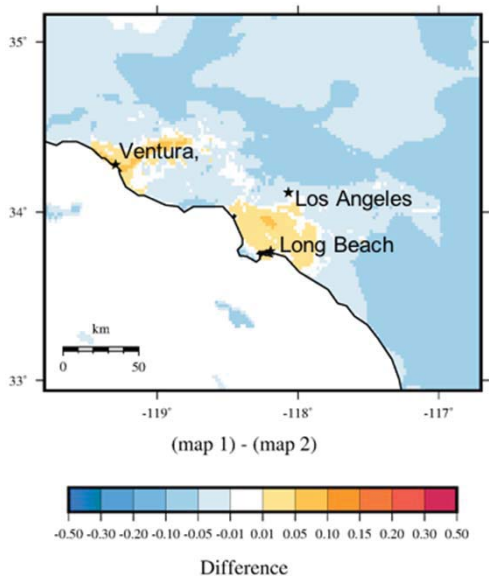


Differences much more significant at longer periods

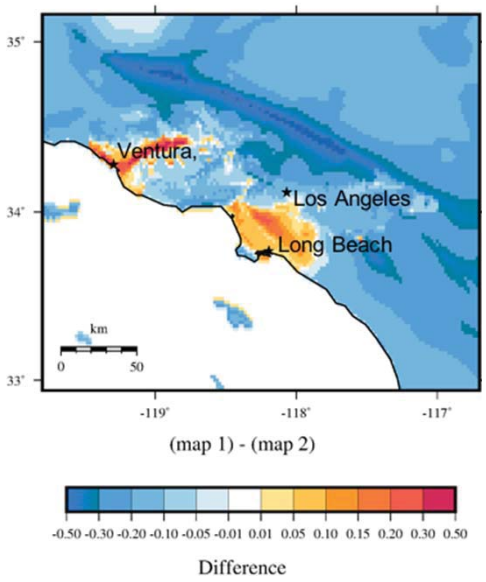
2. Basin Effects

Site Class D
2% probability of exceedance in 50 years,

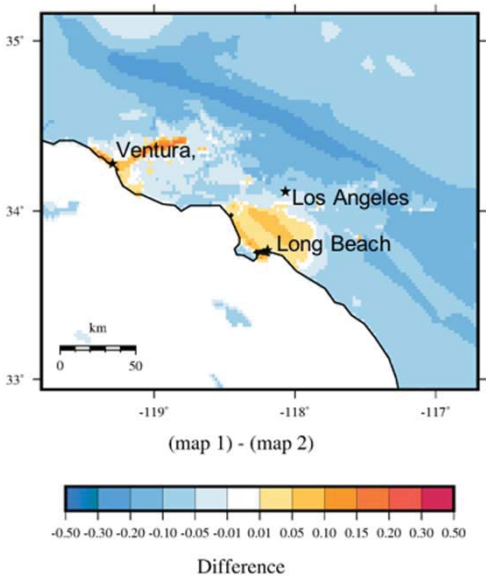
Local-Default
0.2 sec



Local-Default
1 sec



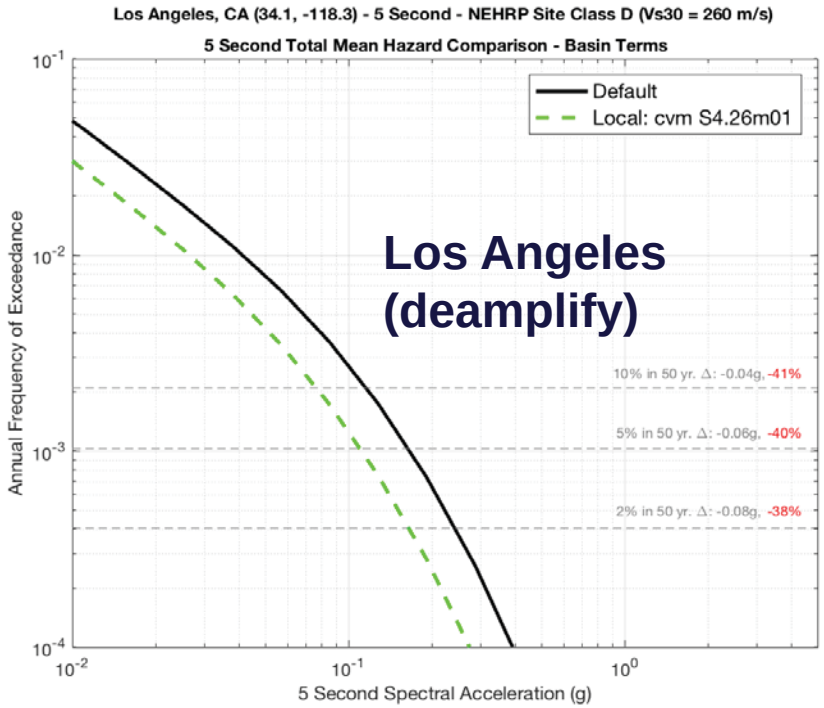
Local-Default
5 sec

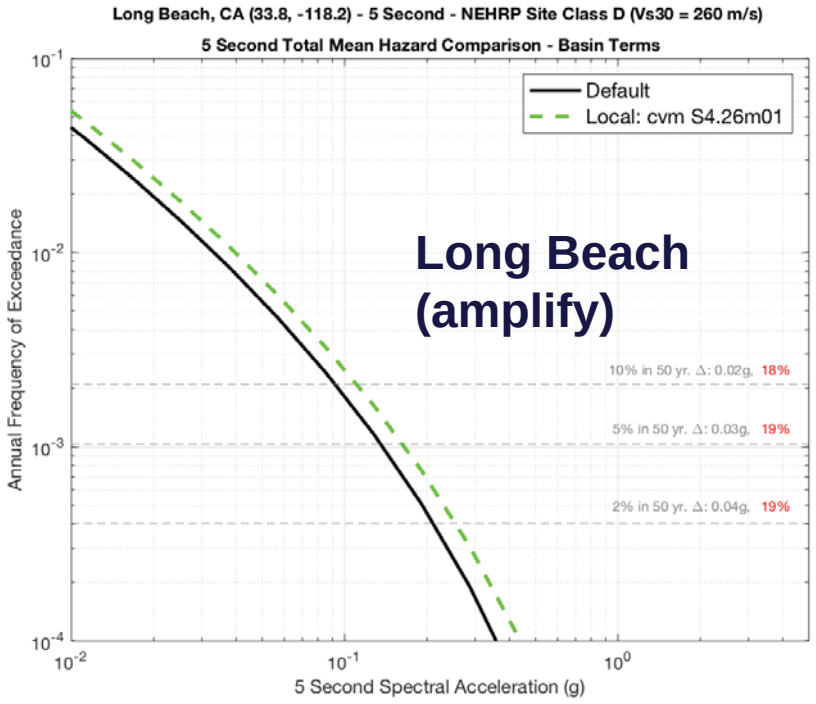


Differences much more significant at longer periods

2. Basin Effects

5 Second, Site Class D
Hazard Curves
Los Angeles Basin

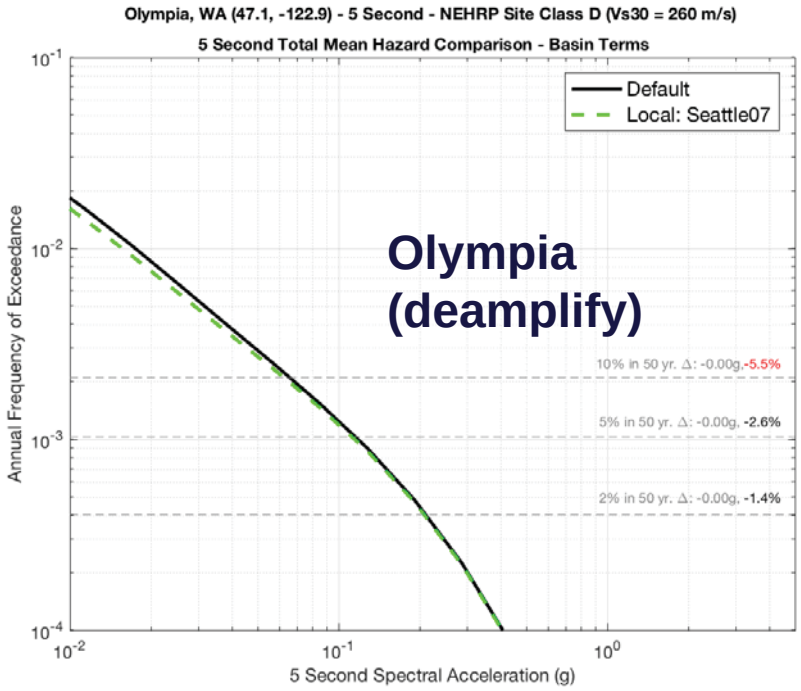


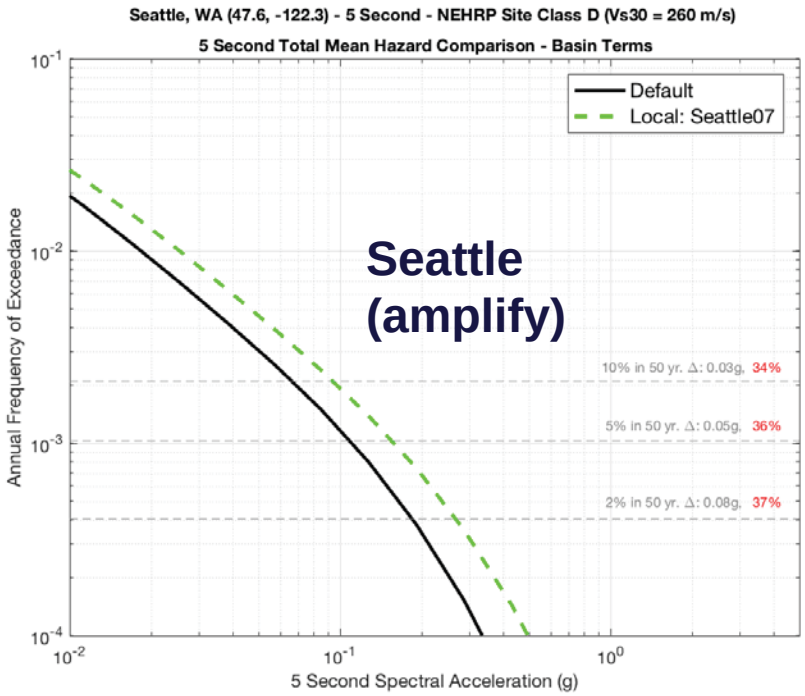


Basin edges usually are shallower (deamplification, left fig),
but they also have more uncertainty on Zx values

2. Basin Effects

5 Second, Site Class D
Hazard Curves
Seattle Basin

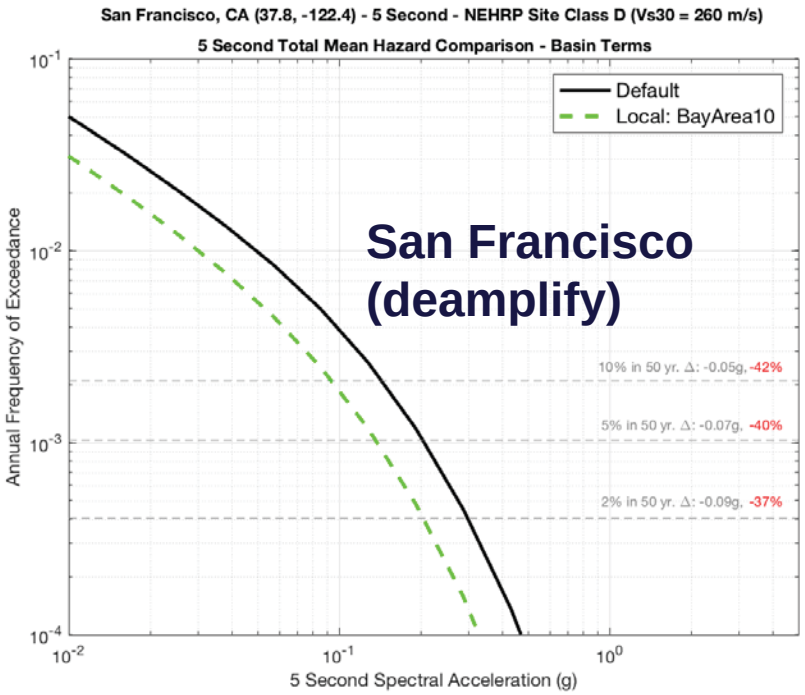


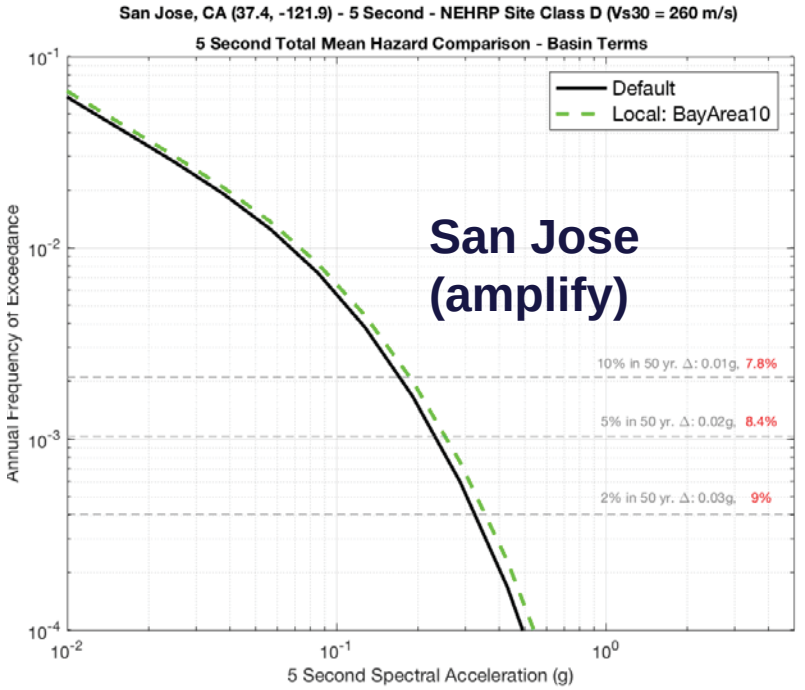


Basin edges usually are shallower (deamplification, left fig),
but they also have more uncertainty on Zx values

2. Basin Effects

5 Second, Site Class D
Hazard Curves
San Francisco, Bay Area





Basin edges usually are shallower (deamplification, left fig),
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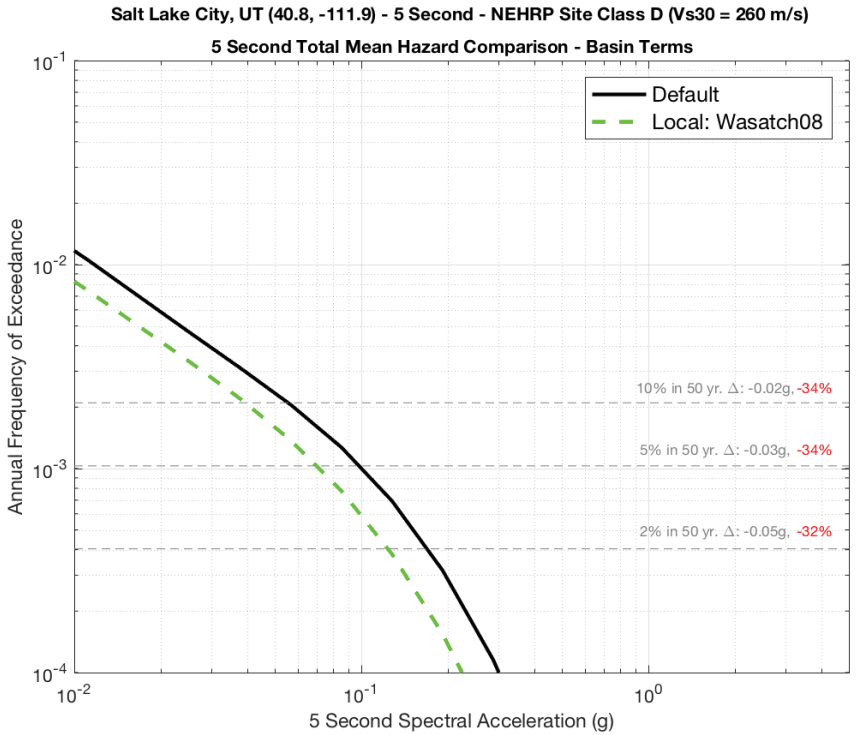
2. Basin Effects

5 Second, Site Class D
Hazard Curves
Salt Lake City



2. Basin Effects

Two options being considered after workshop:

Option A:

Use local models inside the four basins (use Vs30-based default model outside the basin)

- Issues with smoothing at the basin edges
- Deamplifications may happen

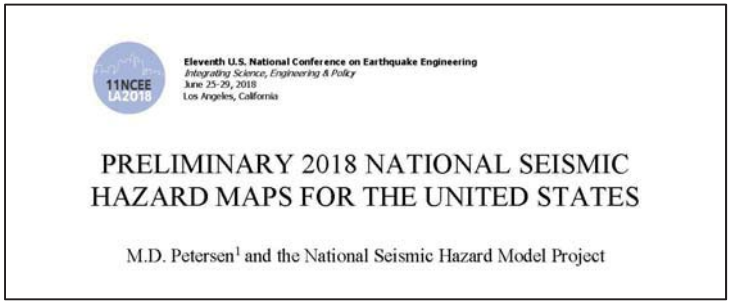
Option B:

Use local models only for the deepest portion of the basin (Z2.5>3km), where amplification happens and we have more confidence in the estimates.

- Smoothing at the basin edge not a problem
- Such amplifications have been supported by simulations

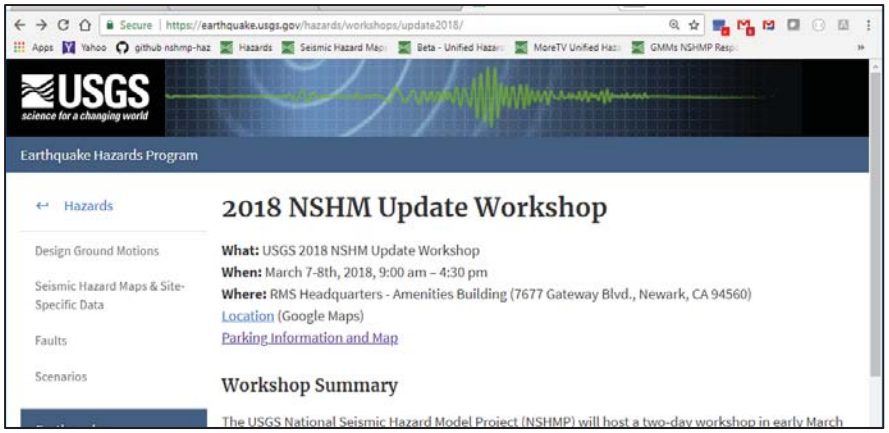
Resources

- 11NCEE Conference Paper:



June 25-29,
Mini-Workshop on Needs of Users of the USGS National Seismic Hazard Model

- March 7-8 Workshop Presentations:



Will be available soon

Summary of USGS NSHM Updates

- Draft of 2018 USGS National Seismic Hazard Model (NSHM) was presented at the March 7-8 Workshop
- Output will include additional spectral periods (longer) and site classes (softer)
- Three main updates:
  (1) NGA-East, (2) basin effects, (3) seismicity catalog
- Updated NSHM will be developed and ready for public comments by July 2018