

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

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

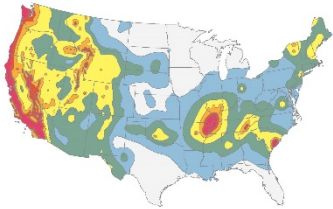
**Sanaz Rezaeian & Nicolas Luco**  
Research Structural Engineers  
U.S. Geological Survey, Golden, CO





**Documentation for the 2014 Update of the  
United States National Seismic Hazard Maps**

Maria D. Petersen, Morgan P. Moschetti, Peter M. Petersen, Charles S. Mueller, Kathleen M. Hailer,  
Arthur D. Frankel, Yueshan Zeng, Susan Krawiec, Stephen C. Hansen, Oliver S. Boyd, Paul Fehd,  
Rui Upton, Kenneth S. Rukstales, Nico Leno, Russell L. Whitaker, Robert A. Williams and  
Anna H. Olsen



Open-File Report 2014-1061

U.S. Department of the Interior  
U.S. Geological Survey

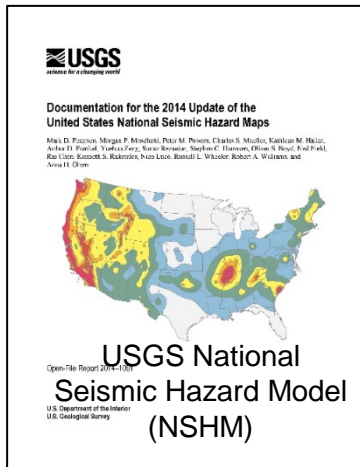


*EERI Seminar on Next Generation Attenuation Models*

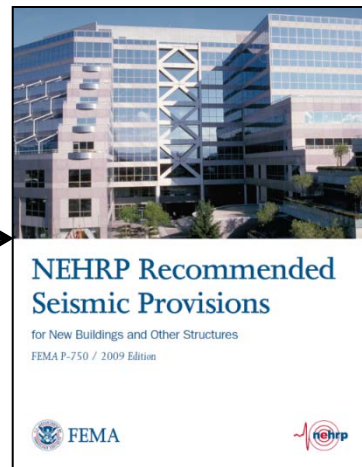
# Past USGS NSHM Updates

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

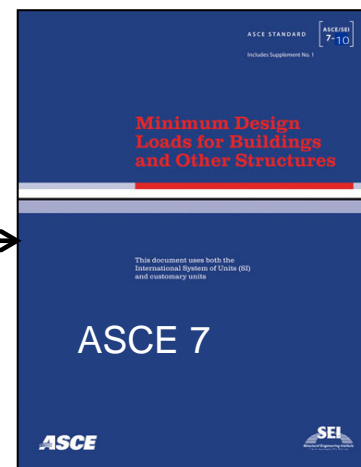
2018



2020



2022



2024

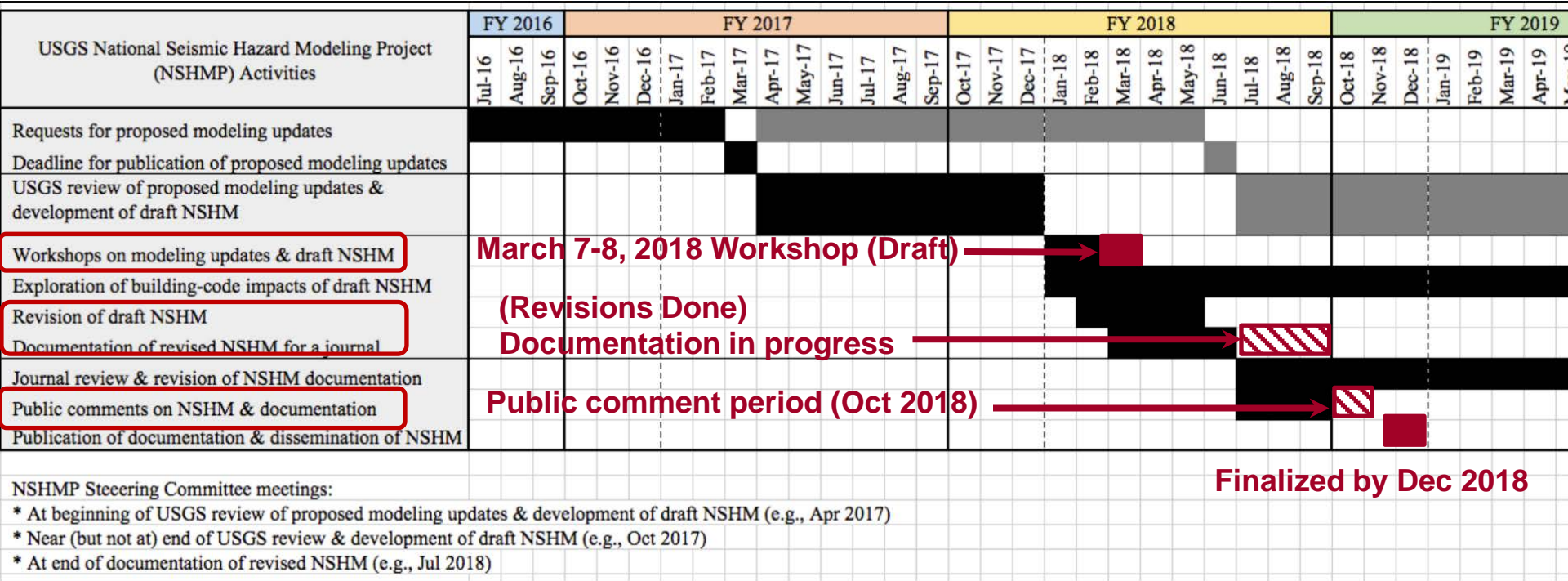


2017 Structural Engineers Association of California (SEAOC) Convention – Building Seismic Safety Council (BSSC) Session

“Progress on the 2018 USGS National Seismic Hazard Model” Rezaeian & Luco (USGS), August 14-15, 2018

# Schedule of Upcoming NSHM Updates

## 2018 Schedule in Black



After 2018, next update will be in 2020

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

# Updates for 2018 NSHM

Discussed in the March Workshop  
Revisions made March-August based on comments.

## 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** (necessary for Multi-Period Response Spectrum)

## Source / Fault Characterization:

### California: **3. Seismicity Catalog**

- Minor (no UCERF4)

### Intermountain West:

- Working Group on Utah Earthquake Probabilities, 2016

### Pacific Northwest:

- None/minor

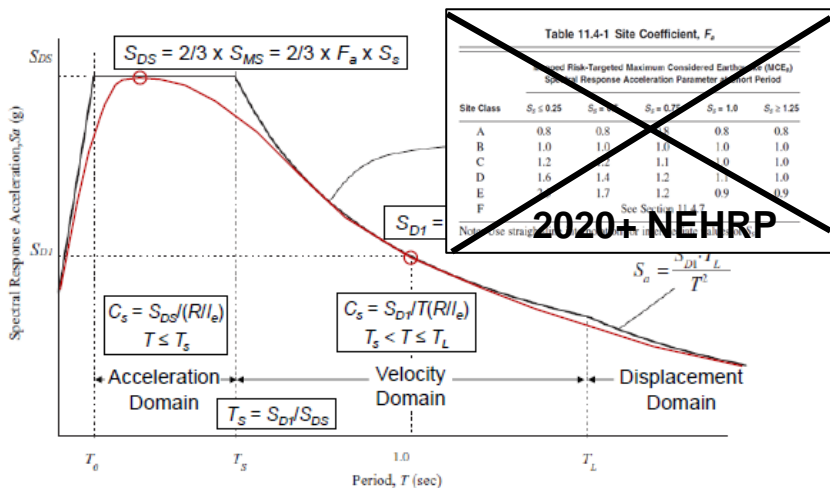
### Central & Eastern U.S.:

- Catalog of past earthquakes
- Induced seismicity exclusions

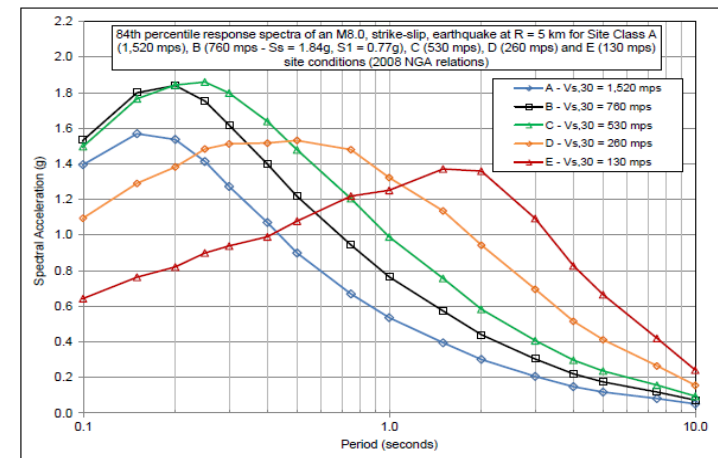
# Multi-Period Response Spectrum

A Project '17 issue that influences 2018+ USGS NSHMs

## Current Design Spectrum (based on $S_s$ & $S_1$ for BC):

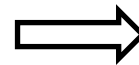


## Multi-Period Response Spectrum: (Fig from Charlie Kircher)



## Future USGS Deliverables:

1. Provide more periods
2. Directly implement  $V_{s30}$  into GMPEs



GMPEs must be applicable for all periods &  $V_{s30}$ 's of interest\*.  
(\* Spectral shape factors for other regions)

# Multi-Period Response Spectrum

Provide hazard curves for 22 periods and 8 site classes:

Period T (s)	Site Class							
	A (AB)	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								

## 2014 GMPE Shortcomings for long T and soft soil:

### 1. CEUS:

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

### 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

# 1. NGA-East

**Hard Rock Sites, Site Class A ( $V_{s30}=3000\text{m/s}$ ):**

□ 2014 NSHMs: 9 GMPEs

□ 2018 NSHMs:

**A. 14 Updated “Seed” GMPEs**

- 12 GMPEs (updates to the previous 9)  
used in NGA-East, 2 new models
- No weights or standard deviations

**B. 17 NGA-East for USGS GMPEs**

- (2017 version with 2018 Addendum)
- 17 models from Sammon's mapping
  - Assigned weights & standard deviations

**USGS CEUS Model:**

**1/3 (Seeds) + 2/3 (NGA-E)**

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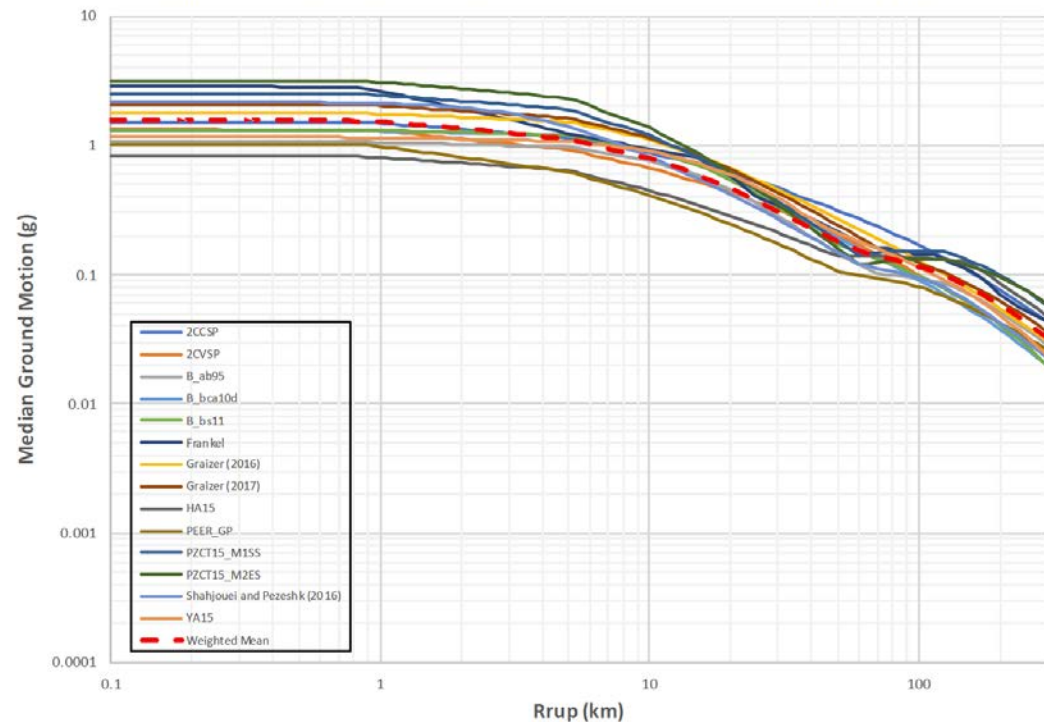
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**USGS CEUS Model:**

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0.2 Second Comparison of Updated NGA-East Seed Median Ground Motions:  $M = 7$ ,  $V_{s30} = 3,000 \text{ m/s}$



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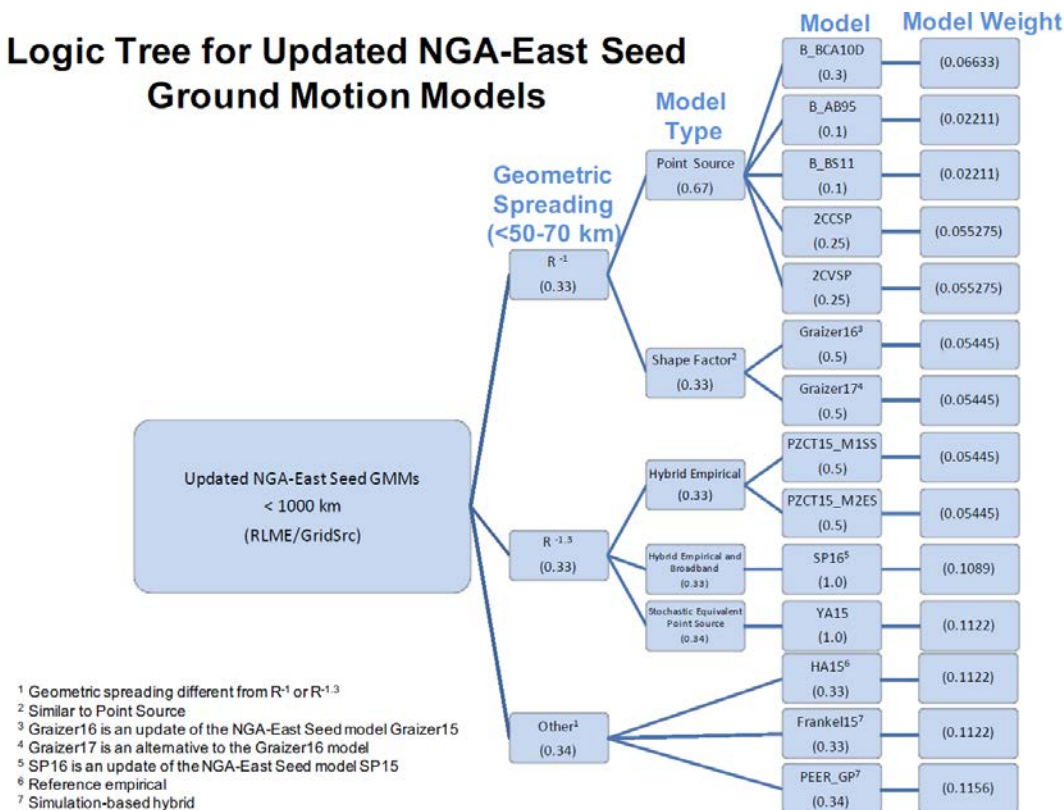
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**USGS CEUS Model:**

**1/3 (Seeds) + 2/3 (NGA-E)**

Weights based on geometric spreading & model type:

## Logic Tree for Updated NGA-East Seed Ground Motion Models



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

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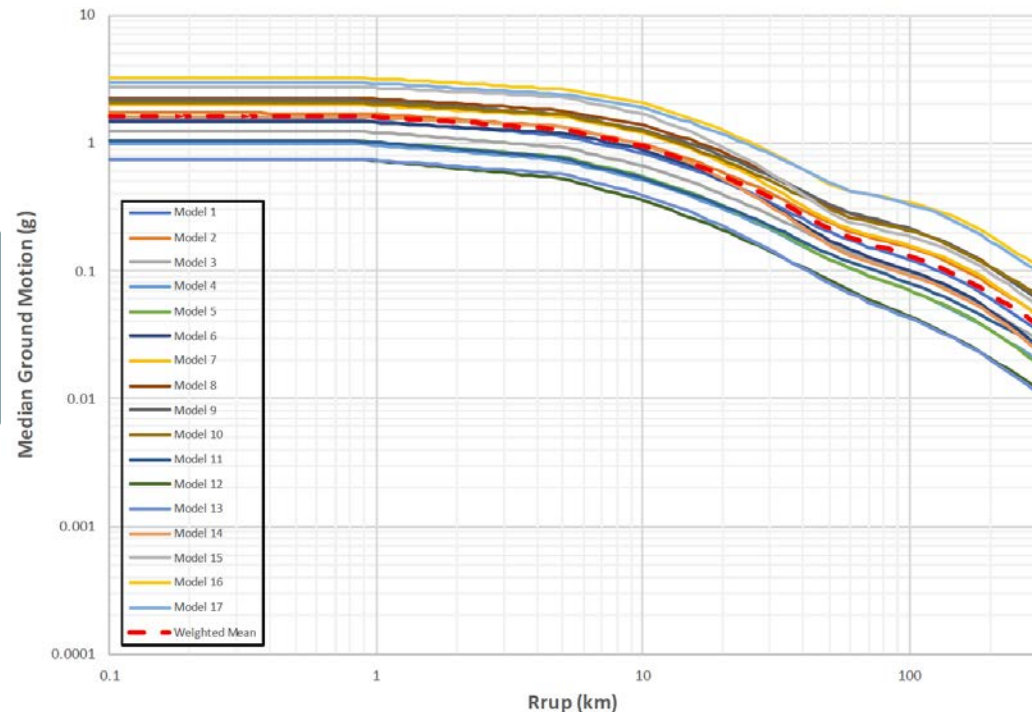
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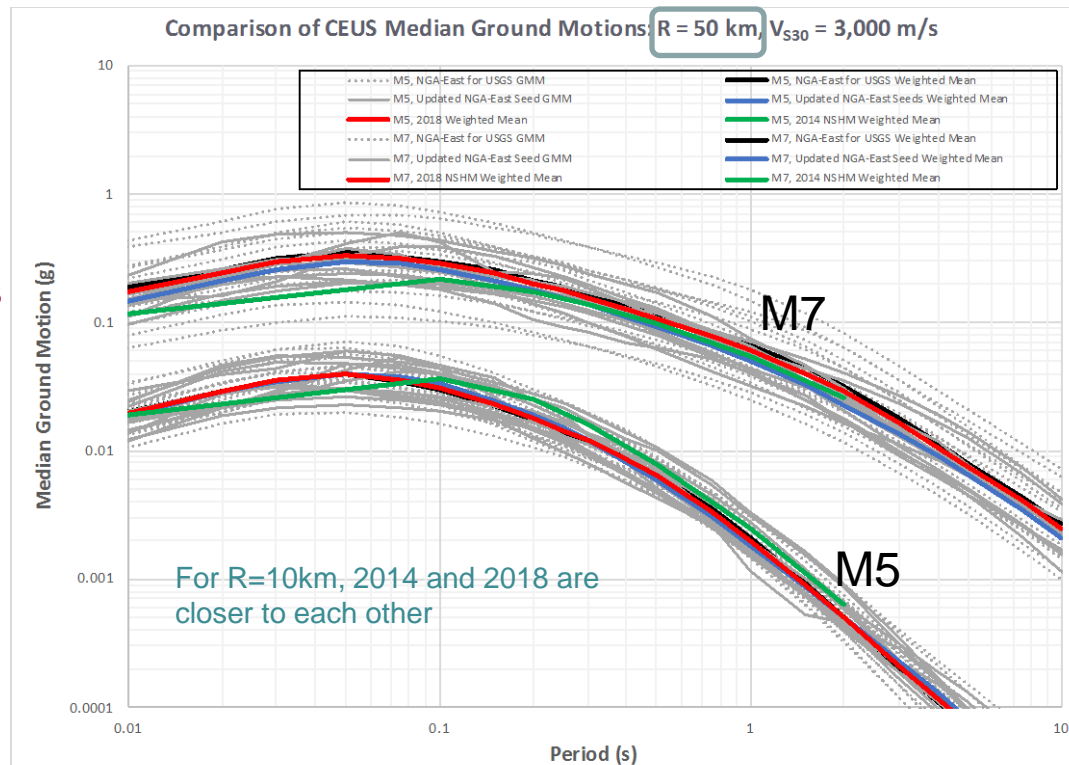
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USGS CEUS Model:  
1/3 (Seeds) + 2/3 (NGA-E)




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

# 1. NGA-East Site Amplification

Site Amplifications (transforming Site Class A to other Site Classes):

$$F_{\text{total}} = F_{760} + F_{\text{linear}} + F_{\text{nonlinear}}$$

	<b>PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER</b>
<b>PEER 2017/04 March 2017</b>	<p><b>Expert Panel Recommendations for Ergodic Site Amplification in Central and Eastern North America</b></p> <p><b>Principal Investigator and Panel Chair:</b> <b>Jonathan P. Stewart</b> University of California, Los Angeles</p> <p><b>Graduate Students:</b> <b>Grace A. Parker</b> University of California, Los Angeles <b>Joseph A. Harmon</b> University of Illinois at Urbana-Champaign</p> <p><b>Authoring Panel Members:</b> <b>Gail M. Atkinson</b> Western University <b>David M. Boore</b> U.S. Geological Survey <b>Robert B. Darragh and Walter J. Silva</b> Pacific Engineering and Analysis <b>Youssef M.A. Hashash</b> University of Illinois at Urbana-Champaign</p> <p>PEER Report No. 2017/04 Pacific Earthquake Engineering Research Center Headquarters at the University of California, Berkeley</p> <p>March 2017</p>

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

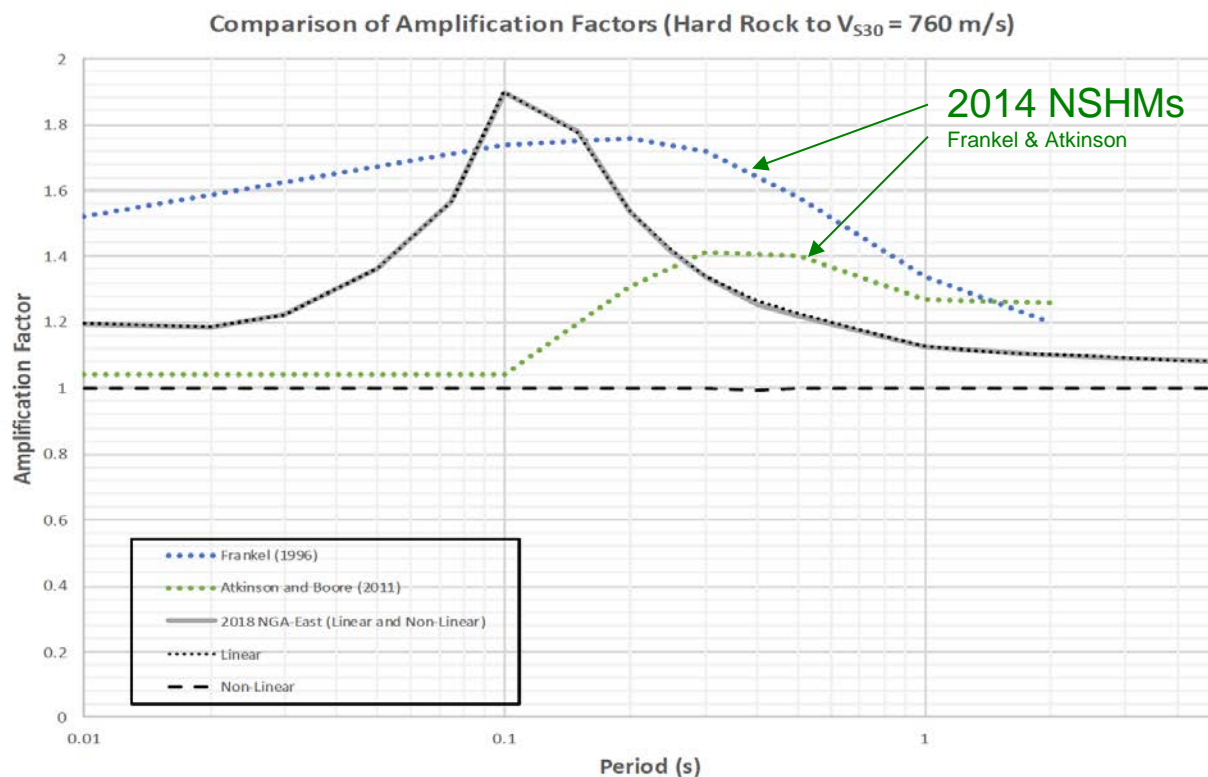
*“Progress on the 2018 USGS National Seismic Hazard Model” Rezaeian & Luco (USGS), August 14-15, 2018*

# 1. NGA-East Site Amplification

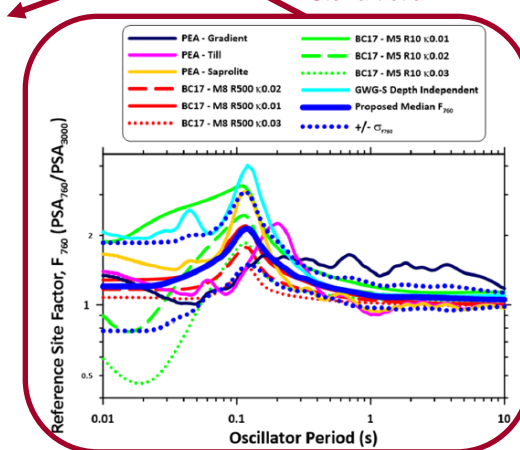
Site Amplifications (transforming Site Class A to other Site Classes):

$$F_{\text{total}} = F_{760} + F_{\text{linear}} + F_{\text{nonlinear}}$$

Site class A to BC



2018 NSHMs  
Stewart et al.



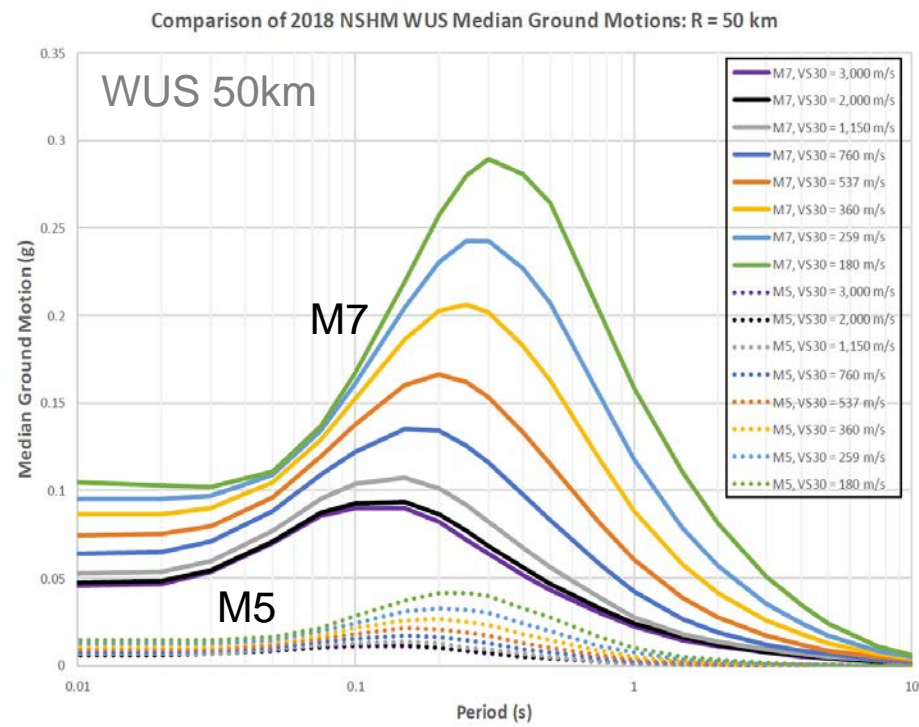
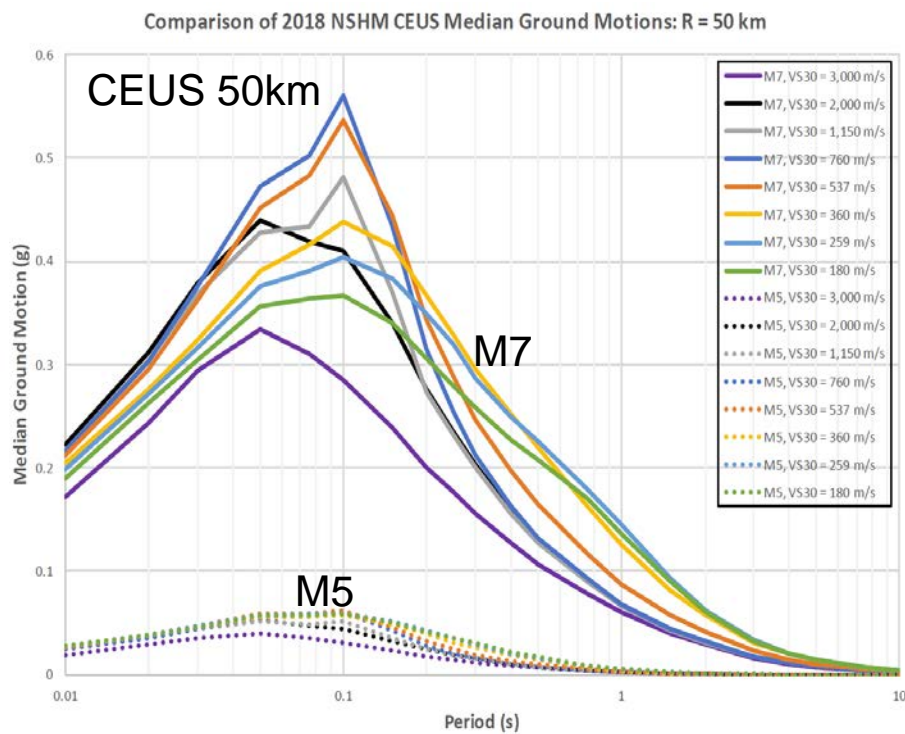
Building Seismic Safety Council (BSSC) Provisions Update Committee (PUC) Meeting

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$$F_{\text{total}} = F_{760} + F_{\text{linear}} + F_{\text{nonlinear}}$$

Site class BC to all other site classes



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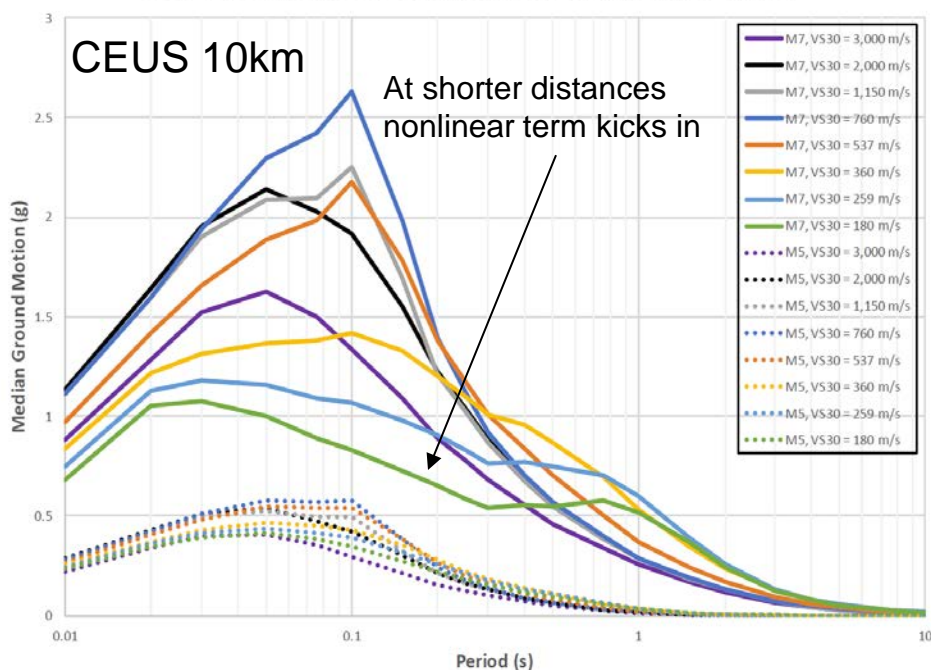
# 1. NGA-East Site Amplification

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$$F_{\text{total}} = F_{760} + F_{\text{linear}} + F_{\text{nonlinear}}$$

Site class BC to all other site classes

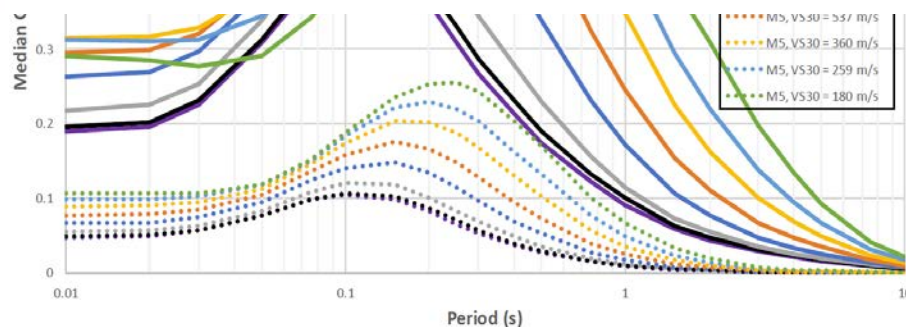
Comparison of 2018 NSHM CEUS Median Ground Motions: R = 10 km



Comparison of 2018 NSHM WUS Median Ground Motions: R = 10 km



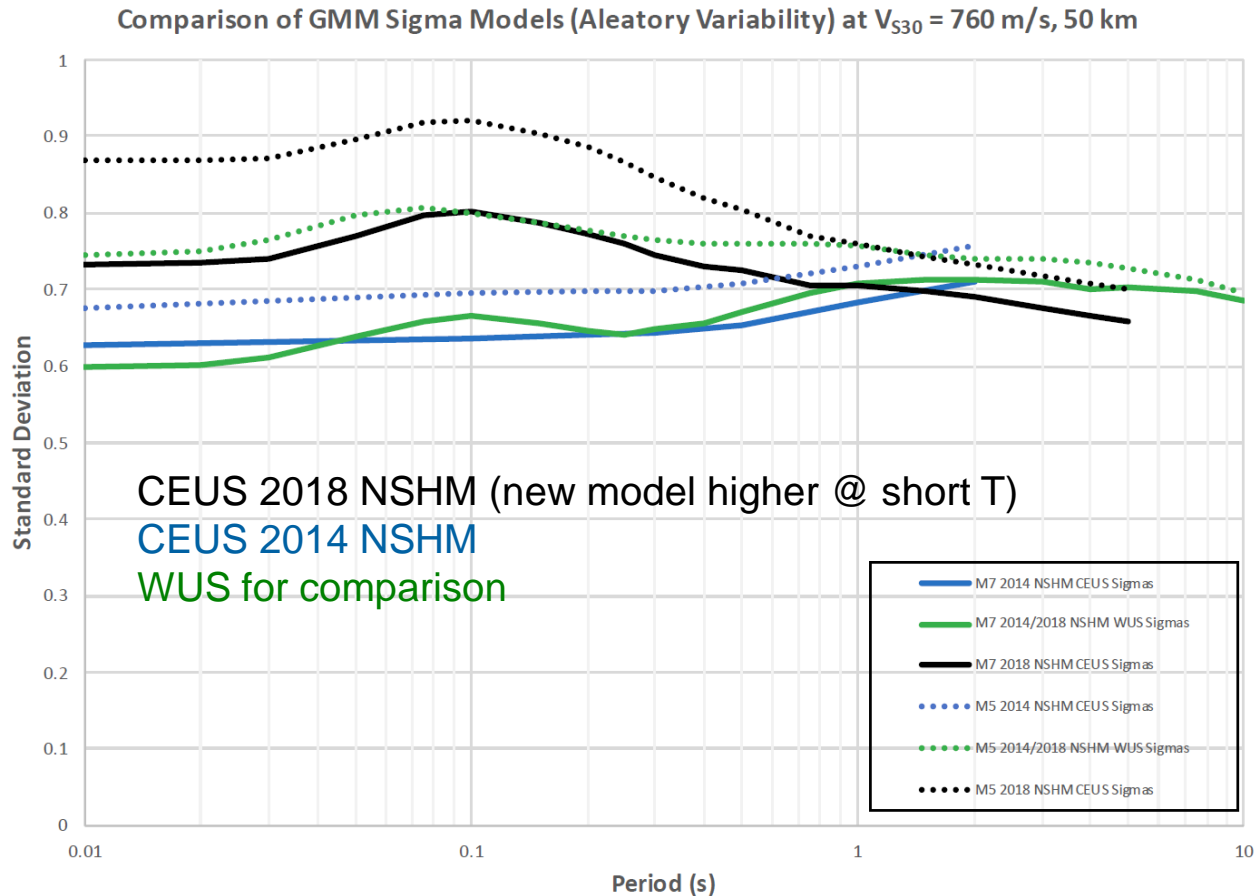
**Result: A more appropriate model for CEUS (compared to using WUS amplification factors)**



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# 1. NGA-East Sigma

## Standard Deviation (Aleatory Sigma):

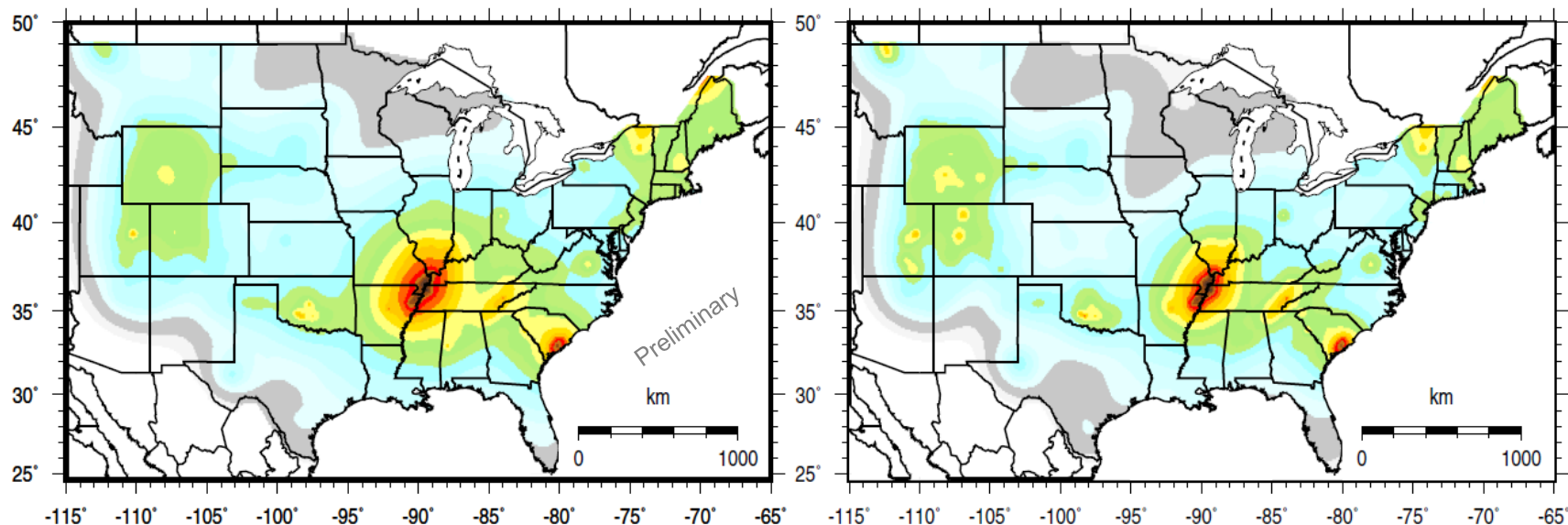


*Currently being discussed... may lower the sigma (short periods) by using the previous models (EPRI based)*

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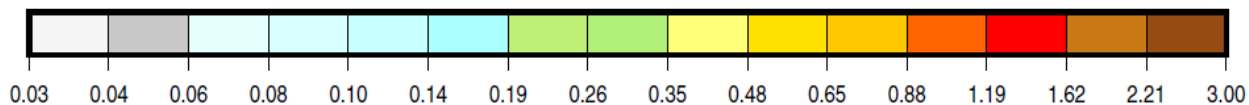
# 1. NGA-East Results

0.2 Sec, 2% PE in 50 years, uniform site class BC (760m/s)



2018 NSHM CEUS GMMs (map 1)

2014 NSHM CEUS GMMs (map 2)

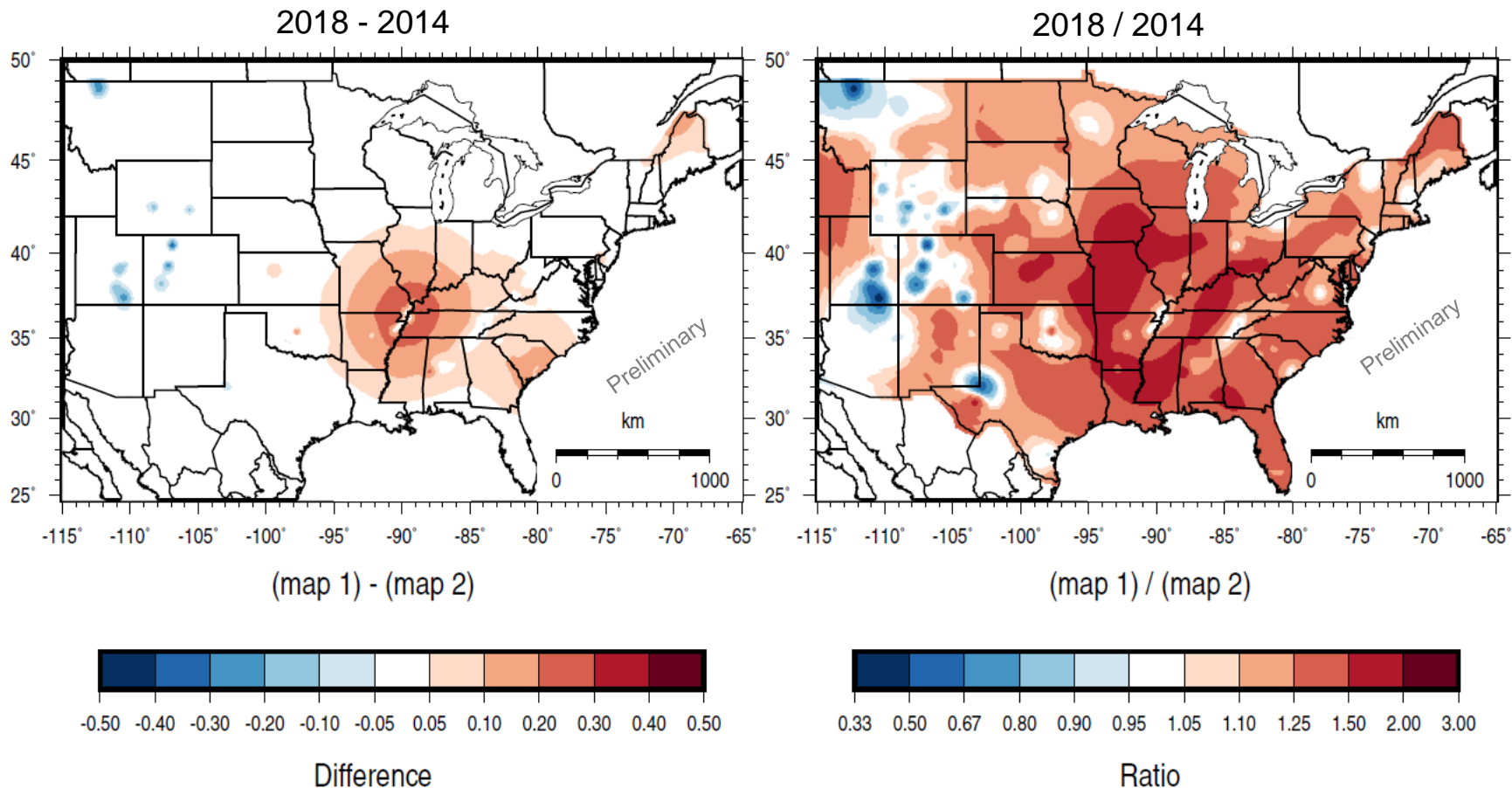


0.2 Second Spectral Acceleration (g)

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# 1. NGA-East Results

0.2 Sec, 2% PE in 50 years, uniform site class BC (760m/s)



*Recall the larger sigma at short periods (this is not the case for longer periods), may be reduced by Dec.*

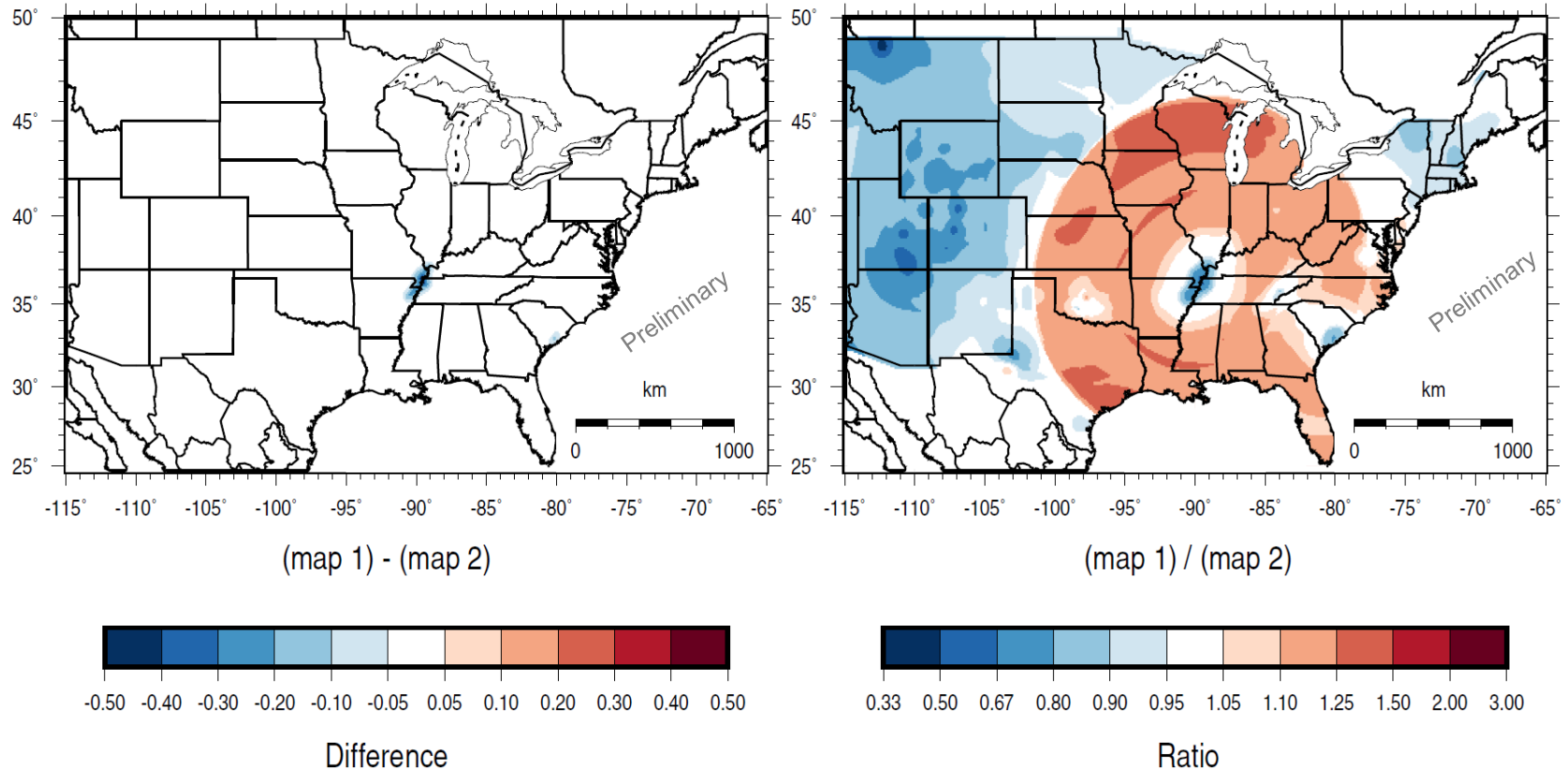
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# 1. NGA-East Results

1 Sec, 2% PE in 50 years, uniform site class BC (760m/s)

2018 - 2014

2018 / 2014

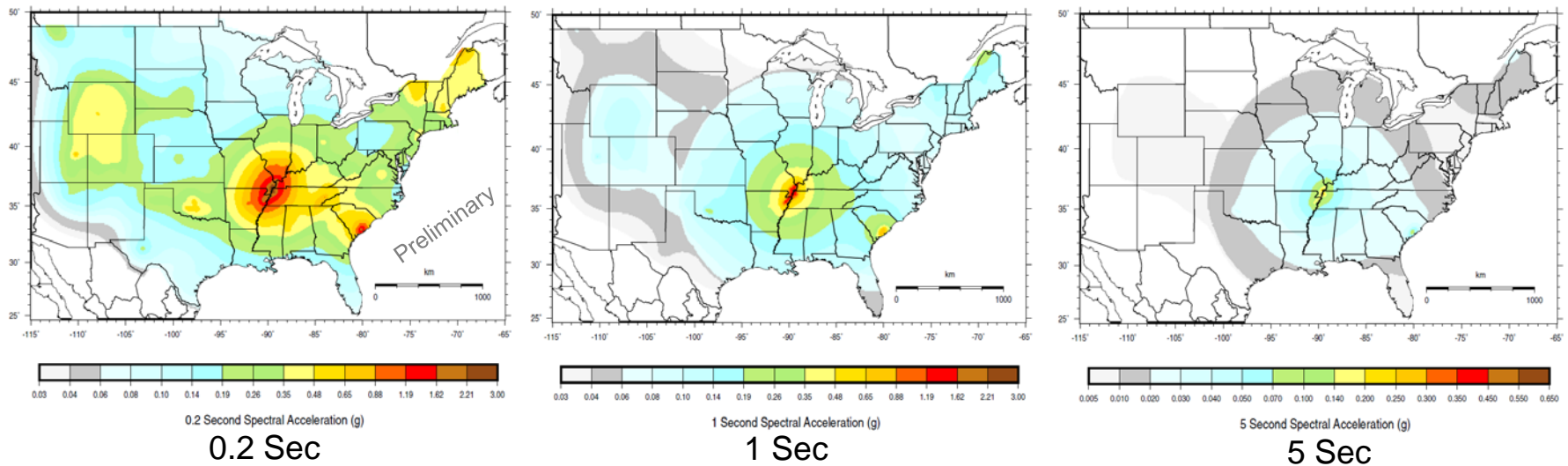


**Building Seismic Safety Council (BSSC) Provisions Update Committee (PUC) Meeting**

*"Progress on the 2018 USGS National Seismic Hazard Model" Rezaeian & Luco (USGS), August 14-15, 2018*

# 1. NGA-East Results

2% PE in 50 years, uniform site class D (260m/s)



*Can't be compared to any previous maps because we couldn't make these before.*

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

# 1. NGA-East Summary

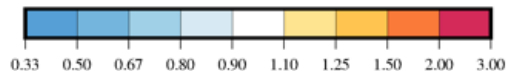
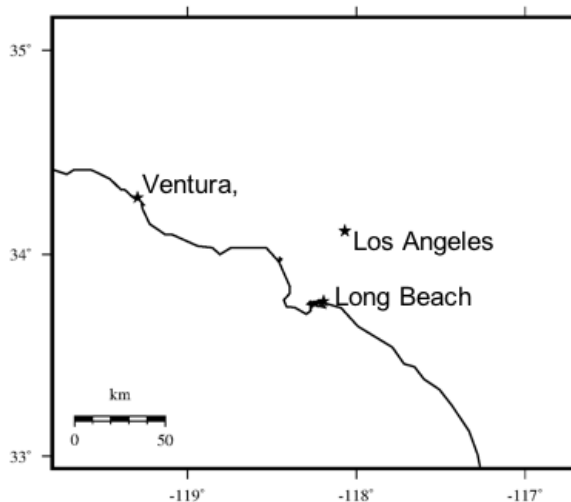
- USGS CEUS GMPE Model:  
1/3 (14 Seeds) + 2/3 (17 NGA-East)
- Site Amplification Model:  
Specific to CEUS  
$$F_{\text{total}} = F_{760} + F_{\text{linear}} + F_{\text{nonlinear}}$$
- Standard Deviation (Aleatory Sigma):  
Higher than 2014 CEUS and WUS models at short periods  
May be revised or reverted back to the EPRI-based model
- Results:  
“Donut” effect compared to 2014 at 0.2 & 1 sec for BC  
All periods and site classes now available (didn’t have before)

# Basin Effects vs. Spectral Period ( $T$ )

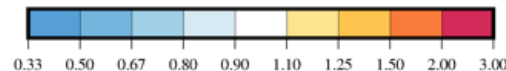
(for 2%-in-50-years ground motions, assuming Site Class D)

## Explicit ÷ Implicit Modeling

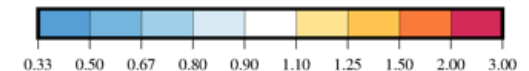
$T = 0.2$  seconds



$T = 1$  second



$T = 5$  seconds

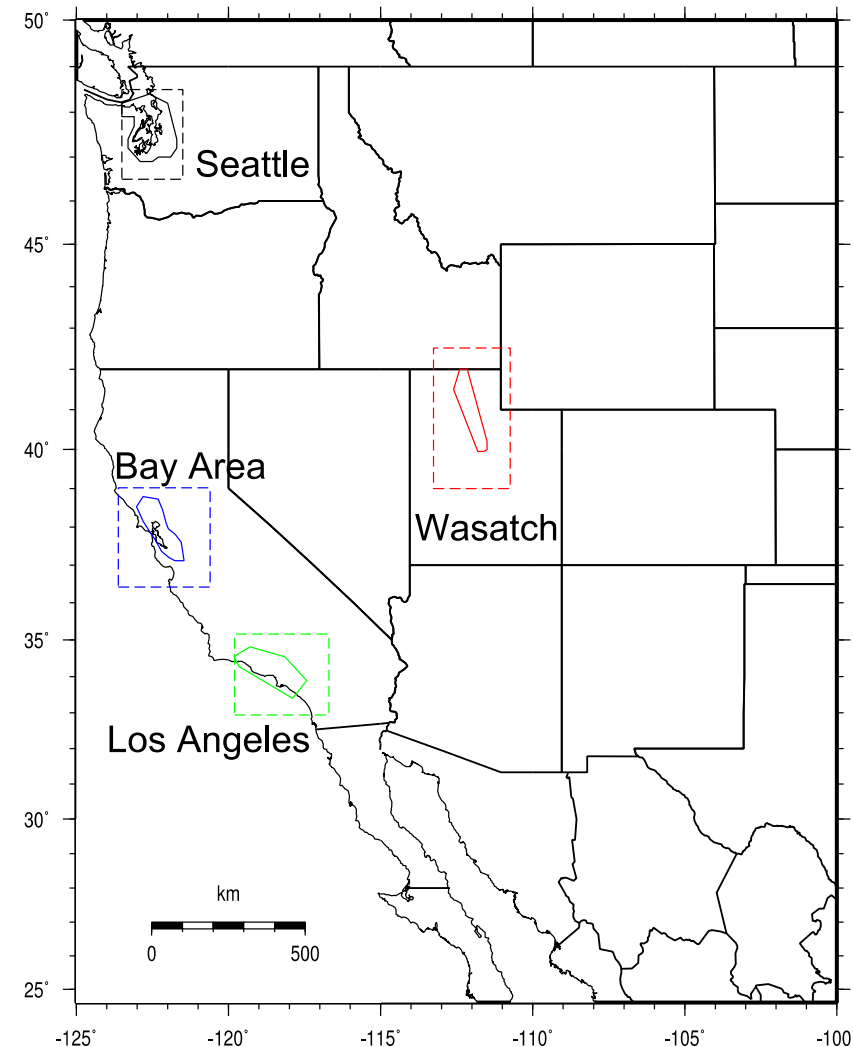


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# Published Basin-Depth Models

- For 4 Western US areas
- Differences w.r.t. “implicit” modeling depends on site class
- *National* Crustal Model under development by USGS (Boyd *et al*)

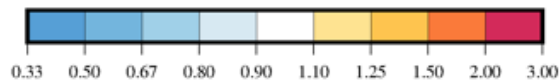
Region	Reference
Los Angeles	Lee et al., 2014
Bay Area	Aagaard et al., 2010
Wasatch	Magistrale et al., 2008
Seattle	Stephenson, 2007



# Deep vs. Shallow Basin Effects

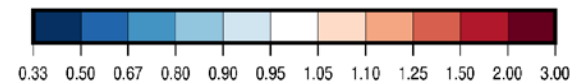
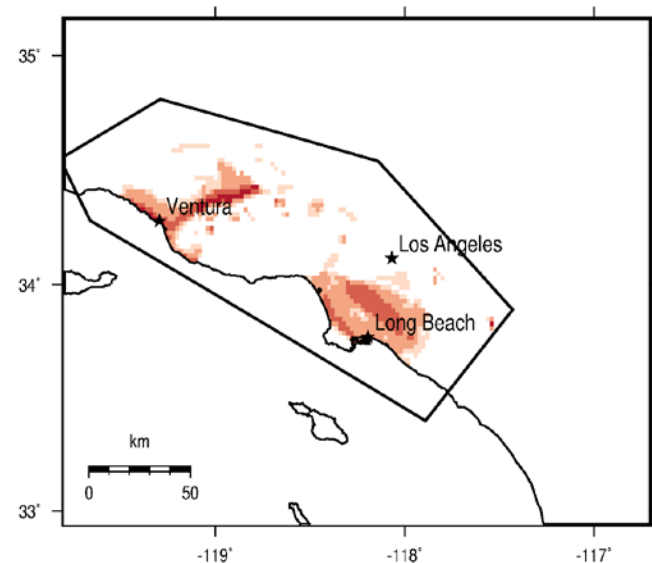
(for 2%-in-50-years ground motions, assuming Site Class D,  $T = 5$  seconds)

## Deep & Shallow



Explicit ÷ Implicit Modeling

## Deep Only

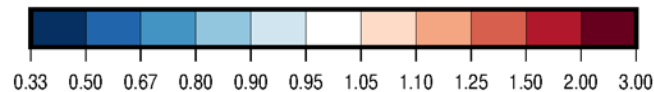
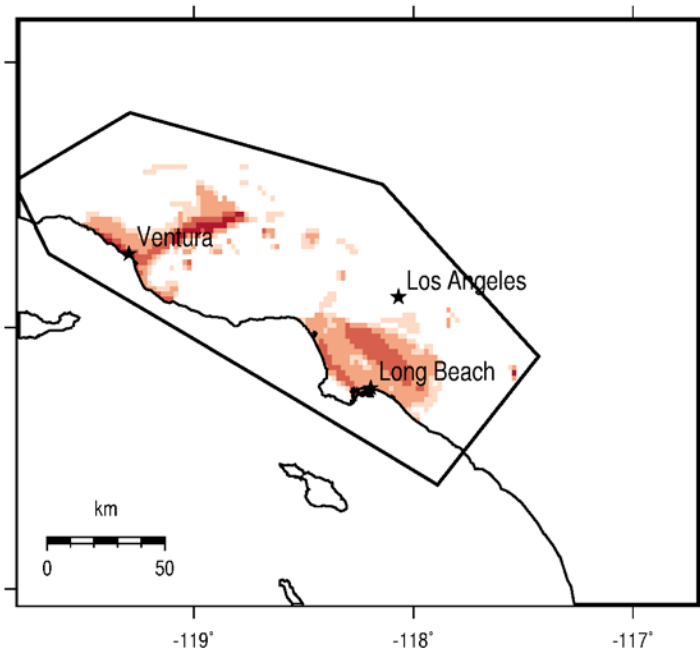


Explicit ÷ Implicit Modeling

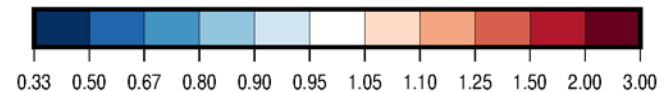
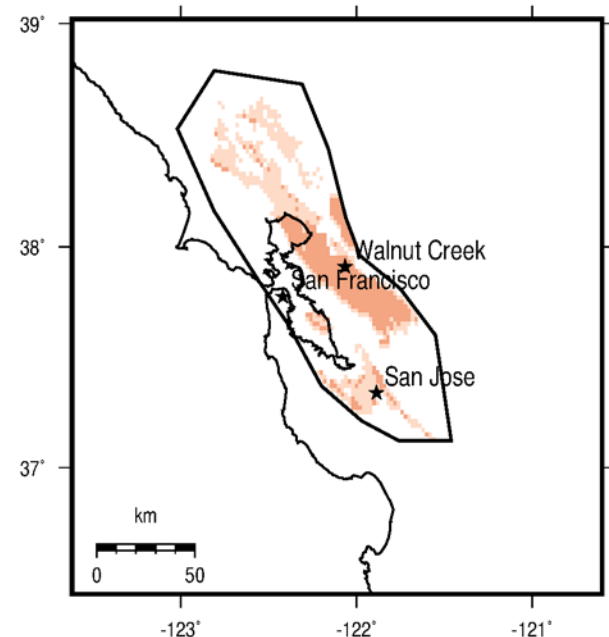
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# Example Deep Basin Effects

(for 2%-in-50-years ground motions, assuming Site Class D,  $T = 5$  seconds)



Explicit ÷ Implicit Modeling

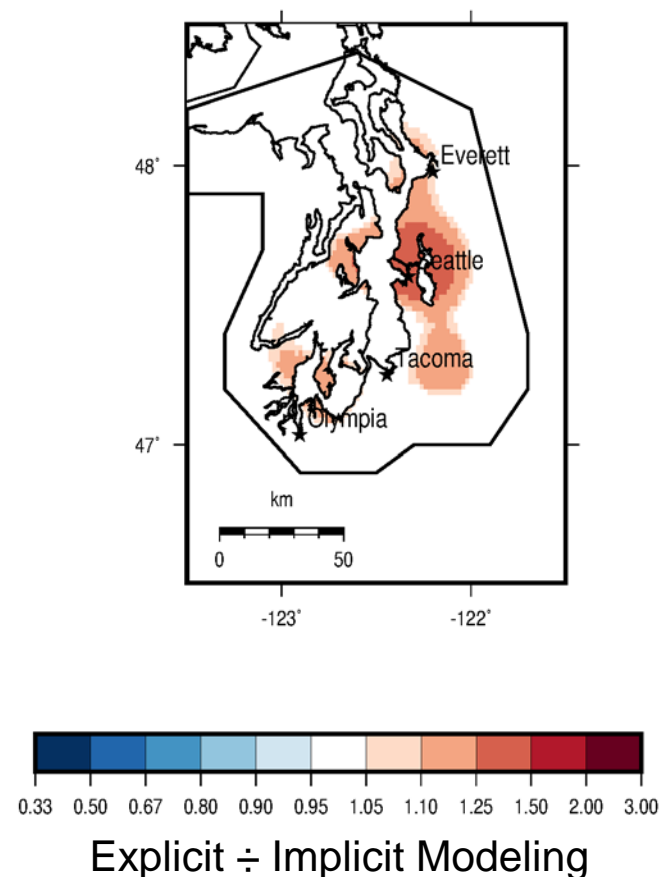
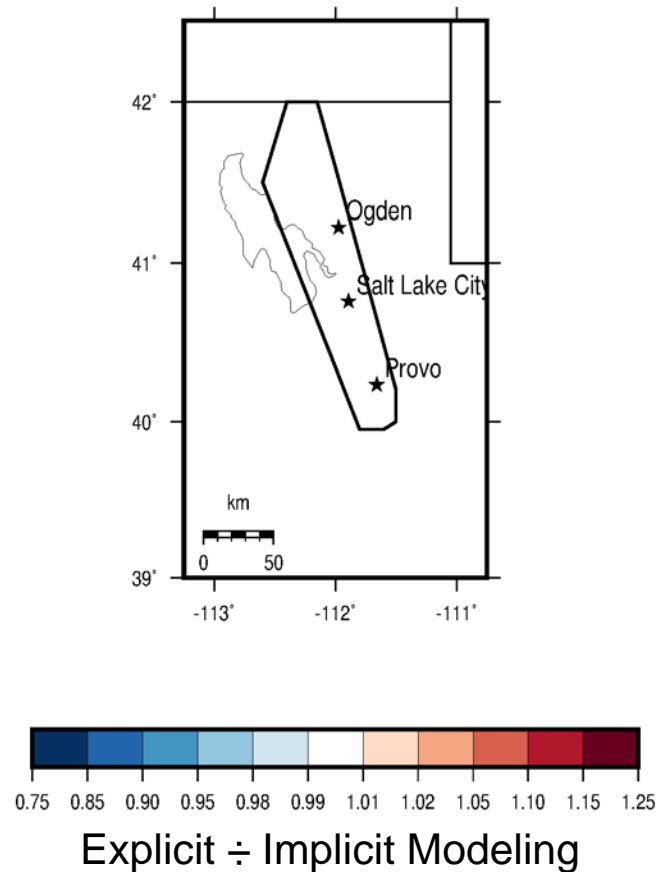


Explicit ÷ Implicit Modeling

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

# Example Deep Basin Effects

*(for 2%-in-50-years ground motions, assuming Site Class D,  $T = 5$  seconds)*



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

# Summary of USGS NSHM Updates

- Draft of 2018 USGS National Seismic Hazard Model (NSHM) was presented at the March 7-8 Workshop. Revisions have been made and will be finalized by the end of August. Public review comment period follows. Done in December.
- Output will include additional spectral periods (longer) and site classes (softer)
- Three main updates:  
(1) NGA-East, (2) basin effects, (3) seismicity catalog
- 2020 NSHM next: subduction GMPEs & simulations