

Multi-Period Response Spectrum (MPRS) for example WUS & CEUS sites

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

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Review: Derivation of “Design” Ground Motions

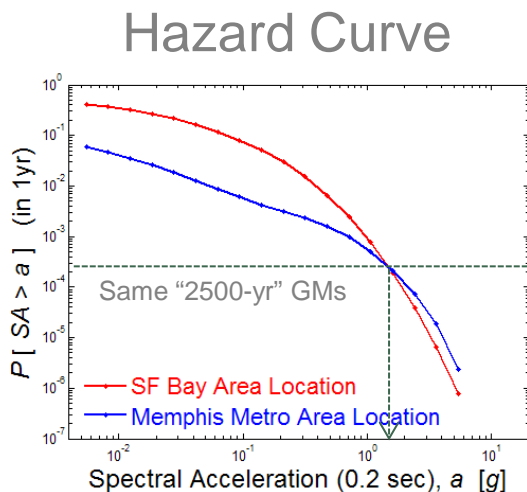
At a given period and site class (0.2s and 1.0s at BC):

1. Risk-Targeted Ground Motion (starting in ASCE 7-10)
2. Maximum Horizontal Direction Ground Motion (starting in ASCE 7-10)
3. Deterministic Cap
4. Site Coefficients (updated in ASCE 7-16)
5. Spectral Shape based on 2 periods

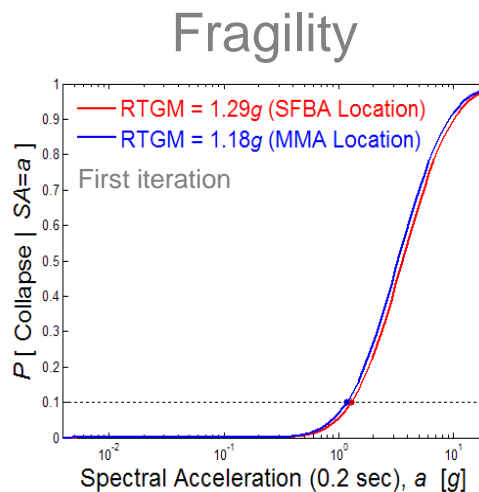
Review: Derivation of “Design” Ground Motions

At a given period and site class (0.2s and 1.0s at BC):

1. Risk-Targeted Ground Motion (starting in ASCE 7-10)



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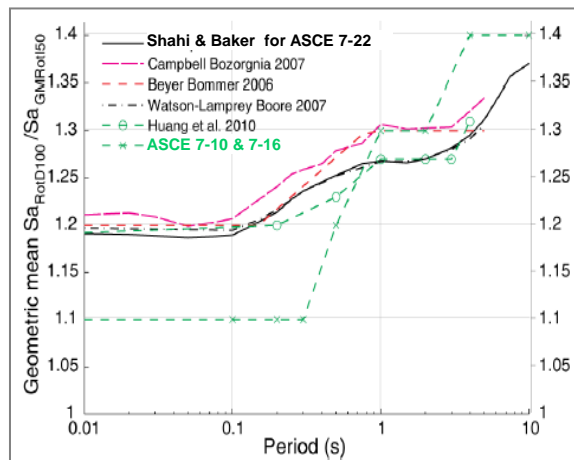
Risk-Targeted Ground Motion

(defined by Project '07 as 1% probability of collapse in 50years)

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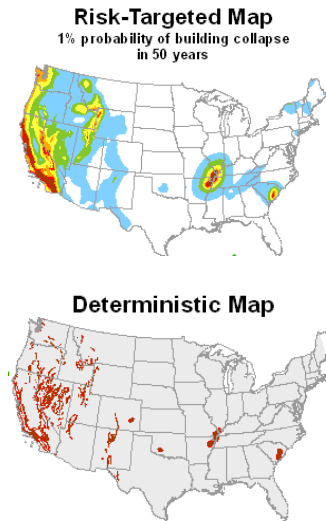


This presentation, uses Shahi & Baker model

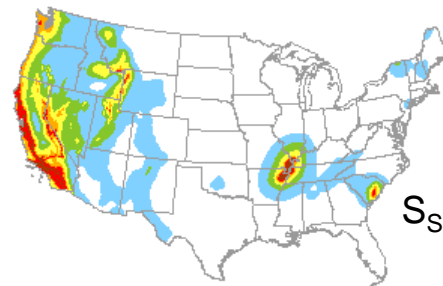
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3. Deterministic Cap



MCE_R Ground Motion Map
2012 International Building Code



S_S and S_1 maps

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1. Risk-Targeted Ground Motion (starting in ASCE 7-10)
2. Maximum Horizontal Direction Ground Motion (starting in ASCE 7-10)
3. Deterministic Cap
4. Site Coefficients (updated in ASCE 7-16)
based on WUS data

$$S_{MS} = F_a \times S_S$$

$$S_{M1} = F_v \times S_1$$

Table 11.4-1 Site Coefficient, F_a

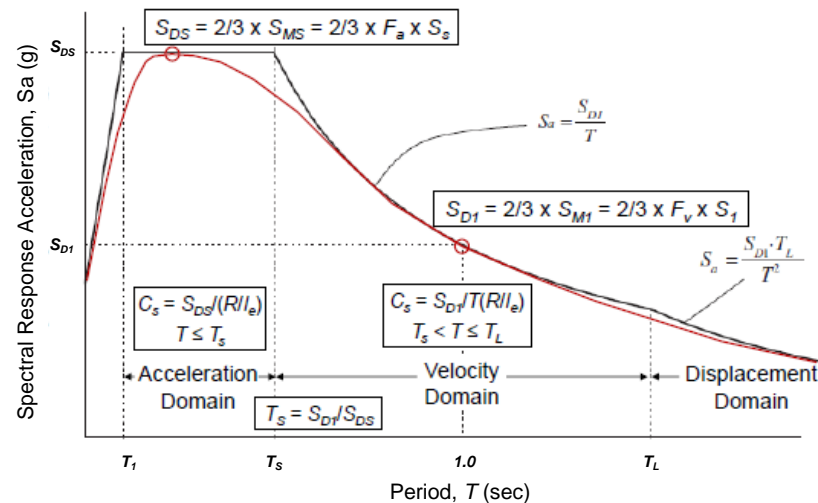
Mapped Risk-Targeted Maximum Considered Earthquake (MCE _R) Spectral Response Acceleration Parameter at Short Period					
Site Class	$S_S \leq 0.25$	$S_S = 0.5$	$S_S = 0.75$	$S_S = 1.0$	$S_S \geq 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7				

Note: Use straight-line interpolation for intermediate values of S_S .

Review: Derivation of “Design” Ground Motions

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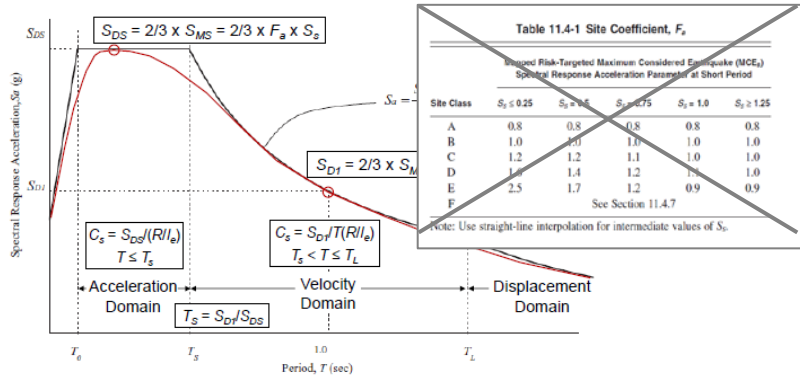
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Multi-Period Response Spectrum (MPRS)

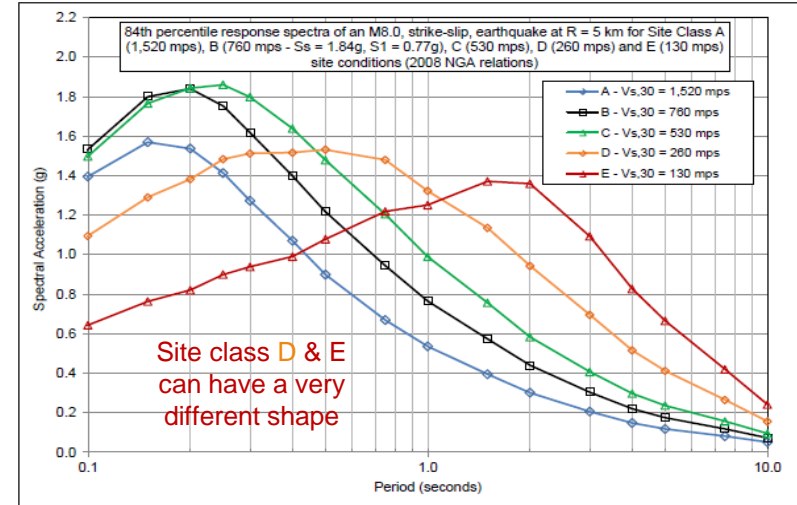
Current Design Spectrum (based on S_s & S_1 for BC):



Project '17 solution is for USGS to:

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

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



~~New~~ Review: Derivation of “Design” Ground Motions

At a given period and site class (0.2s and 1.0s at BC):

1. Risk-Targeted Ground Motion (starting in ASCE 7-10)

2. Maximum Horizontal Direction Ground Motion (starting in ASCE 7-10)

3. ~~Deterministic Gap~~ Not done here → Probabilistic MPRS

4. ~~Site Coefficients (updated in ASCE 7-16)~~

5. ~~Spectral Shape based on 2 periods~~

Do this for 22 periods
& 8 site classes (use V_{s30}
as direct input into GMPEs
to get hazard curves)

Shahi & Baker used here

Used here to compare MPRS with ASCE 7-10 & 7-16

All hazard curves are based on the draft* 2018 NSHMs → Comparisons show the differences in procedures

available for all periods and site classes for:

- WUS: 158 test sites (including the 29 NEHRP sites)
- CEUS: 95 test sites (including the 5 NEHRP sites)

* Finalized by Dec

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Additional Periods & Site Classes

Provide hazard curves for 22 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								

GMPE changes from 2014 to 2018 NSHMs:

WUS & Subduction:

- Remove models not applicable for soft sites (Idriss14) & long periods (Atkinson&Boore03)
- Subduction GMPEs modified (CB14 site & basin term)
- Basin effects for long T and soft sites: amplifications may be added later (using default Vs30based basin term in this presentation)

CEUS:

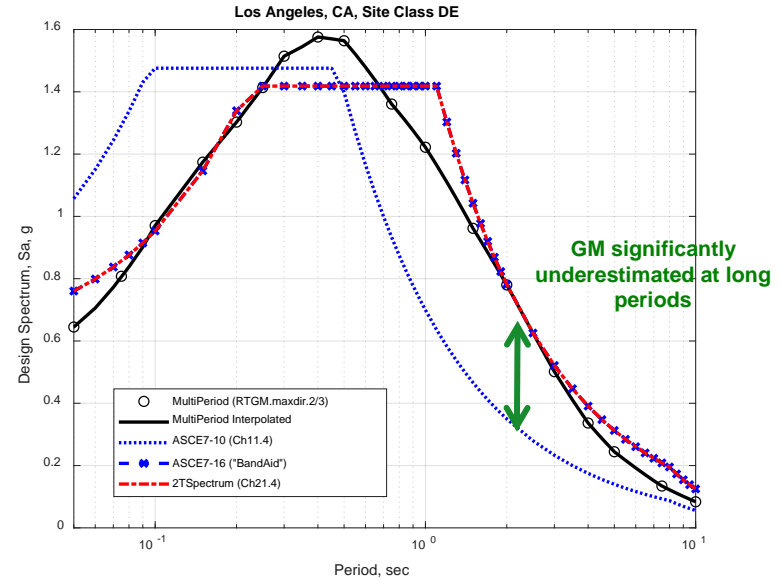
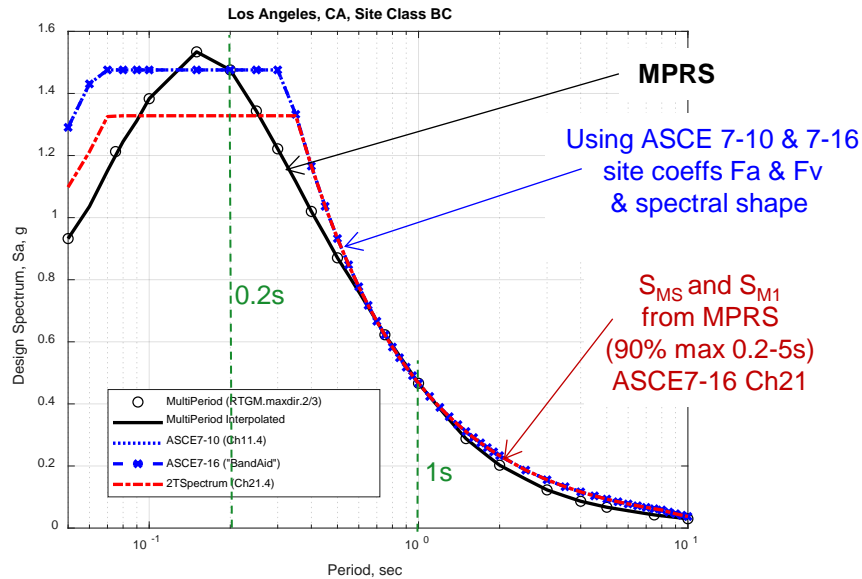
- New models. 2014 GMPEs only applicable up to 2sec and site class A.

Other Regions: AK, HI, GU&AS, PRVI

- Response Spectrum Shape Factors

MPRS WUS Example

Example: Los Angeles, CA (-118.25 , 34.05)
Draft 2018 NSHMs

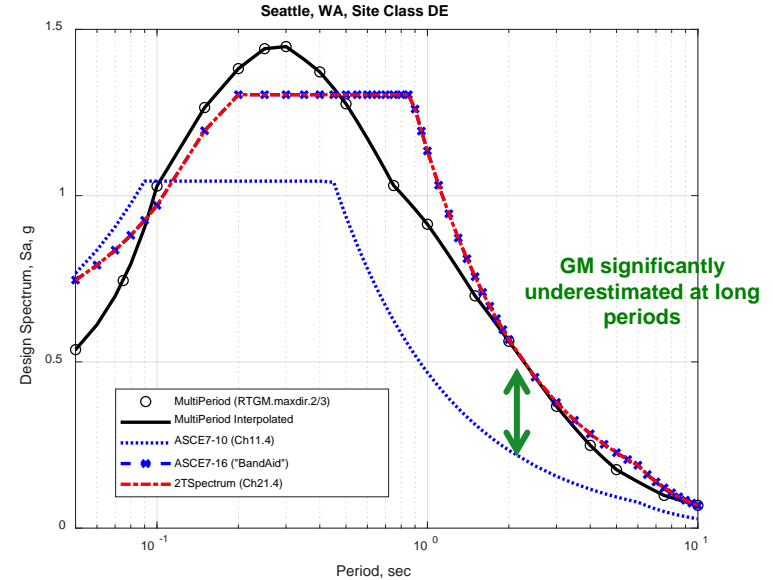
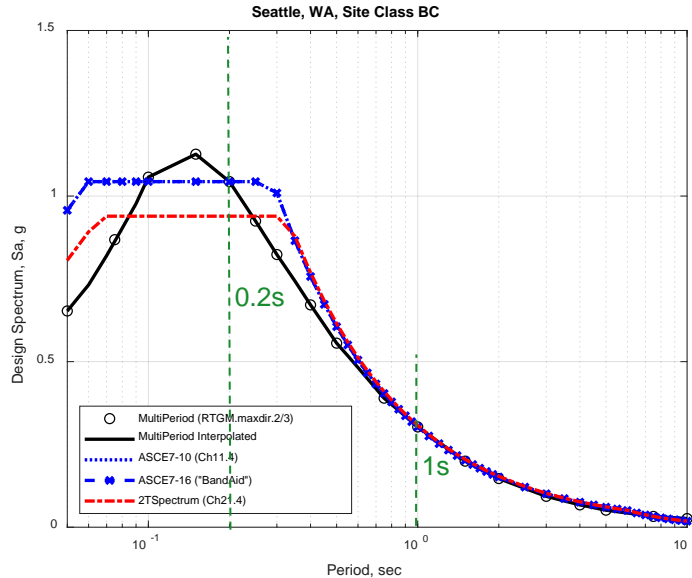


Note: the ASCE7-16 fixed the problem by requiring site-specific analysis ("BandAid").

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MPRS WUS Example

Example: Seattle, WA (-122.3 , 47.6)
Draft 2018 NSHMs

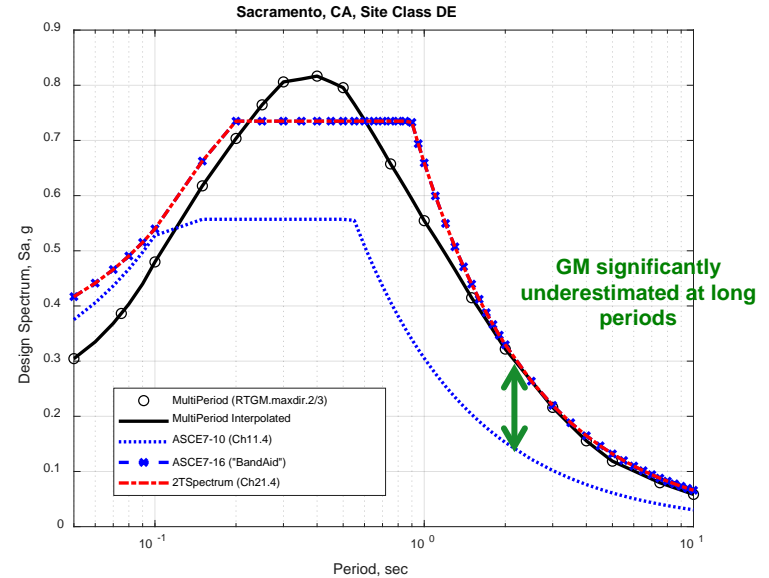
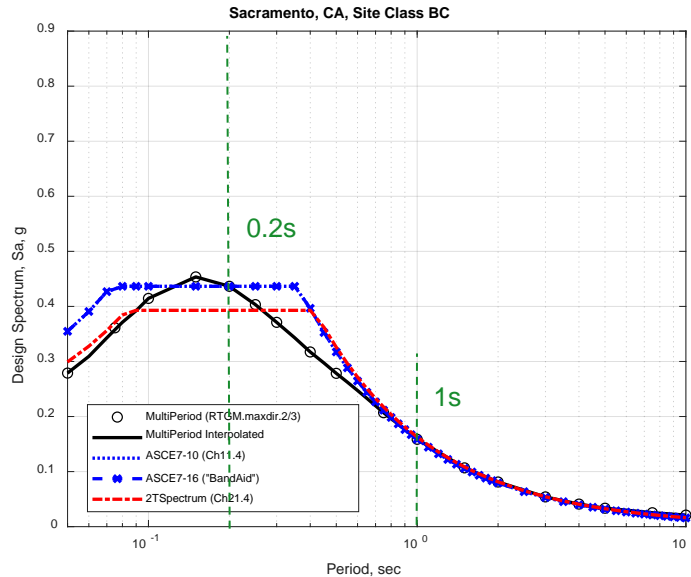


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MPRS WUS Example

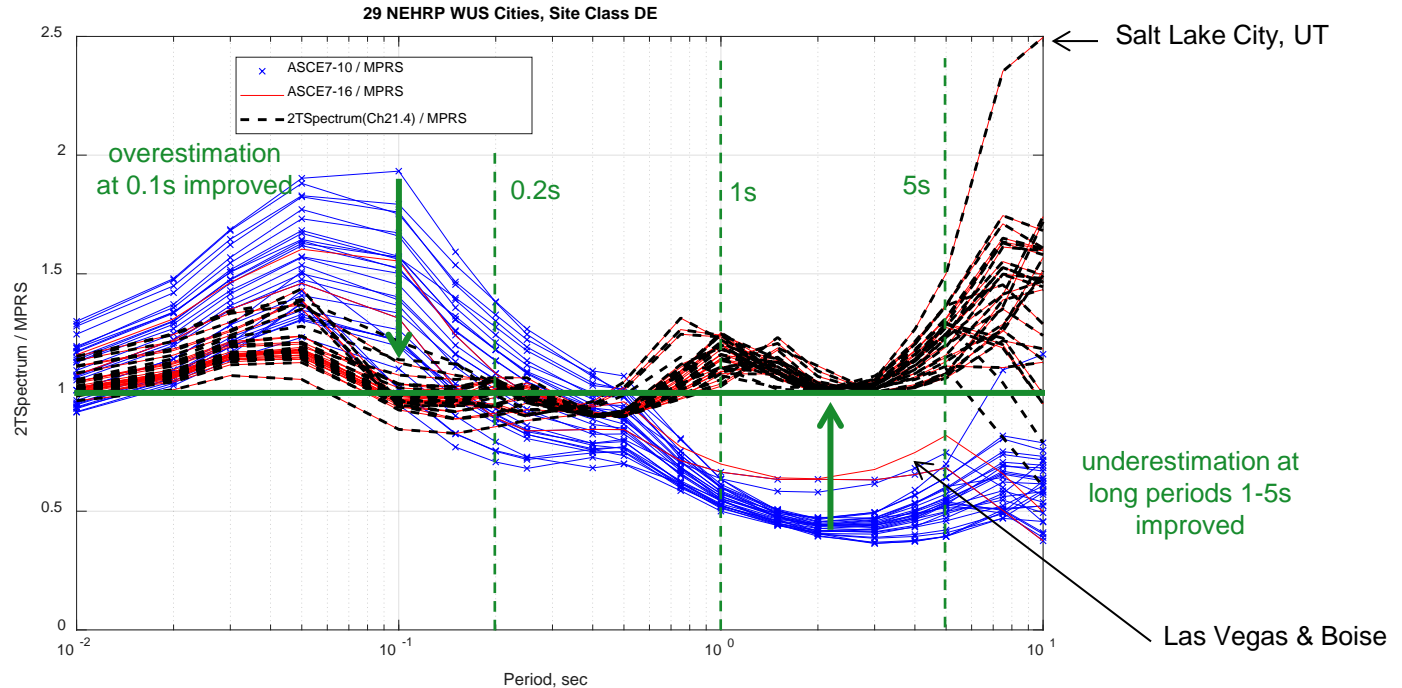
Example: Sacramento, CA (-121.5 , 38.6)
Draft 2018 NSHMs



Note: the ASCE7-16 fixed the problem by requiring site-specific analysis ("BandAid").

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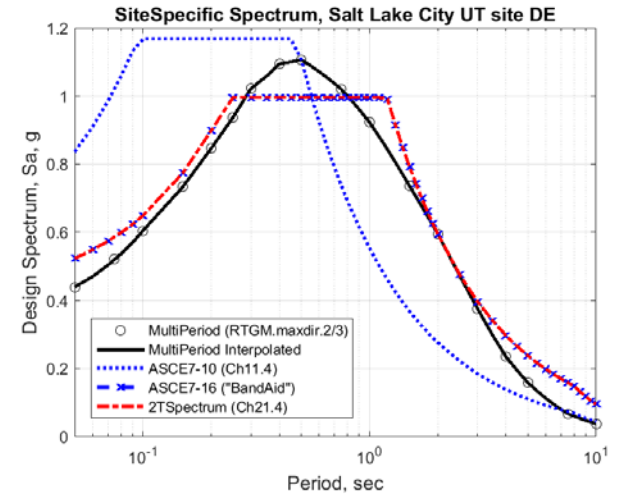
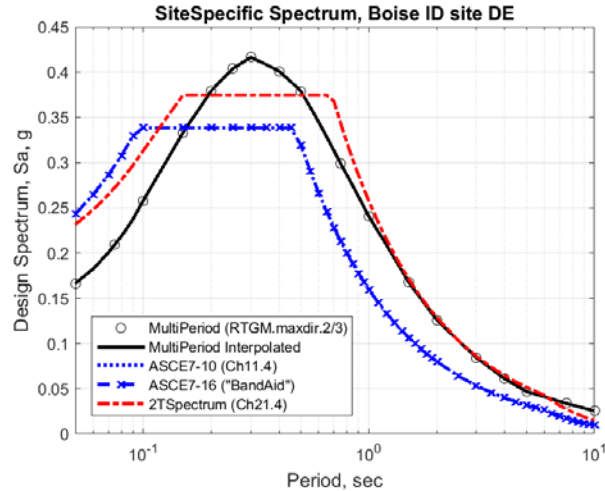
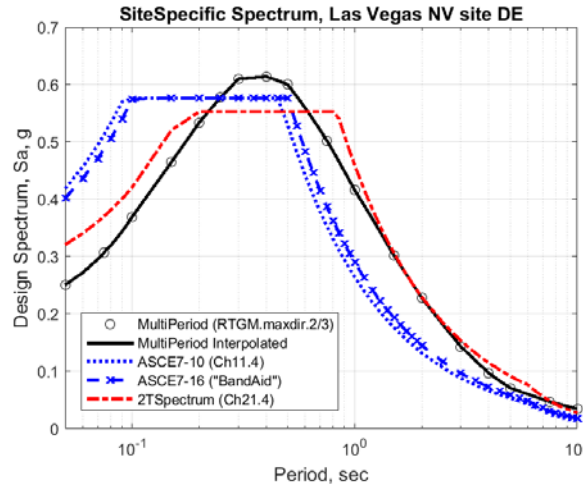
29 WUS NEHRP Cities



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MPRS WUS Example

Las Vegas & Boise
(not site specific in ASCE 7-16)
Draft 2018 NSHMs



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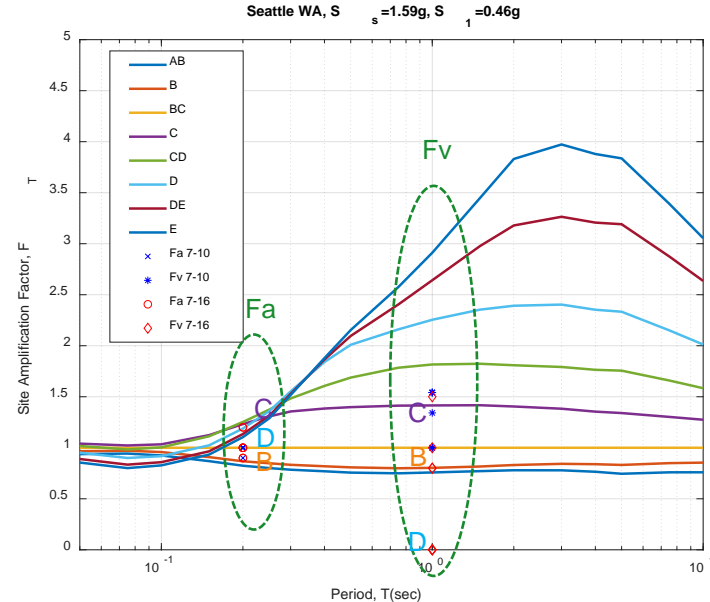
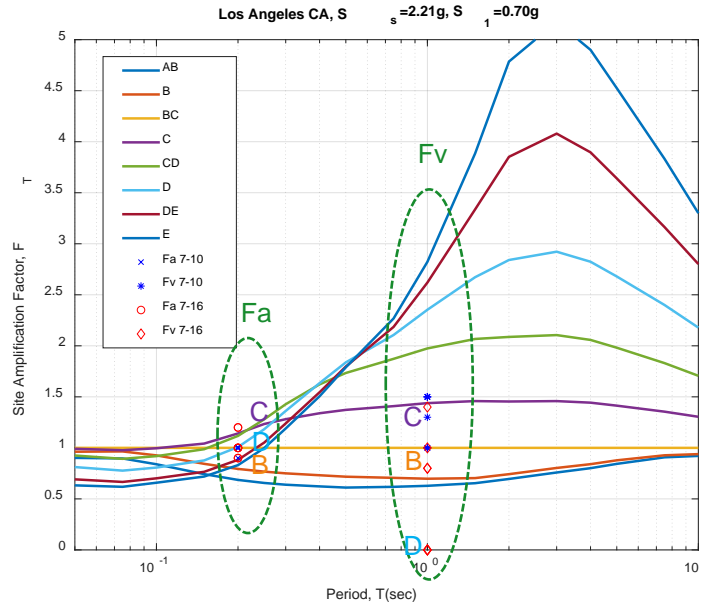
Site Coefficients using MPRS

$F_a = S_{0.2}$ at a site class $\div S_{0.2}$ at BC

$F_v = S_1$ at a site class $\div S_1$ at BC

$F_T = S_a$ at a site class $\div S_a$ at BC

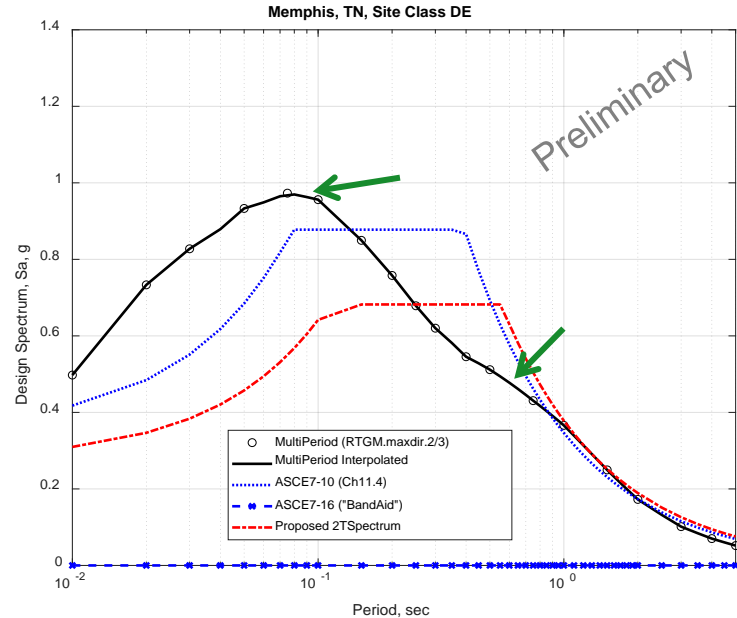
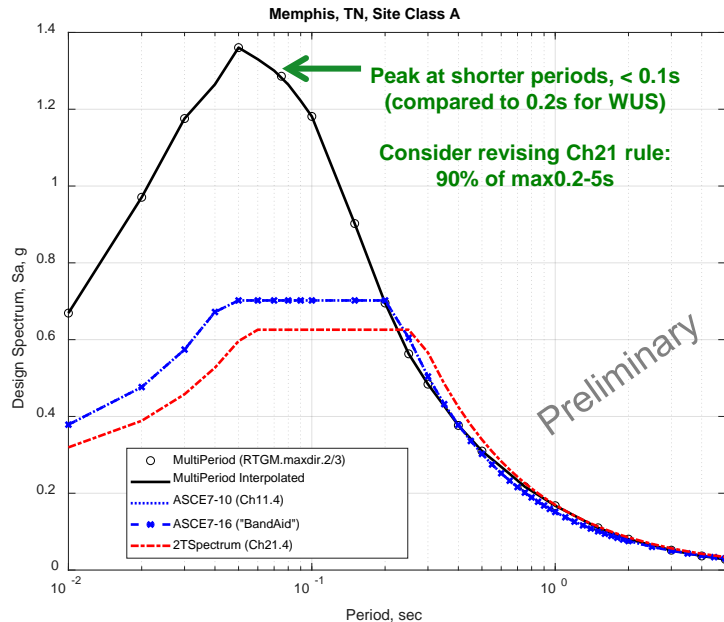
- F_a improved in ASCE 7-16
- F_v improved by requiring site specific analysis
- Site Coefficient could be very different at longer periods



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MPRS CEUS Example

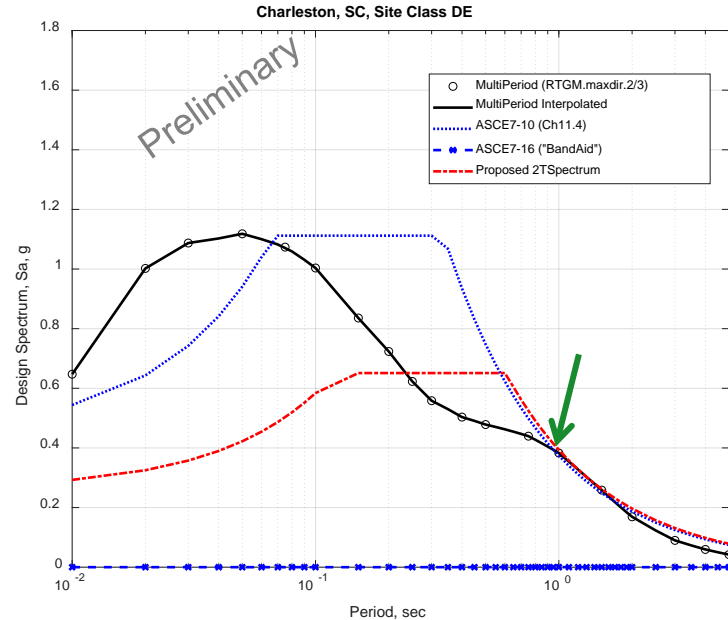
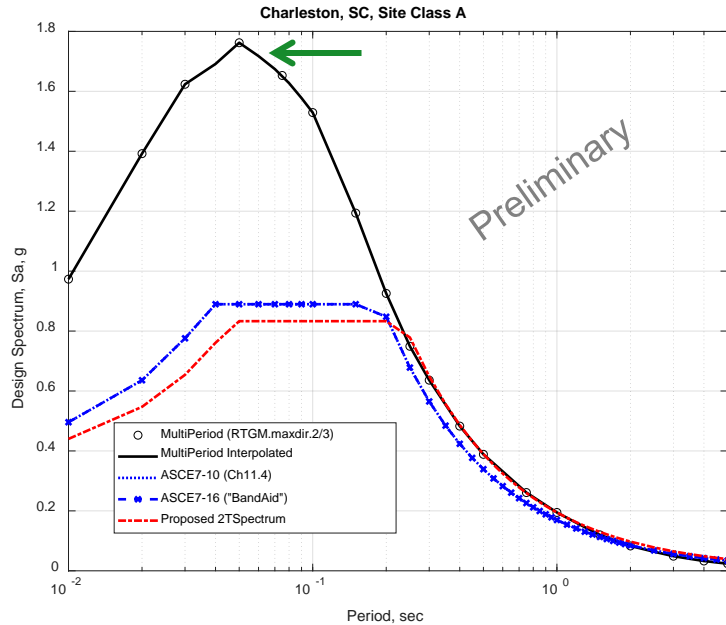
Example: Memphis, TN
Draft 2018 NSHMs



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MPRS CEUS Example

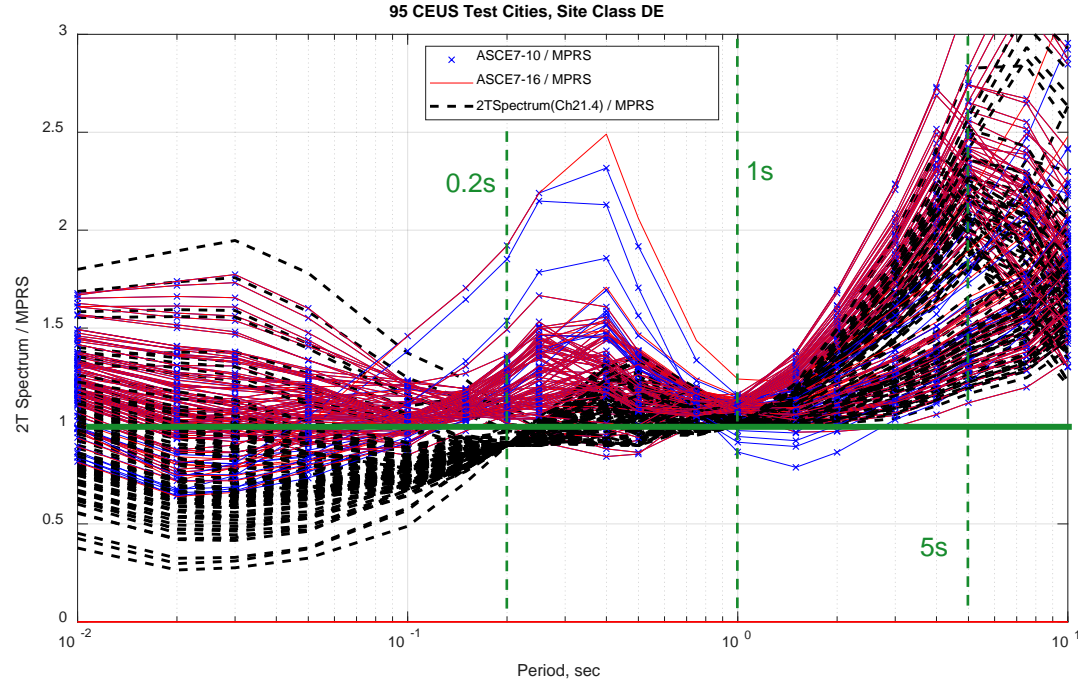
Example: Charleston, SC
Draft 2018 NSHMs



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95 CEUS Test Sites

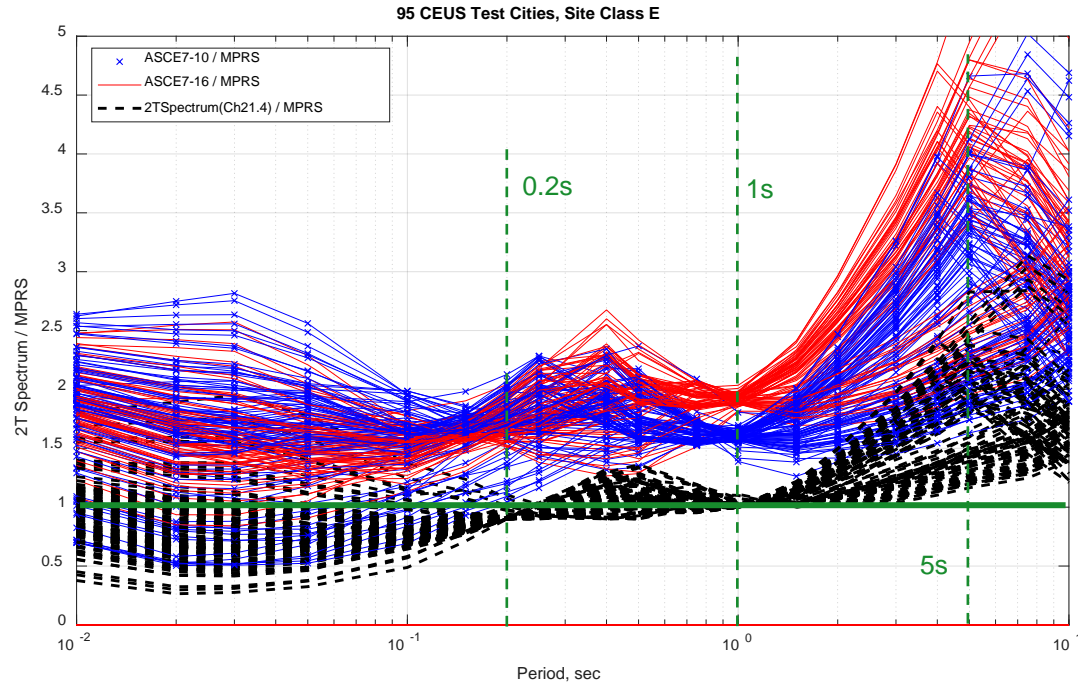
Not much improvement
Consider revising Ch21
2TSpectrum



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95 CEUS Test Sites

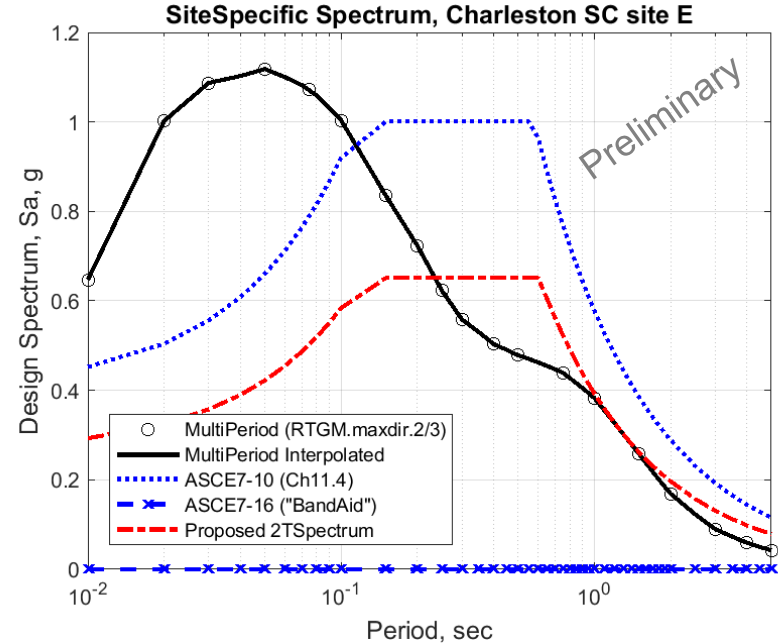
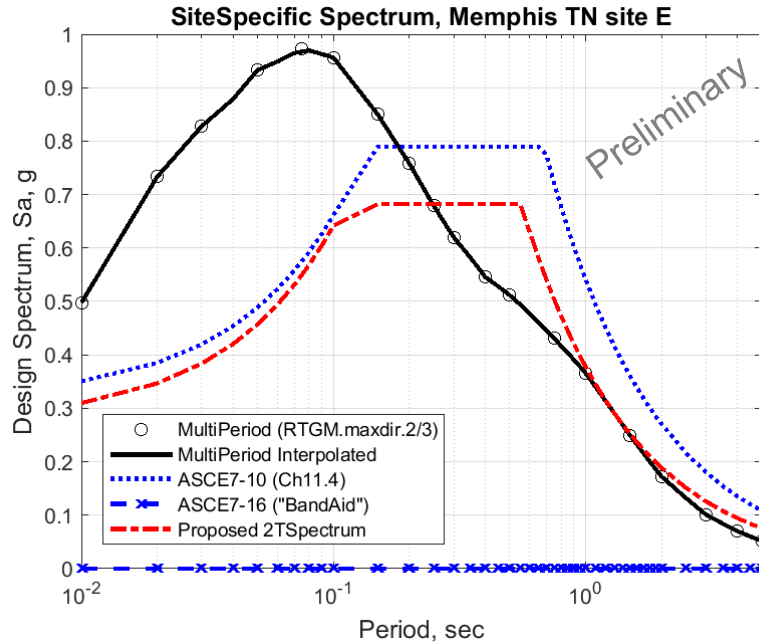
2TSpectrum better for Softer
Soil E



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MPRS CEUS Example

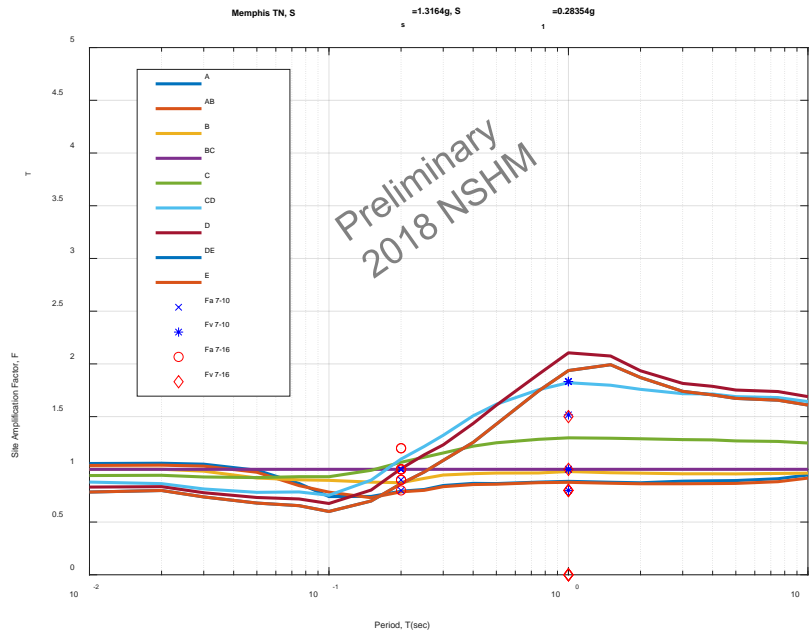
Draft 2018 NSHMs



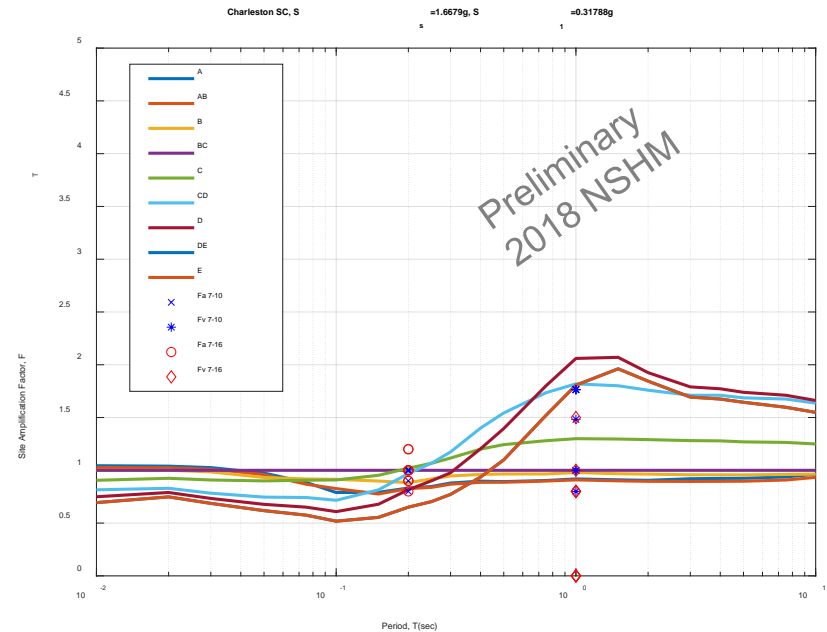
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Site Coefficients using MPRS

$$F_T = S_a \text{ at a site class} \div S_a \text{ at BC}$$



CEUS very different from WUS



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Response Spectrum Shape Factors (RSSF)

Other Regions:

AK, HI, GU&AS, PRVI

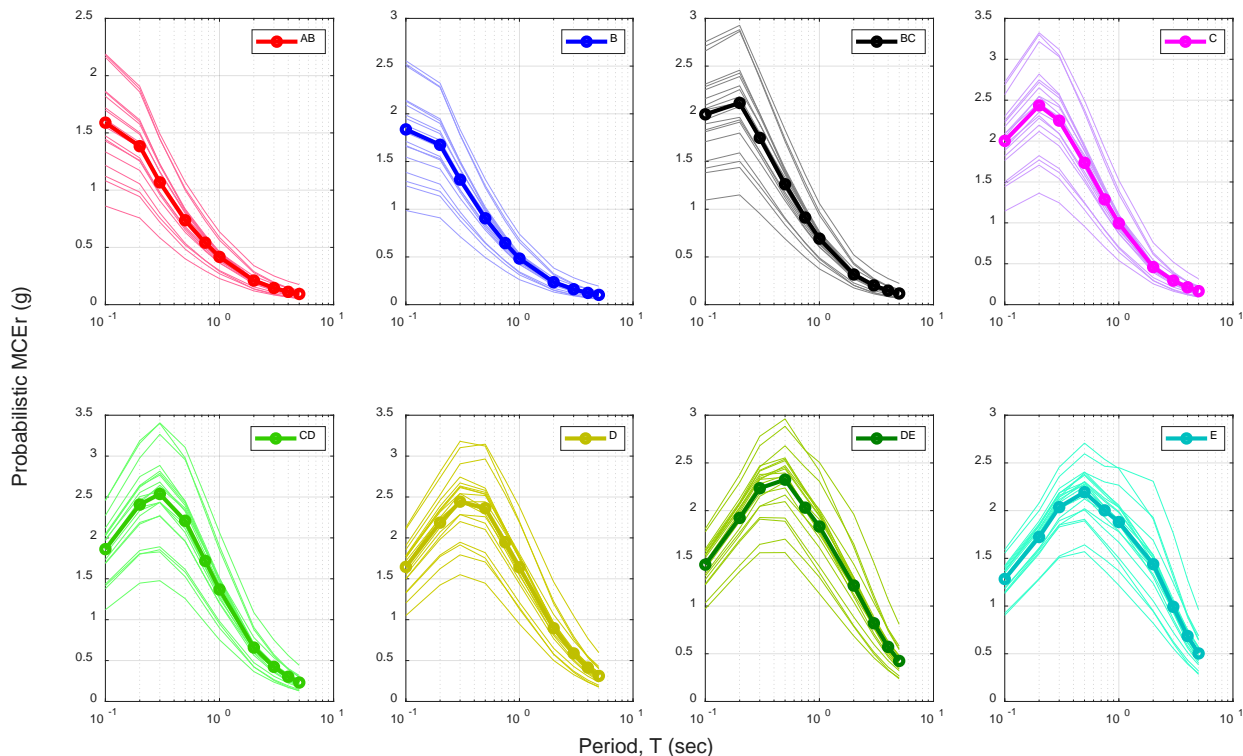
Develop RSSF based on WUS
GMPEs, until USGS updates are
available for each region

Select sites with similar hazard
(e.g., similar TL, Ss, or $R_s=S_s/S_1$)

Group 1 example:
NEHRP cities in WUS after
removing Sacramento, PNW (WA,
OR), UT, NV, ID, and

Figure: Preliminary
Based on 2014 NSHM
11 periods

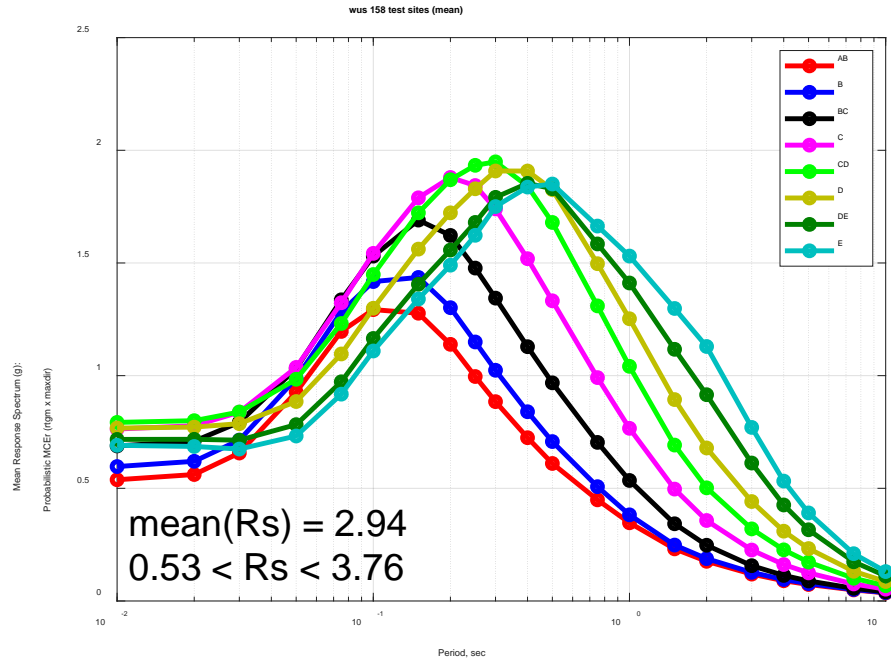
Group 1, WUS example sites and their mean



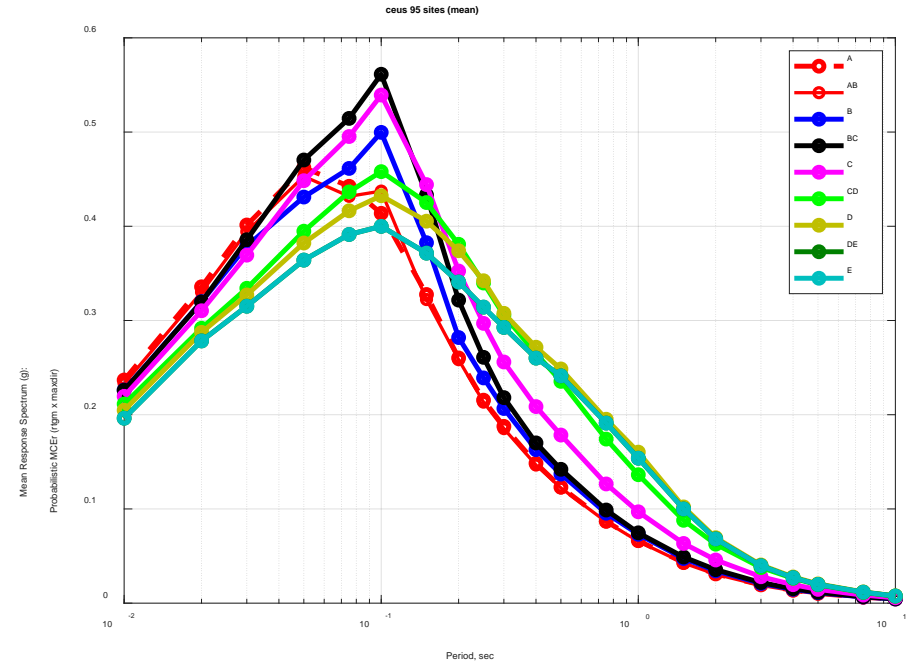
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Response Spectrum Shape Factors (RSSF)

WUS: 158 test sites



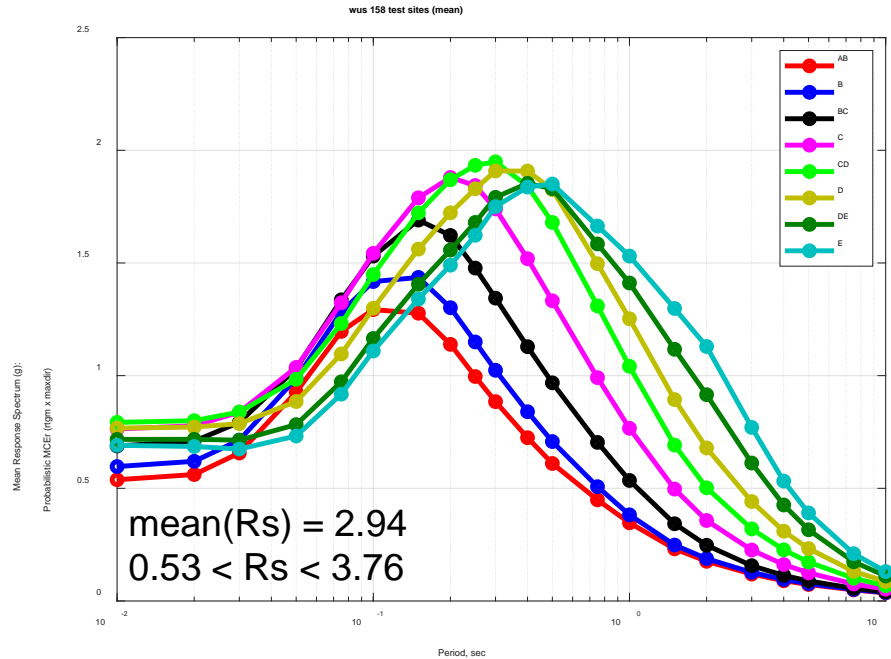
CEUS: 95 test sites



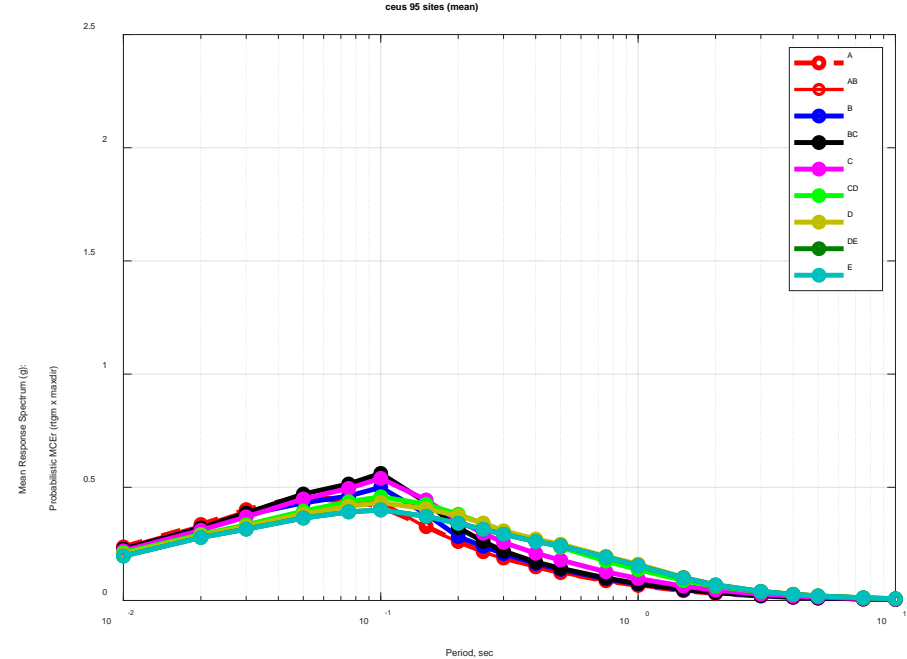
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Response Spectrum Shape Factors (RSSF)

WUS: 158 test sites



CEUS: 95 test sites



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Response Spectrum Shape Factors (RSSF)

WUS:

Next step is to use Census Tract sites and group them properly

by considering TL, Ss, and Ss/S1

In Progress ...

Summary

- The current design spectrum, based on Ss and S1 (BC reference site), can be inaccurate for softer soils, significantly underestimating gm. ASCE 7-16 updated site coefficients and put a “Band-Aid” by referring to site specific analysis (Ch21.4).
- Project ‘17 recommends the use of Multi-Period Response Spectrum (MPRS)
- Future USGS NSHMs will include 22 periods and 8 site classes for MPRS:
 - CEUS can be very different from WUS
- Seismic Code Implementation:
 - Currently developing MPRS Proposal for BSSC PUC for 2020 NEHRP Provisions
 - ASCE 7 Seismic Subcommittee will develop similar MPRS Proposal for ASCE 7-22
- For all other US territories where NSHMs are limited, Response Spectrum Shape Factors will be developed based on WUS