Project 17

Development of Next-Generation Seismic Design Value Maps

Provisions Update Committee
Final Report
15 August 2018

Ronald O. Hamburger, SE
Senior Principal
Simpson Gumpertz & Heger Inc.

Project Goals

- Explore means of stabilizing fluctuating desing requirements triggered by periodic updates to the maps (yo-yo effect)
- Complete work on spectral shape adjustment initiated in prior cycle
- Deterministic ground motions following demise of the “characteristic earthquake magnitude”

Acceptable risk

- The probability that ground motion at a building site will exceed levels that buildings will be designed to resist
- Presently- acceptable risk is defined as: "Less than a 10% notional probability that buildings will experience collapse, given MCE_R shaking"

Building Seismic Safety Council
a council of the National Institute of Building Sciences

Project 17

Acceptable Risk

- Acceptable risk is achieved by:

1. Design requirements (System limits, R, Cd, Ωo coefficients, detailing) capable of providing 90% reliability given a target shaking level.
2. Selecting an appropriate target shaking level – MCE_R
   – Probabilistic seismic hazard analysis

nehrp FEMA USGS science for a changing world

Why Motions Get Large Near Major Active Faults

PHSA in its simplest form:

$$\frac{1}{\substack{Ground\ Motion\ (GM)\\ Return\ Period}} = \frac{1}{\substack{Earthquake\\ Return\ Period}} \times (1 - GM\ Percentile)$$

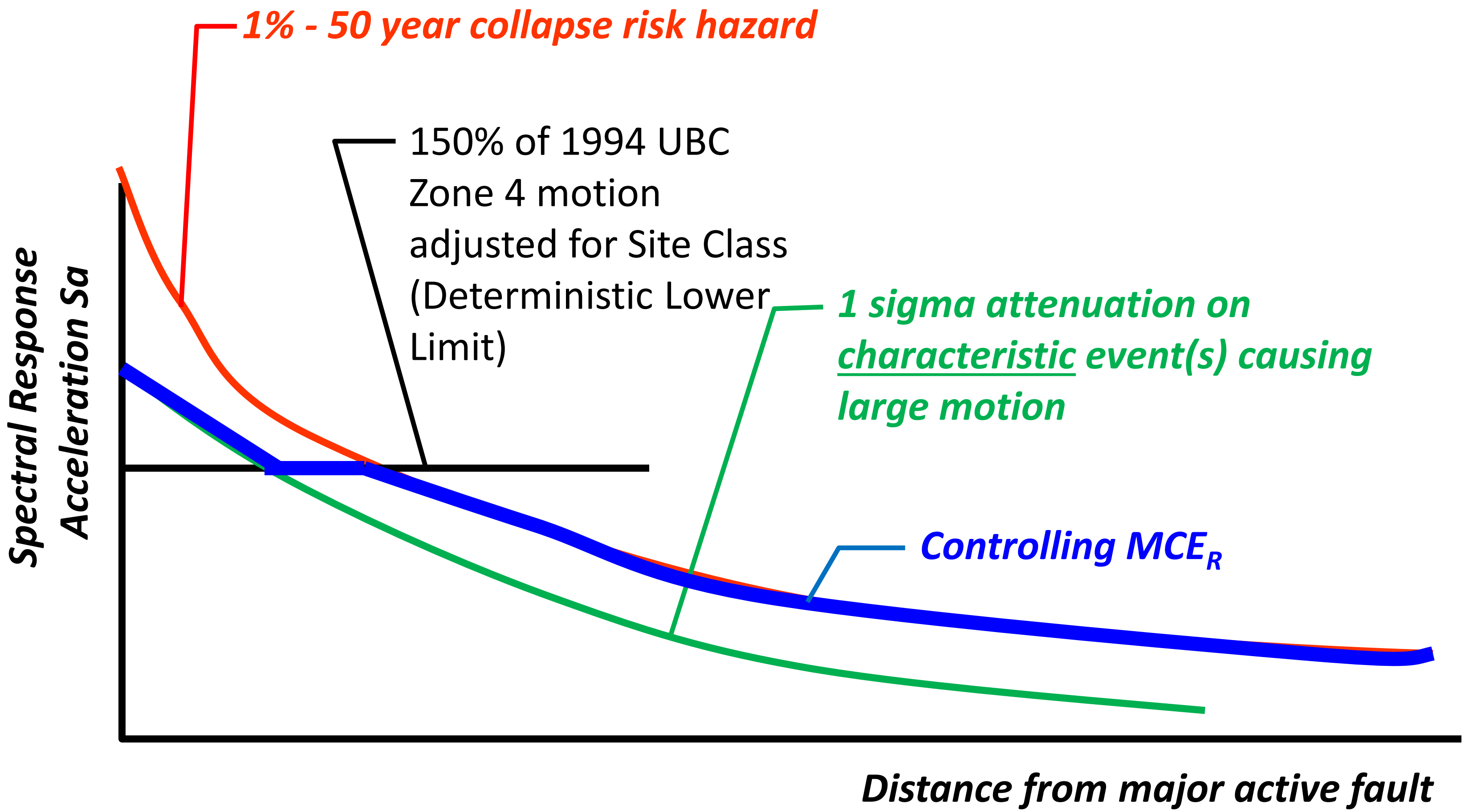
… e.g., for 2,500-year ground motions …

$$\frac{1}{2{,}500\ years} = \frac{1}{1{,}200\ years} \times (1 - 56\%)$$

$$\frac{1}{2{,}500\ years} = \frac{1}{150\ years} \times (1 - 94\%)$$

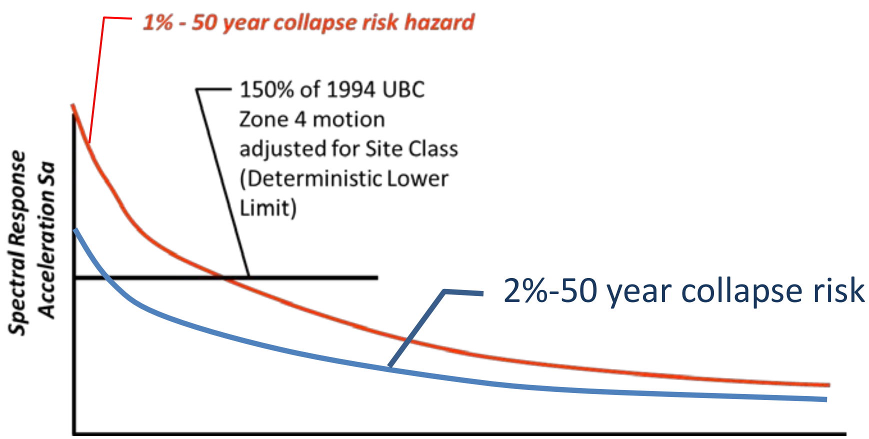
Because uncertainties in ground motion are high, high percentiles result in very large motions

Target Chaking Level (MCE_R)



Characteristic Earthquake

- UCERF 4 eliminated the concept of characteristic earthquake
    1. Reduce the return period for MCE shaking & eliminate need for deterministic limits



Results in increased risk nationwide

Characteristic Earthquake

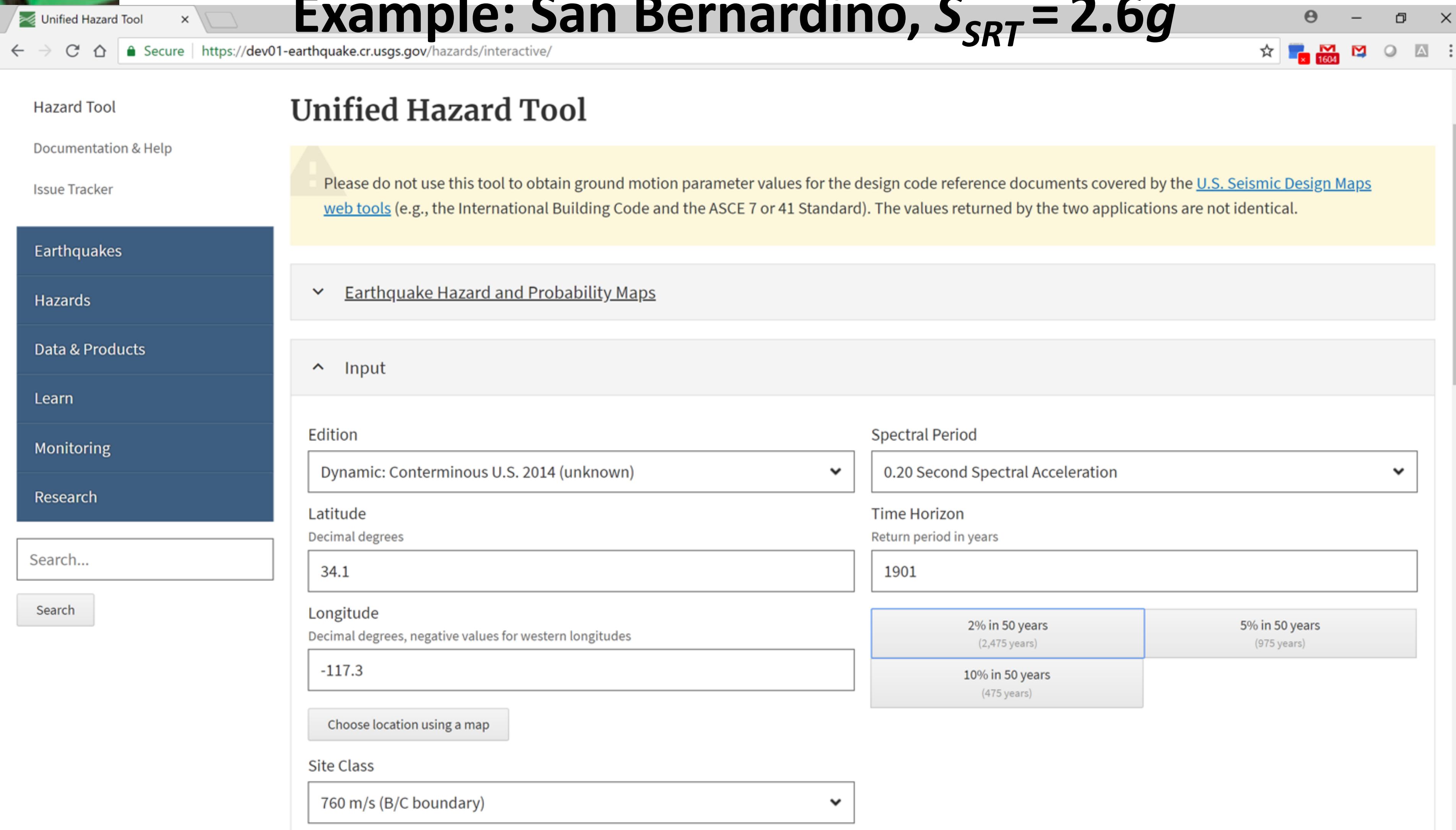
2. Retain current MCE_R but find alternative way to define deterministic limits
   – Select deterministic limit based on limiting “epsilon” (ground motion percentile) for faults contributing significantly to the earthquake hazard on strong shaking sites

Proposal: Procedure at Each Location

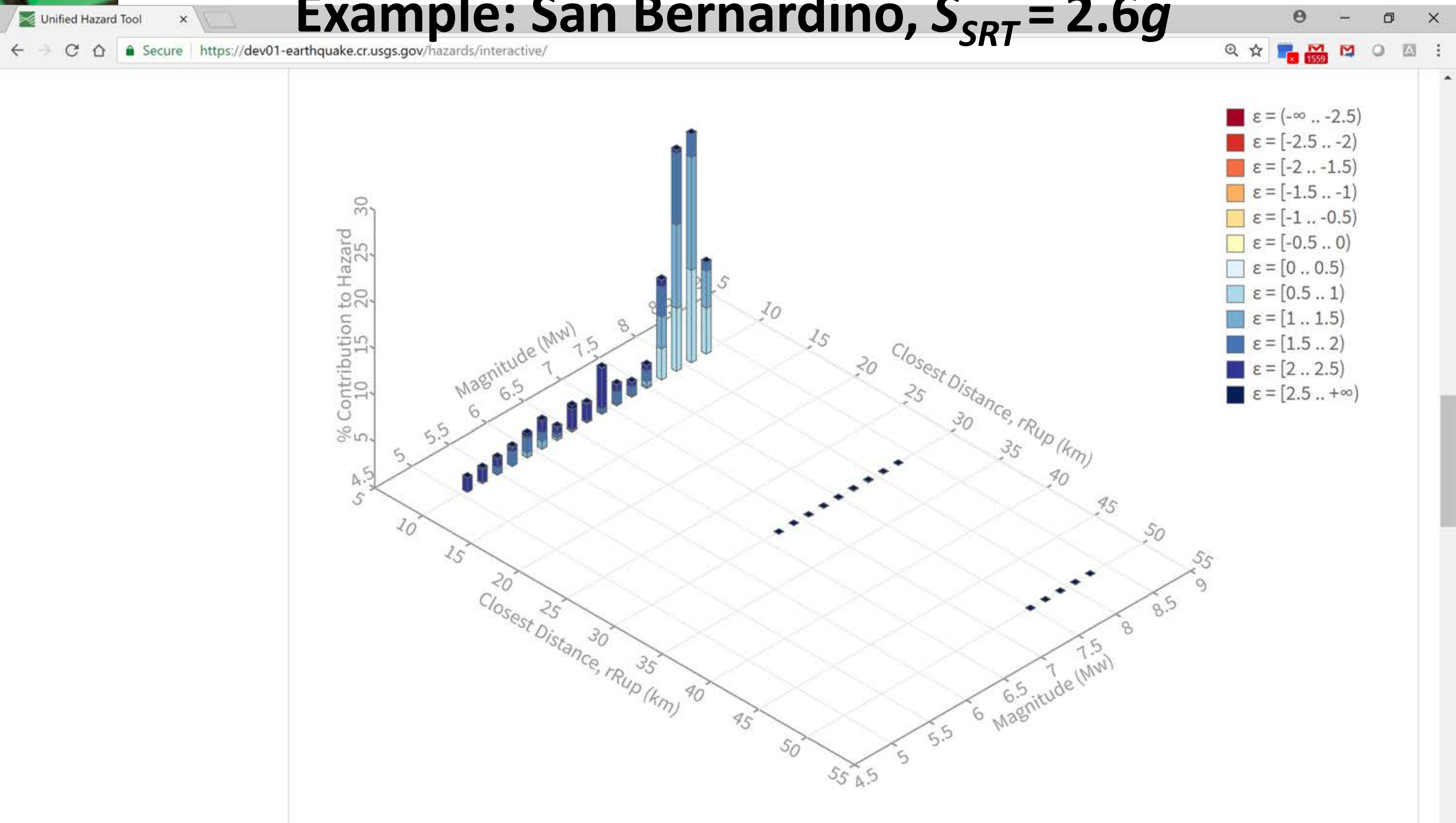
1. Compute Risk-Targeted Ground Motion (**RTGM**).
2. If RTGM exceeds "Deterministic Lower Limit" (150% of 1994 UBC adjusted for site class)

   - At RTGM return period, **deaggregate hazard**.
   - From deaggregation, obtain **deterministic scenarios** that could result in RTGM *(i.e., fault/source names, magnitudes, distances, epsilons, relative likelihoods)*.
   - **Adjust** each deterministic scenario to 84th-percentile ground motion by dividing RTGM by …
     - $\exp(\text{Epsilon}\cdot\sigma) / \exp(1\cdot\sigma)$
   - Use **largest** 84th-percentile ground motion amongst deterministic scenarios with relative likelihood ≥x%.
   - Use lesser of deterministic motion, probabilistic motion, but not less than deterministic floor

Example: San Bernardino, $S_{SRT} = 2.6g$



Example: San Bernardino, $S_{SRT} = 2.6g$



Example: San Bernardino, $S_{SRT} = 2.6g$

Unified Hazard Tool
Secure https://dev01-earthquake.cr.usgs.gov/hazards/interactive/

Deterministic scenarios that could result in 2.6g …

Epsilon≤1.0 S_S

$\boxed{2.4\ g}$

$1.7\ g$

Source Name	Distance (km)	Magnitude	Epsilon	Relative Likelihood
San Jacinto	1.9	8.0	1.1	46%
San Andreas	8.4	7.6	1.7	34%

Capping the epsilons of these scenarios at 1.0 results in 84th-percentile deterministic ground motions.

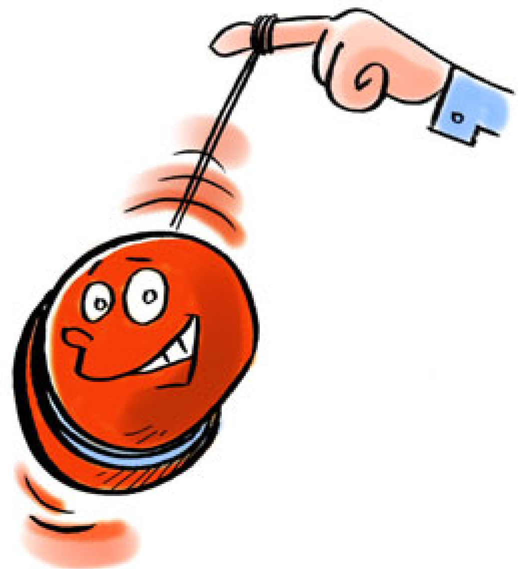
ASCE 7-16 S_S = 2.3*g* (from San Jacinto, *M*=7.7)

Following the current *ASCE 7-16* deterministic capping procedure, use the largest 84th percentile ground motion.

Building Seismic Safety Council
a council of the National Institute of Building Sciences

Project 17

YO-YO EFFECT



nehrp

FEMA

USGS
science for a changing world

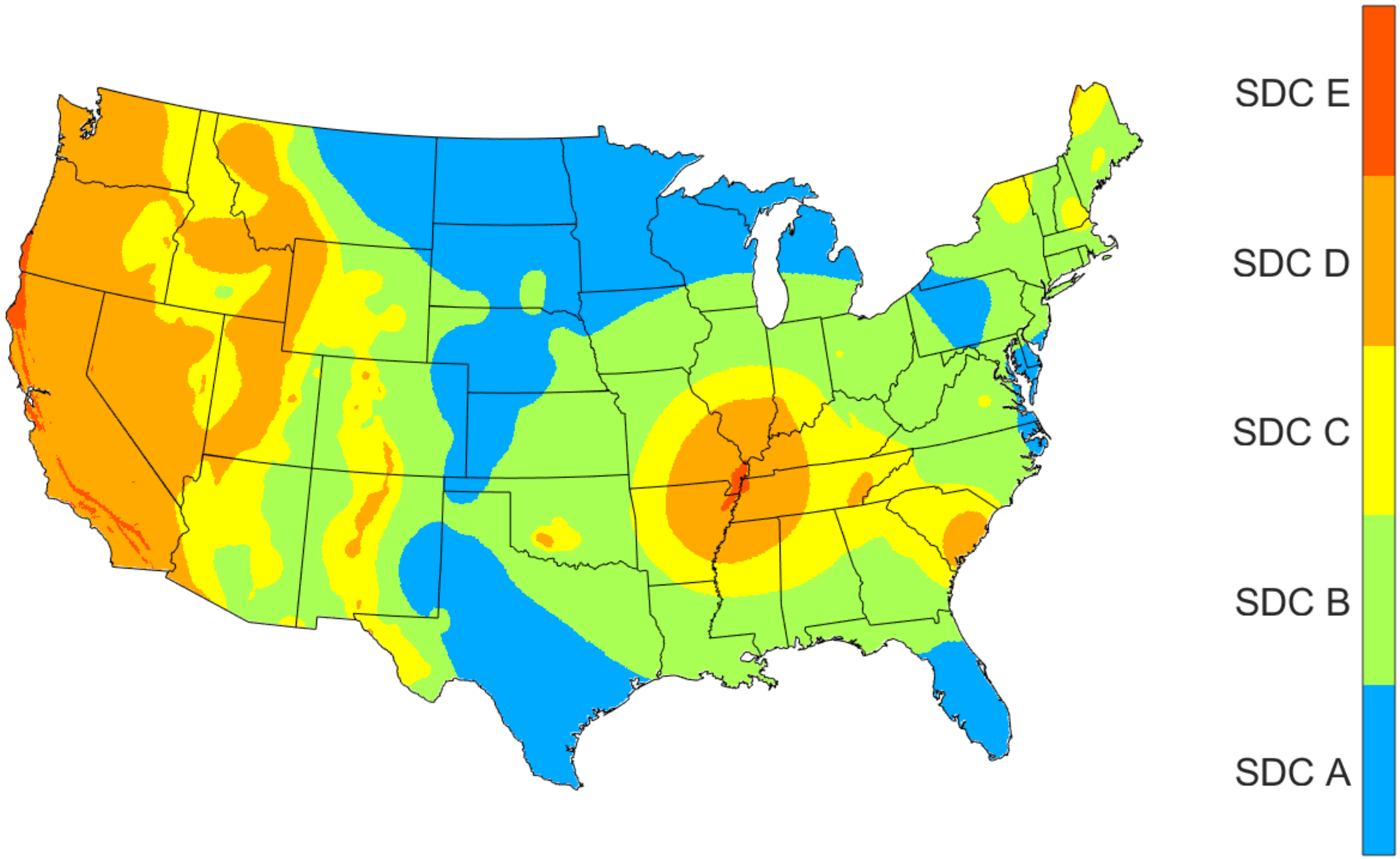
Yo-Yo Effect

- Looked at ways of smoothing ground motion changes with code editions:
  - Reduce significant figures with which motions are reported (10% changes won't be noticeable)
  - Use weighted average approach to develop maps (50% new model, 25% past model, 25% earlier model)
- Minor (+/-15%) changes in ground motion values are annoying but not generally problematic
- Switches in SDCs are problematic

Stabilizing SDCs Recommendation

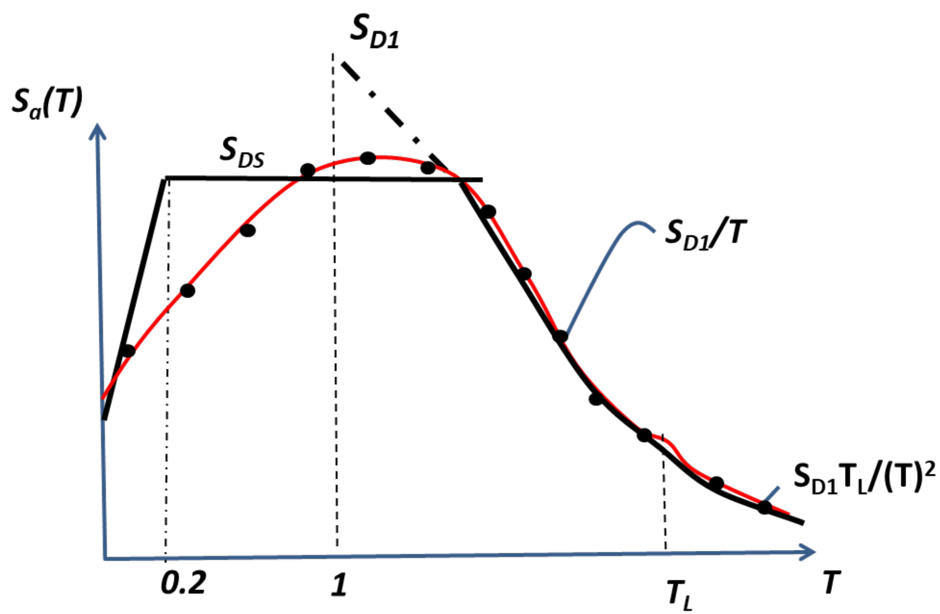
- Use separate SDC map to indicate designation of Design Categories
  - Map tied to ground motion values for a default site class
  - PUC uses judgement to move SDC boundaries or not, depending on reason for increase or decrease in motion and the magnitude of this
- Downsides:
  - Some structures designed too conservative
  - Lot of work for future PUC's

SDC Map



SPECTRAL SHAPE ADJUSTMENT

Multi-point Spectrum



- Values provided at multi periods ranging from 0 to 10 seconds
- F_a and F_v no longer used, sile class used directly in hazard analysis
  - Somewhat finer gradation in site classes
- S_{DS} taken as 90% of max spectral response
- S_{D1} selected, so as to fit the spectral shape

Summary

- Project 17 has passed recommendations to PUC for implementation
- Will develop final project report by September 30, 2018