

**Site-Specific  $MCE_R$  Response Spectra  
for  
L.A. Region from  
3-D Numerical Simulations &  
NGA West2 GMPEs**

**C.B. Crouse**

**AECOM**

UGMS Meeting: November 8, 2017

**MCE<sub>R</sub> Spectra Developed by the SCEC**

**Utilization of Ground-Motion  
Simulations Committee (UGMS)**

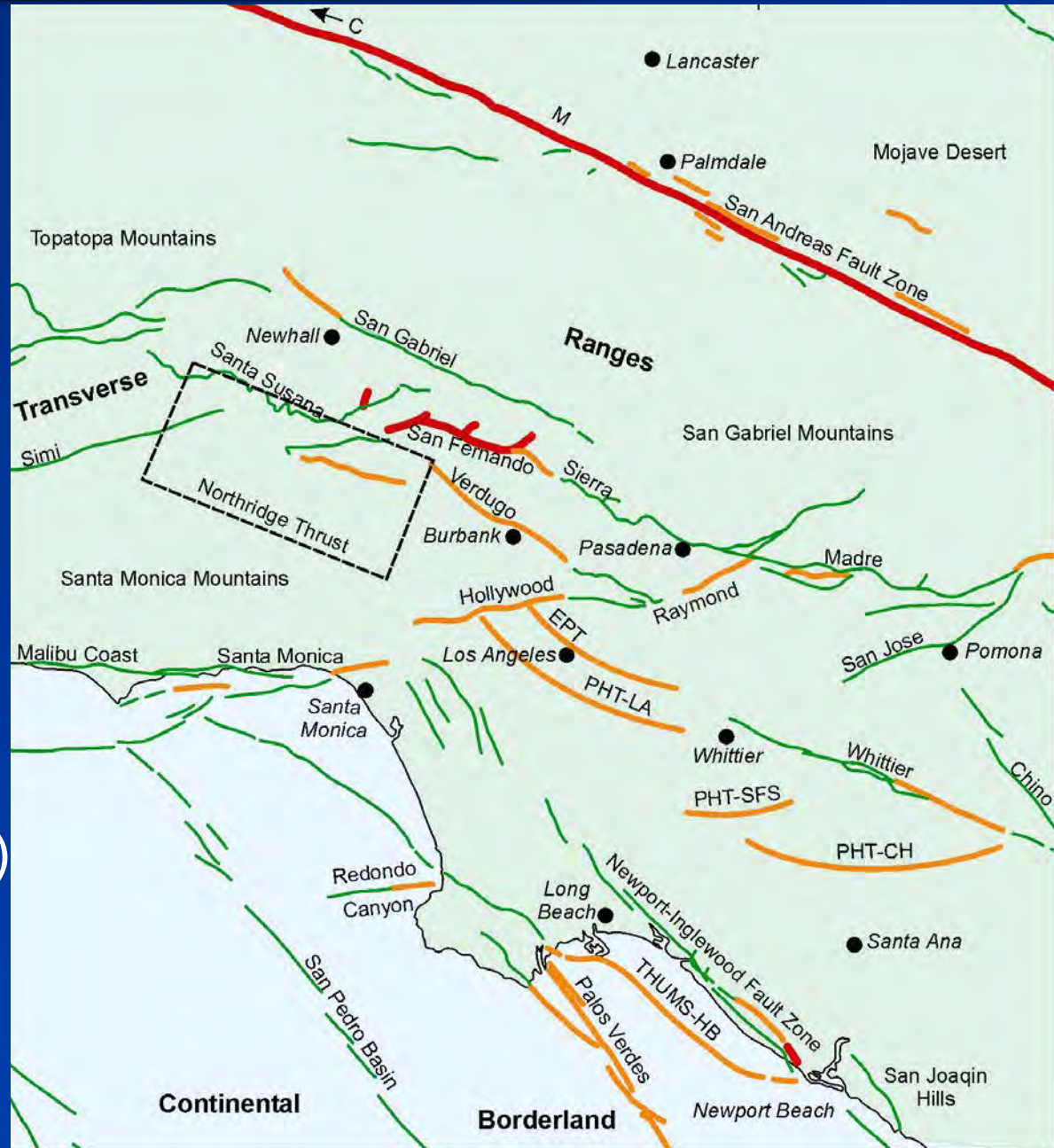
**Formed in 2013**

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# 3-D Simulation Approach

1. Use UCERF2  $M_w$  recurrence models
2. Do simulations  
↓  
H1 & H2 accel.  $a(t)$   
↓  
response spectra,  $S_a(T)$   
↓  
median  $S_a(T)$  &  $\sigma_{ln}$
3. Proceed with PSHA/DSHA (C. 21, ASCE 7-16)
4.  $MCE_R$  Response Spectra

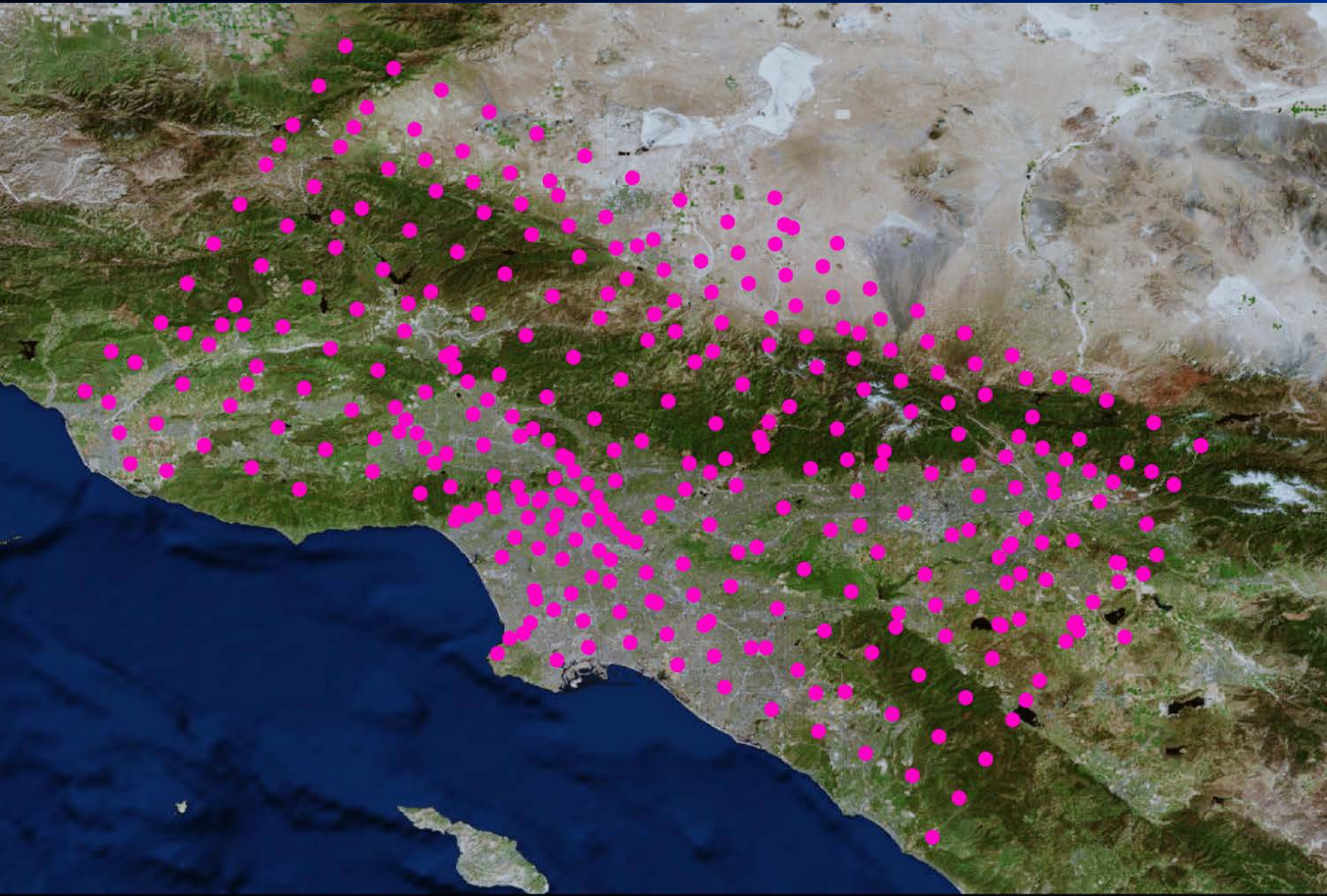


# CyberShake Computational Platform used for Simulations

- 3-D physics-based model of fault rupture and wave propagation for S. CA EQs
- 40,000 regional earthquakes ( $M_w \geq 6$ ) simulated from UCERF2.0 (2008)
  - Multiple hypocenter and slip models for each given  $M_w$  on given fault
  - e.g., 140 models for  $M_w 6.7$  on Northridge fault ( $\sim$  no. for other  $M_w$  on this fault)
- 440,000 ground-motion simulations for each of  $\sim 300$  sites

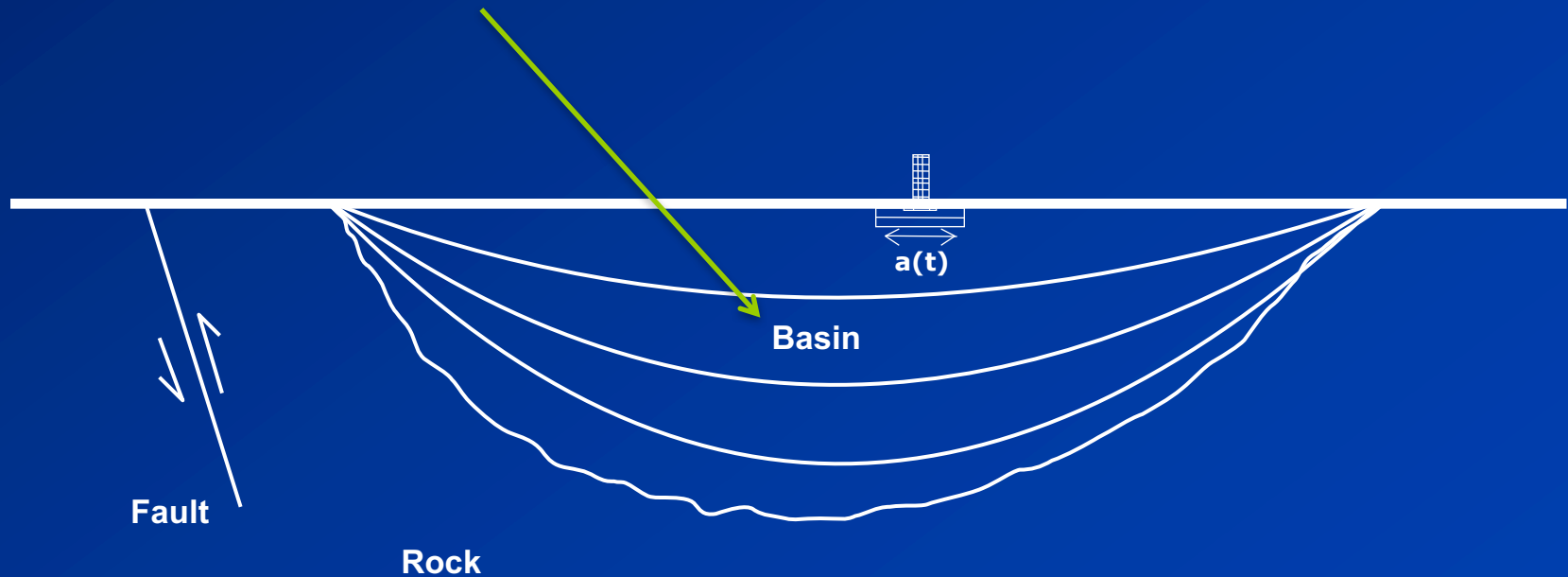


# Simulated Motions computed at ~300 CyberShake Sites



# Advantages of 3D Simulations for L.A. Region

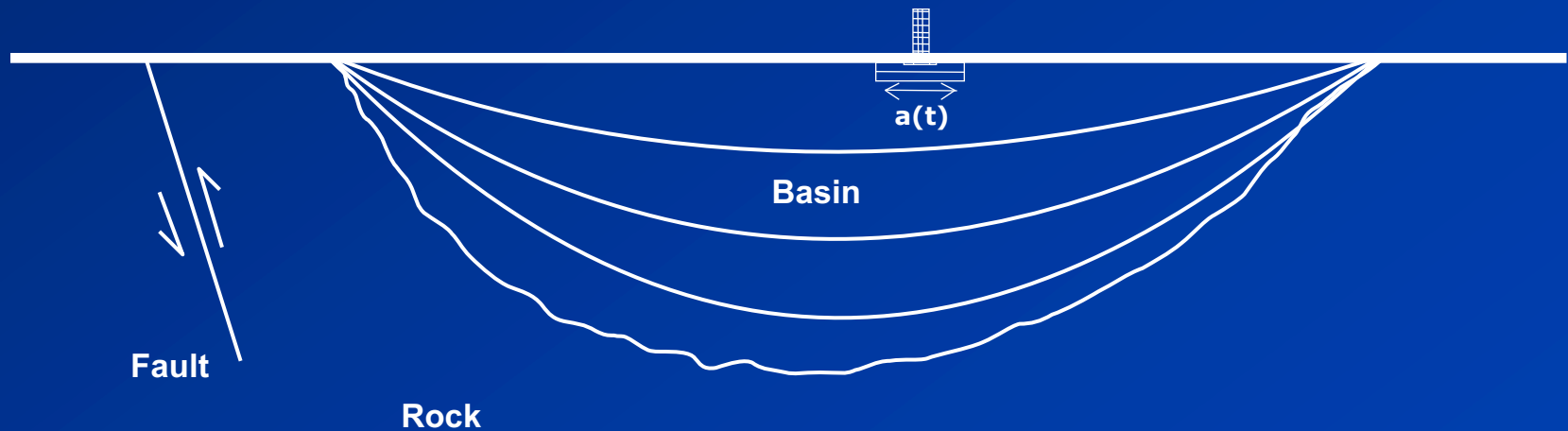
Basin Structure,  $V_p$ ,  $V_s$ , &  $Q$  – Well known for modeling propagation of longer period waves.



# Validation of Simulations

Validated against recordings from moderate  $M$  events.

UGMS has done limited validations for 1994  $M_w$  6.7 Northridge earthquake.



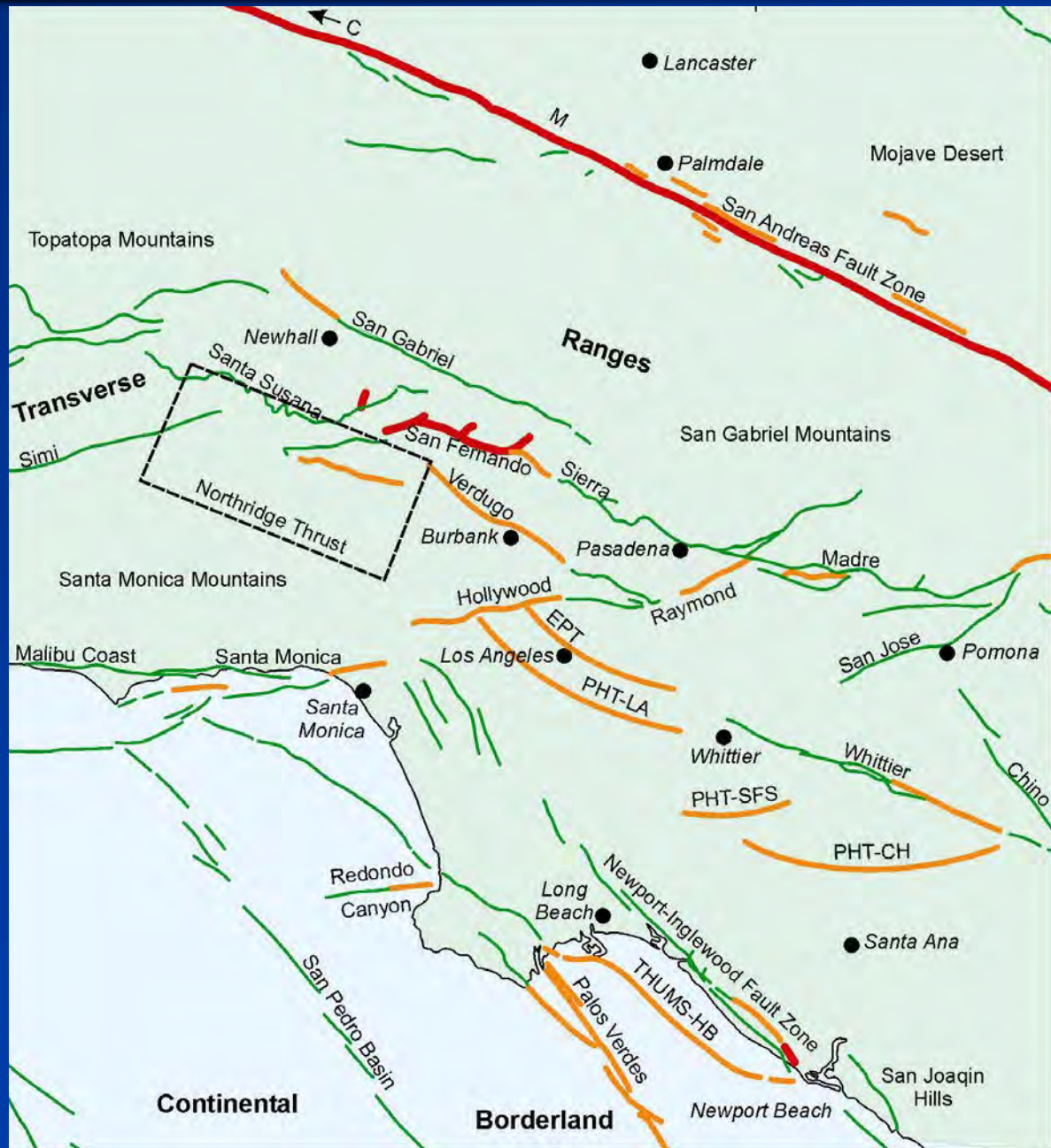


# M8 Simulation on San Andreas



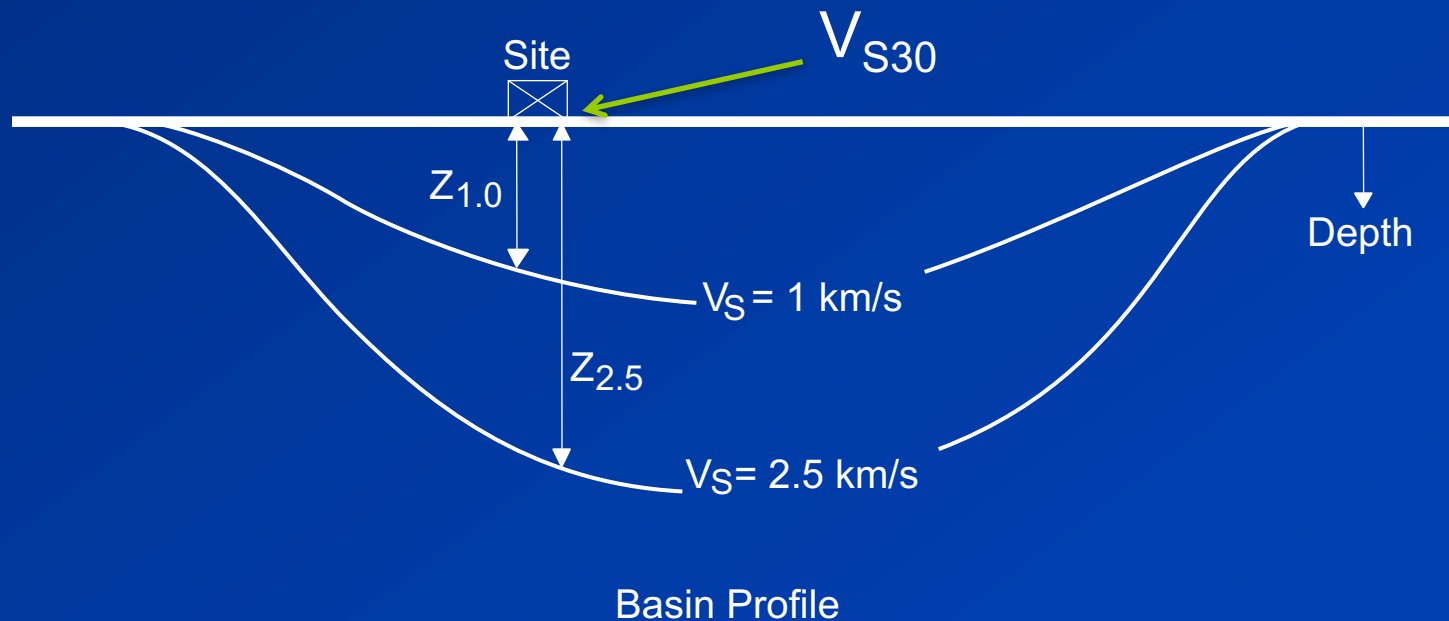
# Site-Specific Approach using NGA West2 GMPEs

1. Use UCERF3  $M_w$  recurrence models
2. Select ground-motion eqns.
  - Four NGA West 2 eqns.
    - basin depth ( $Z_{1.0}$  or  $Z_{2.5}$ )
    - Shear-wave vel. ( $V_{S30}$ )
  - Substitute  $Z_{1.0}$ ,  $Z_{2.5}$ ,  $V_{S30}$  values into eqns.
3. Proceed with PSHA/DSHA (C. 21, ASCE 7-16)
4.  $MCE_R$  Response Spectra



# 2013 NGA West2 Equations with Basin Depth Terms

- Abrahamson et al –  $Z_{1.0}$
- Boore et al –  $Z_{1.0}$
- Campbell & Bozorgnia –  $Z_{2.5}$
- Chiou & Youngs –  $Z_{1.0}$



# Why New $MCE_R$ are Improvement to $MCE_R$ from Chapter 11

## ASCE 7-16

- Site-Specific for Los Angeles Region
- Better job in accounting for:
  - local & regional geology
  - fault directivity & fling (CyberShake)
  - 3-D effects of fault rupture & basin structure on ground motion (CyberShake)



# Why New $MCE_R$ are Improvement to $MCE_R$ from Chapter 11

## ASCE 7-16

- Eliminates need for  $F_a$  &  $F_v$  tables, which:
  - Don't directly account for basin effects
  - Have step changes at site-class boundaries
  - Are constant for each site class, which covers broad range of  $V_{s30}$

## MCE<sub>R</sub> Response Spectra

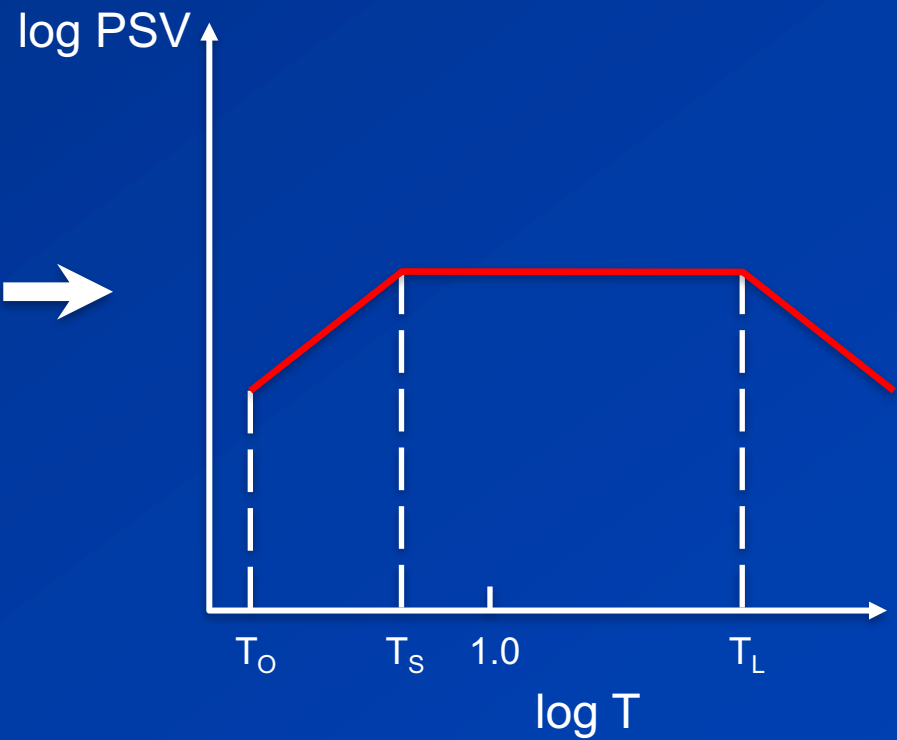
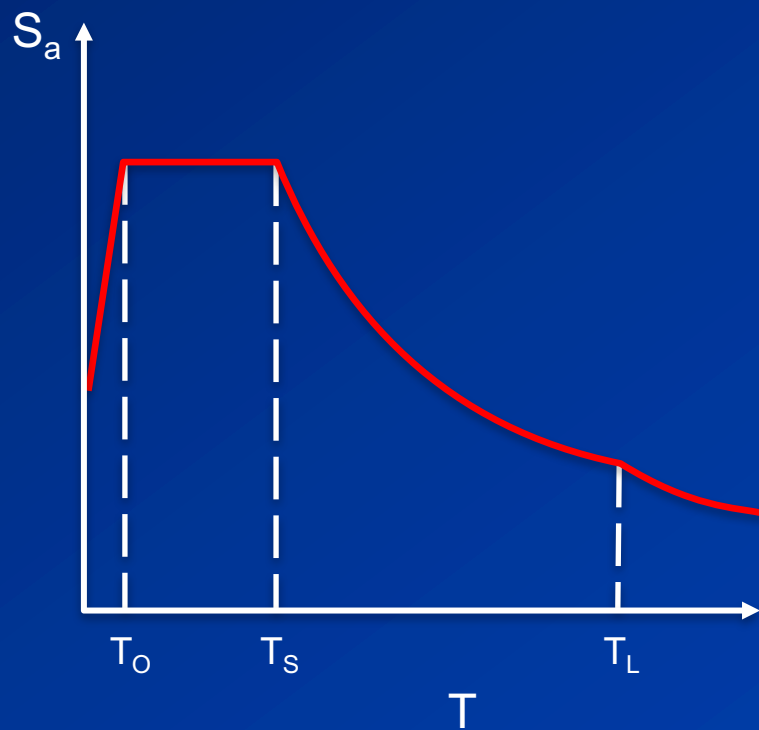
- CyberShake ( $T = 2 - 10$  sec)
- NGA West2 GMPEs ( $0 - 10$  sec)

## Determination of $MCE_R$ Response Spectra, $T = 2 - 10$ sec

- Computed  $MCE_R$  from both approaches at selected sites in L.A. area
- Developed procedure for combining two  $MCE_R$
- Checked final  $MCE_R$  for many L.A. area sites

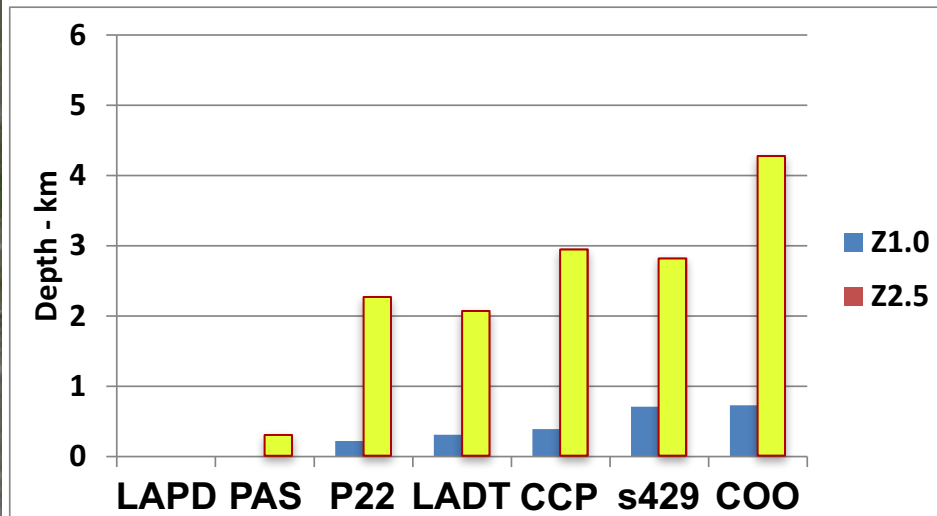
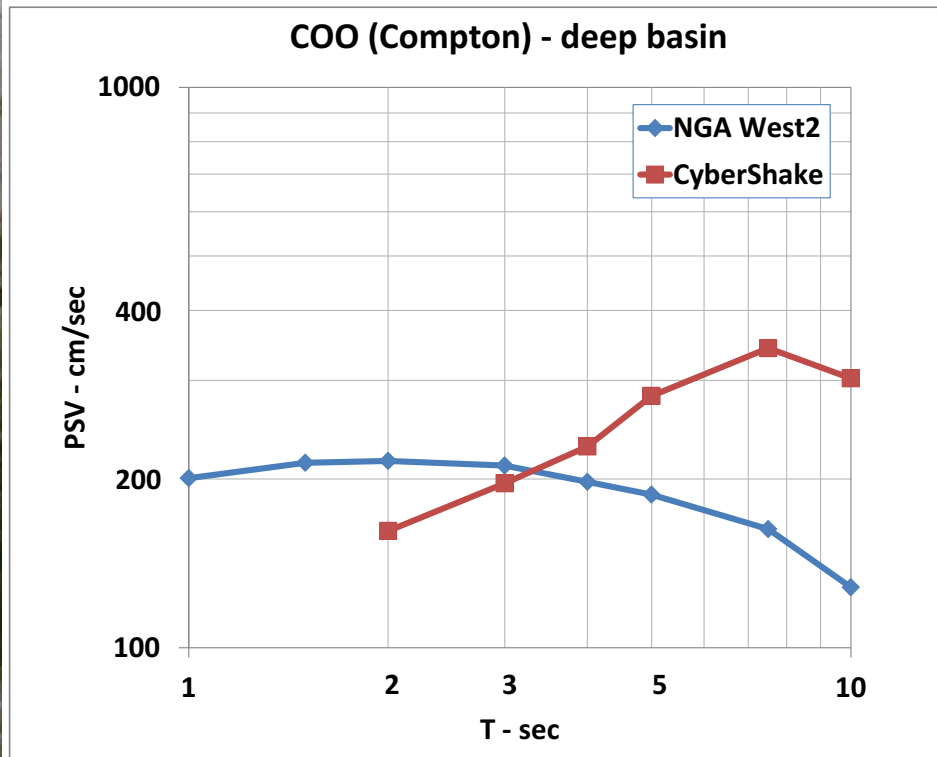
# Transform $S_a$ to PSV

$$\text{PSV} = (T/2\pi)S_a$$





# MCE<sub>R</sub> PSV for 7 Sites to Illustrate Trends



# Weighted Averaging of MCE<sub>R</sub> Response Spectra

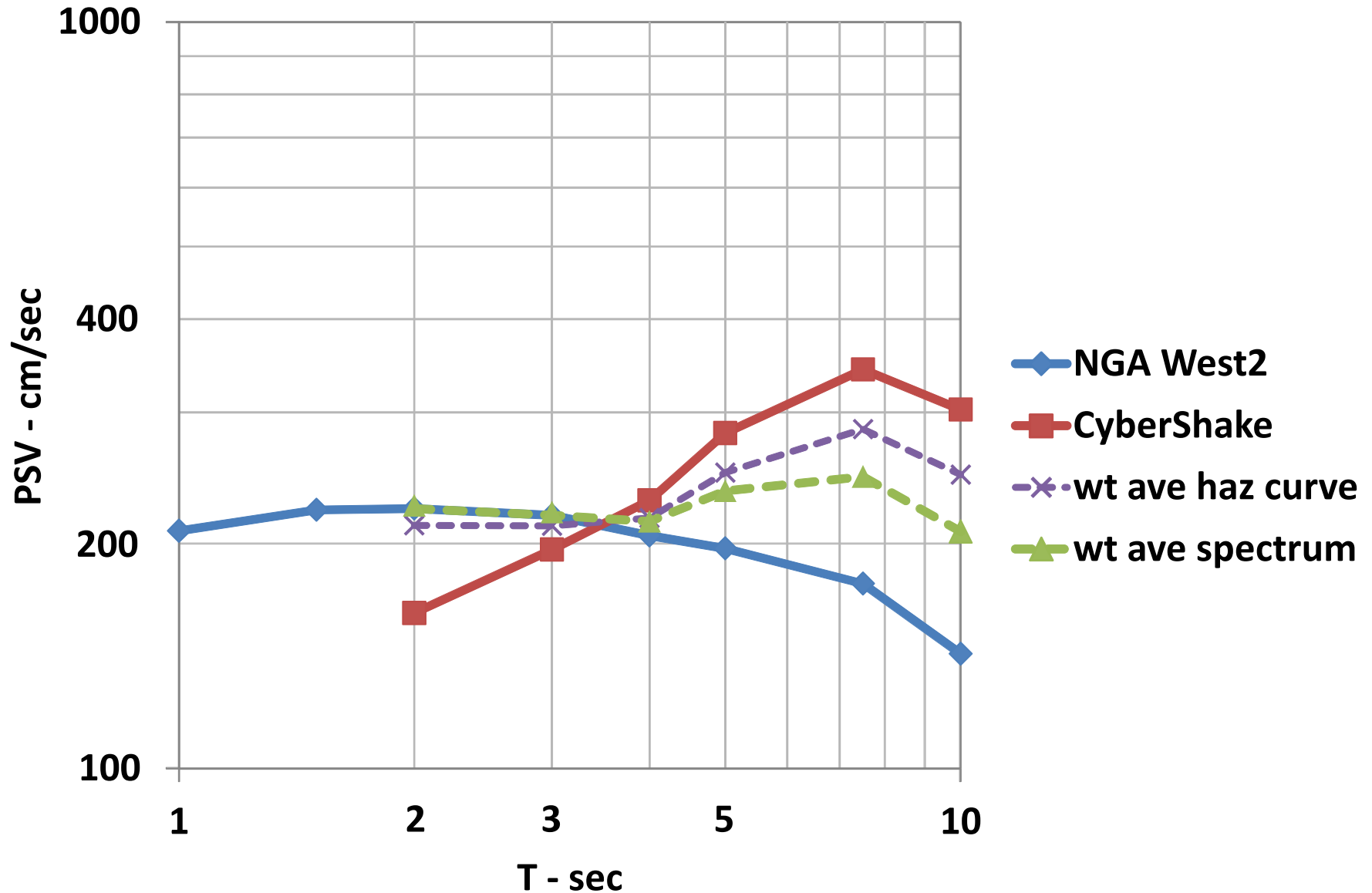
Source Model

G-M Models

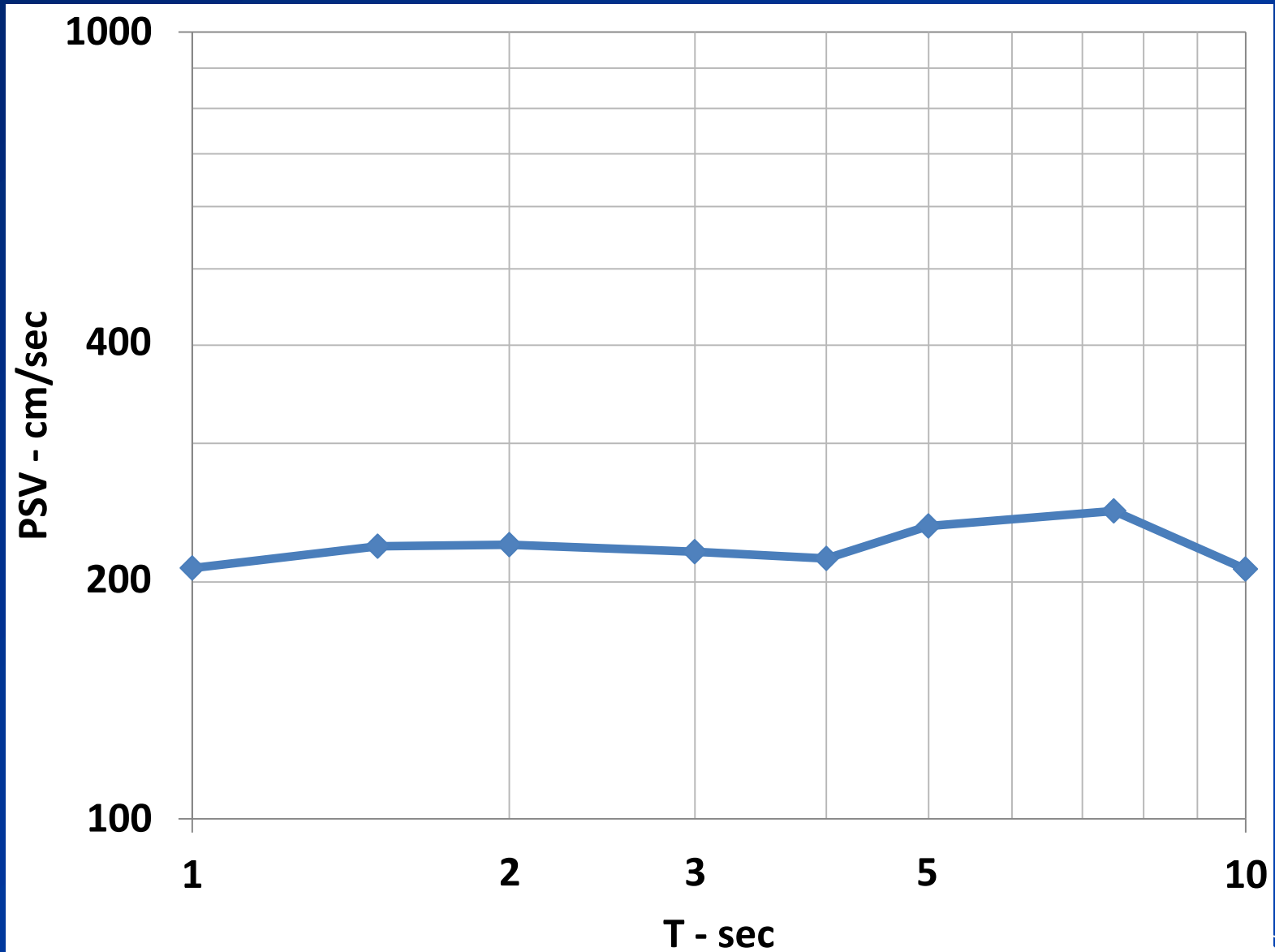
Weights

	GMPE		Collective Weights for Periods, T - sec				
	NGA West2	Individual Weight	< 2	2	3	4	≥ 5
UCERF3	AKS	0.25	1	0.8	0.7	0.6	0.5
	BASS	0.25					
	CB	0.25					
	CY	0.25					
UCERF2	CyberShake		0	0.2	0.3	0.4	0.5

# COO (Compton) - Deep Basin

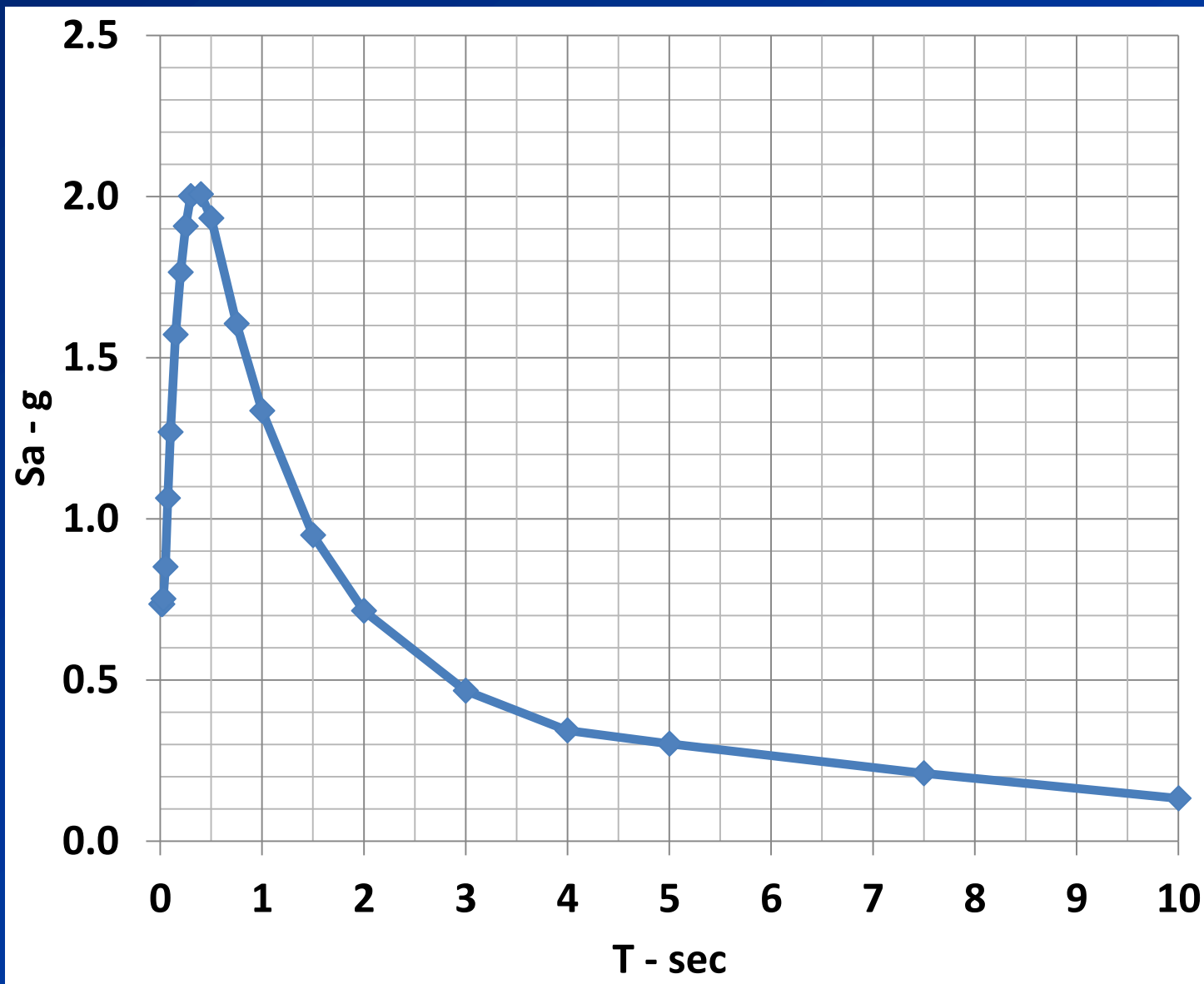


# $MCE_R$ : COO (Compton) - Deep Basin

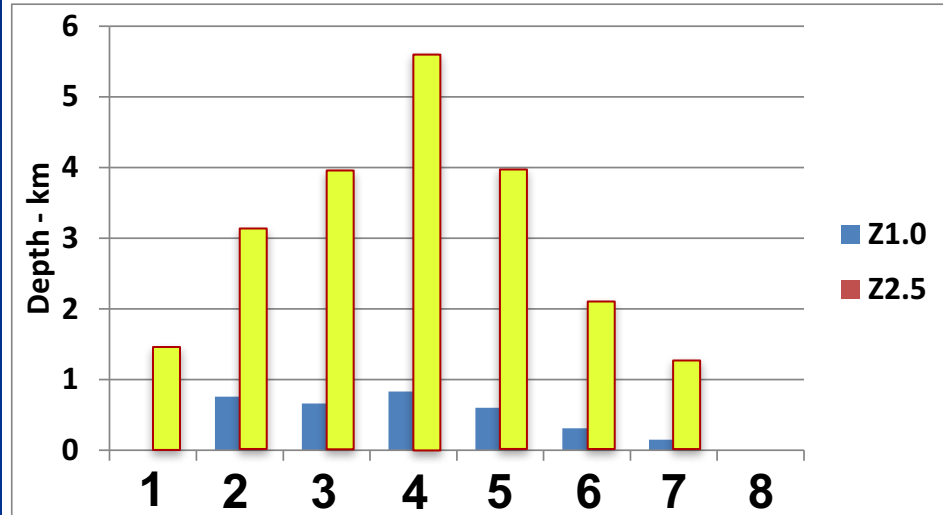
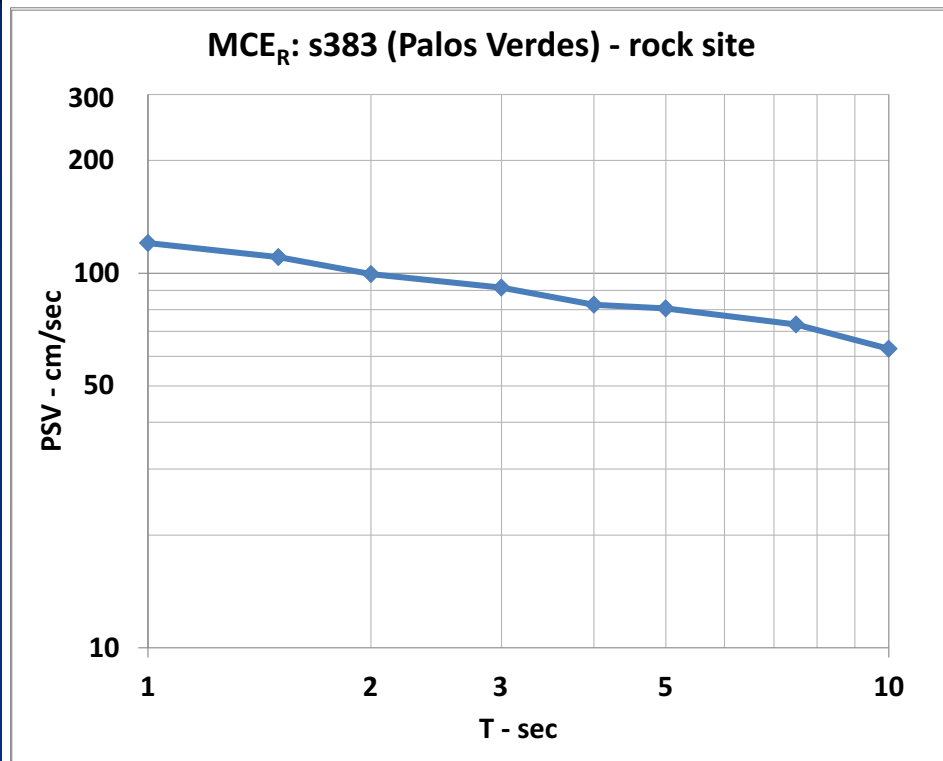




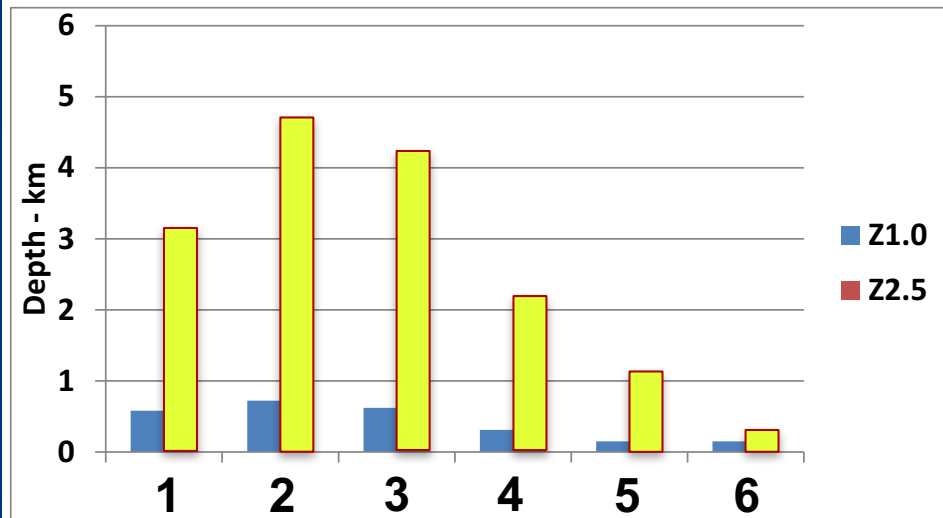
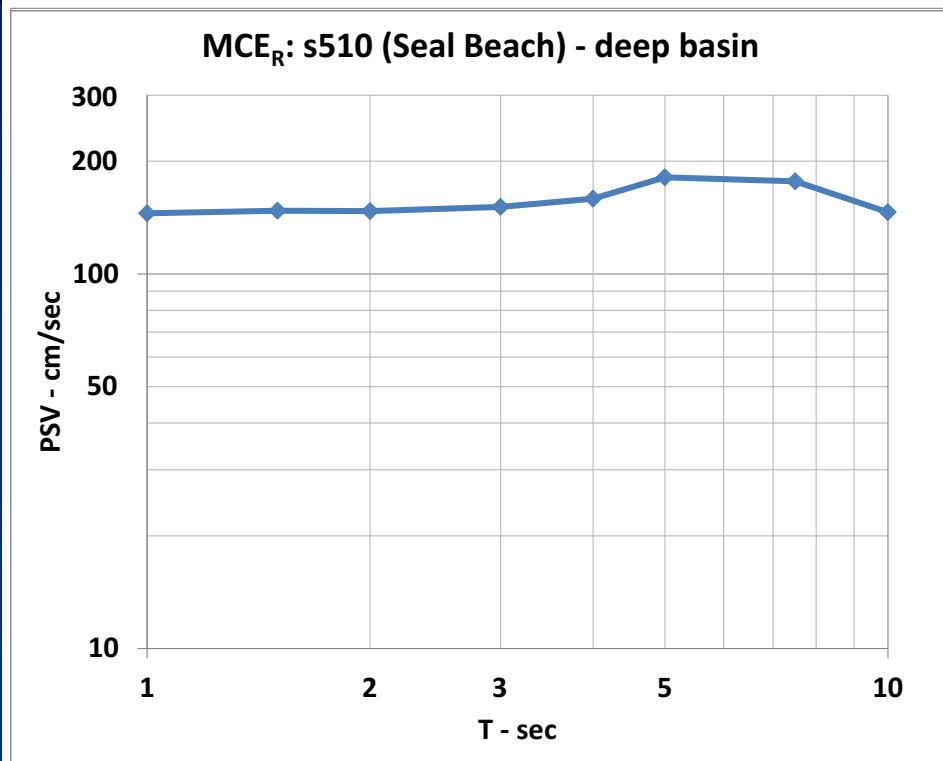
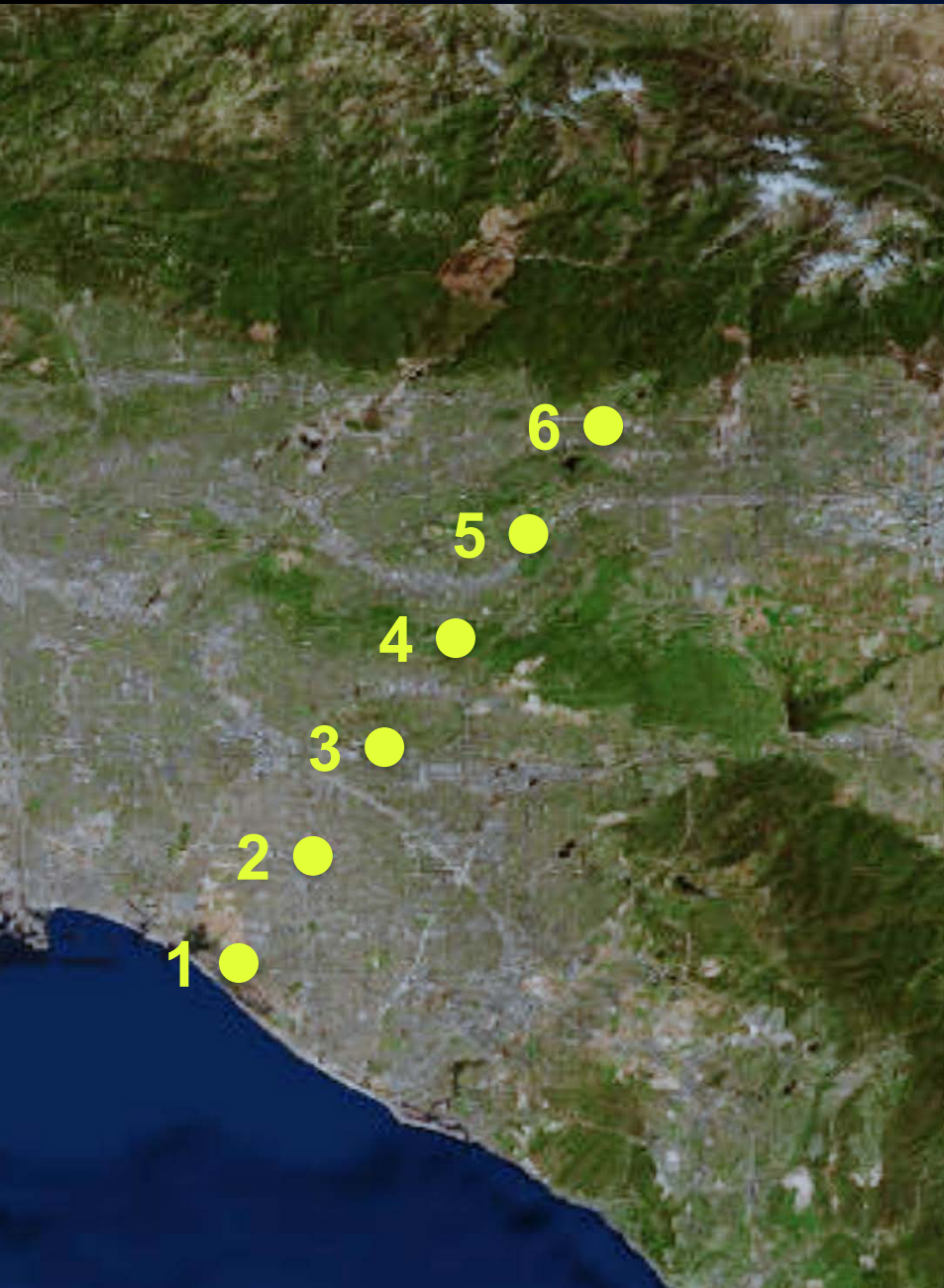
# $MCE_R$ : COO (Compton) - Deep Basin



# Line 1



# Line 2



## Intermediate Goal of UGMS

- Site-Specific  $MCE_R$  for L. A. area
  - Alternative to ASCE 7-16 “maps” (Ch 22) for Southern California and  $F_a$  &  $F_v$  (Ch 11)
  - Resource to city/county officials & geotechnical & structural engineers
- SCEC/UGMS look-up tool
  - ~ USGS web app tool



**Provides site-specific  
 $MCE_R$ , DE &  $PGA_M$**

**Beta version available**

# Future Additions to Look-Up Tool

- Deaggregation Data
  - M-Distance
  - Fault
- Acceleration Time Histories
  - San Andreas M~8 events
- BSE-1 & BSE-2 (ASCE 41-13)

