Site-Specific Earthquake Motions for Design of Structures in L.A. Region from 3-D Numerical Simulations & NGA West2 GMPEs

C.B. Crouse

AECOM

USGS NSHMP Meeting: March 8, 2018

Project to Develop Earthquake Motions Undertaken by

Utilization of Ground-Motion Simulations Committee (UGMS) of Southern California Earthquake Center (SCEC)

Formed in 2013

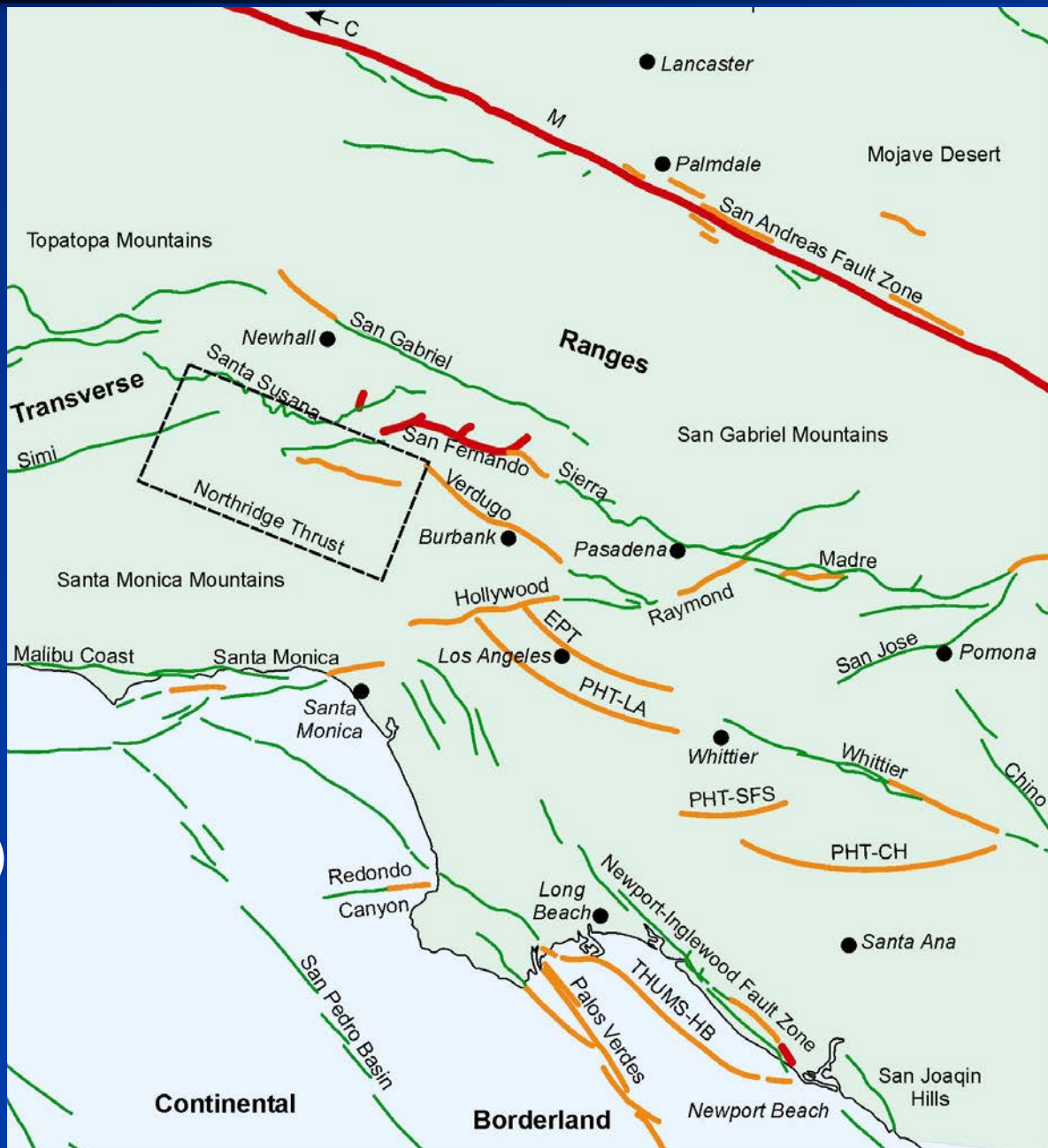
UGMS Committee Members

- C. Crouse – Chair
- T Jordan – SCEC
- N. Luco – USGS
- R. Bachman
- J. Hooper – MKA
- J. Bielak – CMU
- C. Kircher
- M. Hudson – AMEC
- M. Lew – AMEC
- R. Hamburger - SGH
- A. Frankel – USGS
- N. Abrahamson – PG&E
- R. Graves – USGS
- F. Naeim
- C. Hazelton – CSC
- P. Somerville – AECOM
- Jack Baker – Stanford
- J. Anderson – UNR
- S. Rezaeian – USGS
- C. Goulet – SCEC

SCEC

3-D Numerical Simulation Approach

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

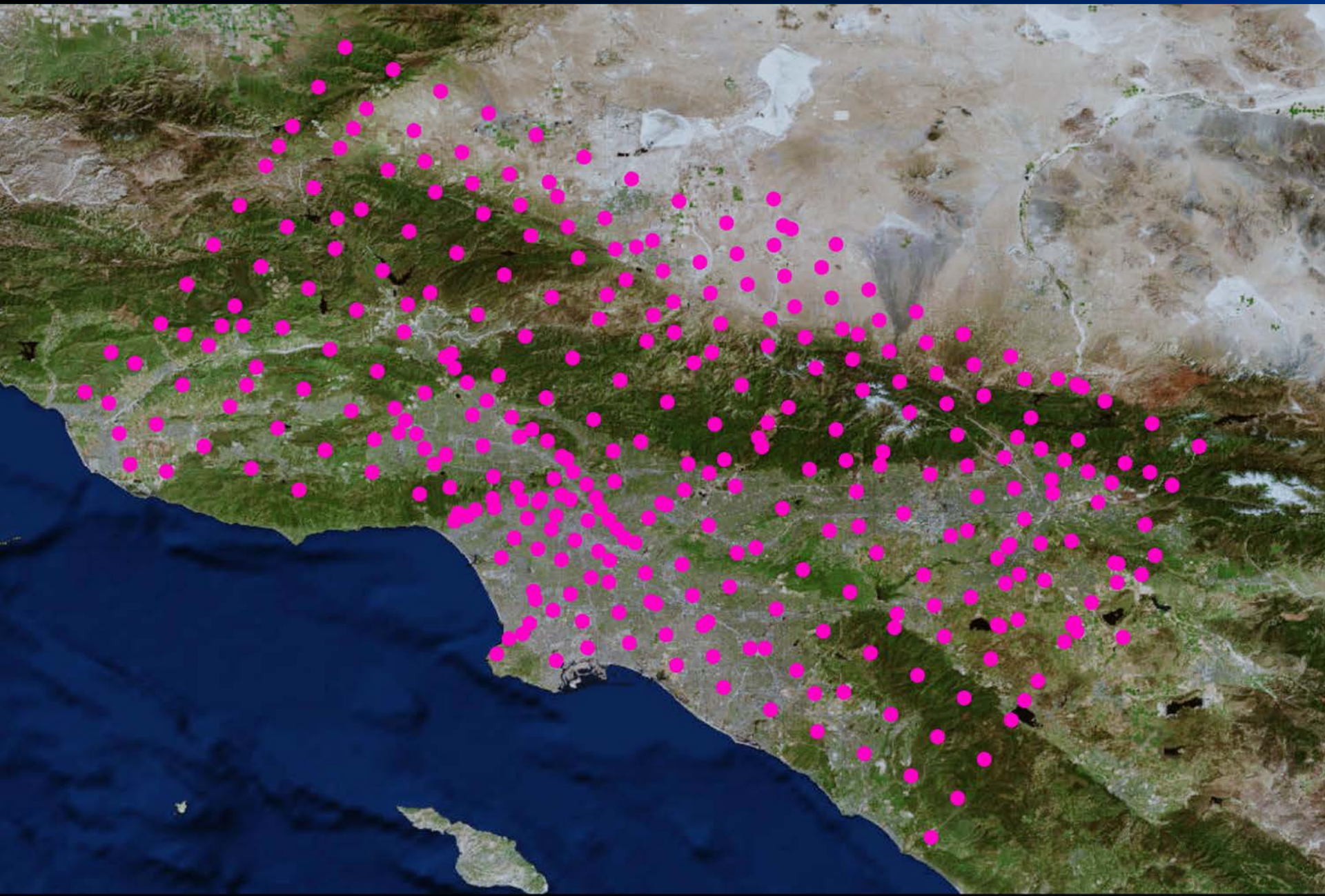


CyberShake Computational Platform used for Simulations

- 3-D physics-based model of fault rupture and wave propagation for S. CA EQs
- 40,000 regional earthquakes (M ≥ 6) were simulated
  - Multiple hypocenter and slip models for each given M on given fault
  - e.g., 140 models for M6.7 on Northridge fault (~ no. for other M on this fault)
- 440,000 ground-motion simulations for each of 336 sites

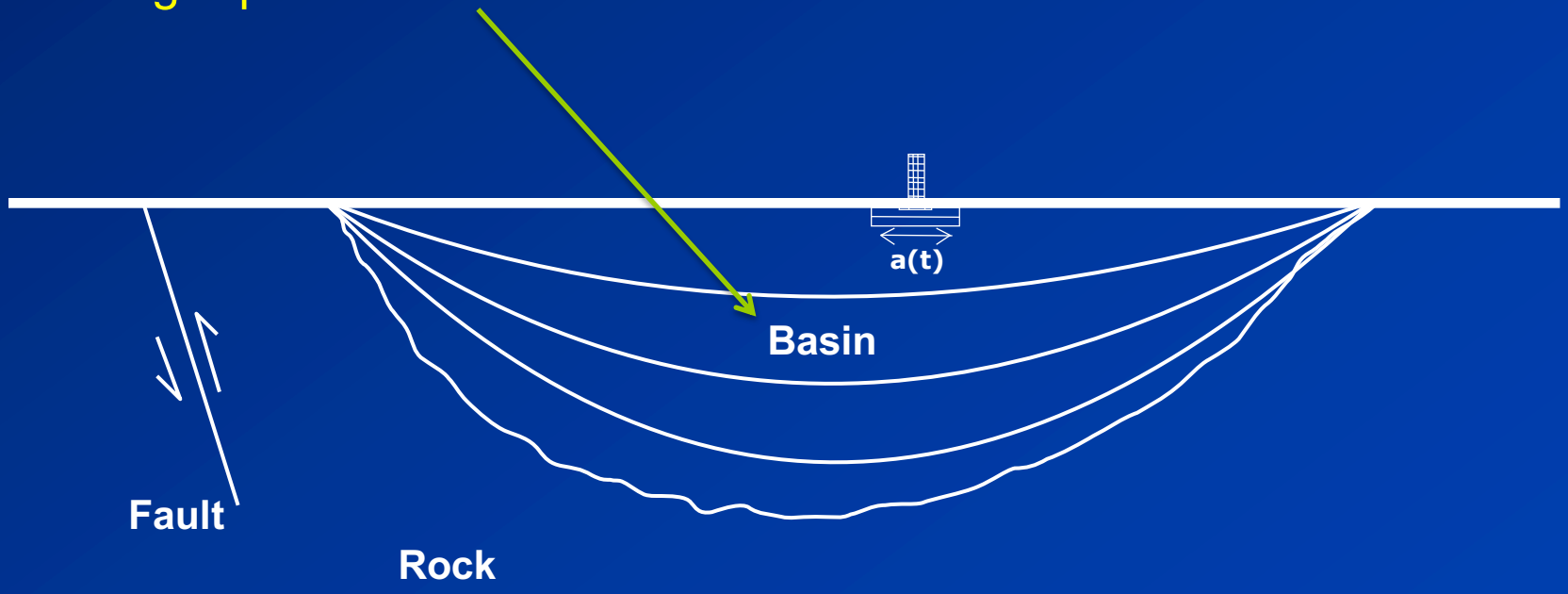
SCEC

Simulated Motions computed at 336 CyberShake Sites



Advantages of 3D Simulations for L.A. Region

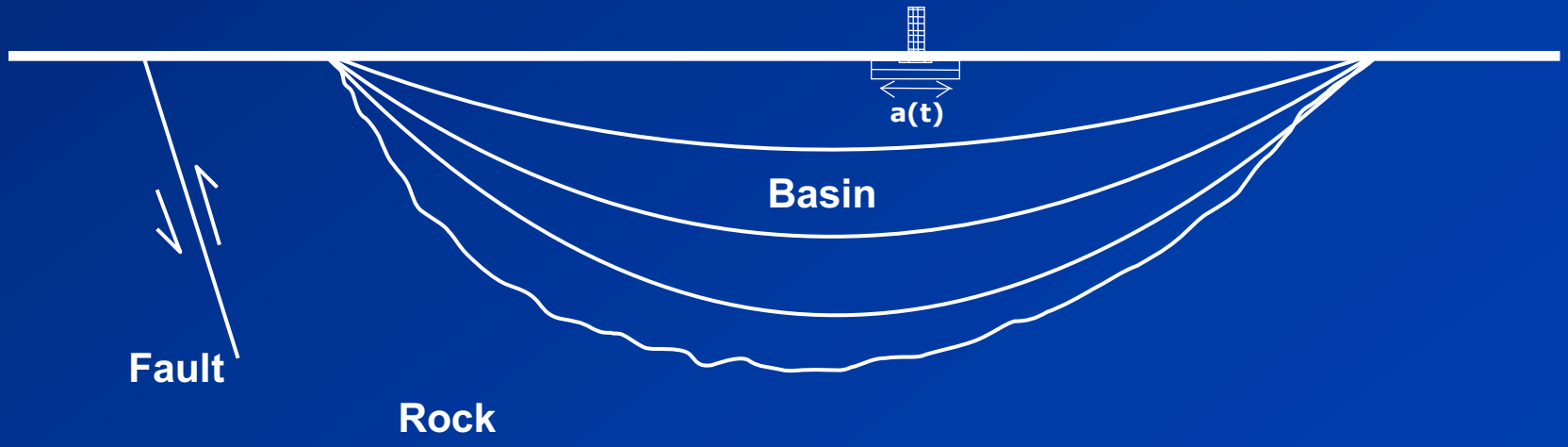
Basin Structure, Vp, Vs, & Q – Well known for modeling propagation of longer period waves.



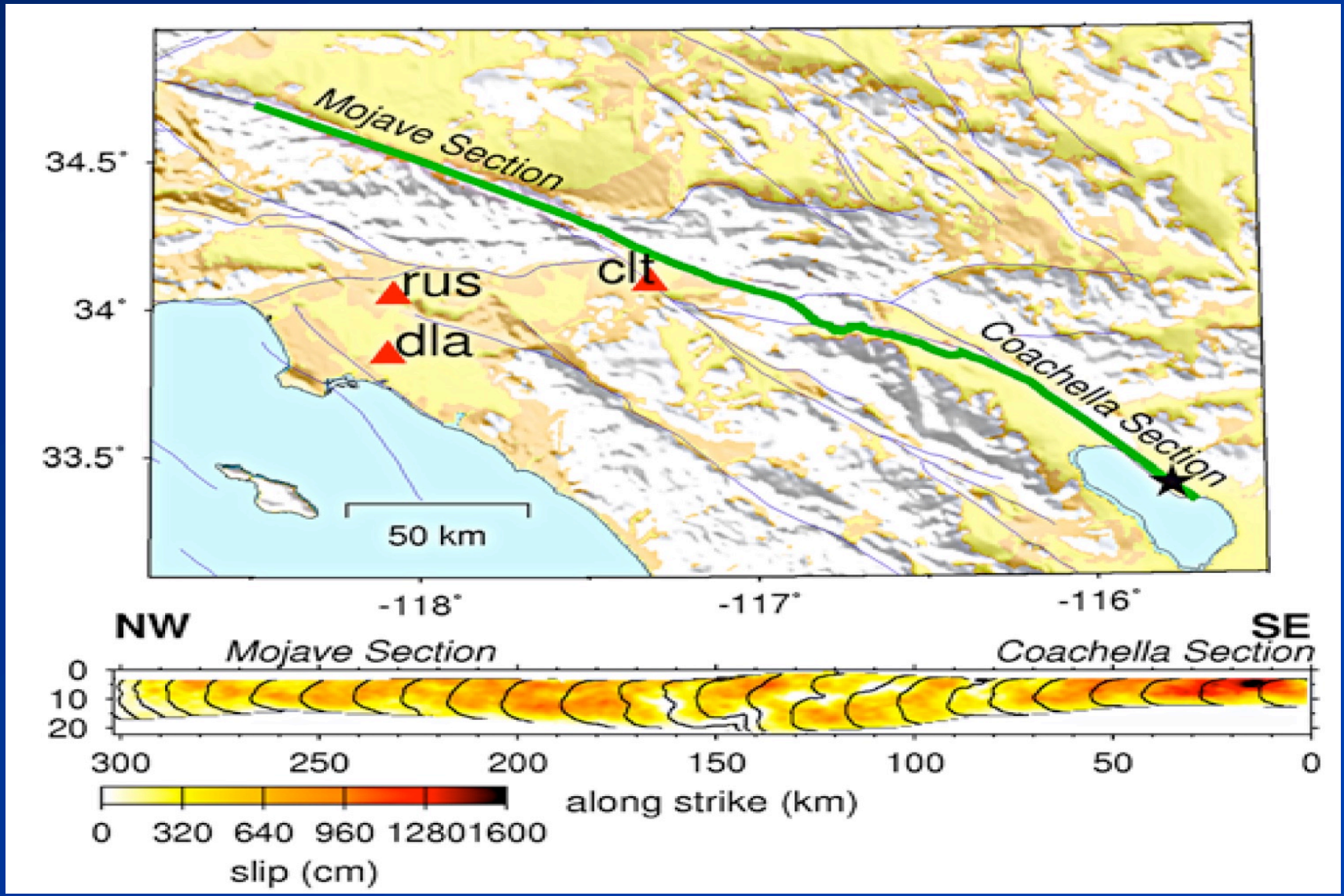
Validation of Simulations

Validated against recordings from moderate M events.

Limited validations done for 1994 M6.7 Northridge EQ.



M 7.8 San Andreas Earthquake Simulations

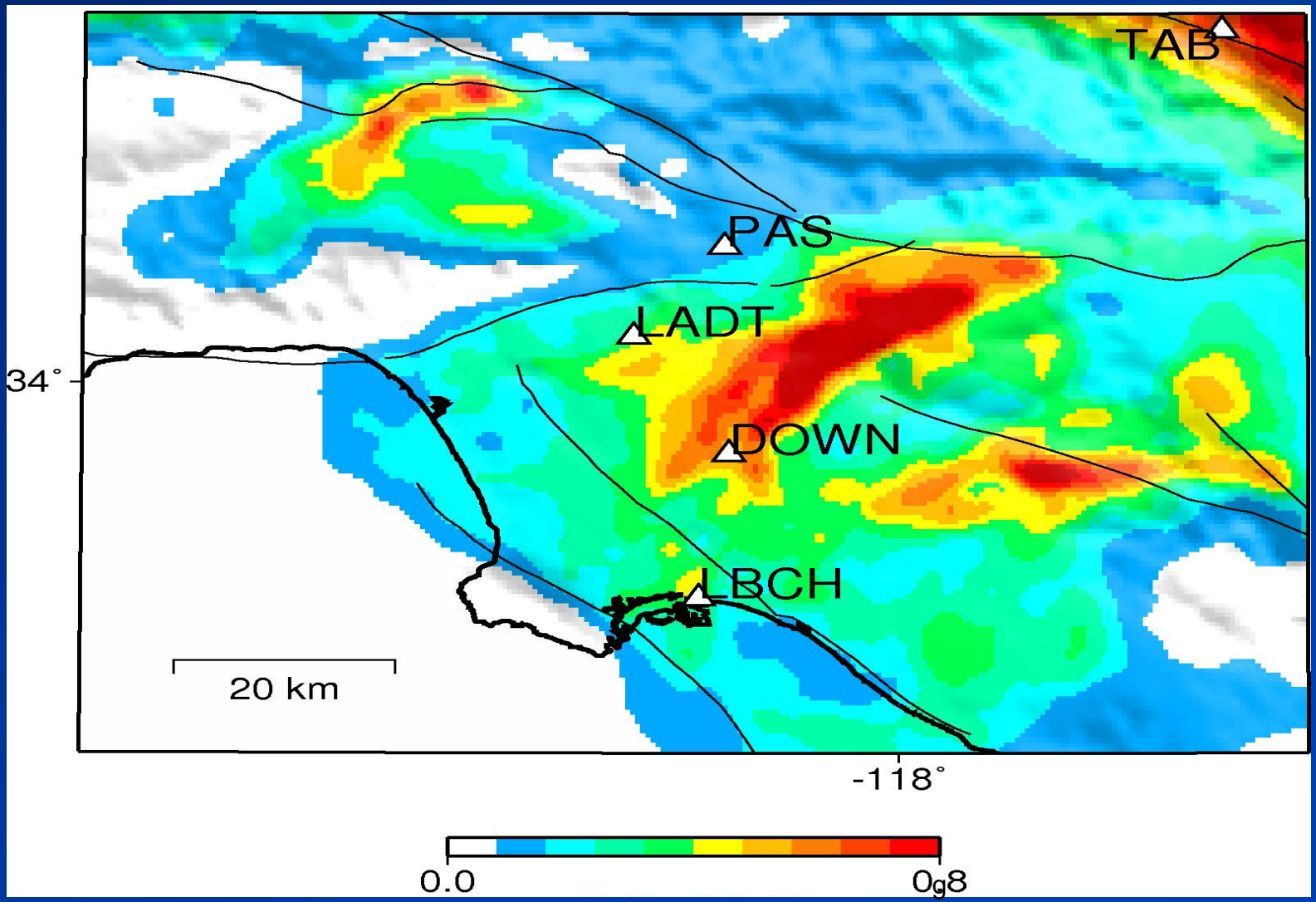


Graves et al. (2008)

SCEC

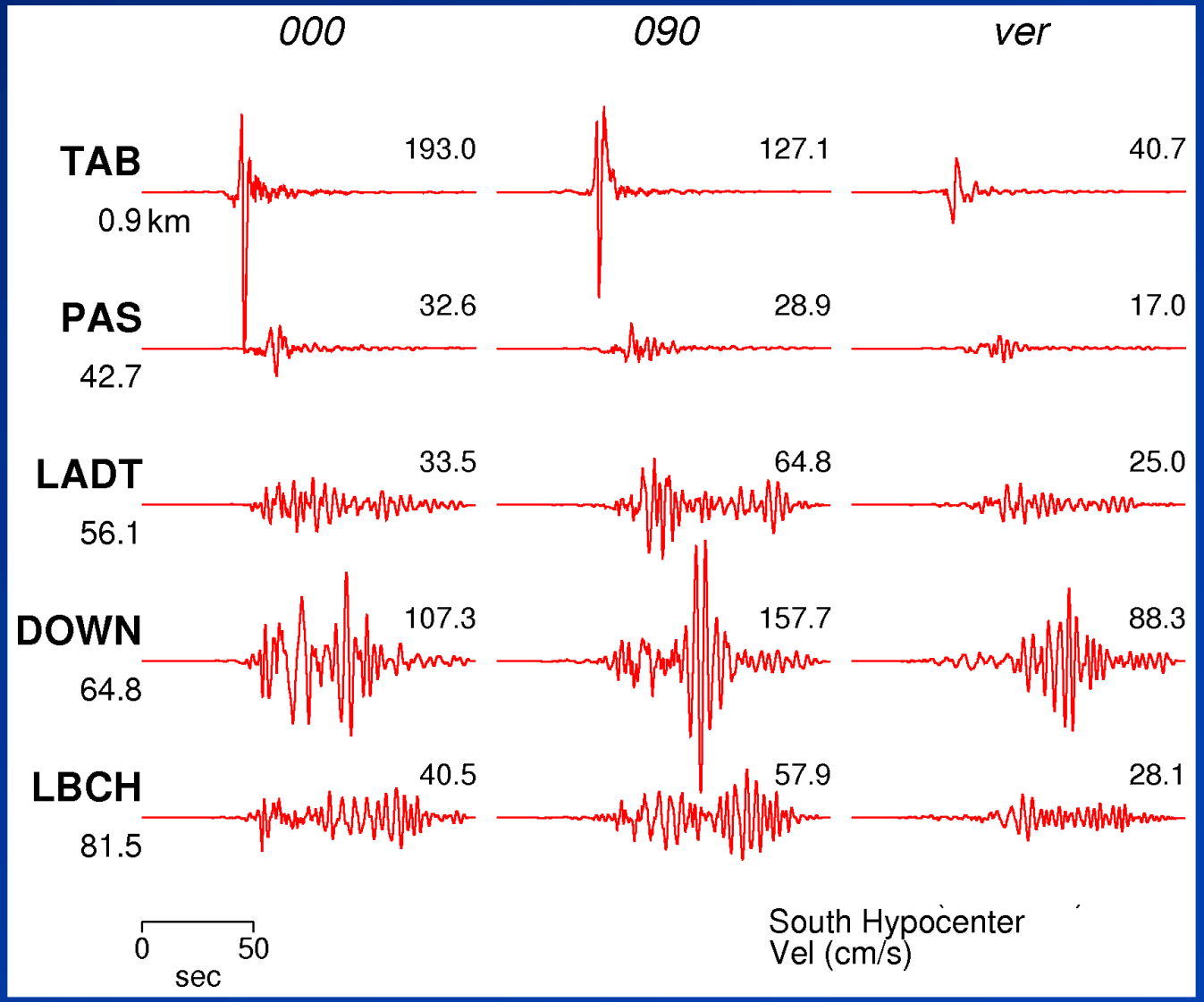
M 7.8 San Andreas Earthquake Simulations

Sa (T = 3 sec, ζ = 5%)



Graves et al. (2008)

Velocity Records for M 7.8 San Andreas Event



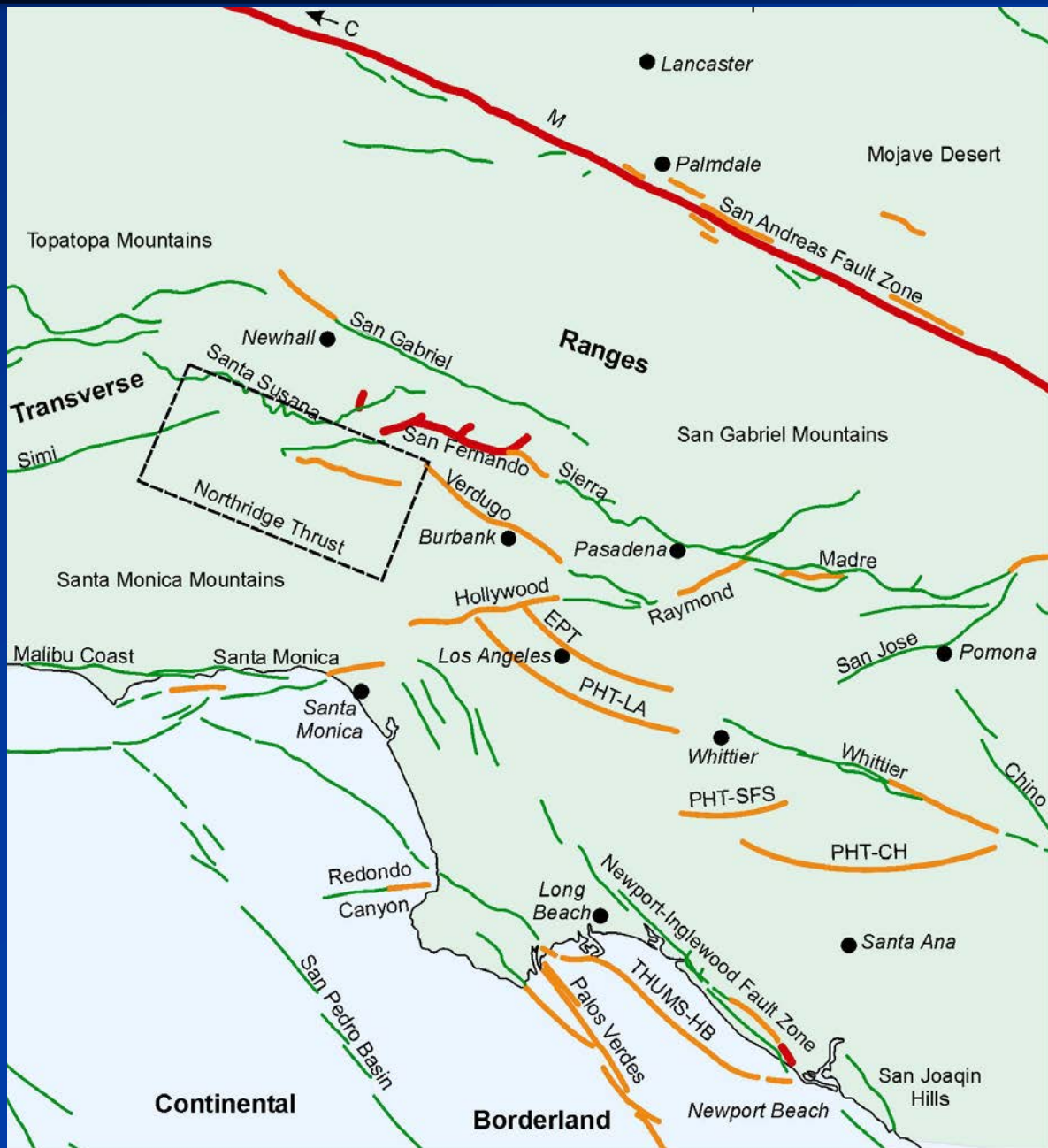
Graves et al. (2008)

SCEC

M8 Simulation on San Andreas

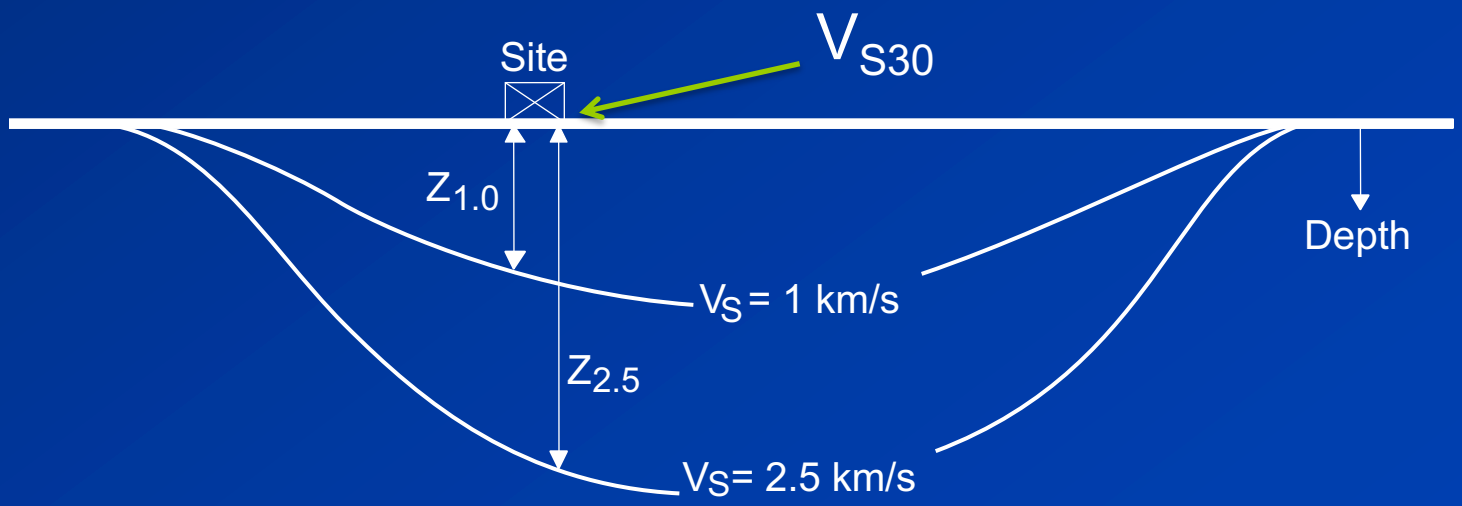
Site-Specific Approach using NGA West2 GMPEs

1. Use UCERF3 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 – $Z_{1.0}$



2-D Basin Profile

SCEC

MCE_R Response Spectra

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

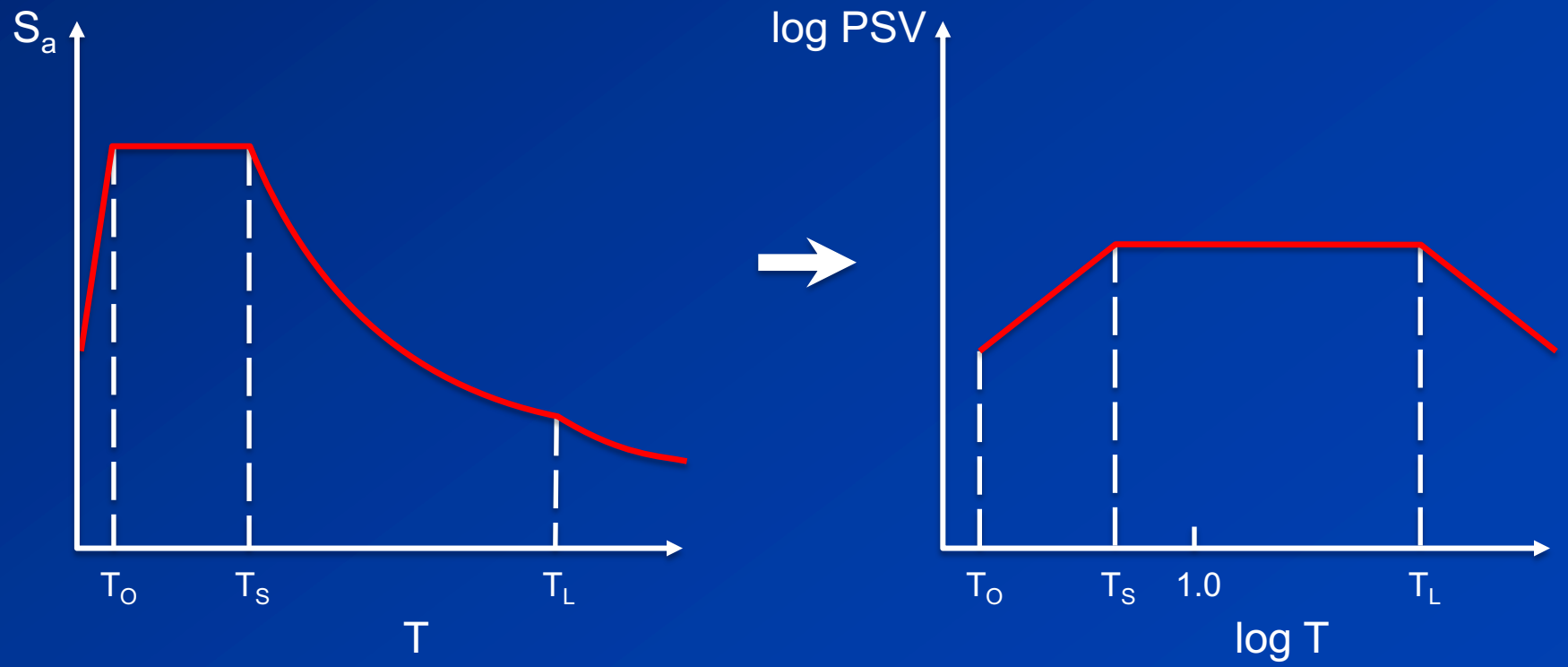
Determination of MCE_R Response Spectra, T = 2 - 10 sec

- 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

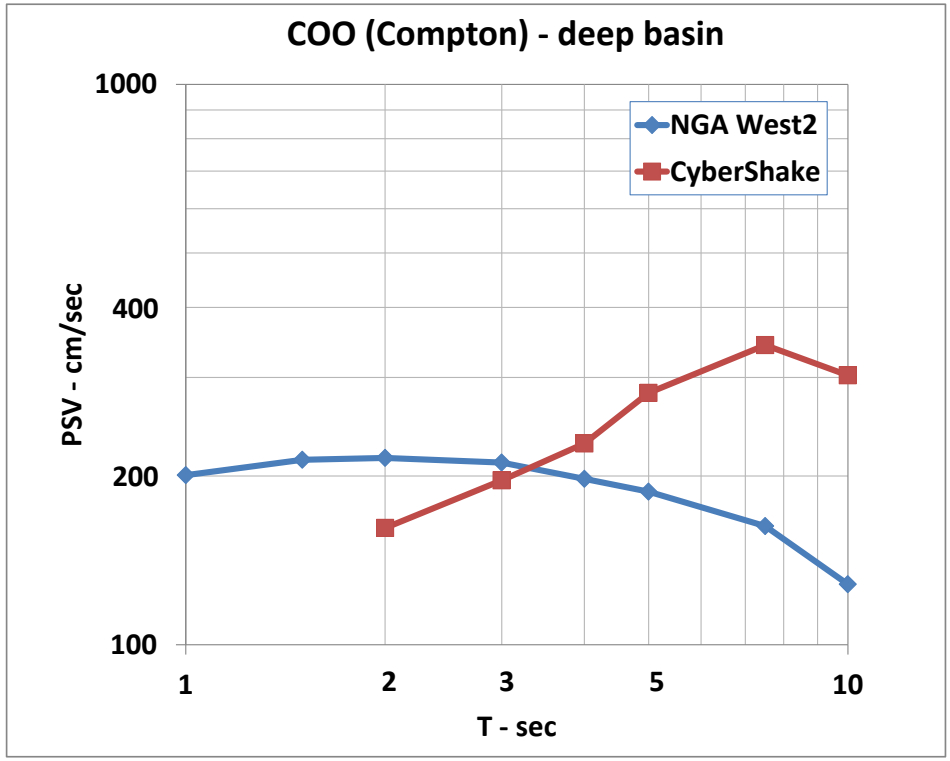
SCEC

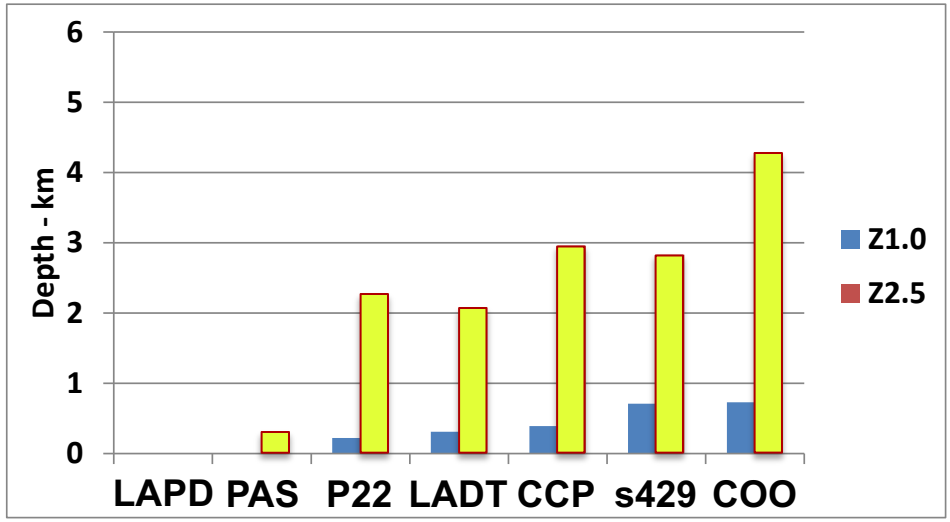
Transform S_a to PSV

$$PSV = (T/2\pi)S_a$$

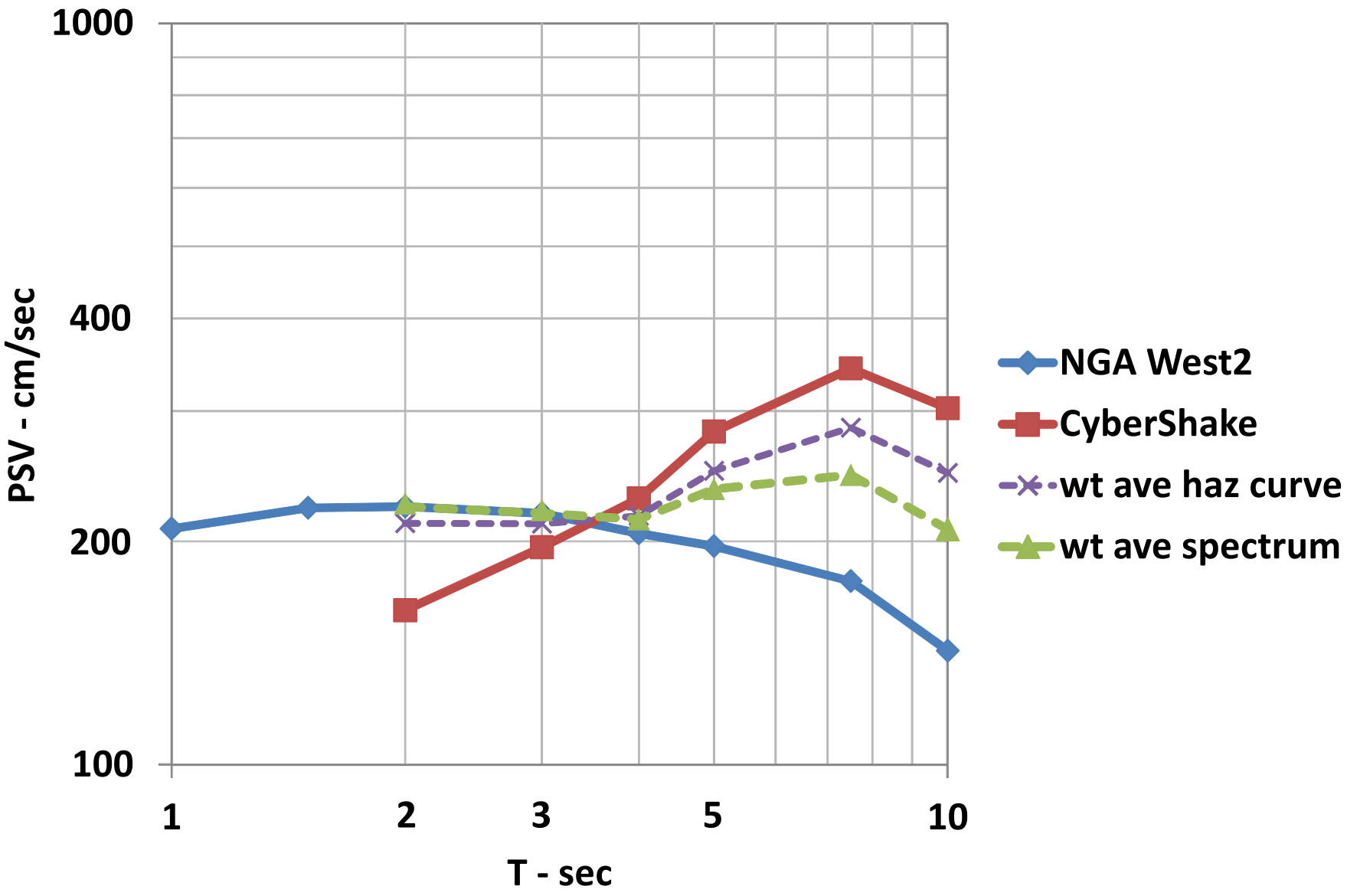


MCE_R PSV for 7 Sites to Illustrate Trends

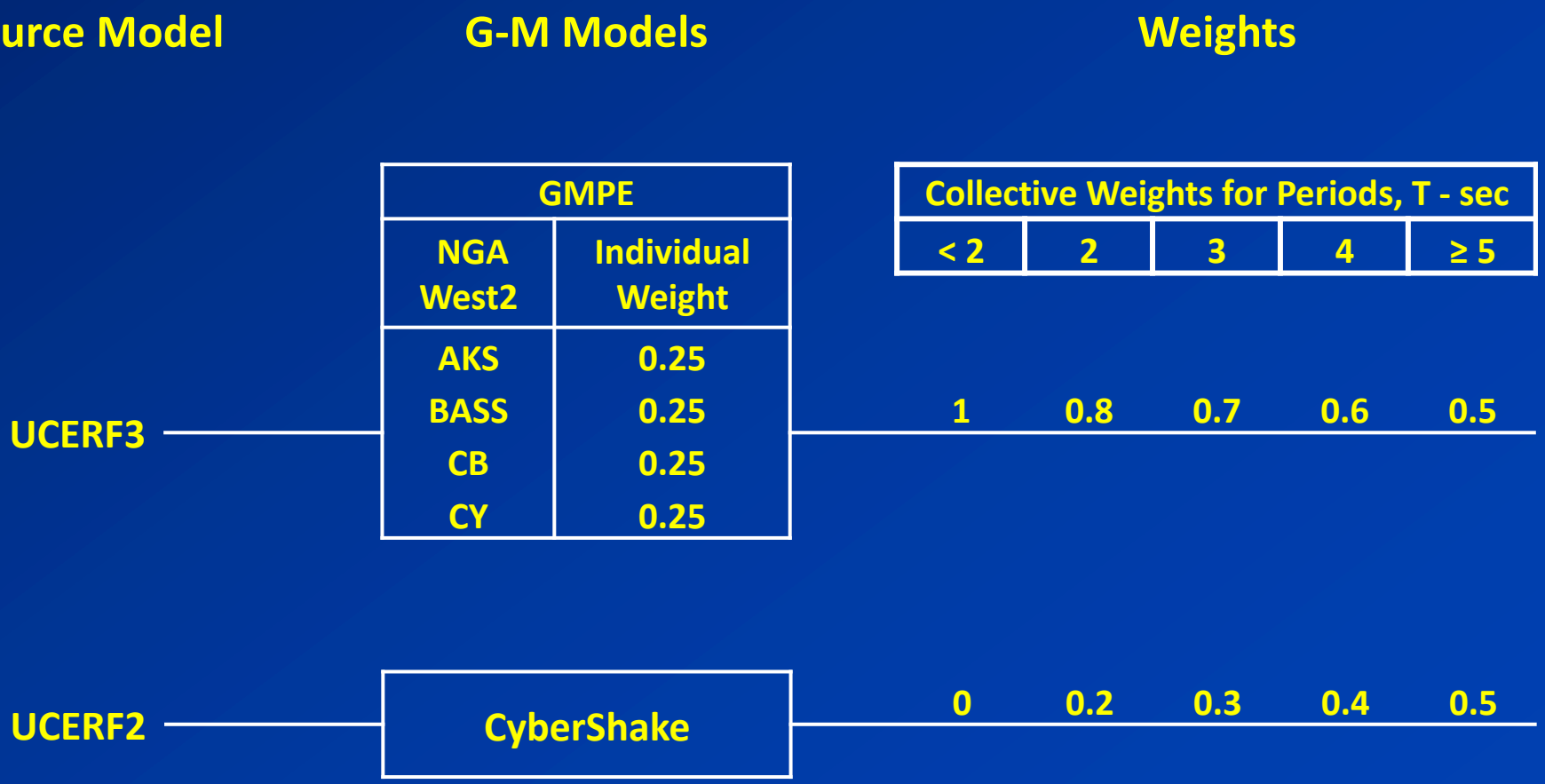




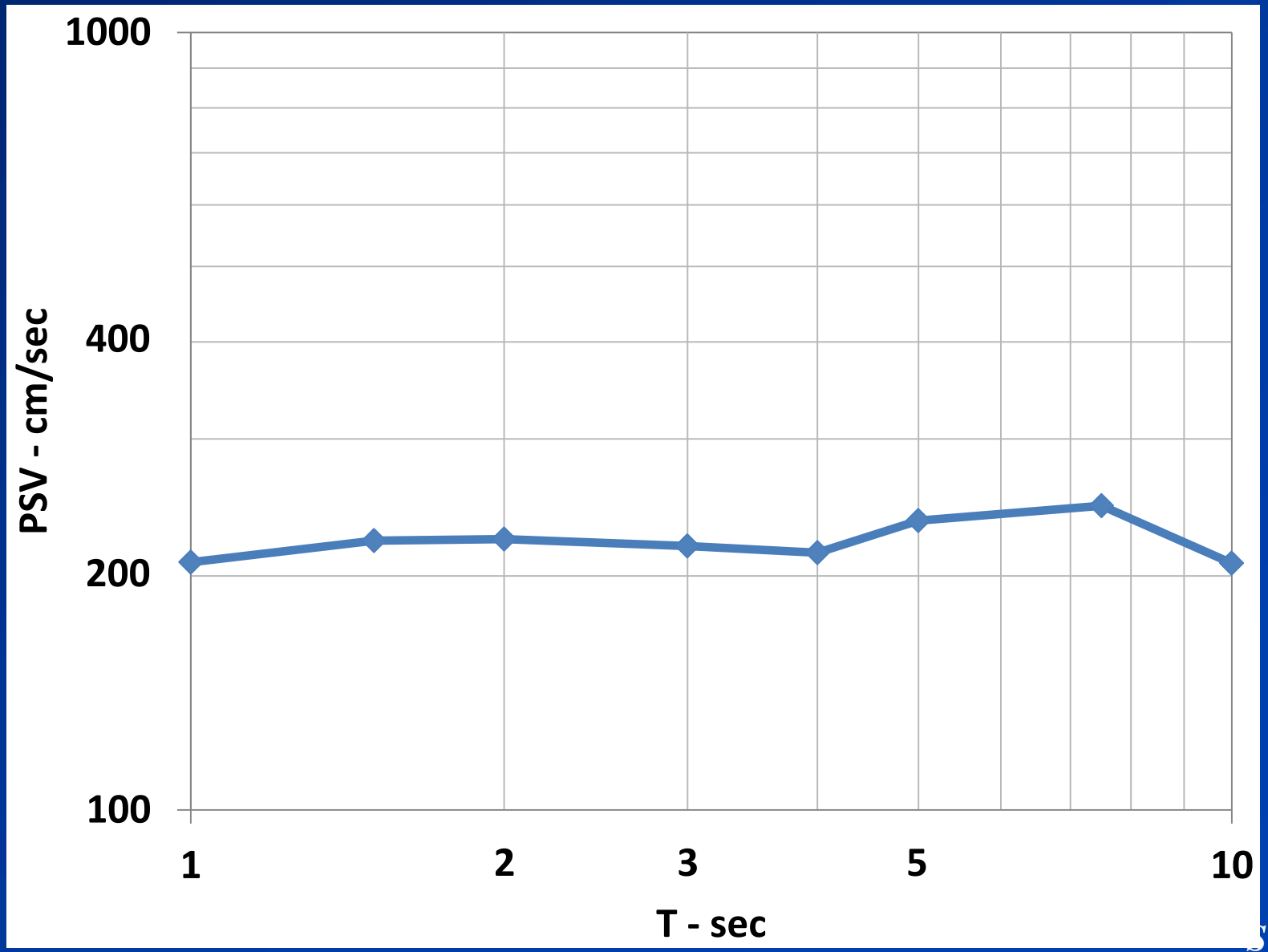
COO (Compton) - Deep Basin



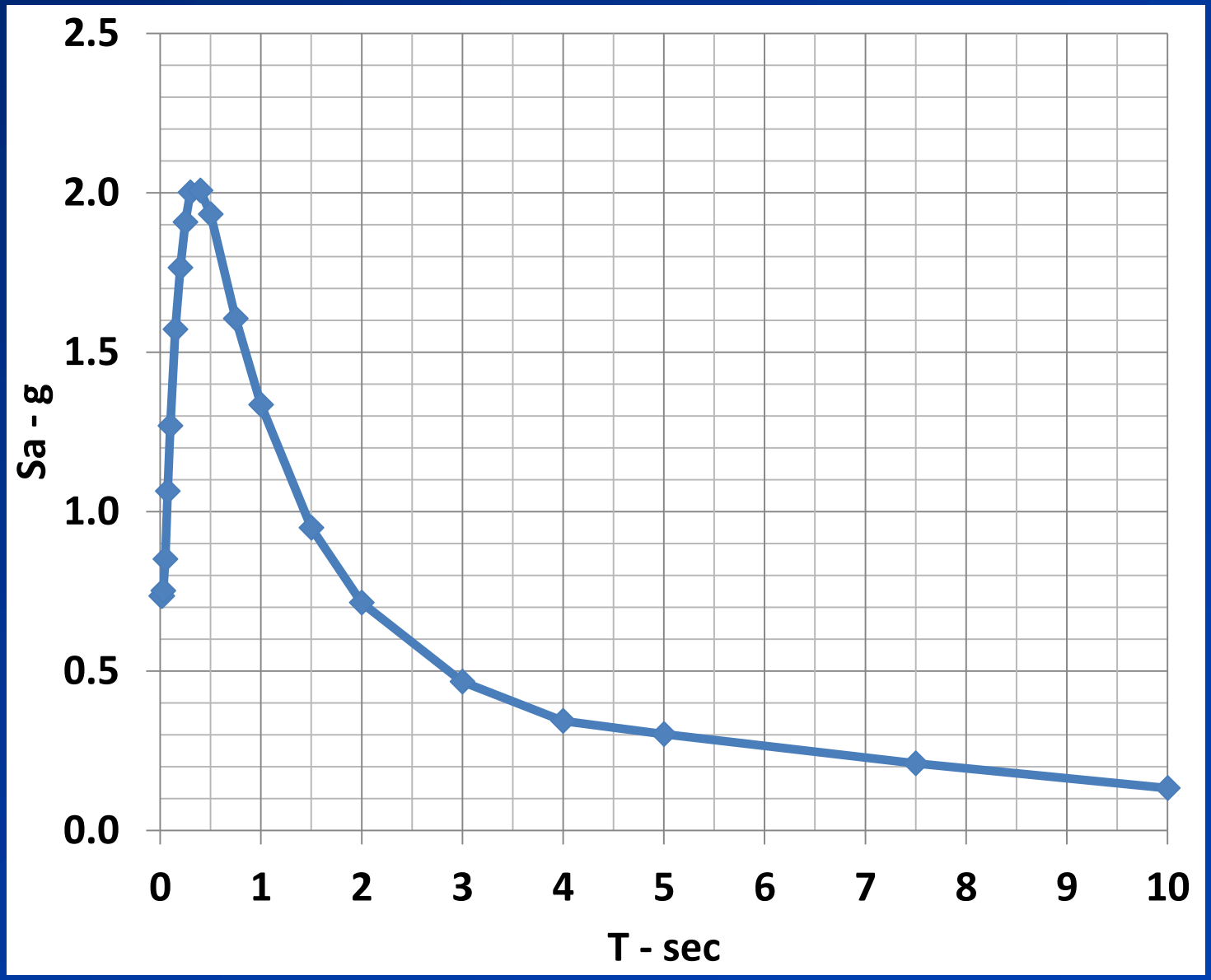
Weighted Averaging of MCE_R Response Spectra



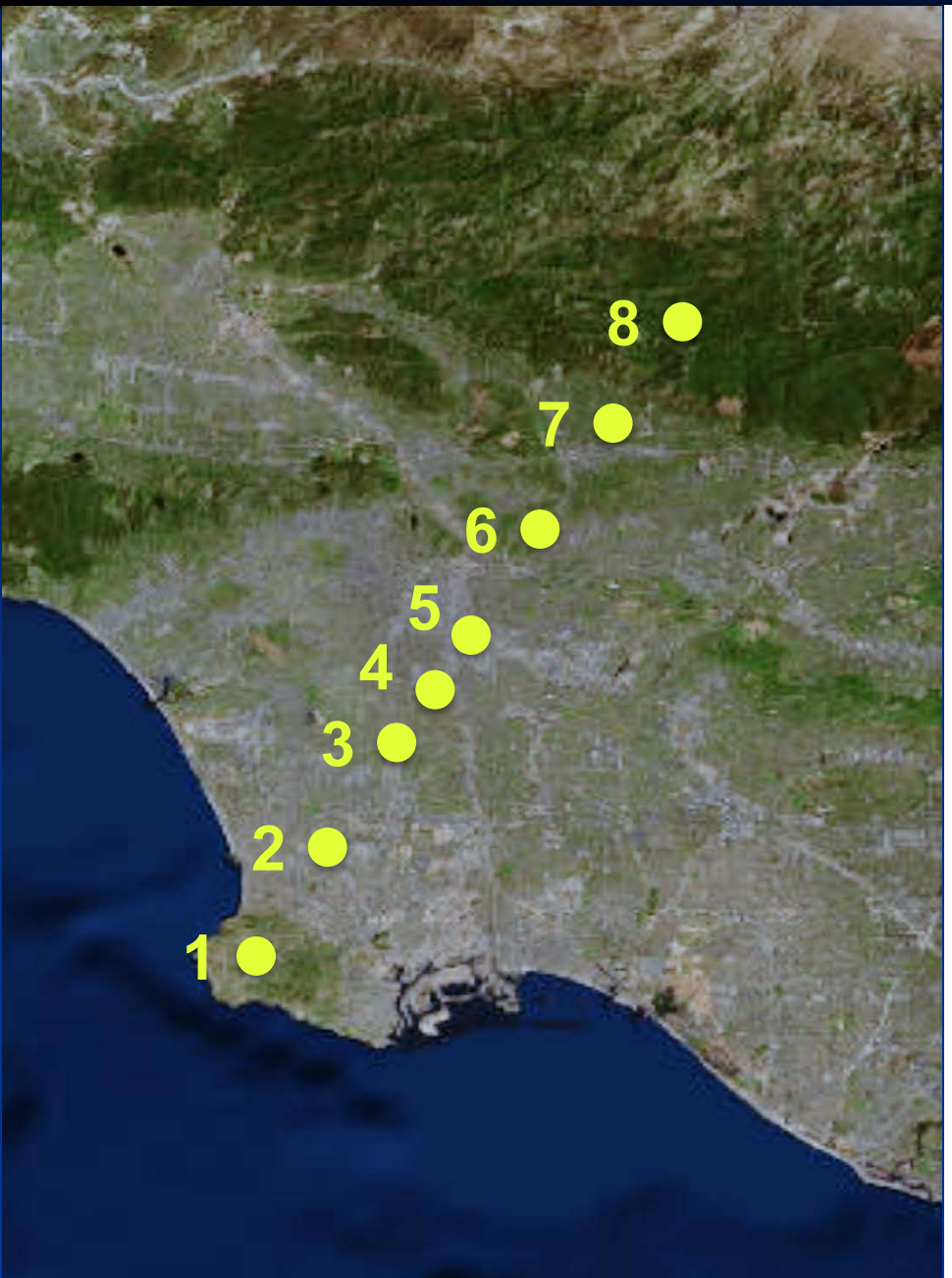
MCE_R: COO (Compton) - Deep Basin

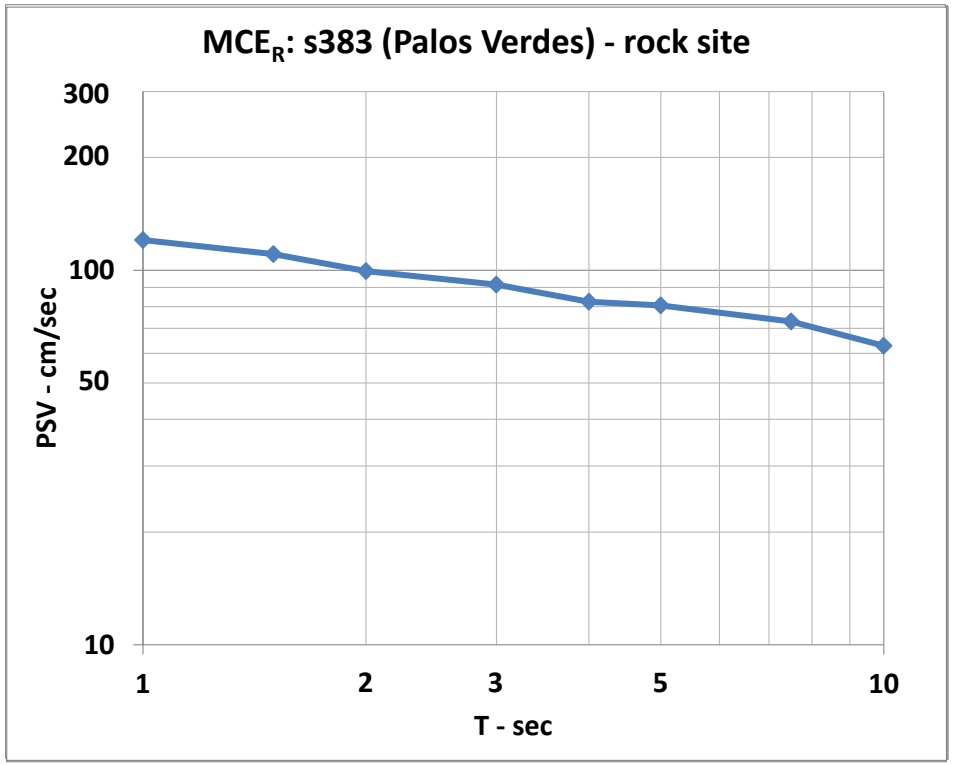


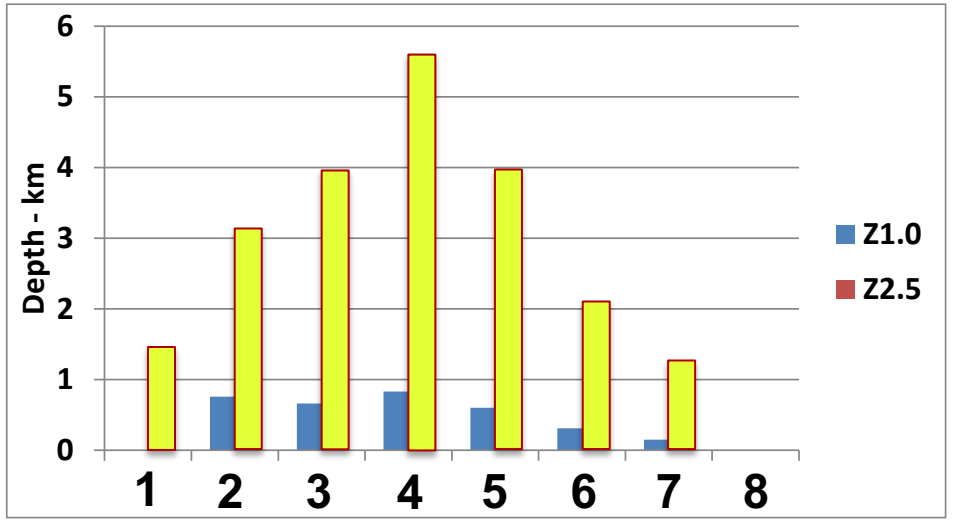
MCE_R: COO (Compton) - Deep Basin



Line 1


8
7
6
5
4
3
2
1


MCE$_R$: s383 (Palos Verdes) - rock site
300
200
100
50
10
PSV - cm/sec
1
2
3
5
10
T - sec


6
5
4
3
2
1
0
Depth - km
1
2
3
4
5
6
7
8
Z1.0
Z2.5

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)

End Products of UGMS Project

- 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

Look-Up Tool at:

https://data2.scec.org/ugms/

Login Info for Look-Up Tool

User name: **scecuser**

Password: **scec1234**