Characteristics of Long-Period (3 to 10 s) Ground Motions Observed in and around the Los Angeles Basin during the Mw7.2 El Mayor-Cucapah Earthquake

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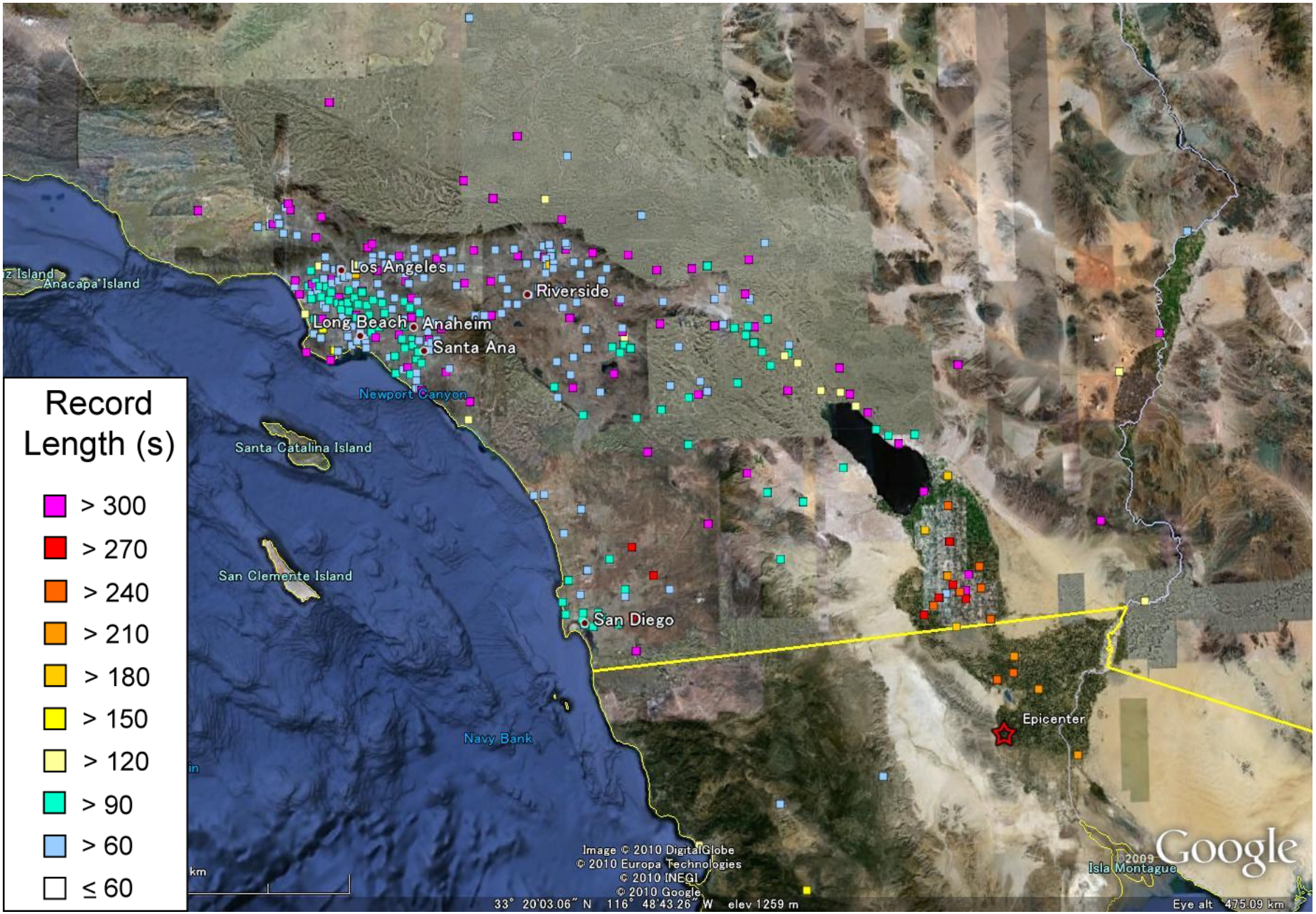
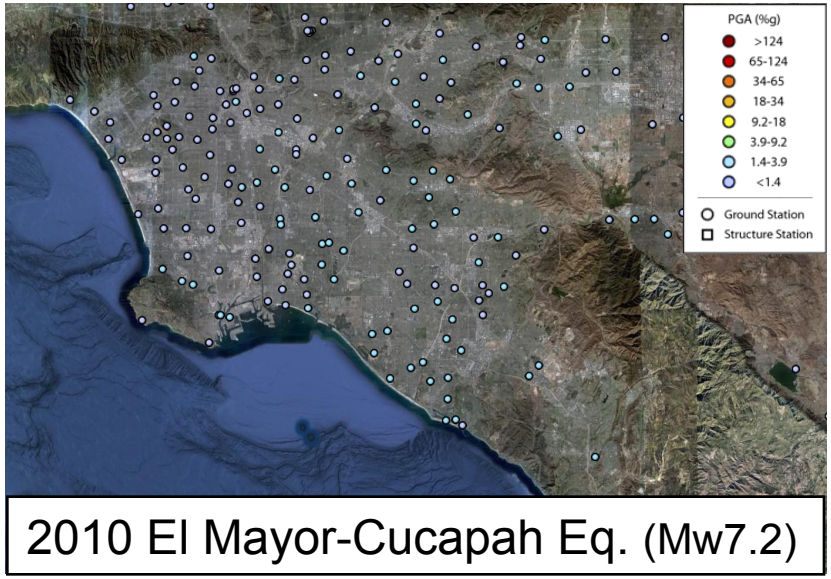
Acknowledgment
This study was supported by Excellent Young Researchers Overseas Visit Program of Japan Society for the Promotion of Science.

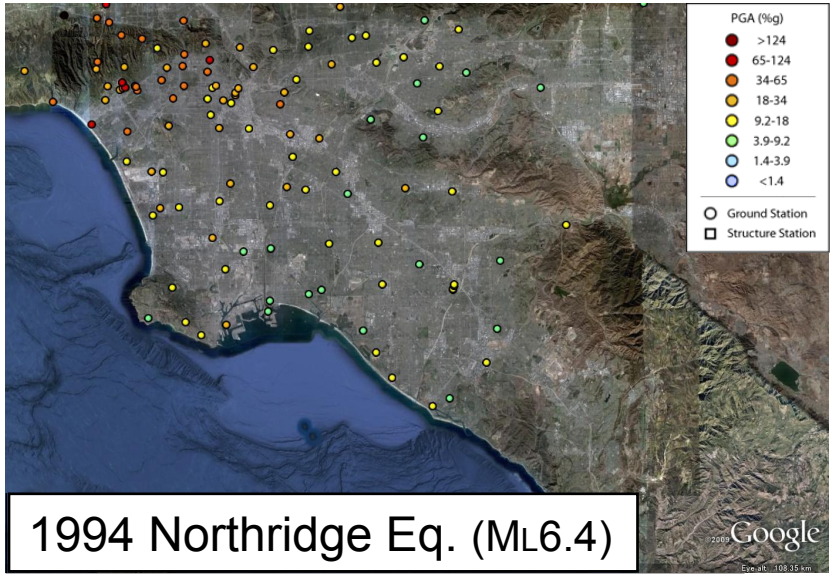
Records Available at Engineering Strong Motion Data Center



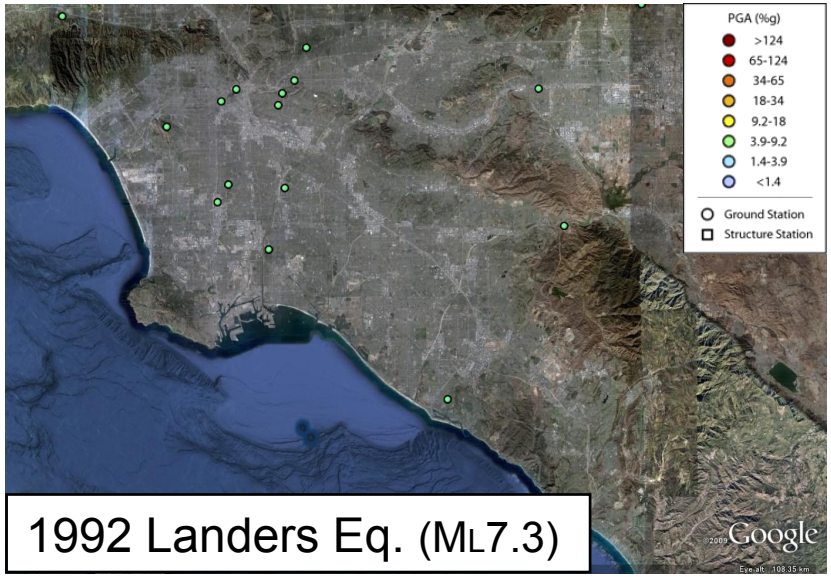
Significance of Studying This Earthquake ~ Number of Records !



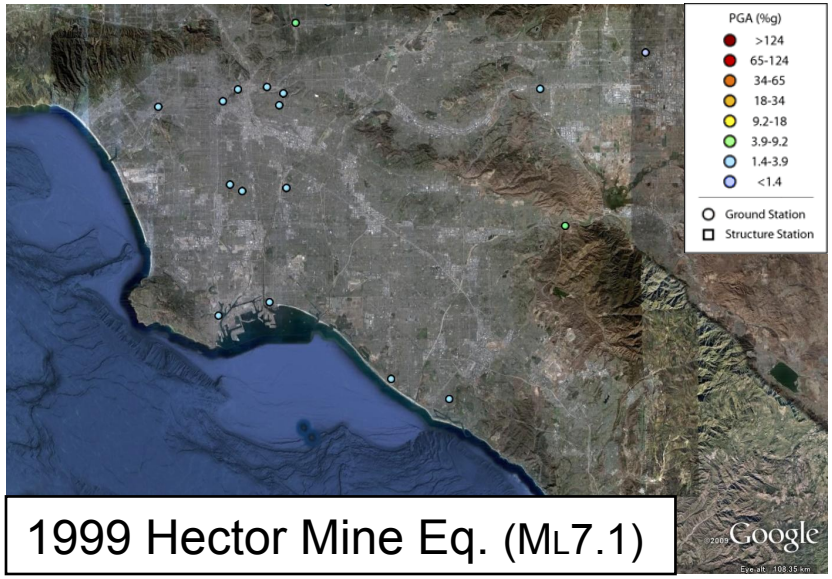
2010 El Mayor-Cucapah Eq. (Mw7.2)



1994 Northridge Eq. (ML6.4)



1992 Landers Eq. (ML7.3)



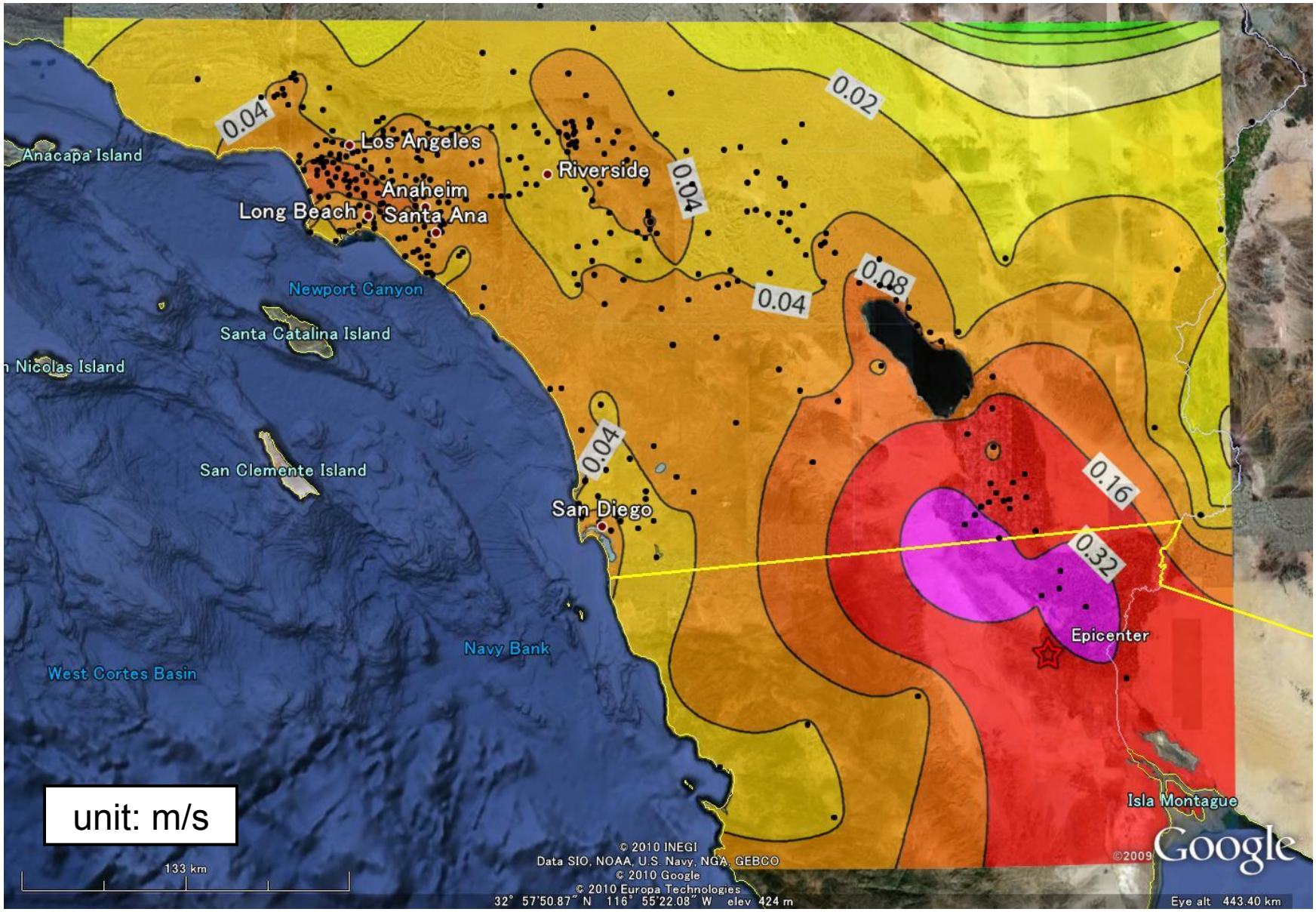
1999 Hector Mine Eq. (ML7.1)

Outline

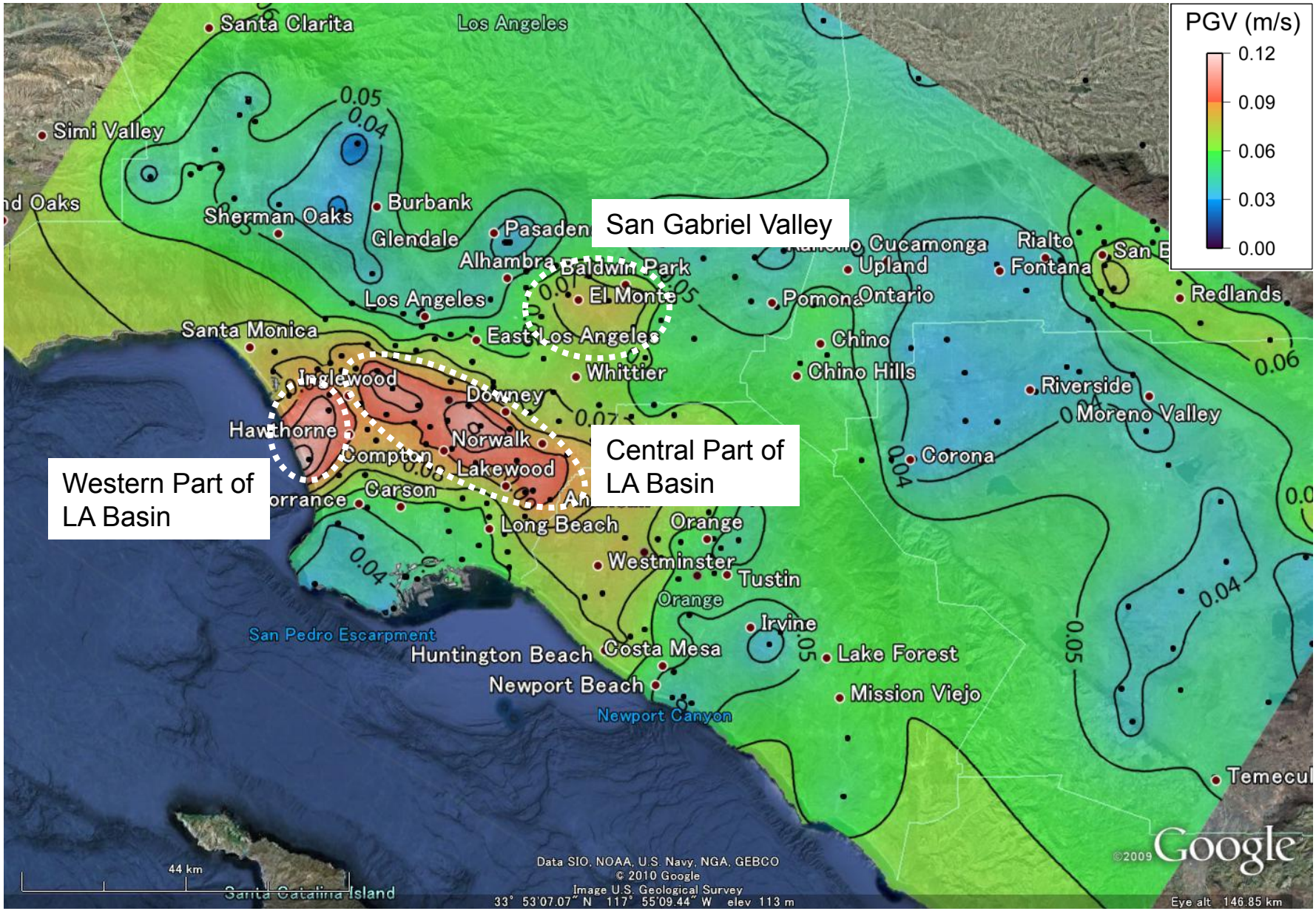
- PGV of Observed Long-Period Ground Motion
- Spectral Amplification Factors Derived from the Observations
- FDM Simulation by Using SCEC CVM-H 6.2

PGV of Observed Ground Motion

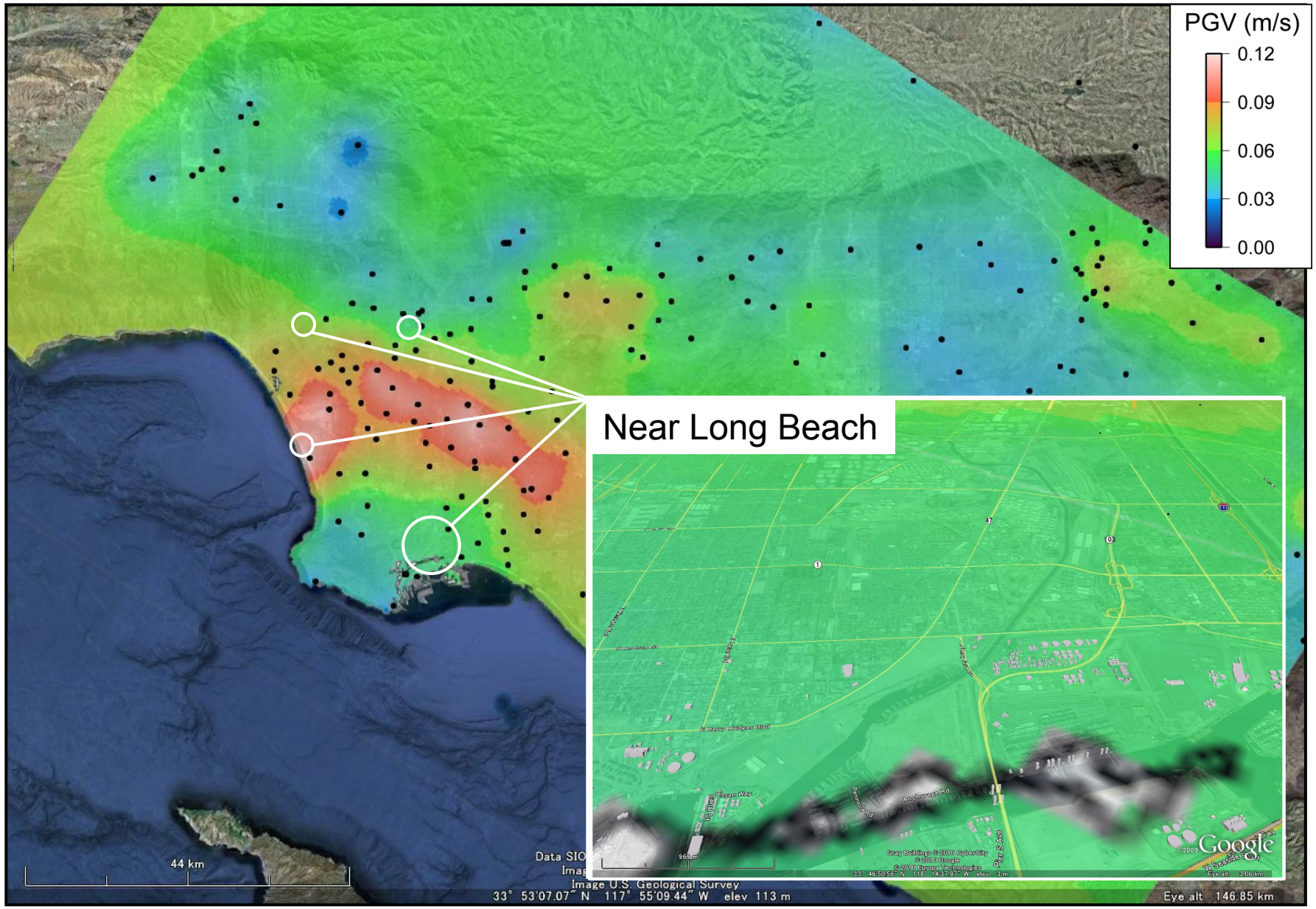
Observed PGV (Period Range: 3 to 16 s)



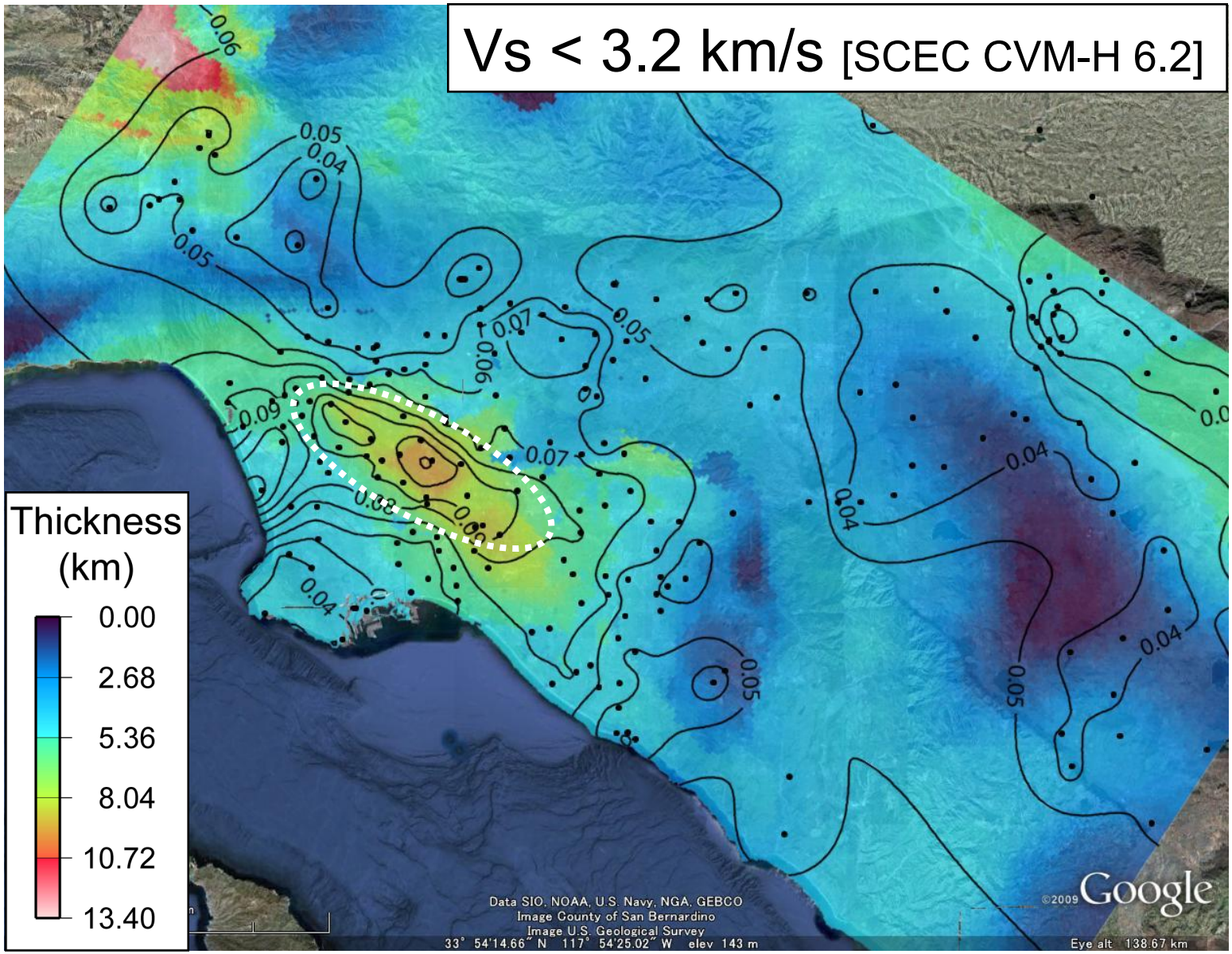
Observed PGV (Period Range: 3 to 16 s)



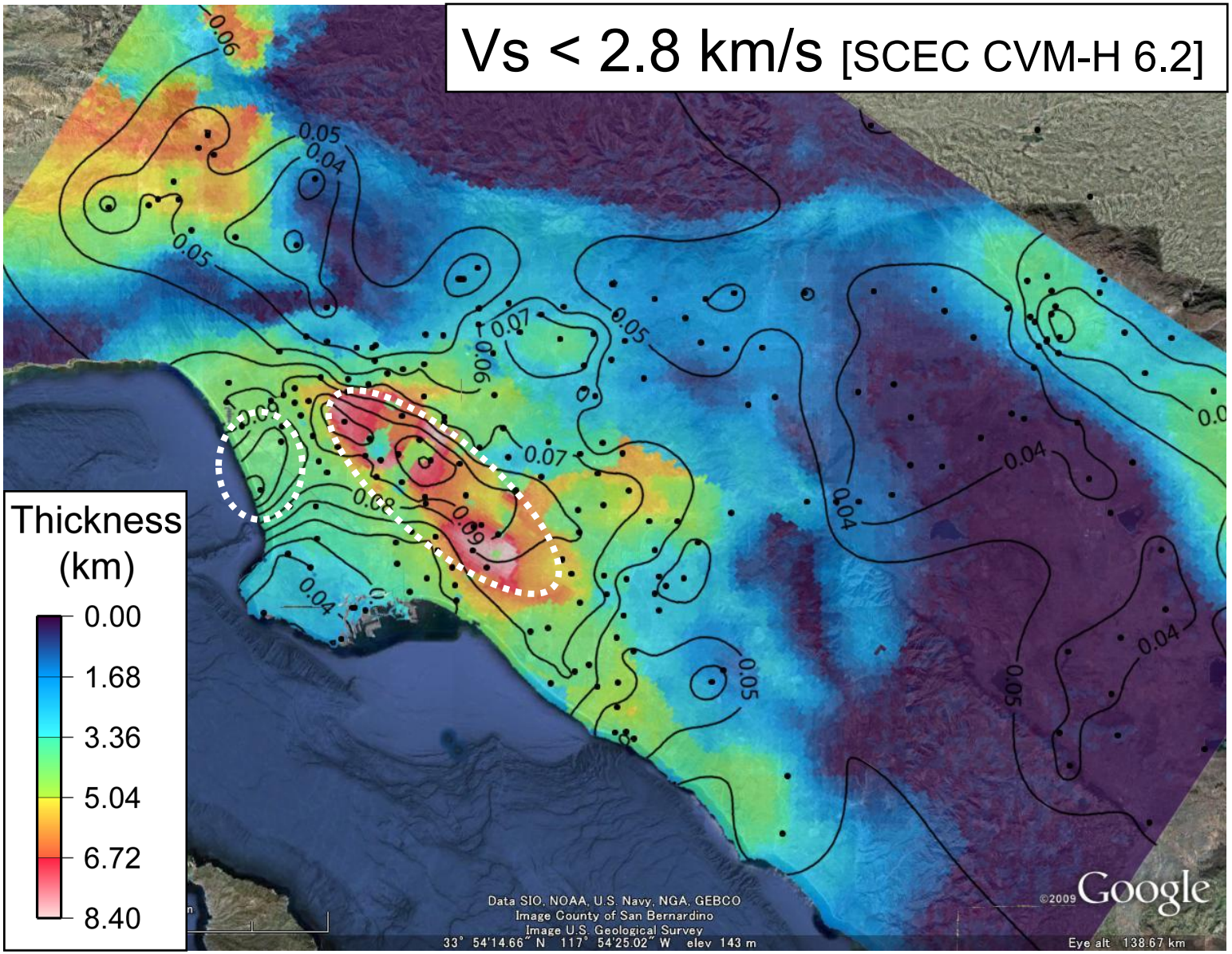
Observed PGV (Period Range: 3 to 16 s)



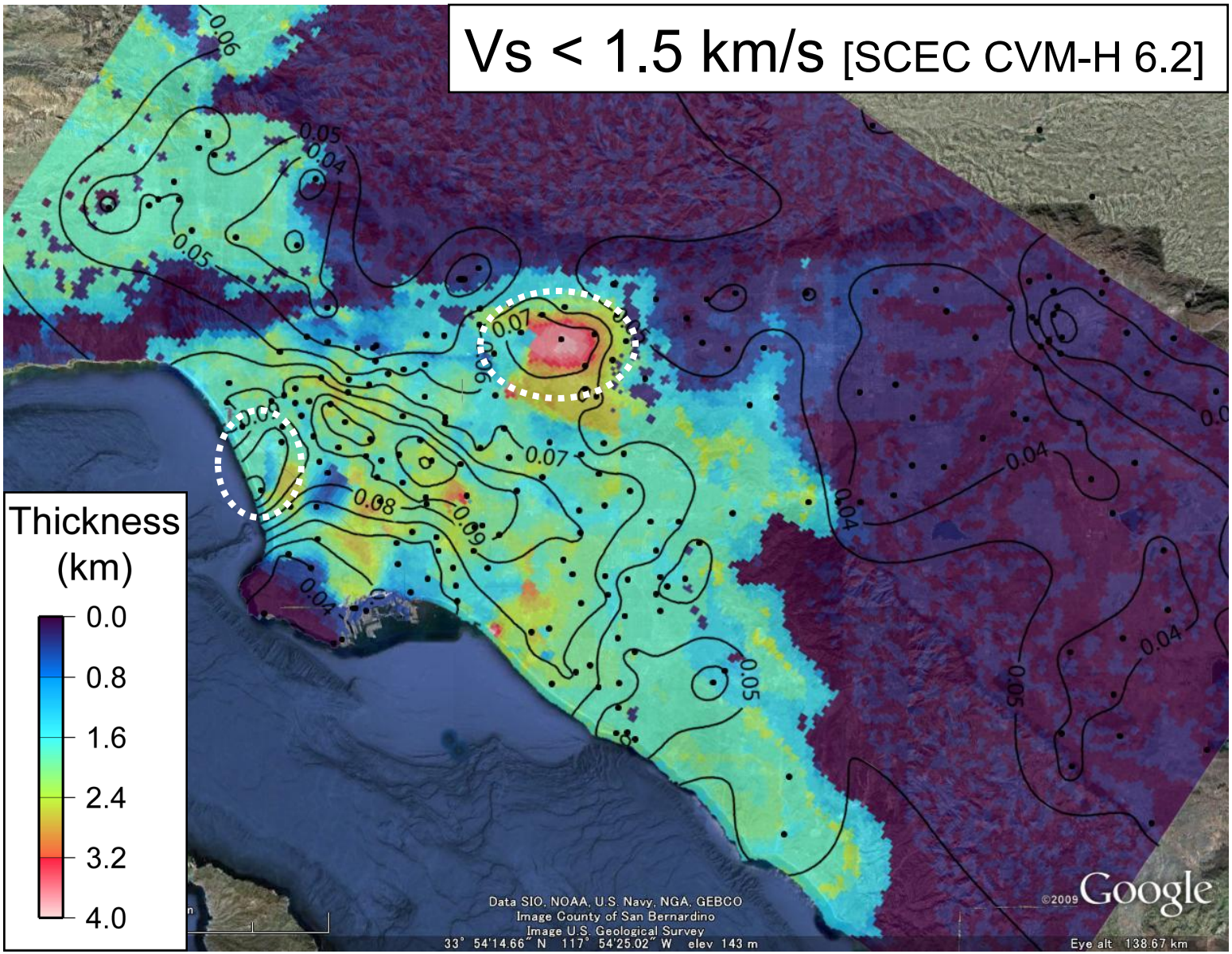
Sediment Thickness(Colors) v's Observed PGV(Contours)



Sediment Thickness(Colors) v's Observed PGV(Contours)



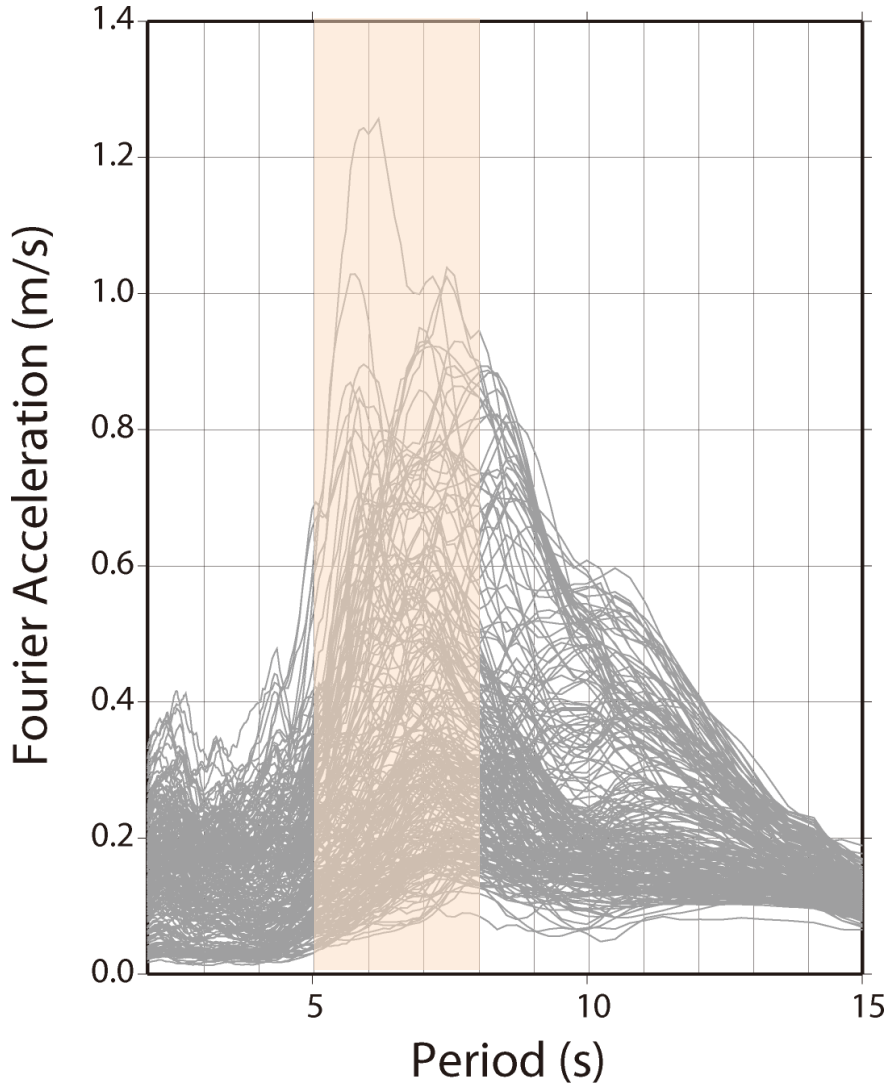
Sediment Thickness(Colors) v's Observed PGV(Contours)



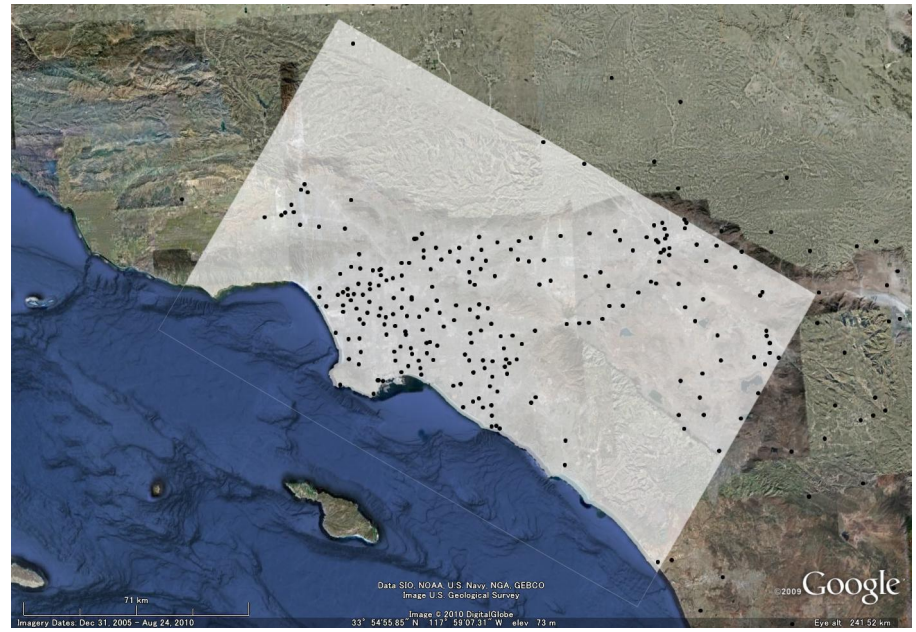
Spectral Amplification Factor

Fourier Acceleration Spectra (RMS of Two Horizontal Comps.)

Fourier Amplitude



Stations from which
Fourier Spectra are Computed



In order to Evaluate Amplification Factors

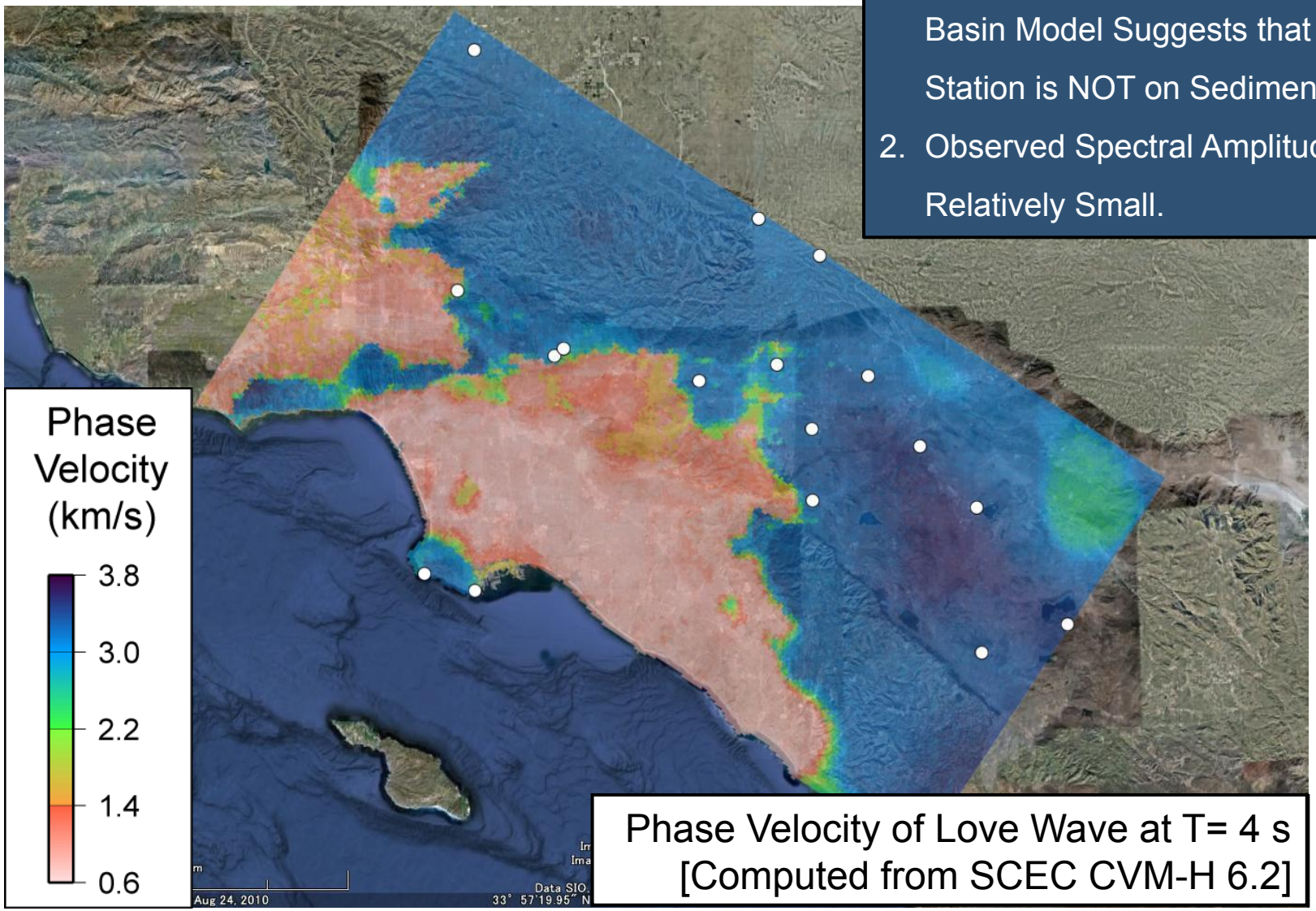
1.Select Appropriate Reference Stations

2.Compute Spectral Ratio

How to Select Reference Stations

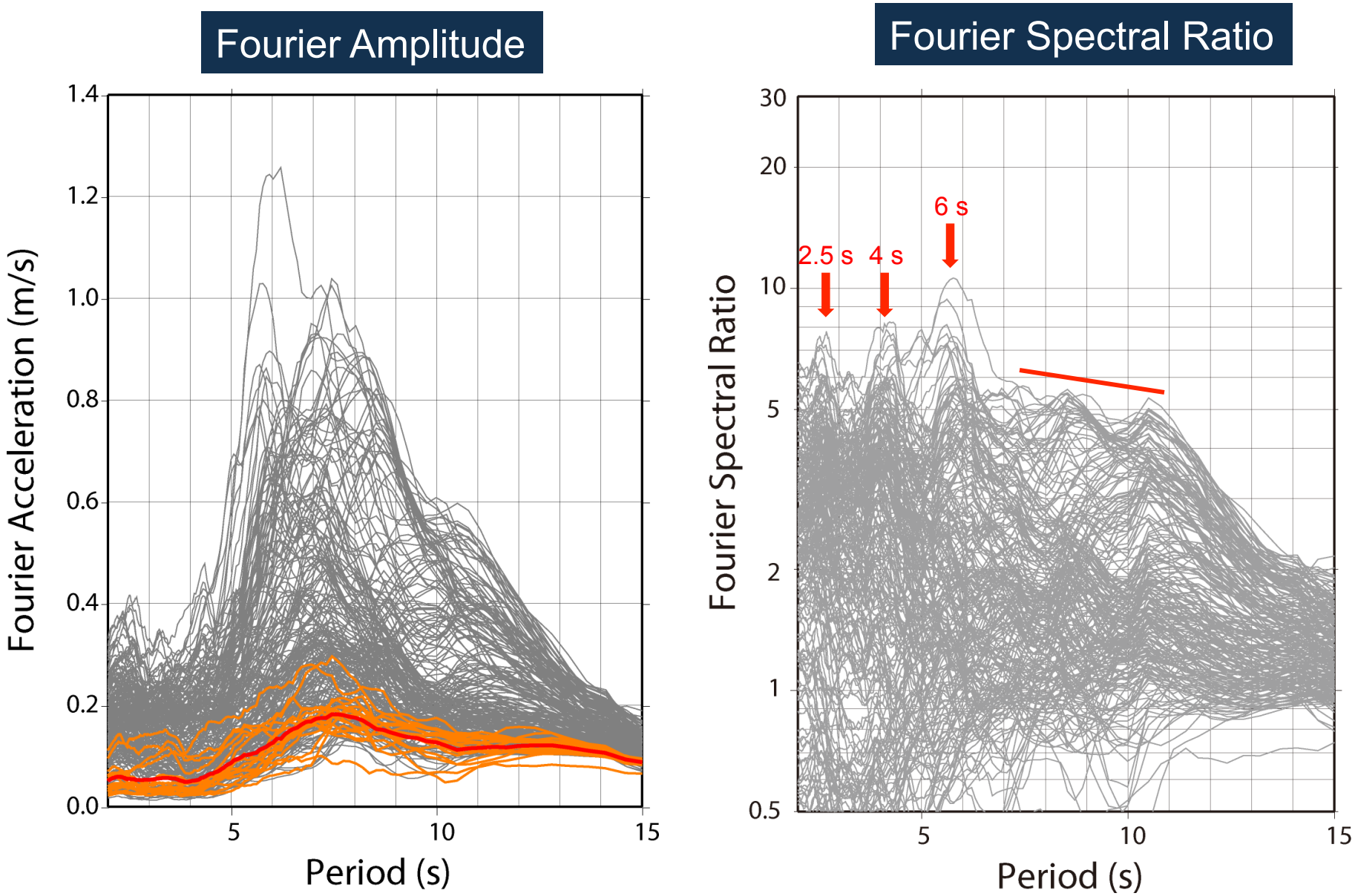
<<Criteria>>

1. Record has Long Duration (> 300 s). Basin Model Suggests that the Station is NOT on Sediment.
2. Observed Spectral Amplitudes are Relatively Small.

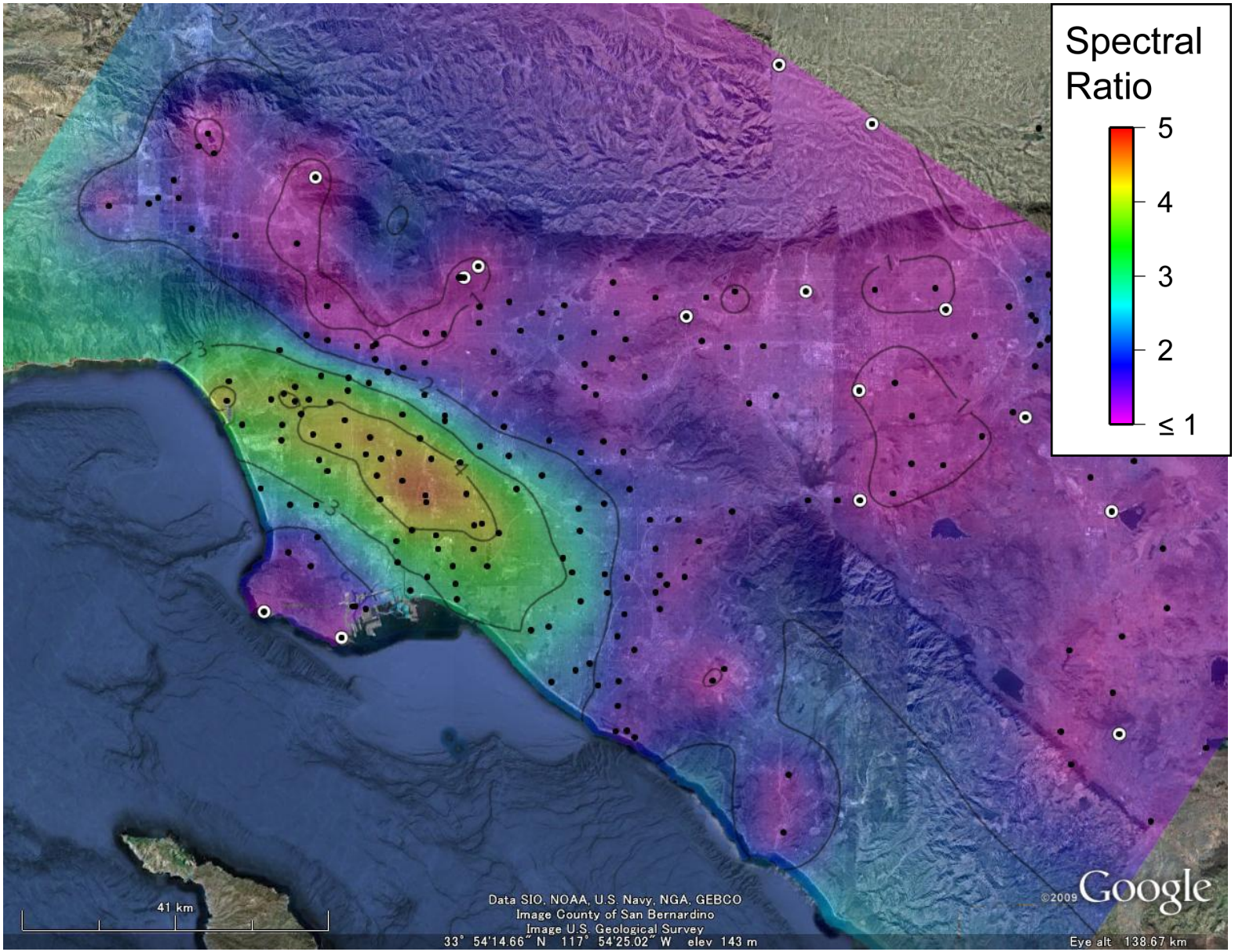


Phase Velocity of Love Wave at T= 4 s
[Computed from SCEC CVM-H 6.2]

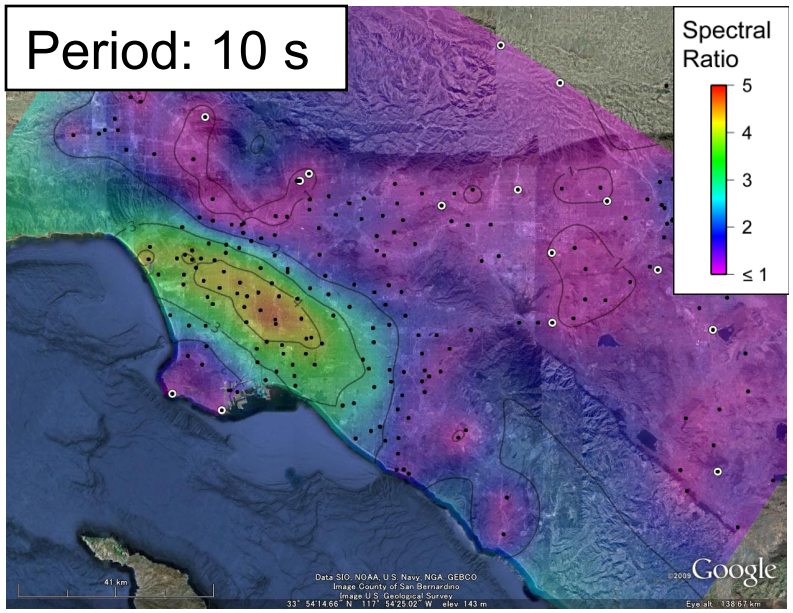
Obs. Fourier Acceleration Spectra (RMS of Horizontal Comp.)

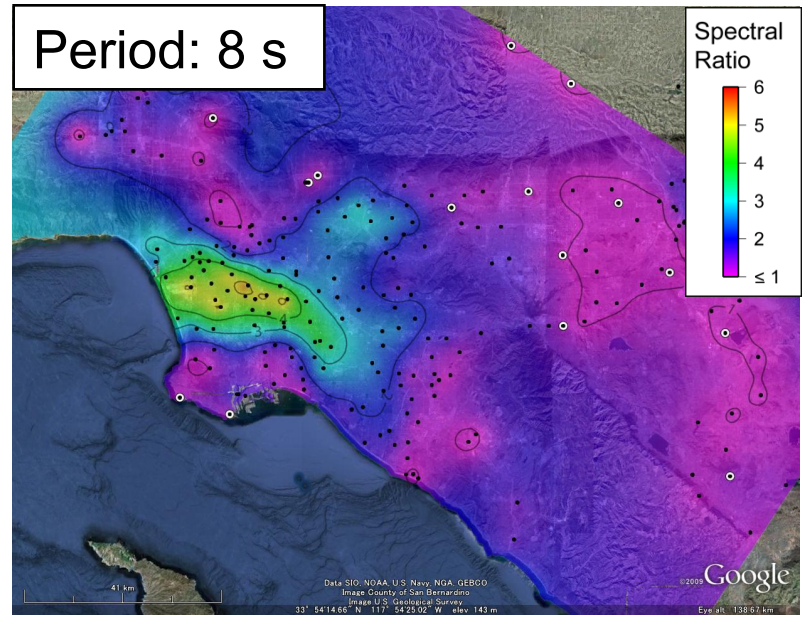


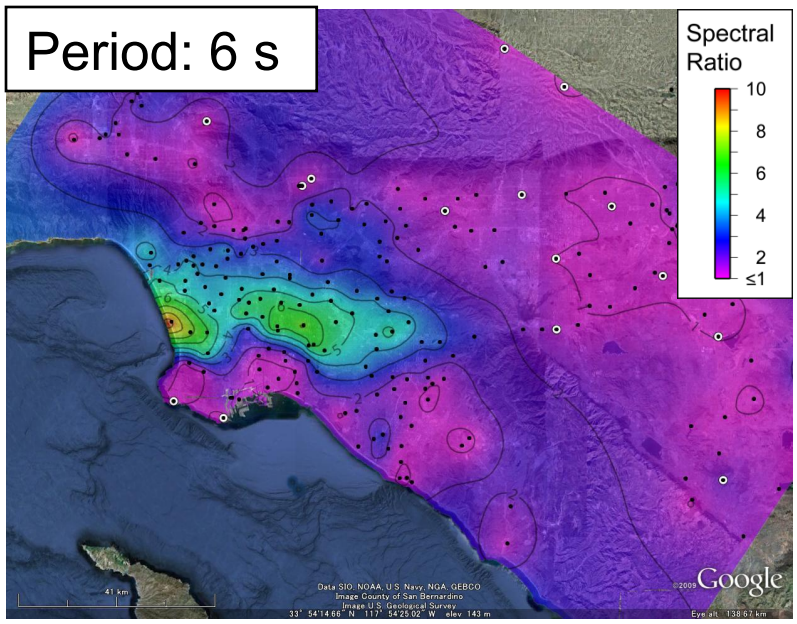
Observed Fourier Spectral Ratio: T=10 s

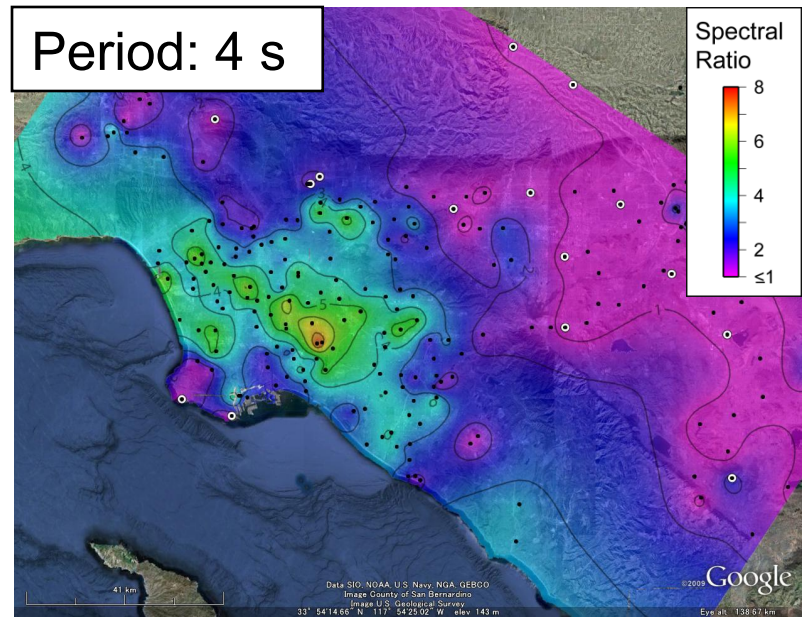


Observed Fourier Spectral Ratio



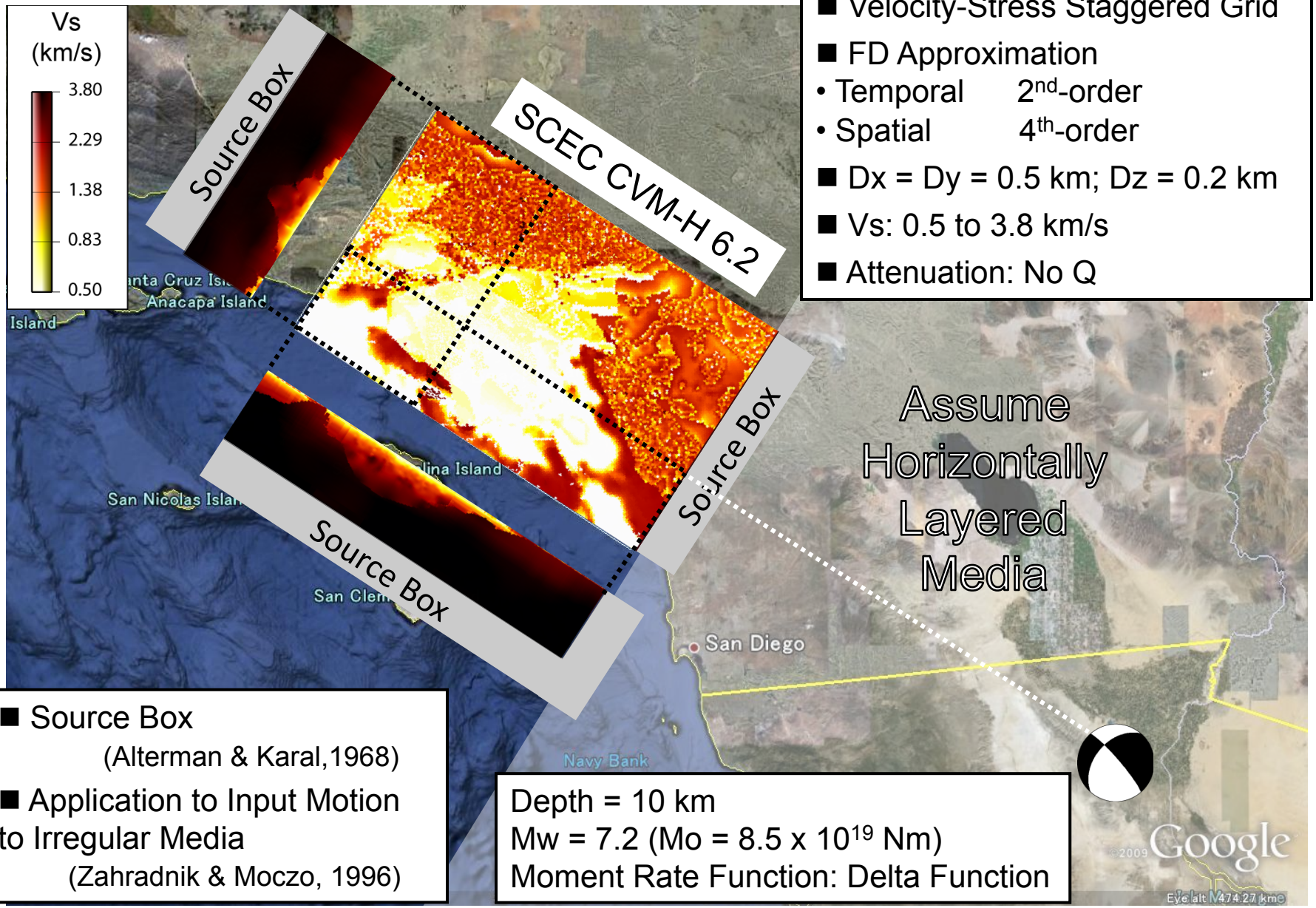






FDM Simulation by Using SCEC CVM-H 6.2

Outline of Simulation



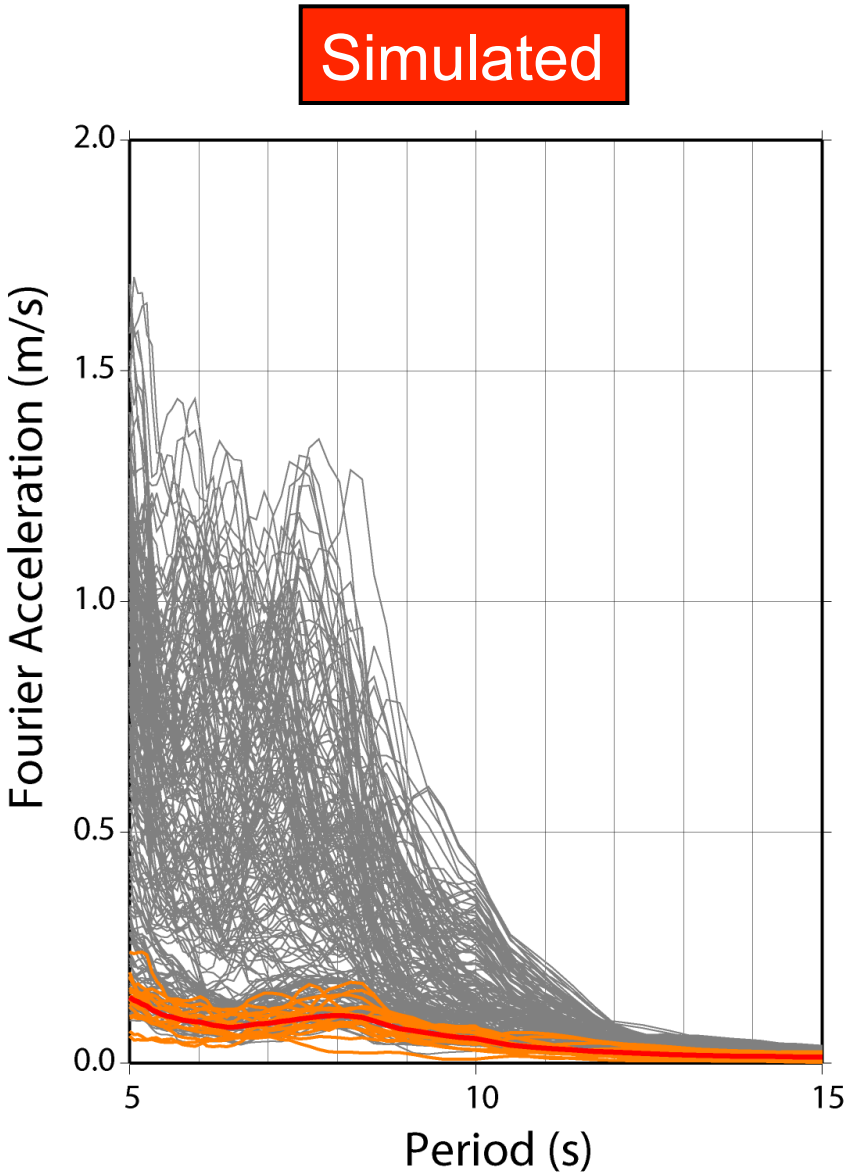
<<FDM>>

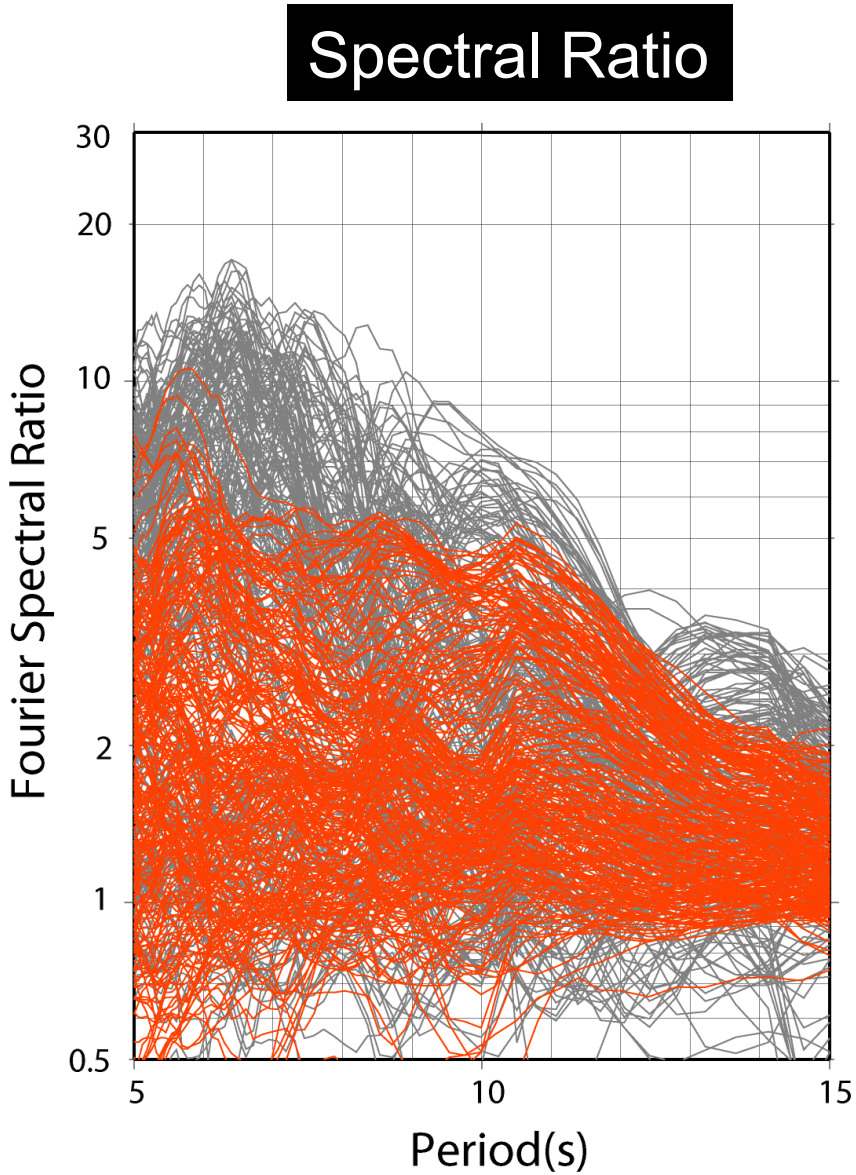
- Velocity-Stress Staggered Grid
- FD Approximation
  - Temporal 2nd-order
  - Spatial 4th-order
- Dx = Dy = 0.5 km; Dz = 0.2 km
- Vs: 0.5 to 3.8 km/s
- Attenuation: No Q

- Source Box
  (Alterman & Karal,1968)
- Application to Input Motion to Irregular Media
  (Zahradnik & Moczo, 1996)

Depth = 10 km
Mw = 7.2 (Mo = 8.5 x 10^{19} Nm)
Moment Rate Function: Delta Function

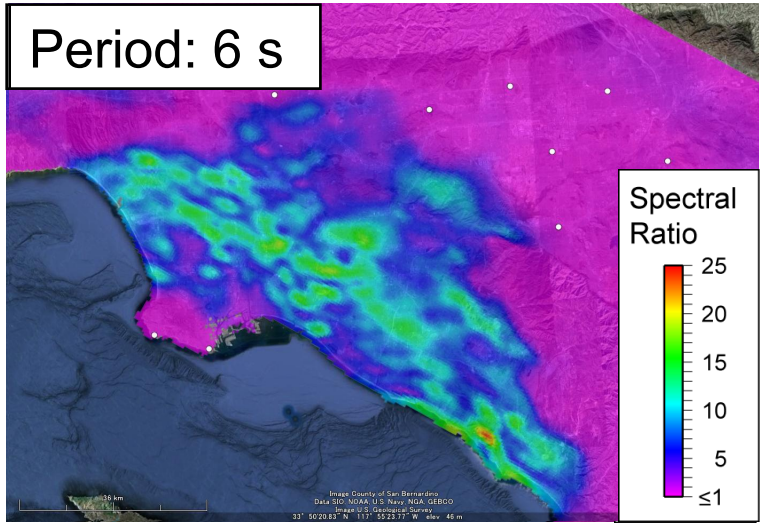
Simulated vs. Observed Fourier Acceleration Spectra

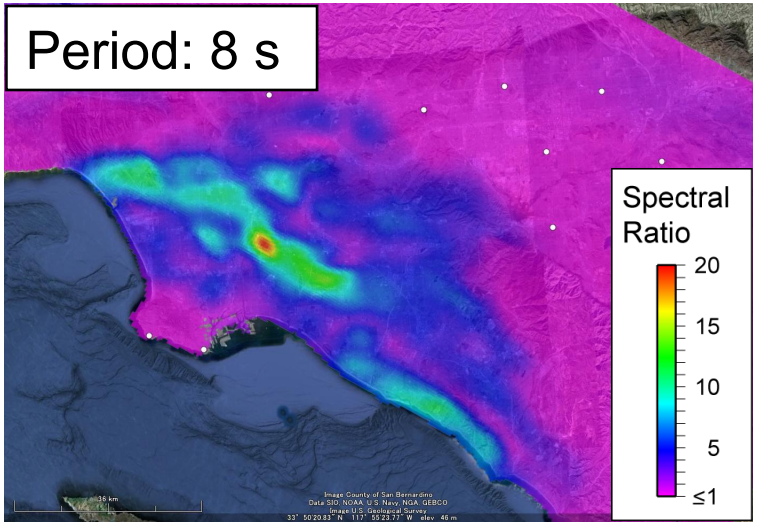




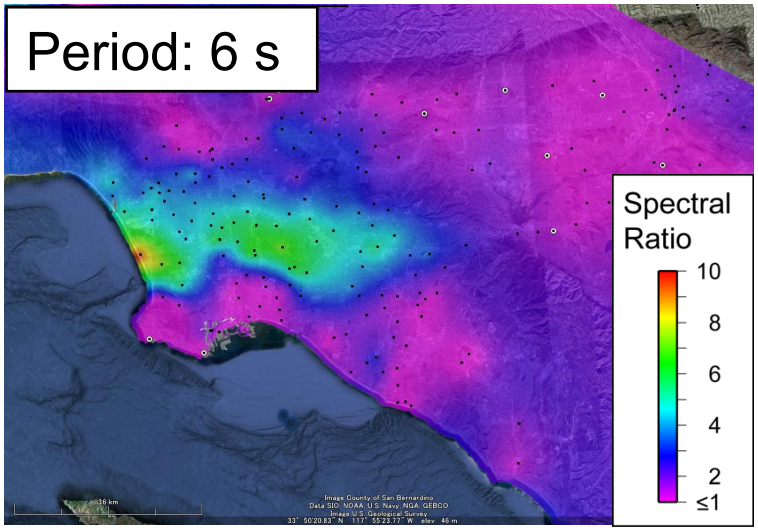
Simulated v's Observed Fourier Spectral Ratio

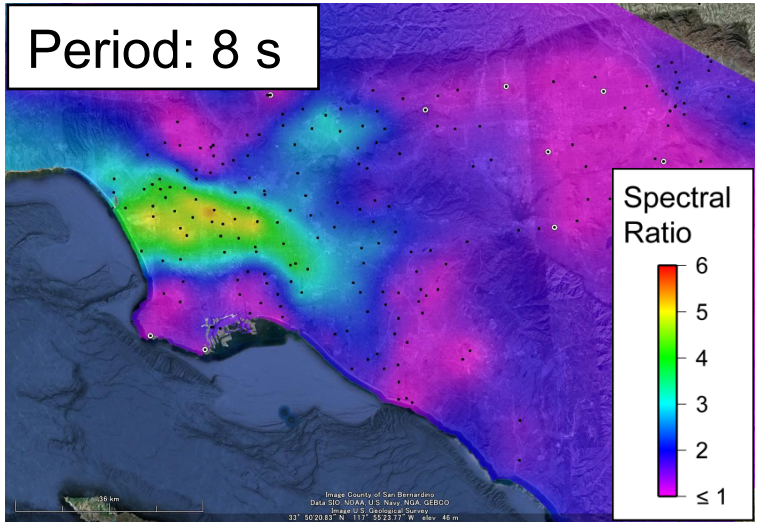
Simulated





Observed





Summary

- Over 200 stations recorded this earthquake in and around the LA Basins.

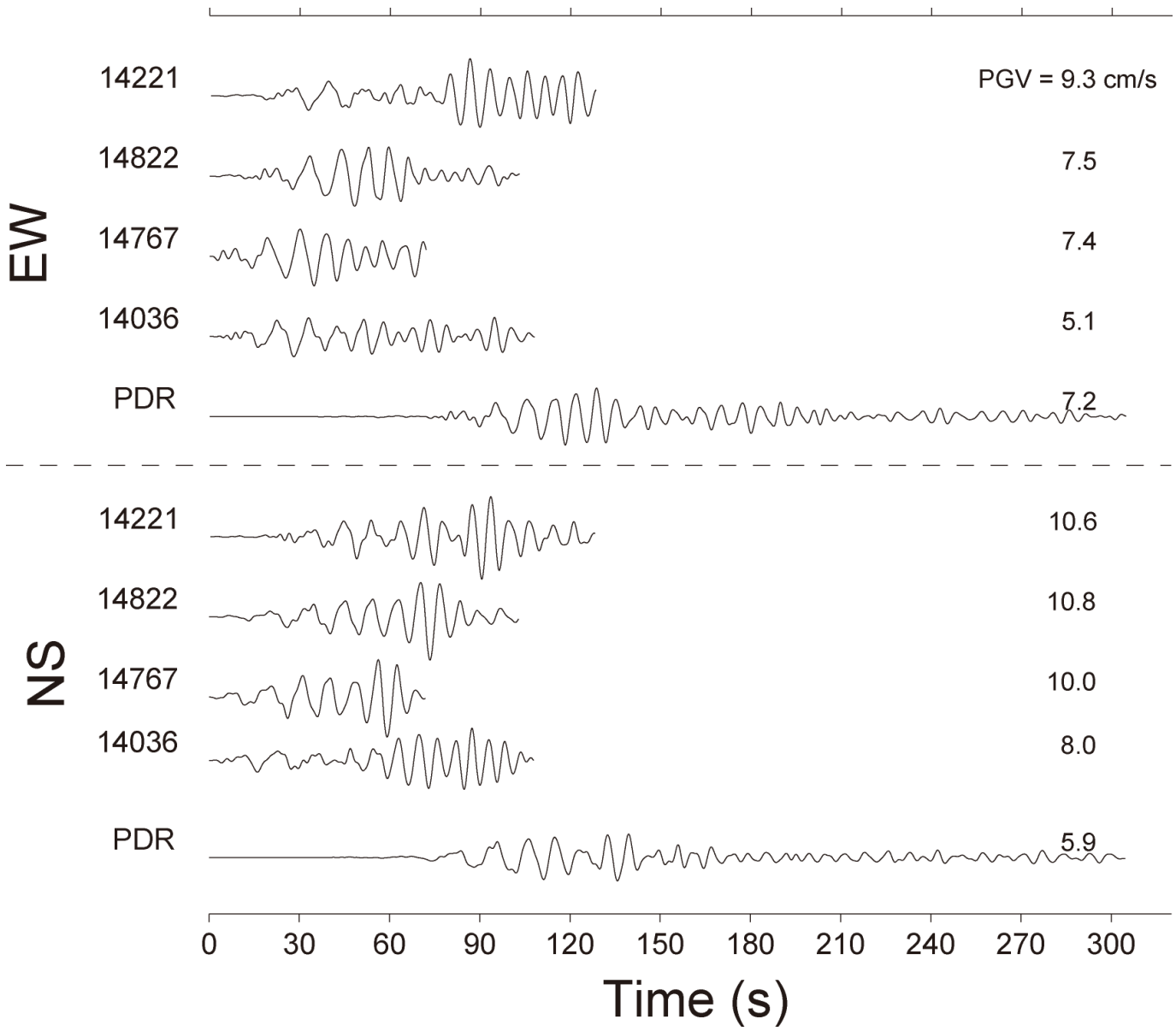
- Higher PGV values were observed at the Western and Central Part of the LA, and San Gabriel Valley Basins as compared to non-basin sites.

- For the Central Part of the LA basin, spatial variation to depth of Vs 3.2 km/s and Vs 2.8 km/s are in good agreement with the observed high PGV values. For San Gabriel Valley, however, spatial variation to depth of Vs 1.5 km/s better agrees with the observed high PGV values.

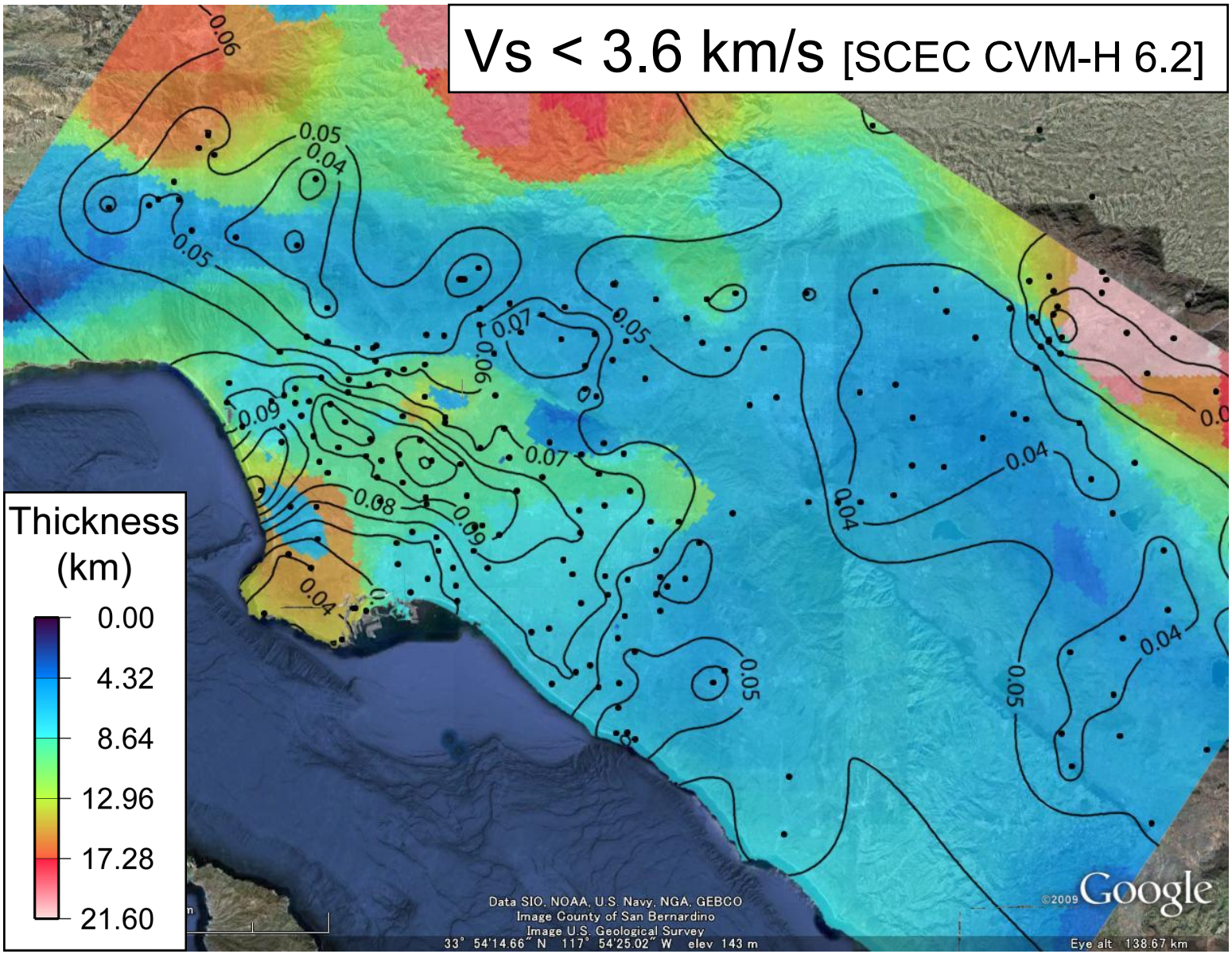
- Spectral amplification factors were evaluated with respect to reference stations on hard rock.
  - At 8 and 10 s, the maximum amplification factor of 5 is observed at the Central Part of the LA Basin. The maximum amplification factor reached to 10 at 6 s at the Western Part of the LA Basin (Manhattan Beach).

- We compared spectral amplification factors computed from observations with those from simulations using a simple point source model and the SCEC CVM-H 6.2.
  - Simulation results generally agreed with observations for spatial variation of amplification factors at long periods over 8 s, however, intensity of amplification factors were overestimated.
  - Including Q-value and/or using detailed source model might improve the agreement between simulations and observations.

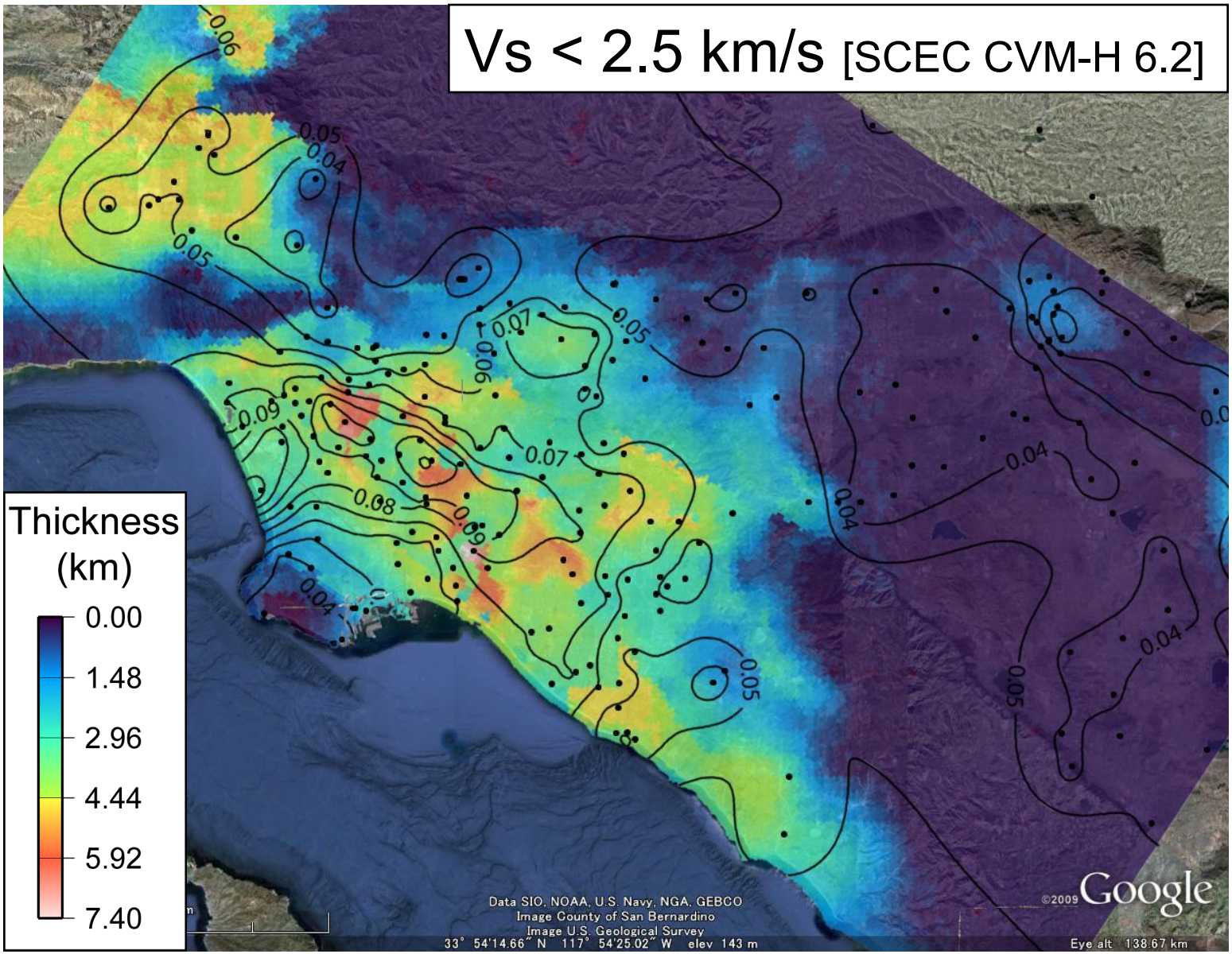
Records around Manhattan Beach (Vel. ; BPF 3 to 16 s)



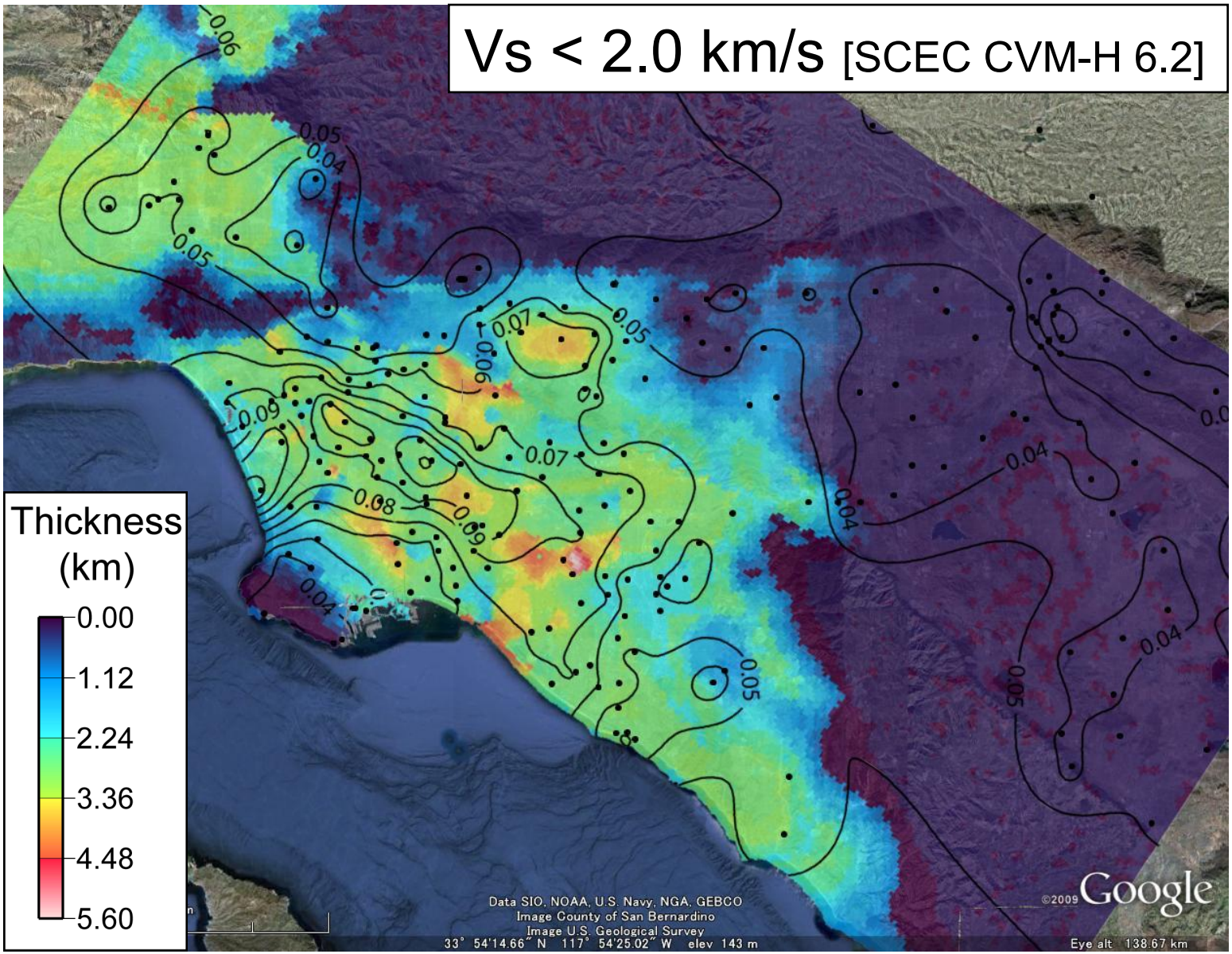
Sediment Thickness(Colors) vs. Observed PGV(Contours)



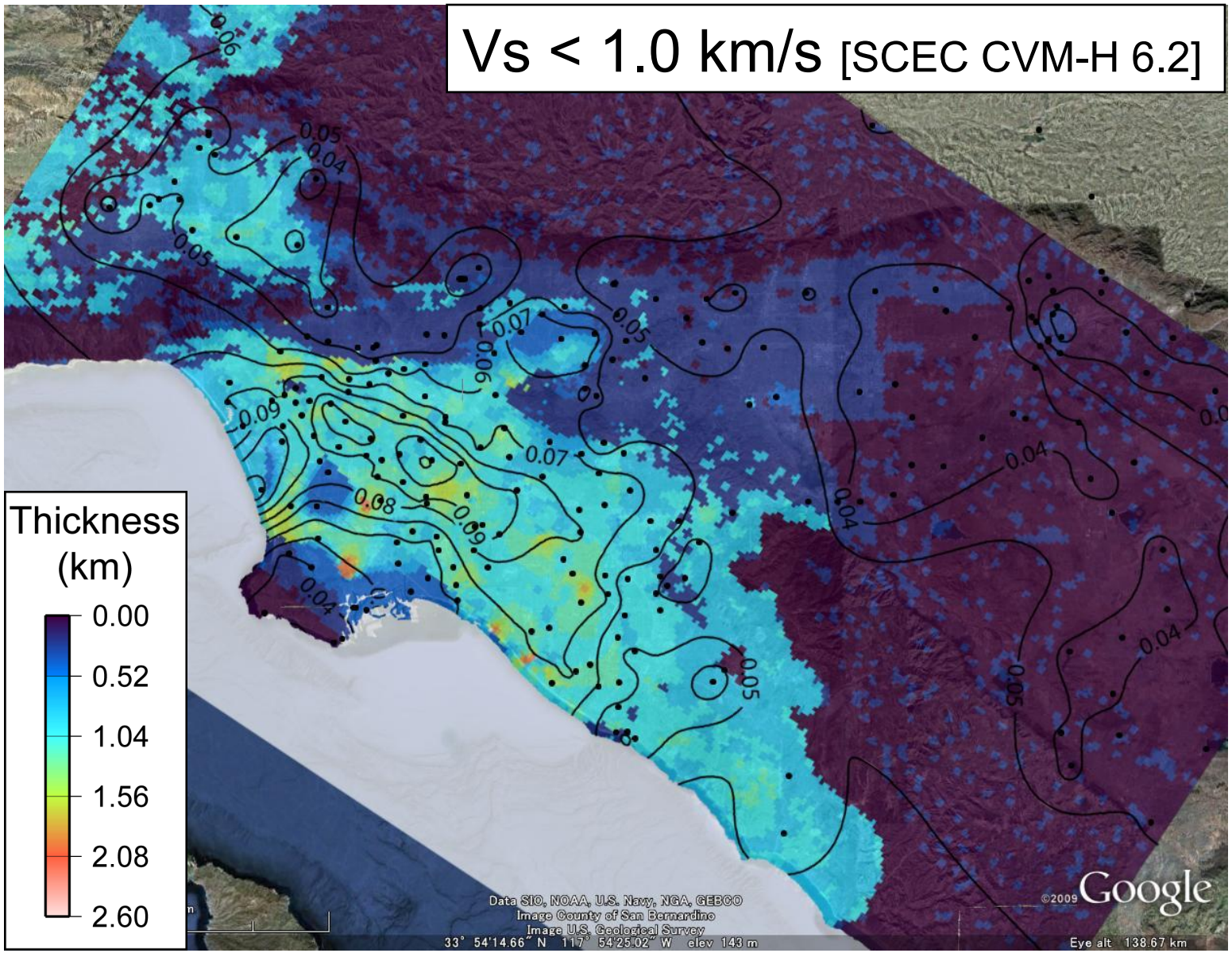
Sediment Thickness(Colors) vs. Observed PGV(Contours)



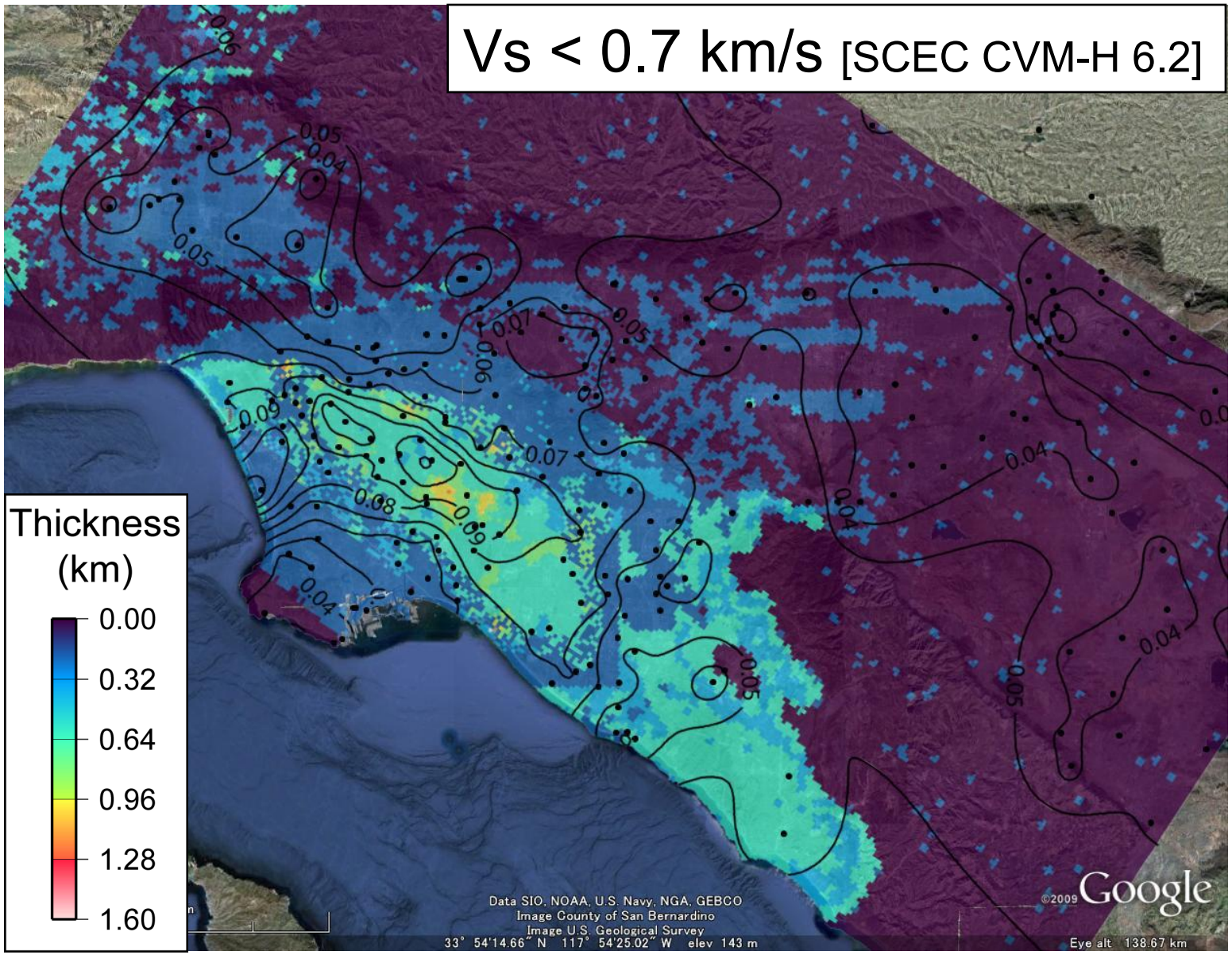
Sediment Thickness(Colors) vs. Observed PGV(Contours)



Sediment Thickness(Colors) vs. Observed PGV(Contours)



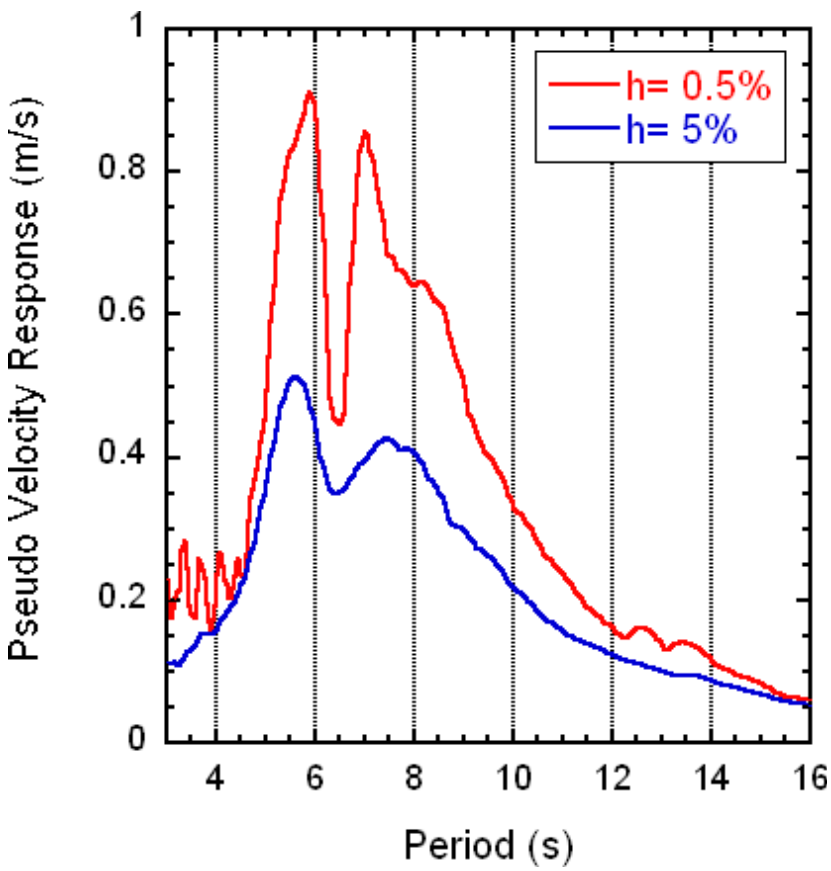
Sediment Thickness(Colors) vs. Observed PGV(Contours)



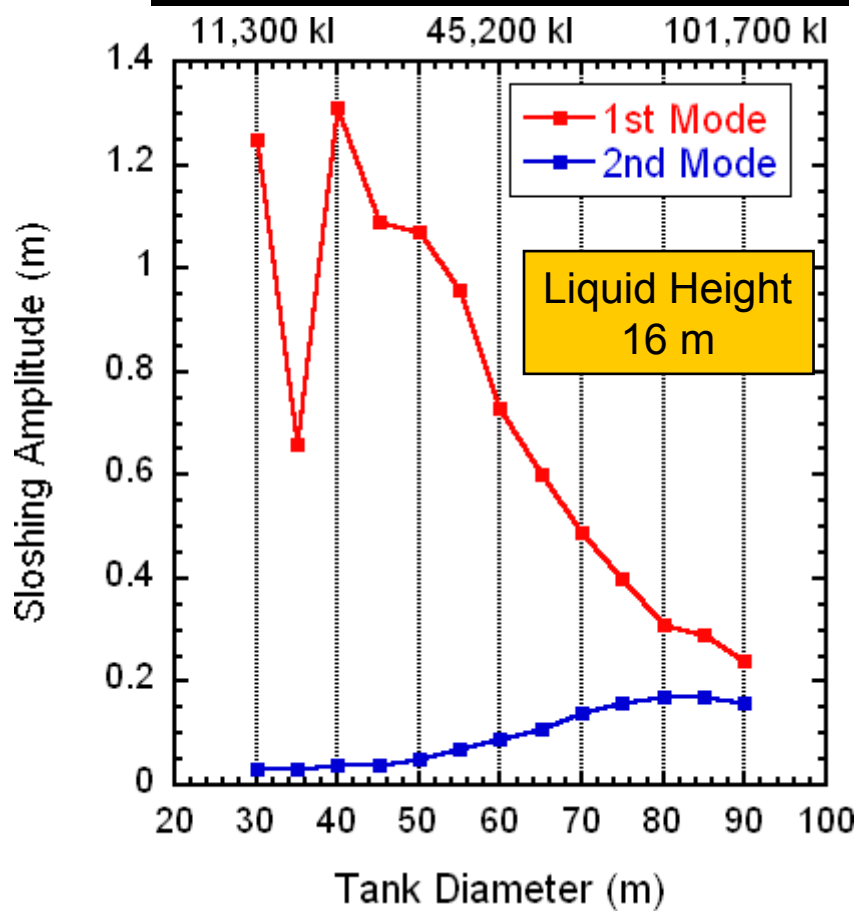
Why Spectra ?

- Long-period structures (e.g., high-rise buildings and large oil tanks) have low damping.
- Their seismic responses are sensitive to spectral ordinates of input ground motions

Velocity Response Spectra



Liquid Sloshing of Large Tanks



FDM used in this Study

<<FDM>>

+ Velocity-Stress Staggered Grid

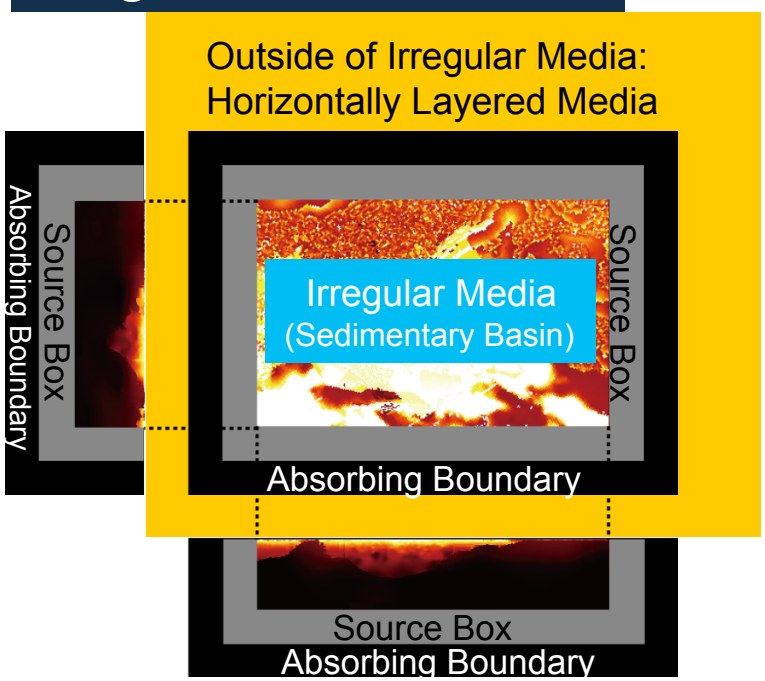
+ FD Approximation
  – Temporal 2nd-order
  – Spatial 4th-order

<<How to Give Input Motion>>

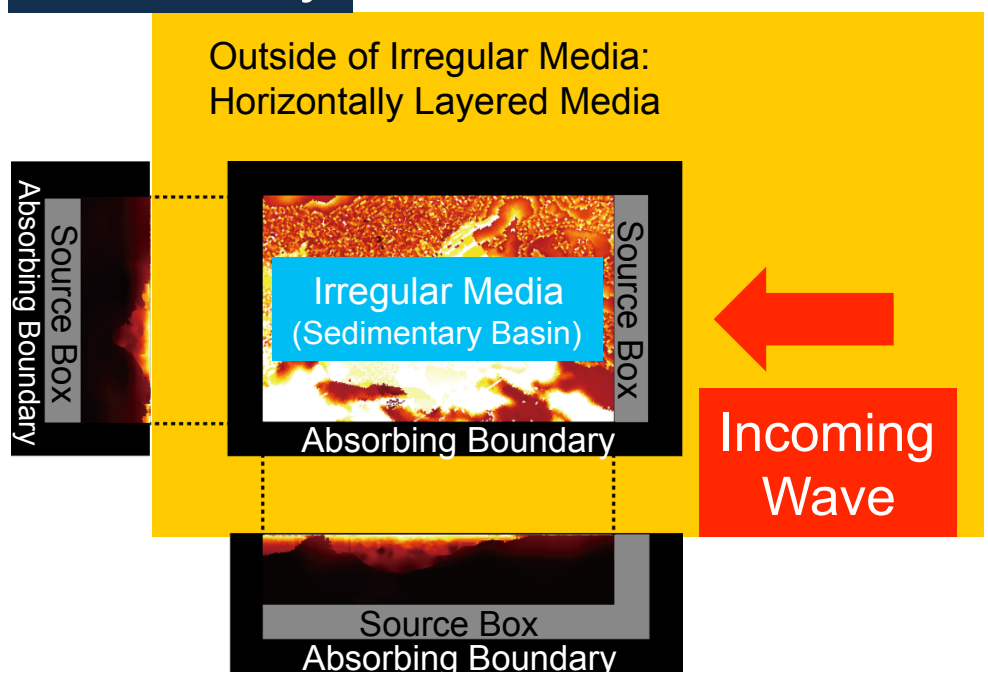
+ Source Box (Alterman & Karal,1968)

+ Application to Input Motion to Irregular Media (Zahradnik & Moczo, 1996)

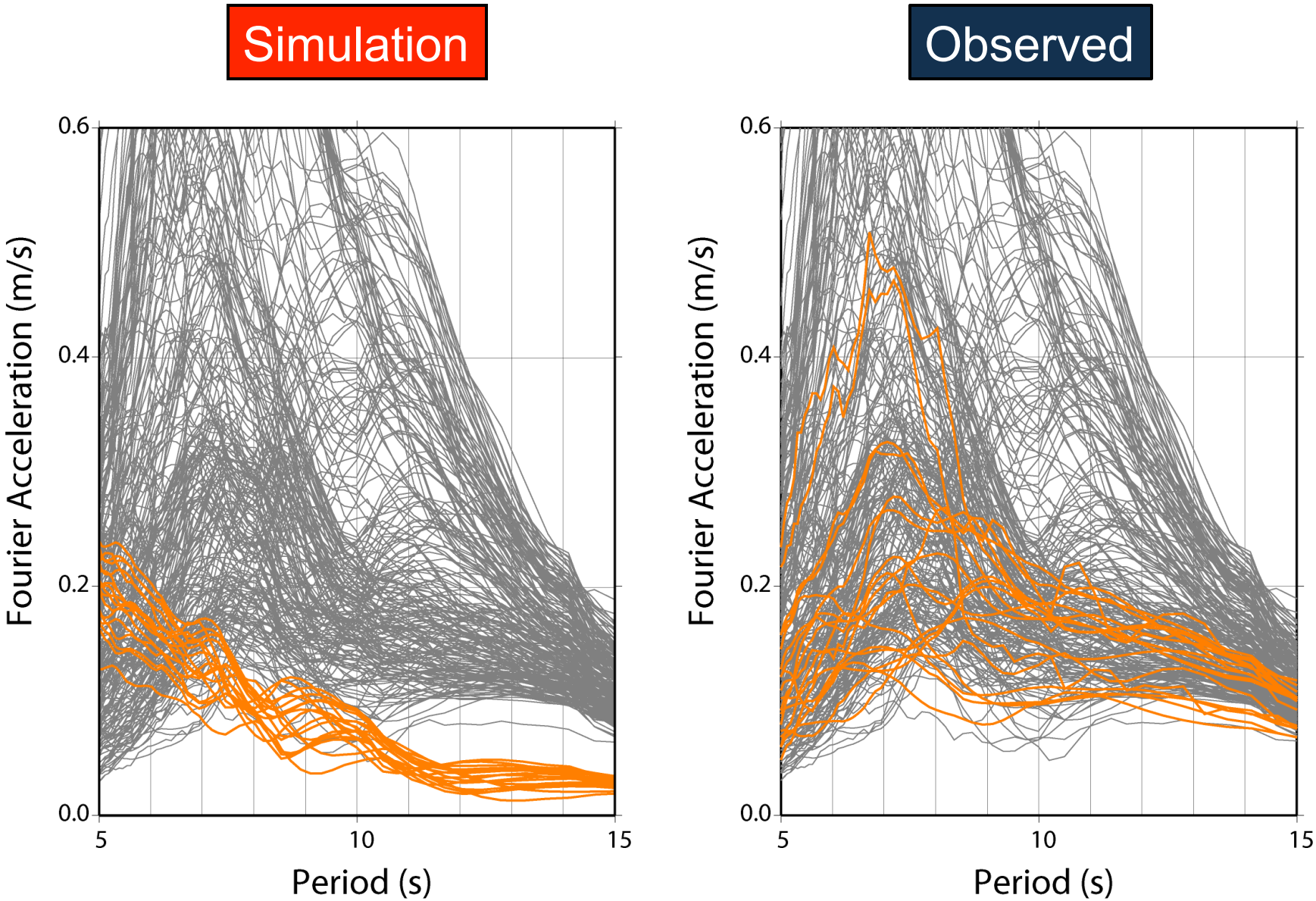
Original Source Box



This Study

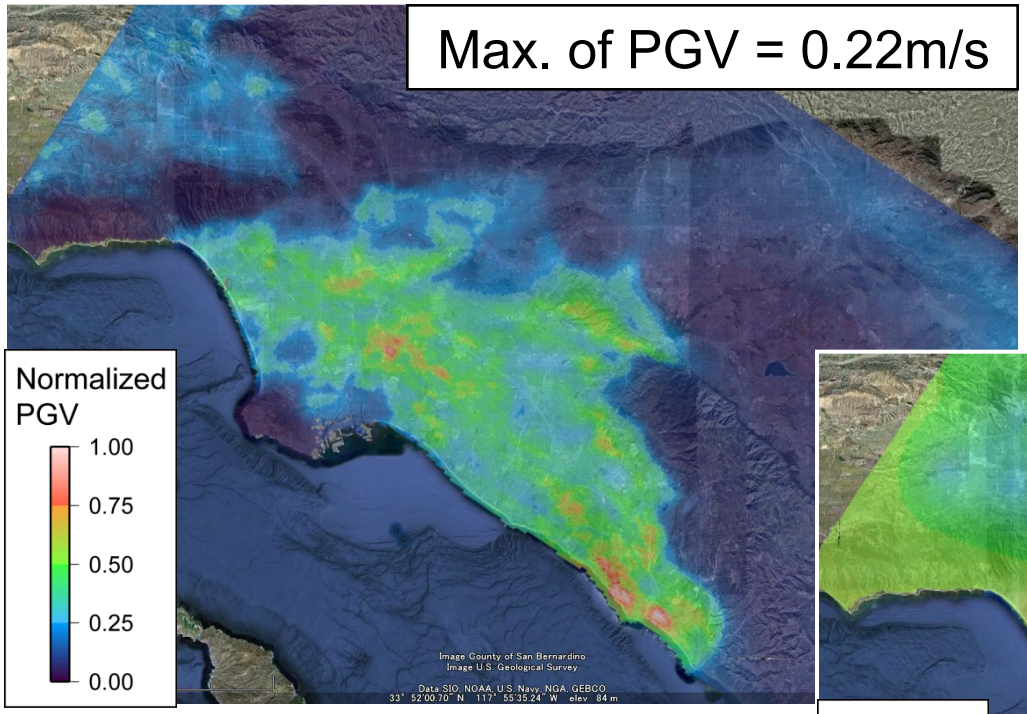


Incident Waves (Fourier Acc. Spectra)

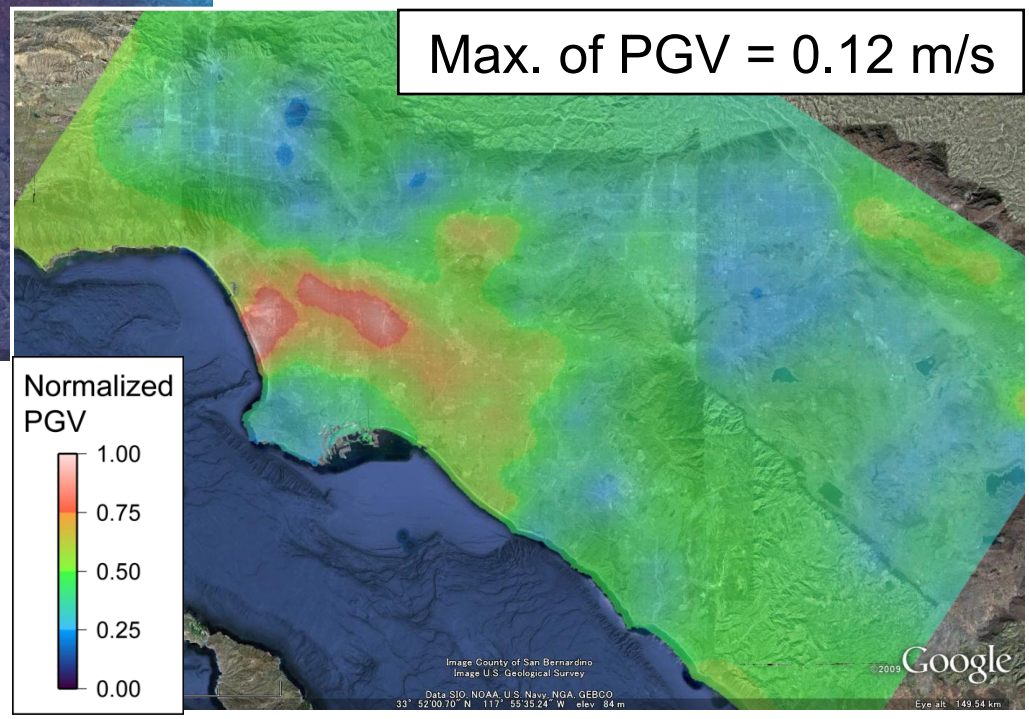


Simulated vs. Observed PGV (Period Range: 5 to 16 s)

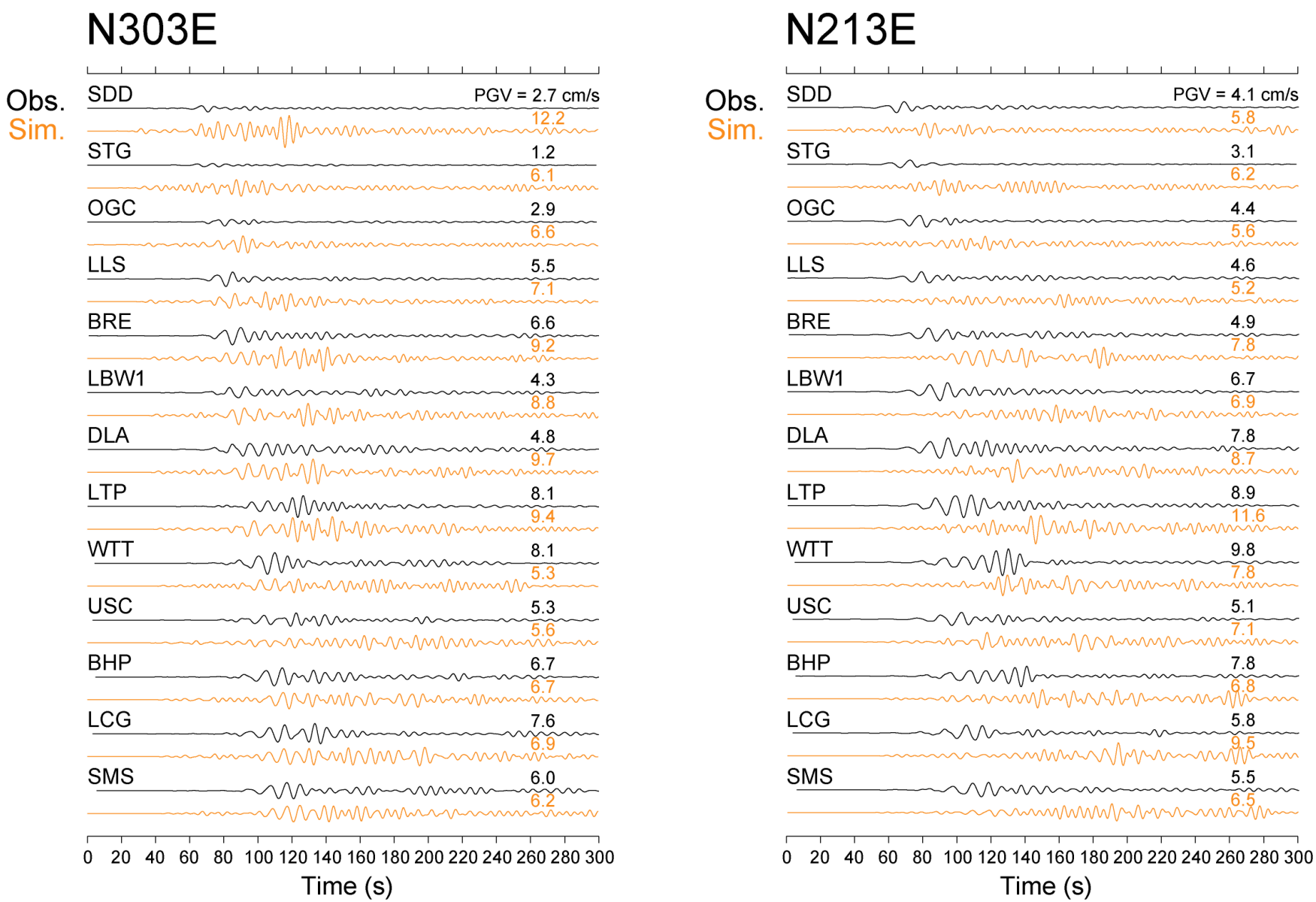
Simulated

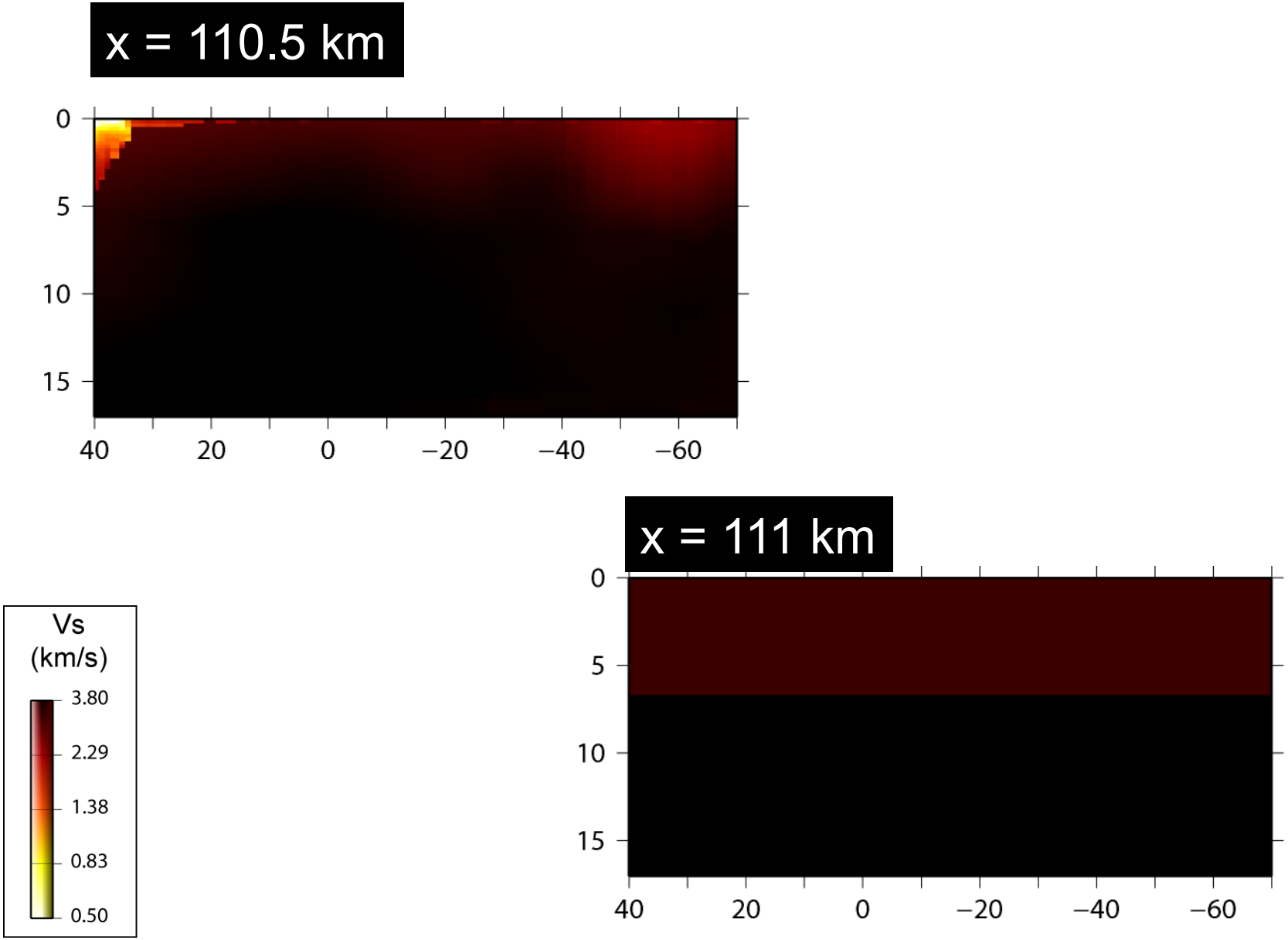


Observed



Simulated vs. Observed Velocity Waveform (Period Range: 5 to 16 s)




x = 110.5 km
0
5
10
15
40
20
0
−20
−40
−60
x = 111 km
0
5
10
15
40
20
0
−20
−40
−60
Vs
(km/s)
3.80
2.29
1.38
0.83
0.50