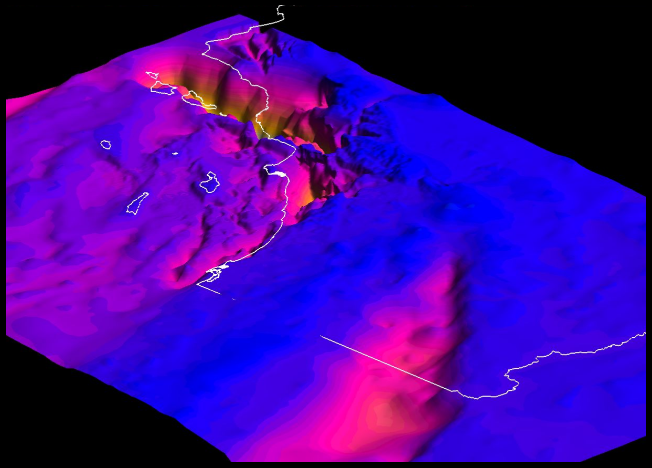
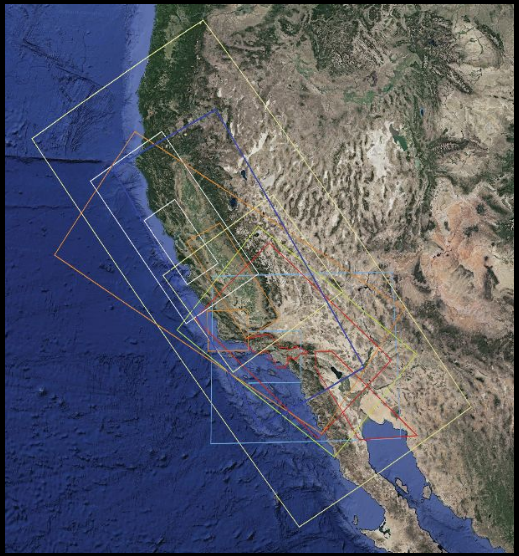
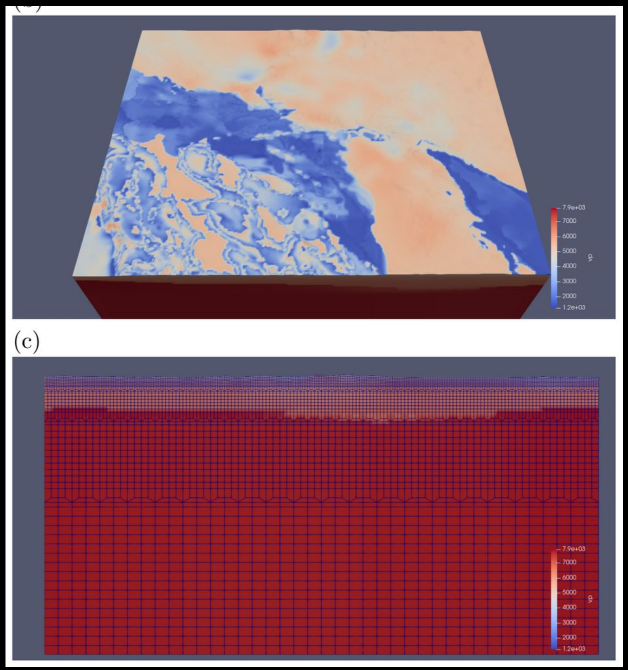
The SCEC CVM effort: new basin models, enhanced access and tomographic updates

A. Plesch, C. Thurber, C. Tape, P. Maechling and J.H. Shaw







SCEC 2021 Annual Meeting, Session 10: Progress and Challenges in SCEC Community Models Development

SCEC CVMS 4.0 – Sediment Velocities

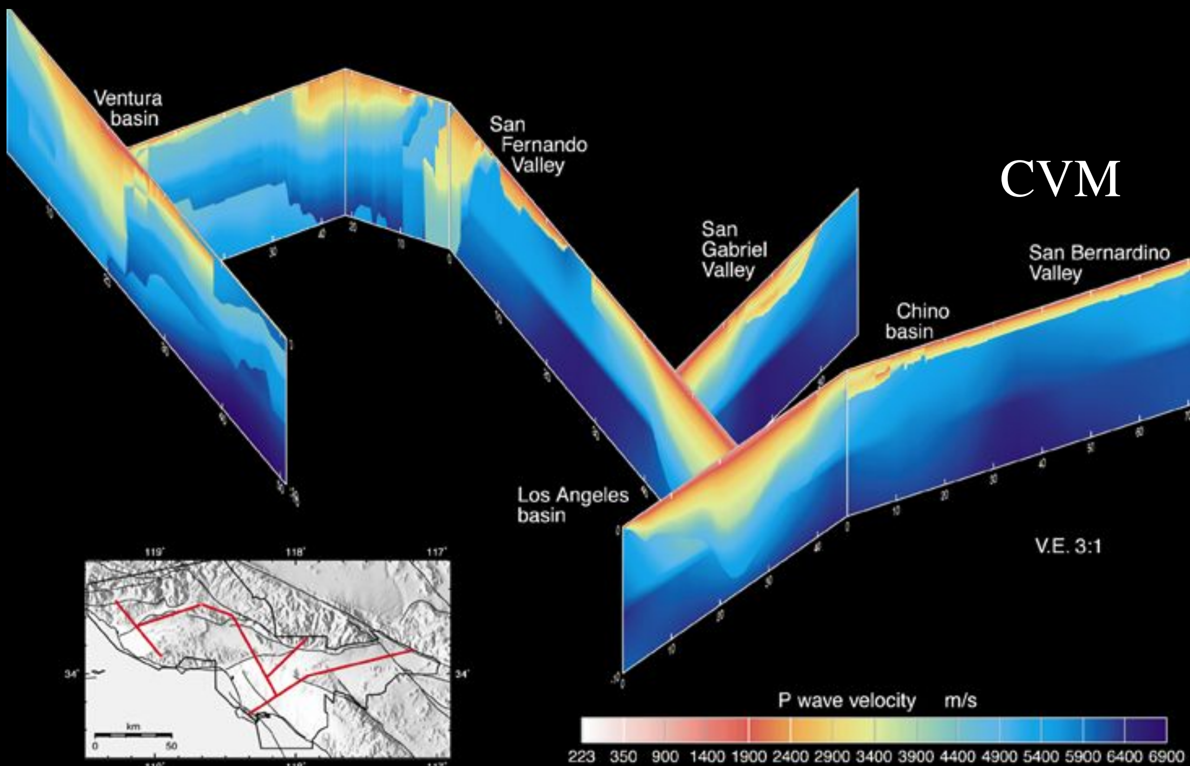
(Magistrale, Day, Clayton, & Graves, 2000, 2005)

- Vp is defined at stratigraphic boundaries as a function of depth(Z) and age (T) using Faust's law:

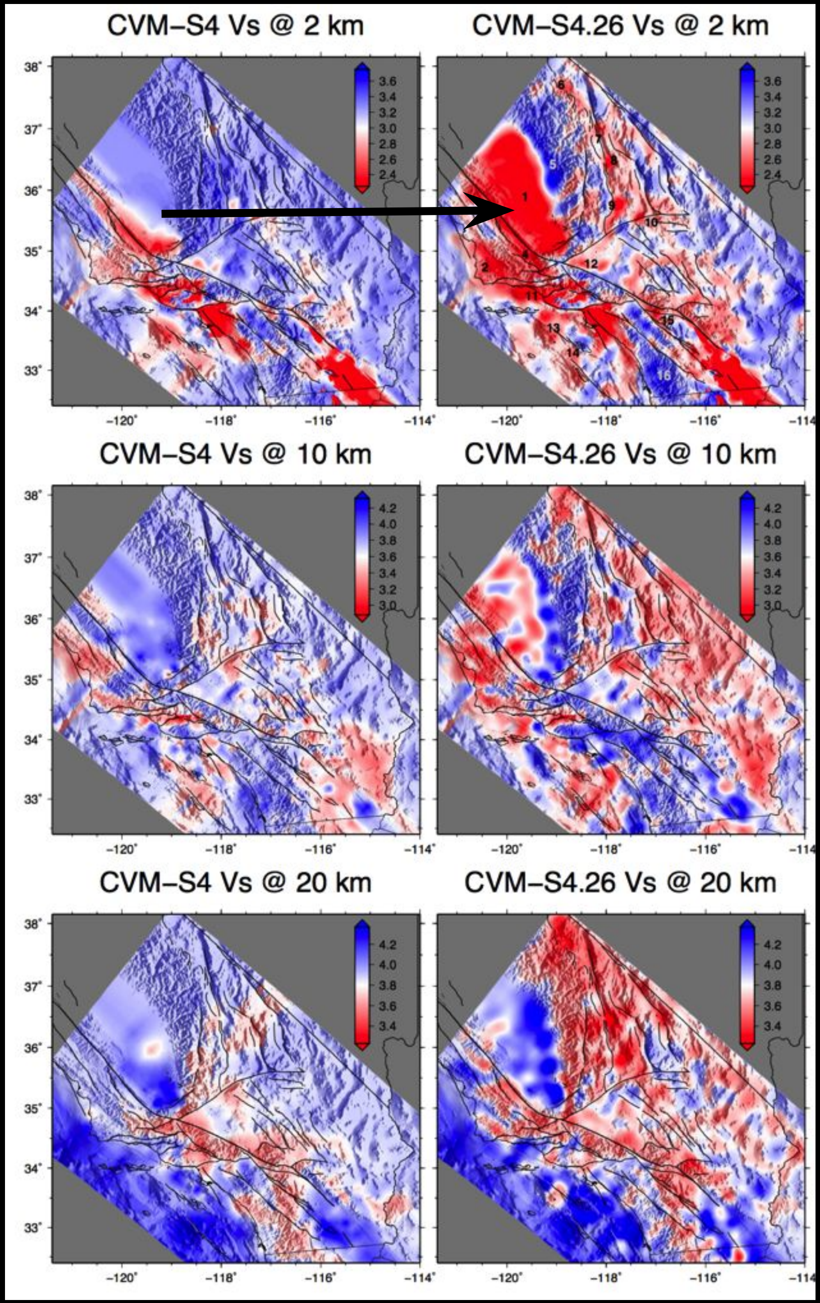
$$v_{\text{int}} = \alpha (ZT)^{1/6}$$

- relation is calibrated using well control

- Vp is linearly interpolated between stratigraphic horizons



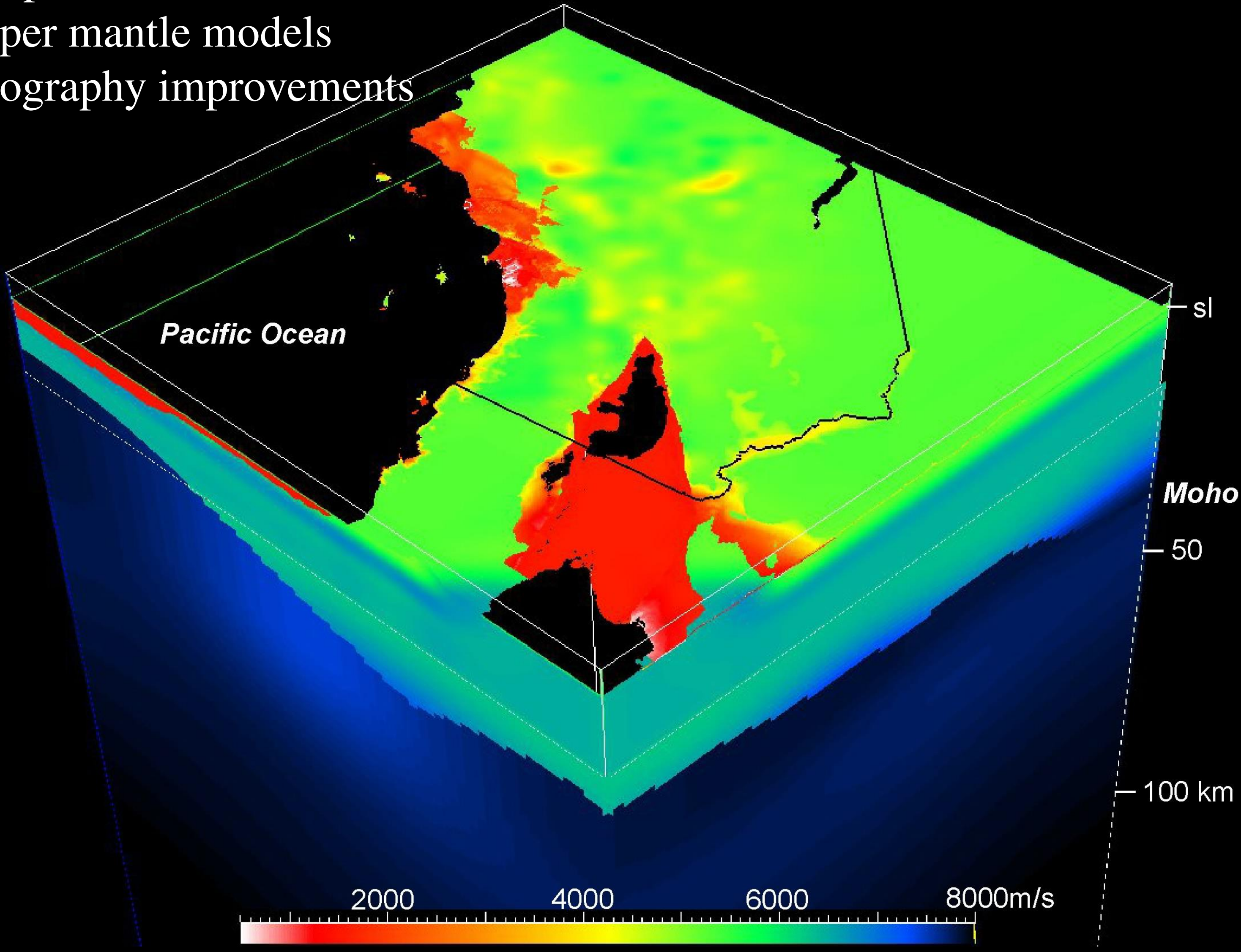
3D waveform tomography (F3DT)



Lee, E.-J., P. Chen, T. H. Jordan, P. B. Maechling, M. A. M. Denolle, and G. C. Beroza (2014), Full-3-D tomography for crustal structure in Southern California based on the scattering-integral and the adjoint-wavefield methods, *J. Geophys. Res. Solid Earth*, 119, doi:10.1002/2014JB011346.

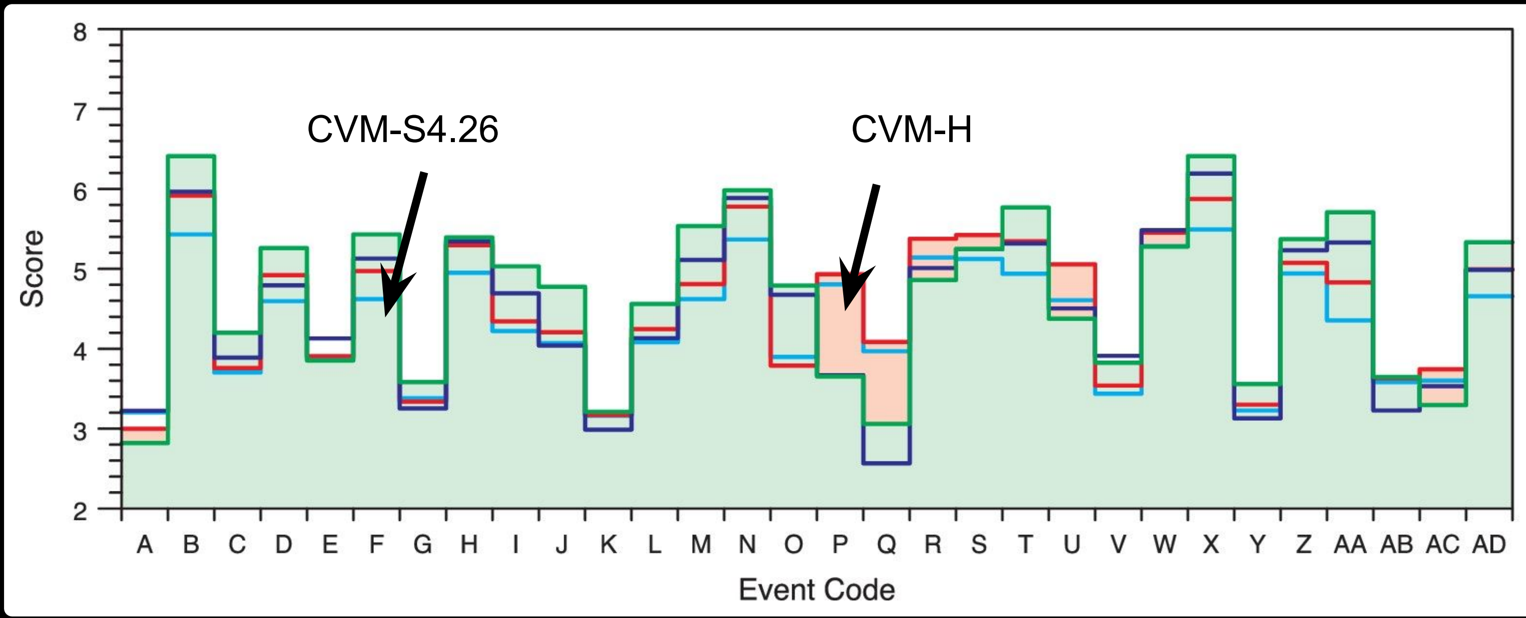
SCEC CVM-H Components

- Basin structures, GTL
- Crustal tomographic models
- Teleseismic upper mantle models
- Waveform tomography improvements



Shaw et al., (2013)

Evaluating the Community Models



Model	Mean FS
S4.26	4.87
S4	4.75
H+GTL	4.82
H	4.60

CVM-S4.26 scores (goodness of fit of synthetic waveforms to observed) highest for many validation earthquakes (A-AD), CVM-H for a few others and not far behind most.

Taborda et al., 2016

SCEC CVM-H Components

- Basin structures
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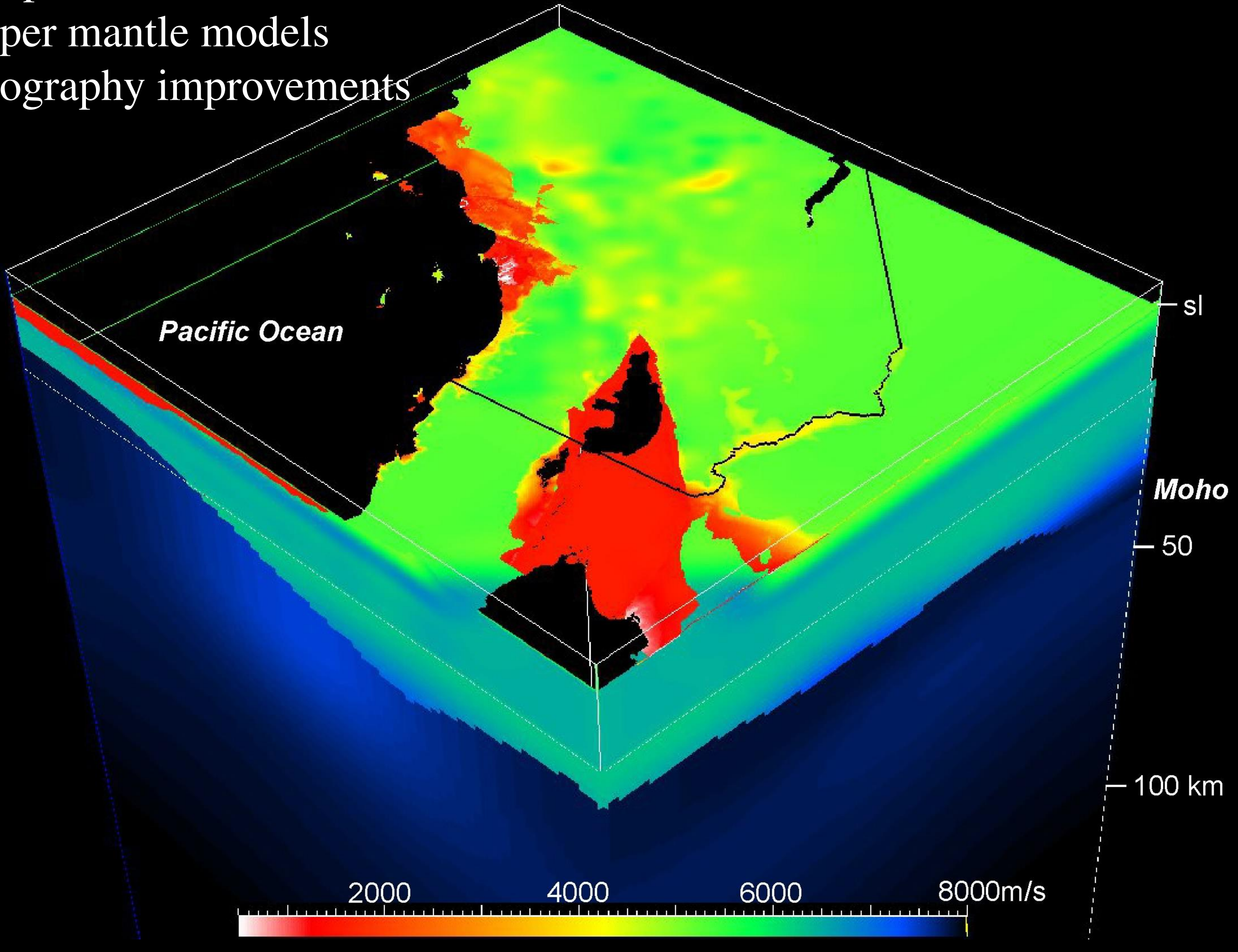
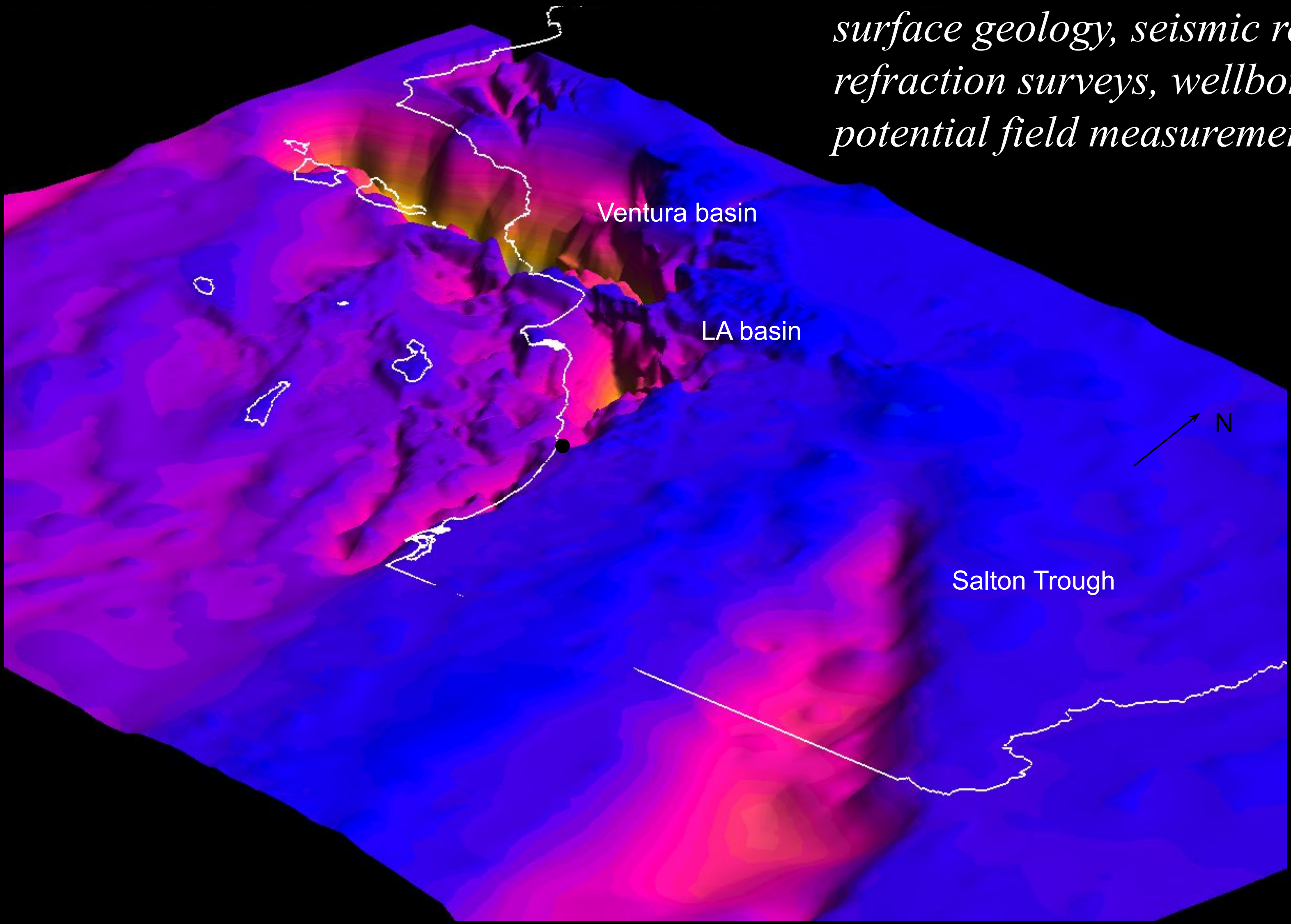
- Teleseismic upper mantle models
- Waveform tomography improvements



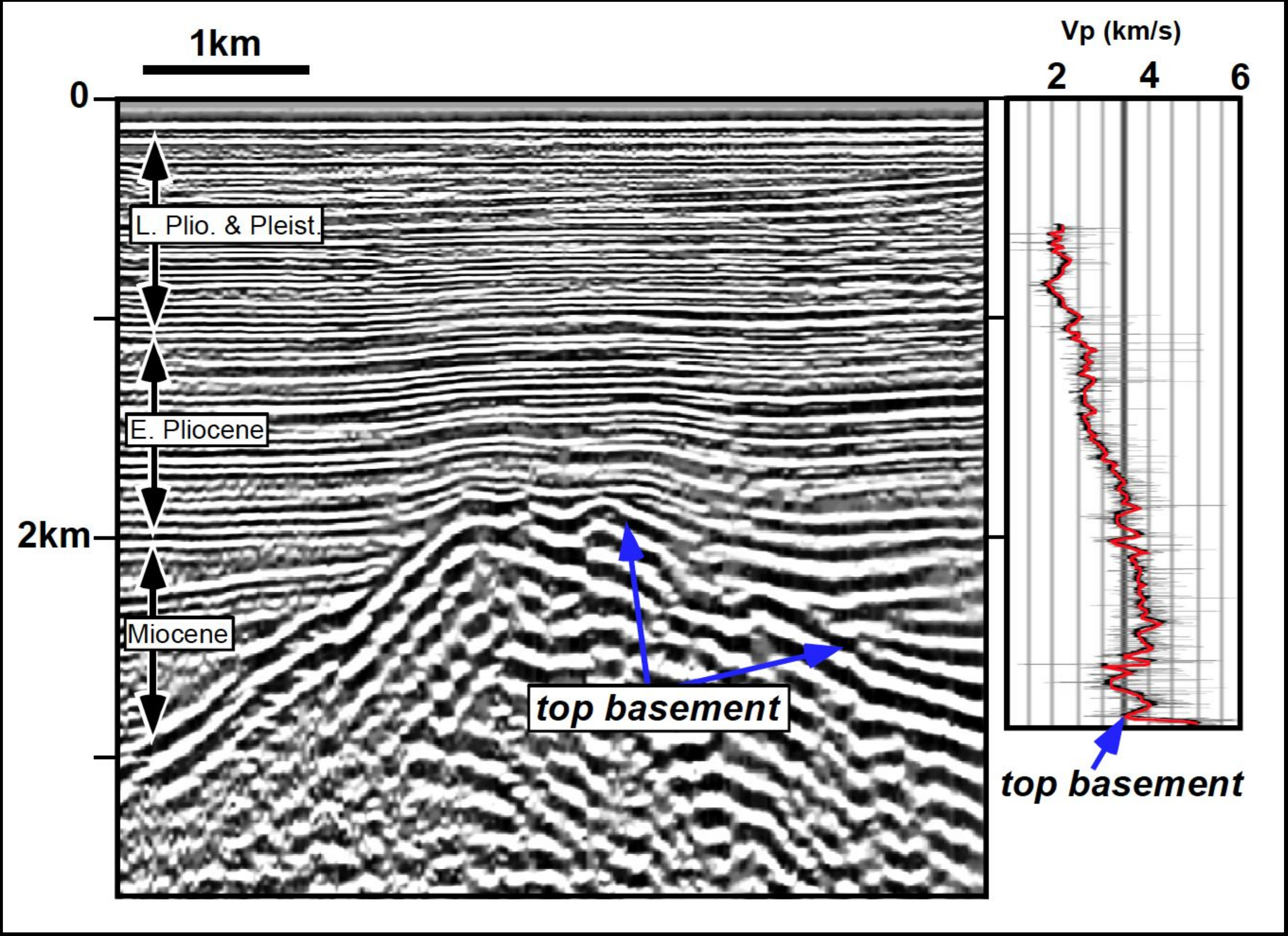
Shaw et al., (2013)

Basement structure in the SCEC CVM-H

Basement structure is defined by surface geology, seismic reflection and refraction surveys, wellbore data, and potential field measurements.

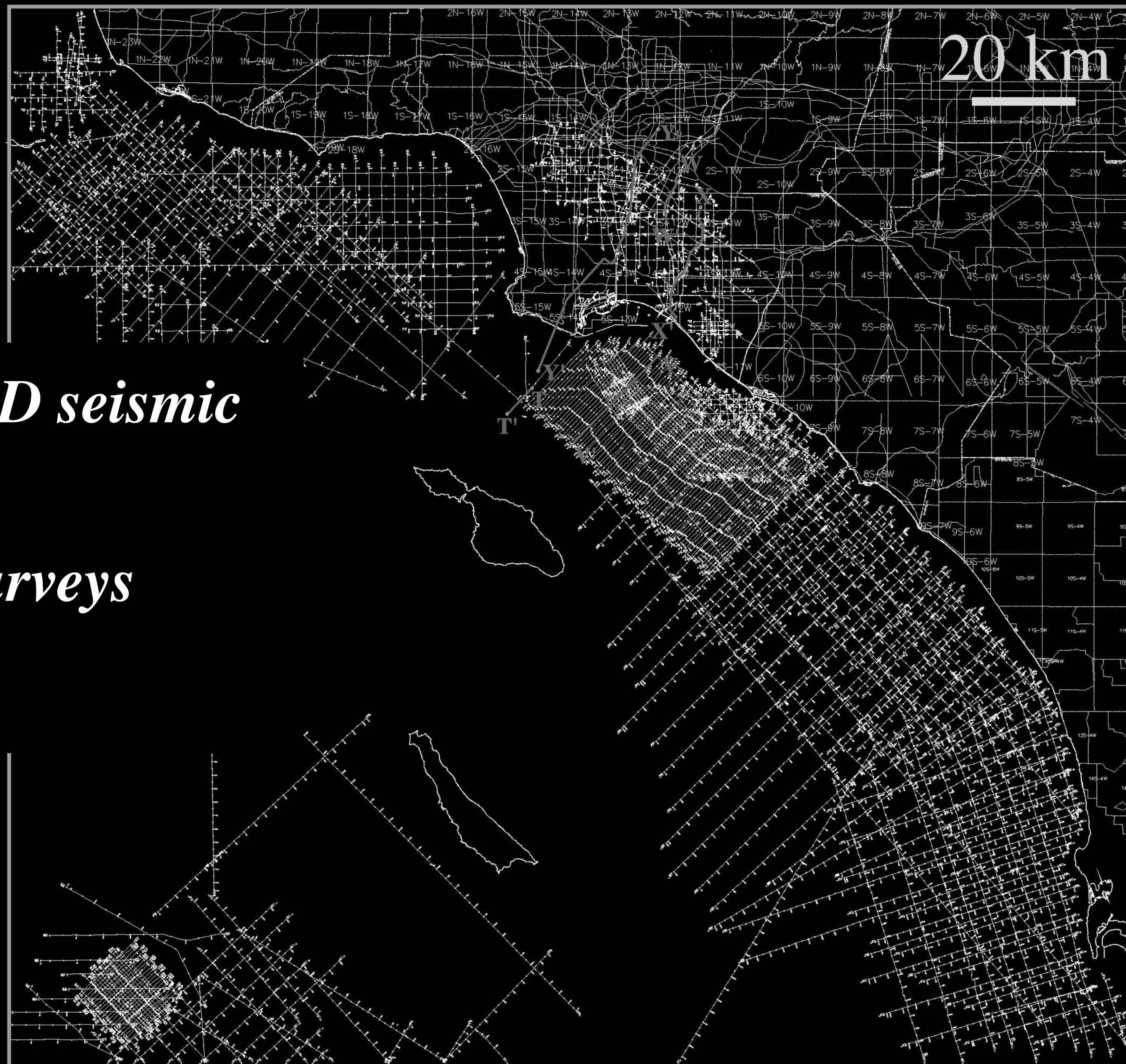


Defining the basement surface

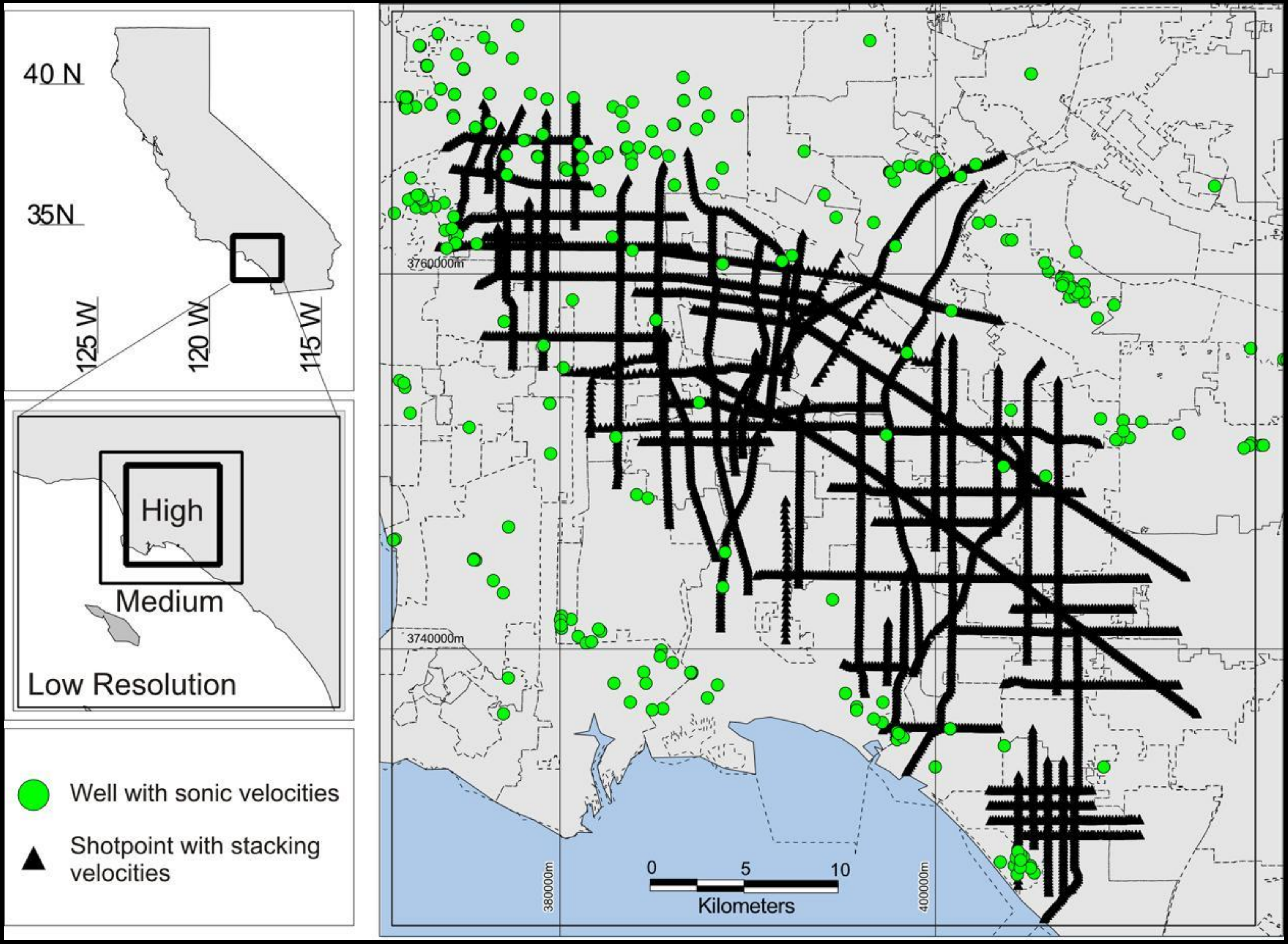


Industry data coverage

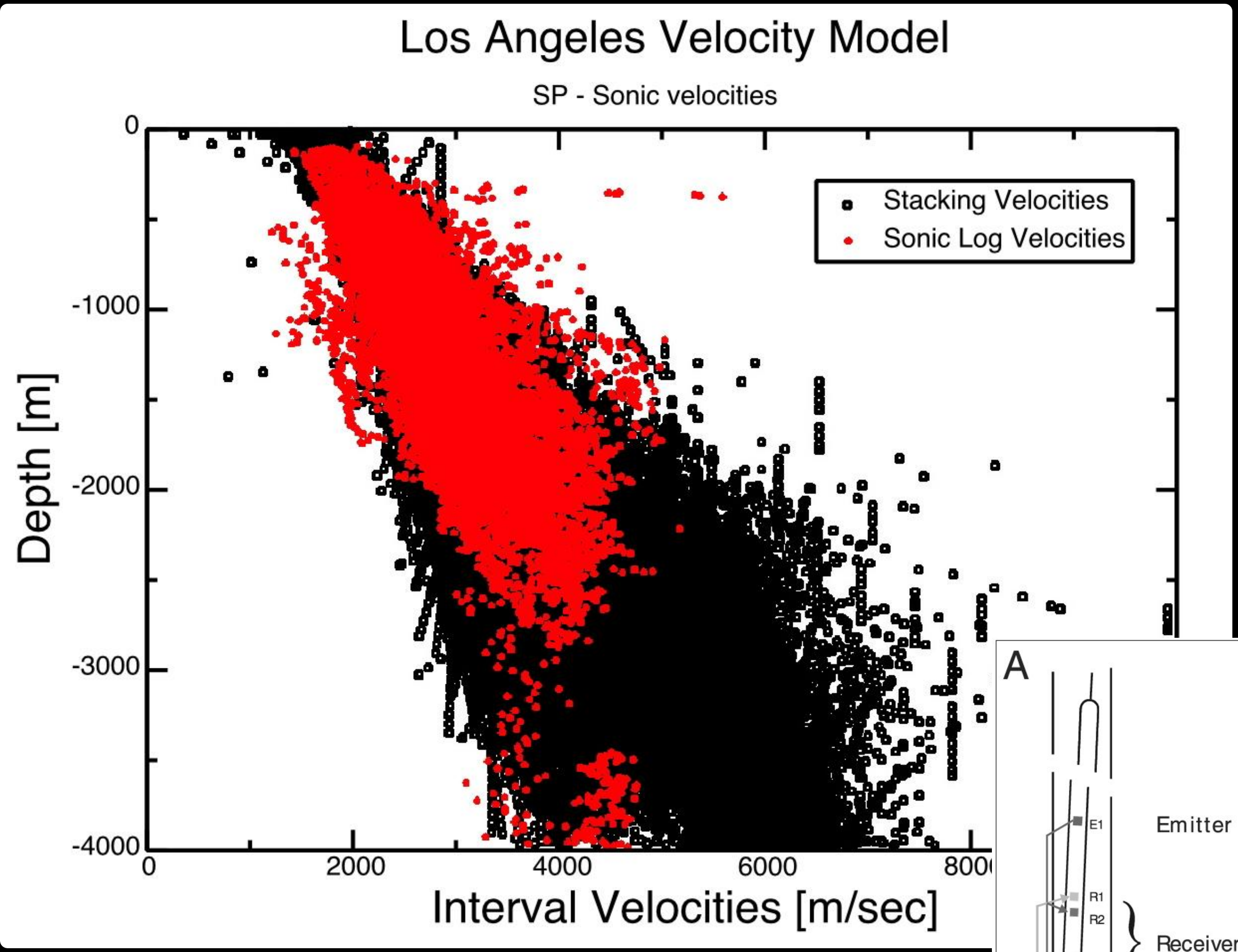
- *100,000 km 2D seismic data*
- *3D seismic surveys*
- *10,000 wells*

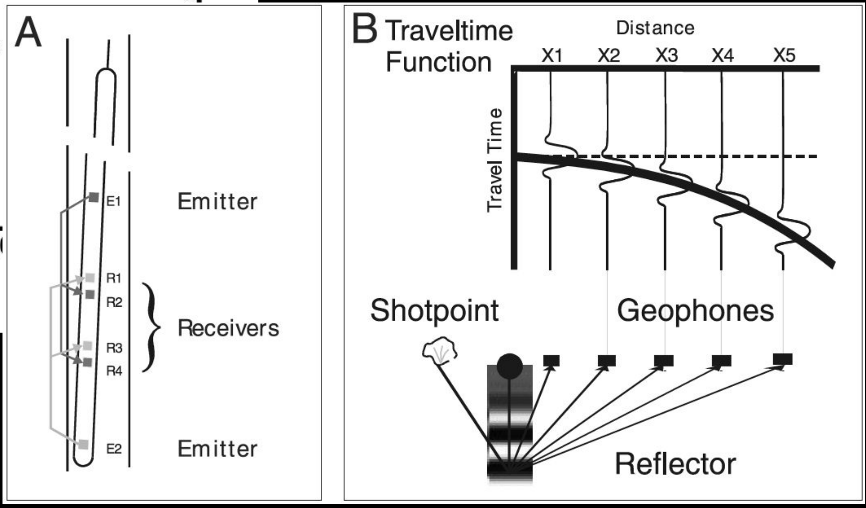


Velocity parameterization through geostatistical interpretation

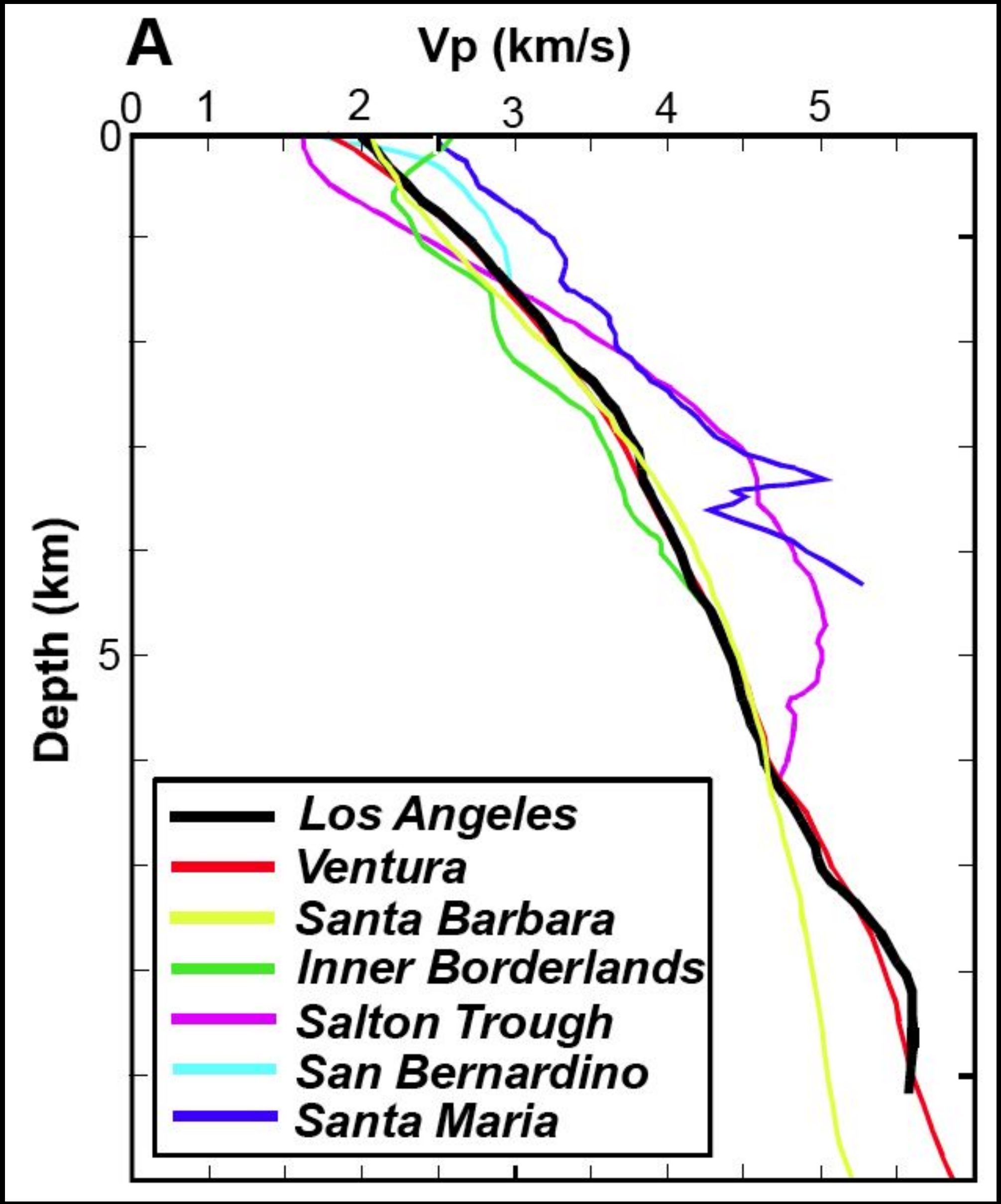


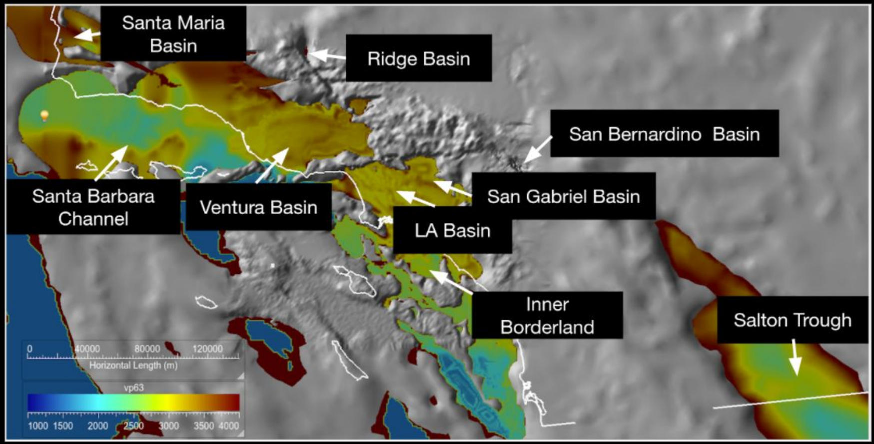
Industry velocity data



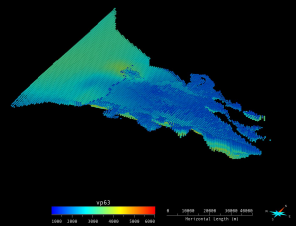


Average basin profiles

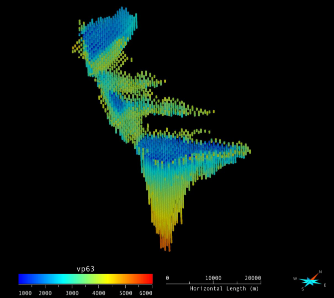




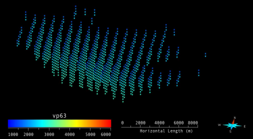
Modular Basins



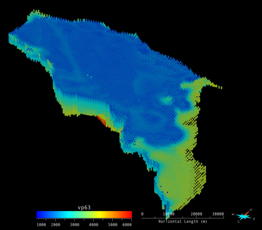
Santa Maria
Basin



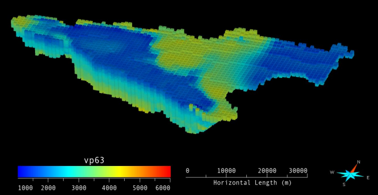
Ridge Basin



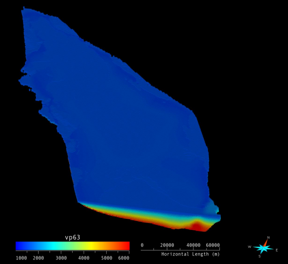
San Bernardino Basin



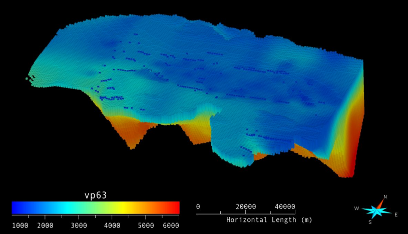
LA Basin



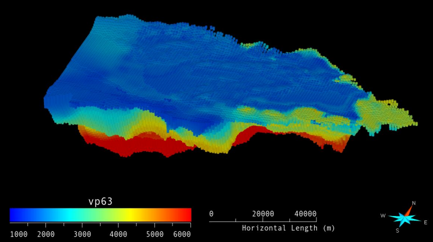
San Gabriel Basin



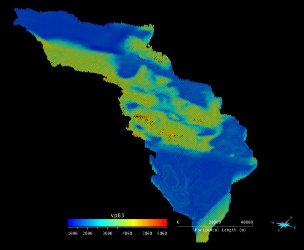
Salton Trough



Santa Barbara
Channel



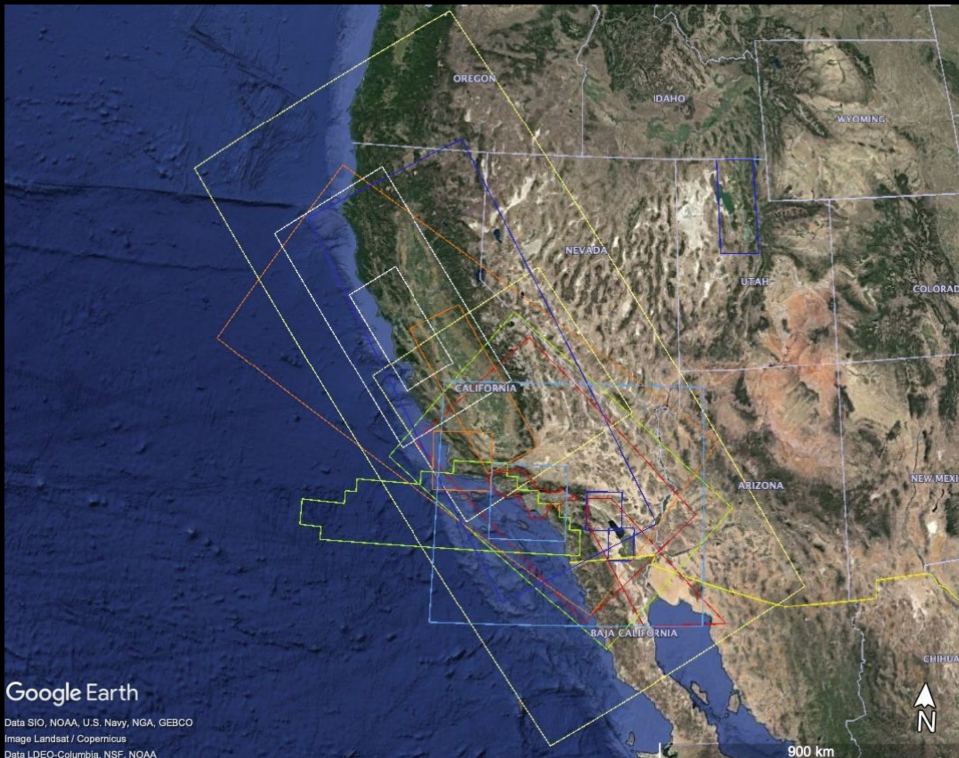
Ventura Basin



Inner
Borderland

- Each basin module is available as grid or unstructured set of point locations.
- Basin modules are populated with CVM-H data but support other models as well.

Unified Community Velocity Model software



http://hypocenter.usc.edu/research/ucvm/UCVM_v19_4_Coverage_Regions_v1.kml

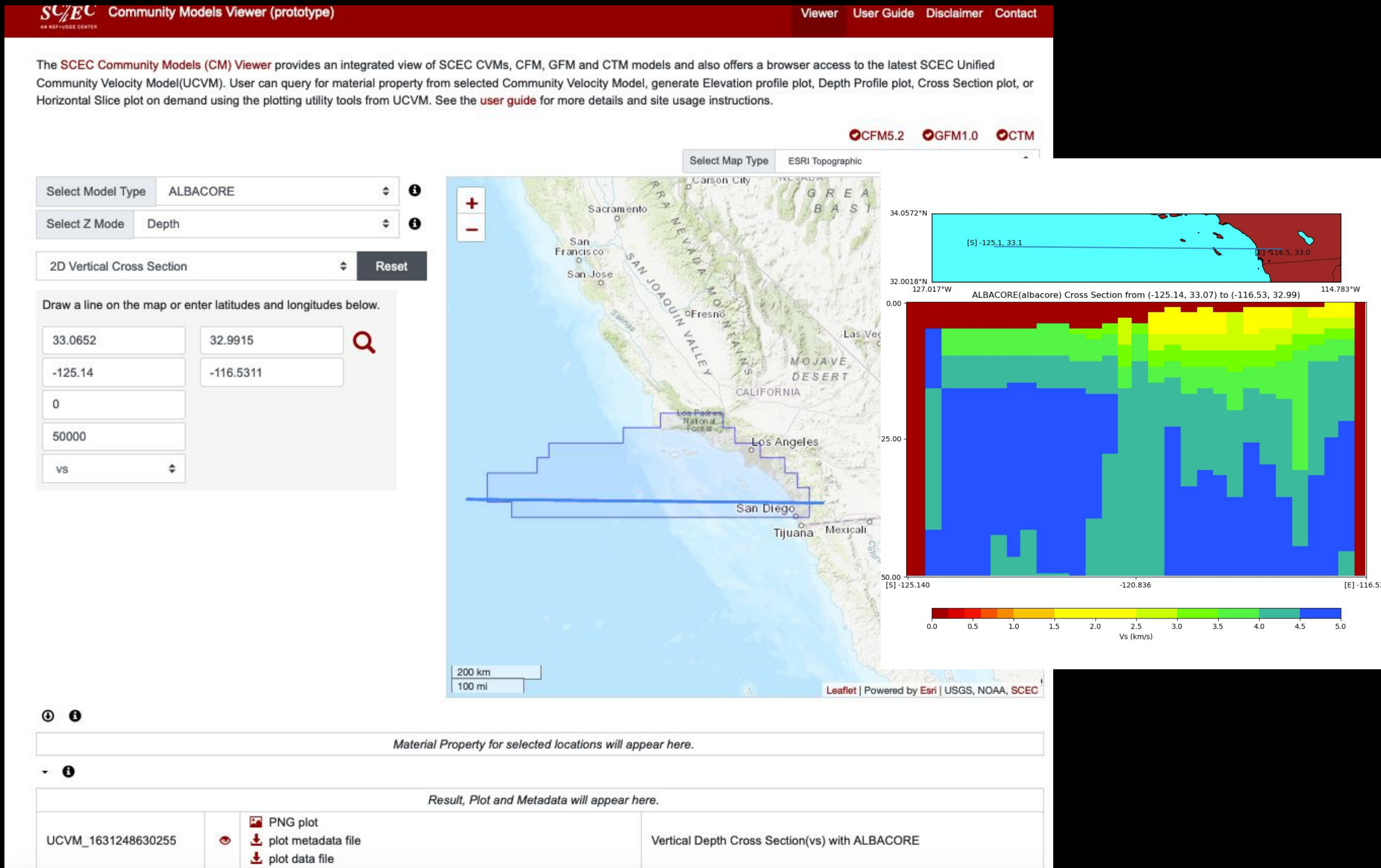
Coverage regions for CVMs registered into UCVM

1. UCVM Digital Elevation model and Vs30 maps: yellow
2. CVM-S4: red, CVM-S4 geotechnical regions: red polygons
3. CVM-H 15.1 low resolution: larger light blue square
4. USGS High Resolution Bay Area: small white rectangle
5. USGS Low Resolution Bay Area: large white rectangle
6. CVM-S4.26 : green rectangle
7. CVM-S4.26M01: green rectangle
8. CCA 06: small yellow rectangle
9. CS17.3: large orange rectangle
10. CS17.3-H: Harvard San Joaquin Basin Model: small orange rectangle
11. CS17.3-H: Harvard Santa Maria Basin Model: orange square
12. CS18.8 CyberShake Study's Tiled Velocity Model: blue rectangle
13. Albacore
14. IVLSU
15. CVLSU
16. WFCVM
17. SoCal 1D, Hadley-Kanamori
18. Northridge 1D

see posters #16 and #20

http://moho.scec.org/UCVM_web/web/viewer.php

Unified Community Velocity Model software



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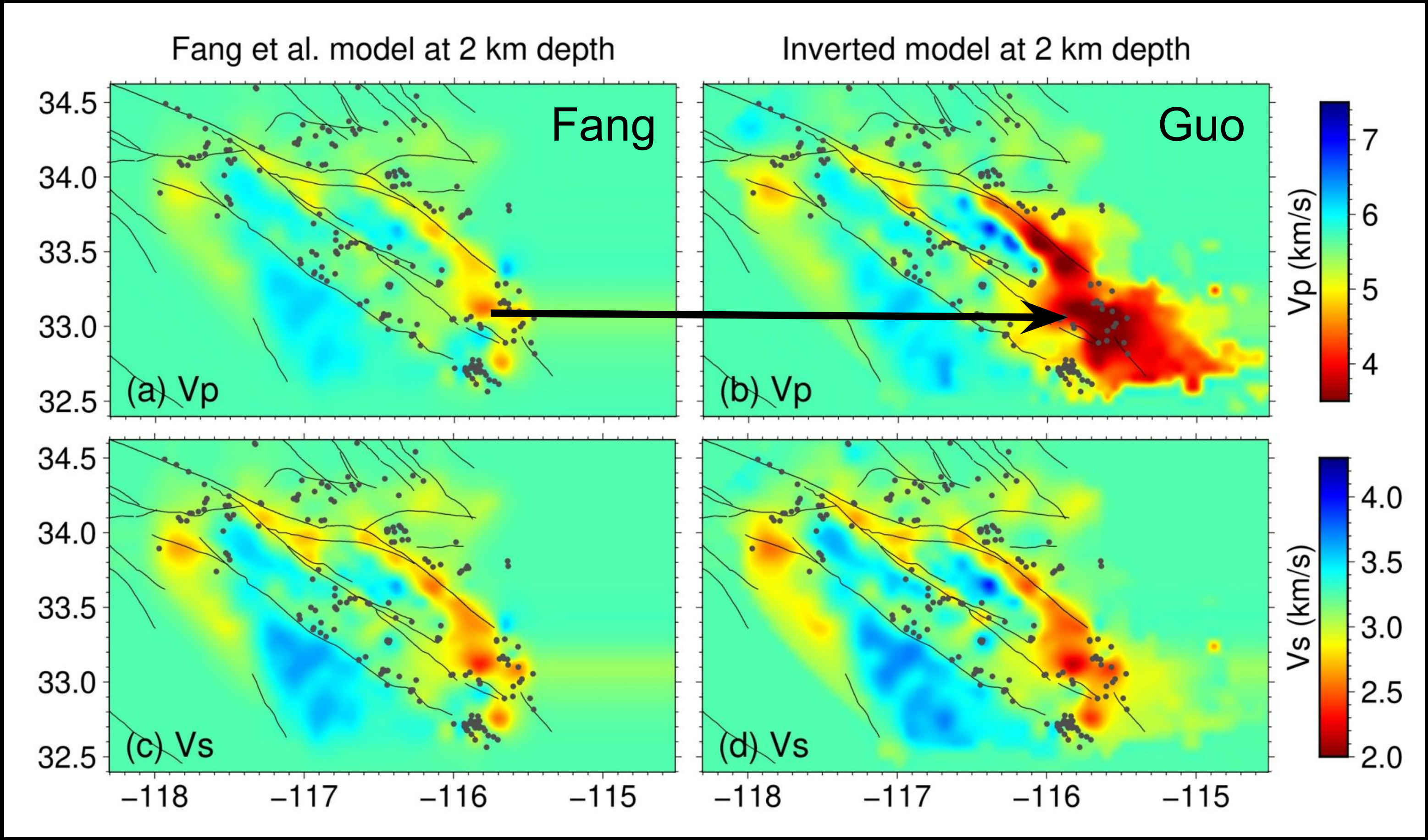
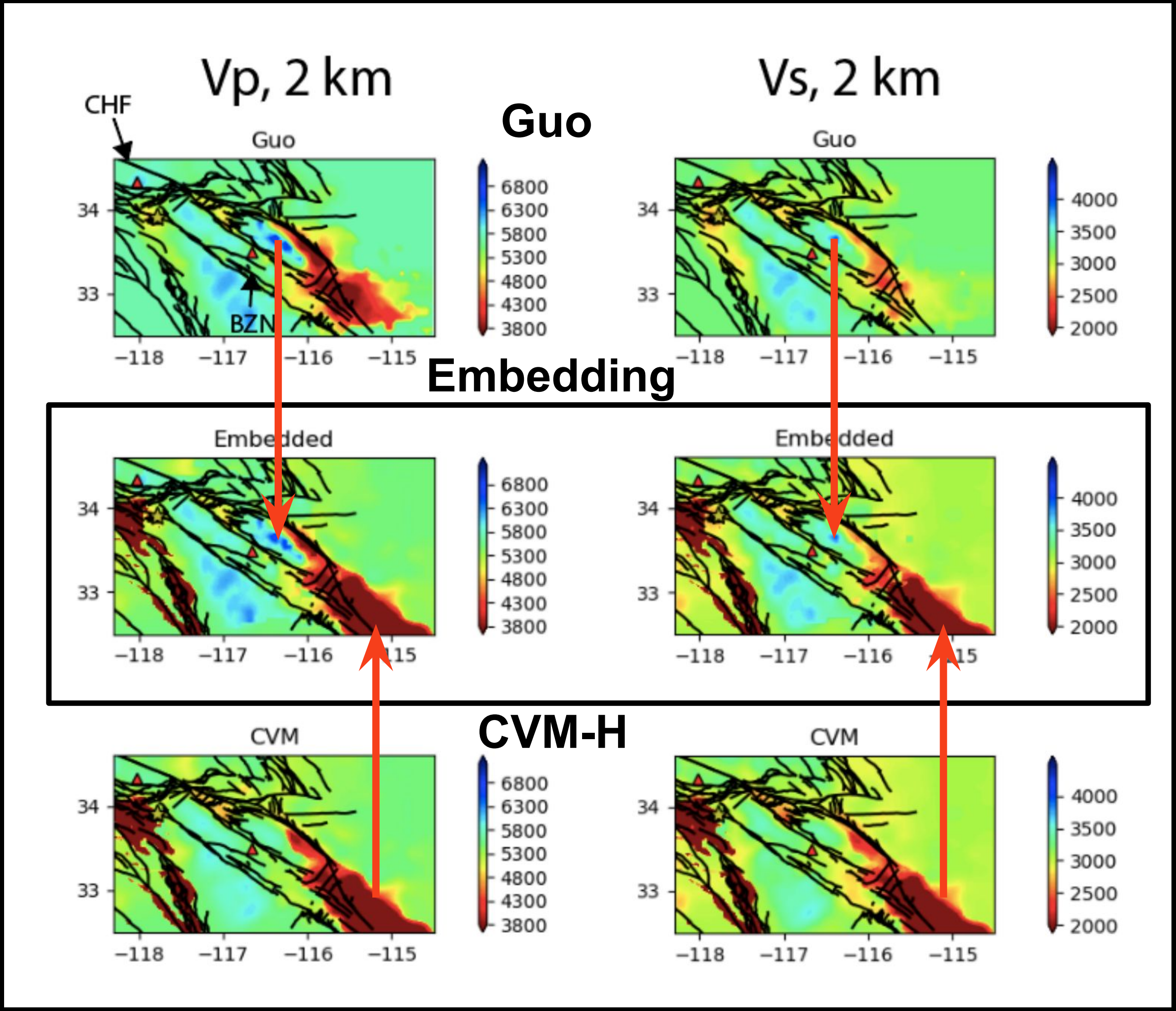
Joint body wave-surface wave tomography



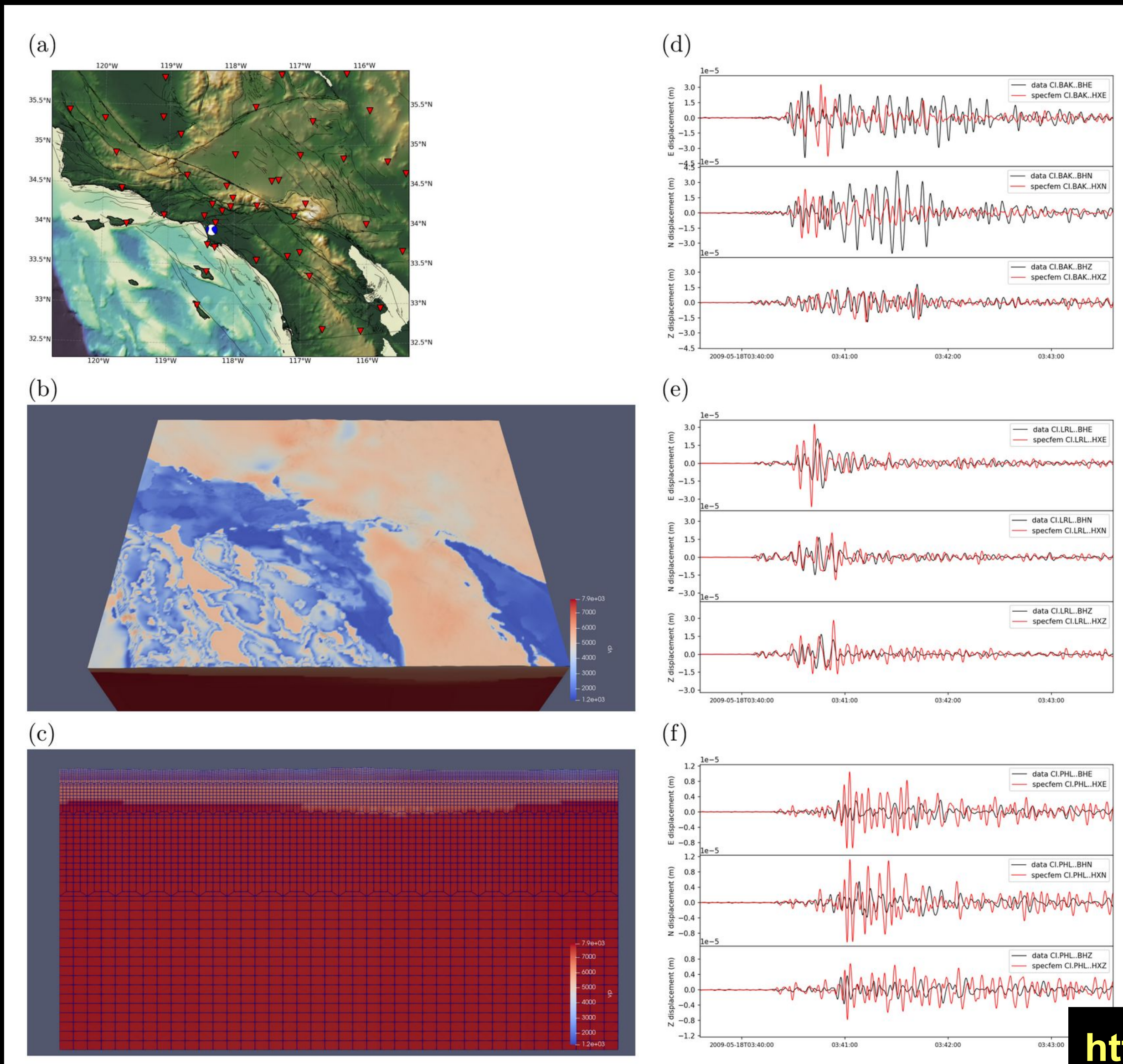
Map-view slices through (left) the Fang et al. (2016) starting model compared to (right) the joint inversion result with expanded data set (>8000 events). (a-b) Vp. (c-d) Vs.; CVM-S starting model and CVM-H model did not perform due to strong gradients.

Joint body wave-surface wave tomography



Comparison between the Guo model (prior to embedding, top), the Guo embedded model (middle) and the CVM-H model (bottom) for Vp (left column) and Vs (right column). The embedded model combines the well resolved portions of the Guo model with the broader 3D velocity coverage of the CVM-H model (see higher velocities at -116.5o in both Guo and embedded models and lowered velocities at -117.5o in both embedded and CVM-H model,). Velocity units are m/s. Stations CHF and BZN (labeled top left) are plotted as red triangles. The event epicenter is plotted with a gold star.

Adjoint tomography infrastructure/workflow improvements



Example components of the workflow:

(a) Choice of 500 km x 400 km simulation domain, along with CI stations.

(b) 3D view of CVM-H15.1 obtained from the netcdf file at the IRIS EMC.
(The default color scale shows red fast and blue slow.)

(c) Side view of the unstructured hexahedral finite-element mesh used for 3D wavefield simulations in SPECFEM3D. Note the three doubling layers, where elements double in length from the shallower to deeper layer. Larger elements are used for higher-velocity mantle material in order to efficiently use the available computational resources.

(d)-(f) Example seismogram comparisons (red synthetic, black data) for stations BAK (Bakersfield), LRL (Laurel Mt.; near Garlock), and PHL (Park Hill; near San Luis Obispo), filtered 3–9 s. BAK typifies a region where the 3D model does not capture the true 3D heterogeneity. LRL shows good fits to relatively simple waveforms, exhibiting bedrock structure. PHL shows a case where the synthetic amplitudes are too high, possibly due to unreasonably slow velocity values in the model.

https://github.com/bch0w/pyatoa

Many relevant contributions in this meeting:

- **larger scale F3DT inversion, on plate scale (#8, #10)**
- **Embedding: Los Angeles Basin High Resolution Models (#209)**
- **Basin structure (#14, #219, #221)**
- **Updates to Bay area model (#9, #11)**
- **missed many**

Tool capabilities:

- **Merging of models, choice of parameters/algorithms ?**
- **physically appropriate sub/supersampling ?**

External resources:

- **IRIS for data ?**
- **Research/Super Computing: just for large problems ? Jupyter hosting ?**