

# **SCEC Unified Community Velocity Model (UCVM) Software Summary**

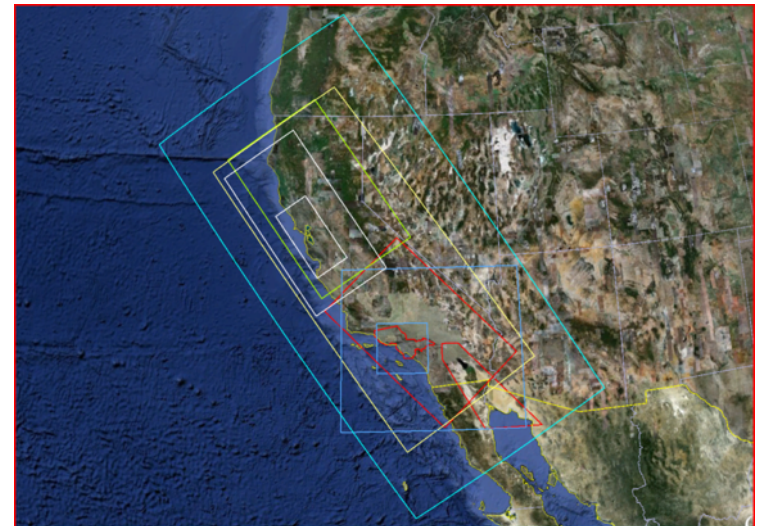
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**USGS Bay Area Velocity Model Meeting**

**21 March 2018**

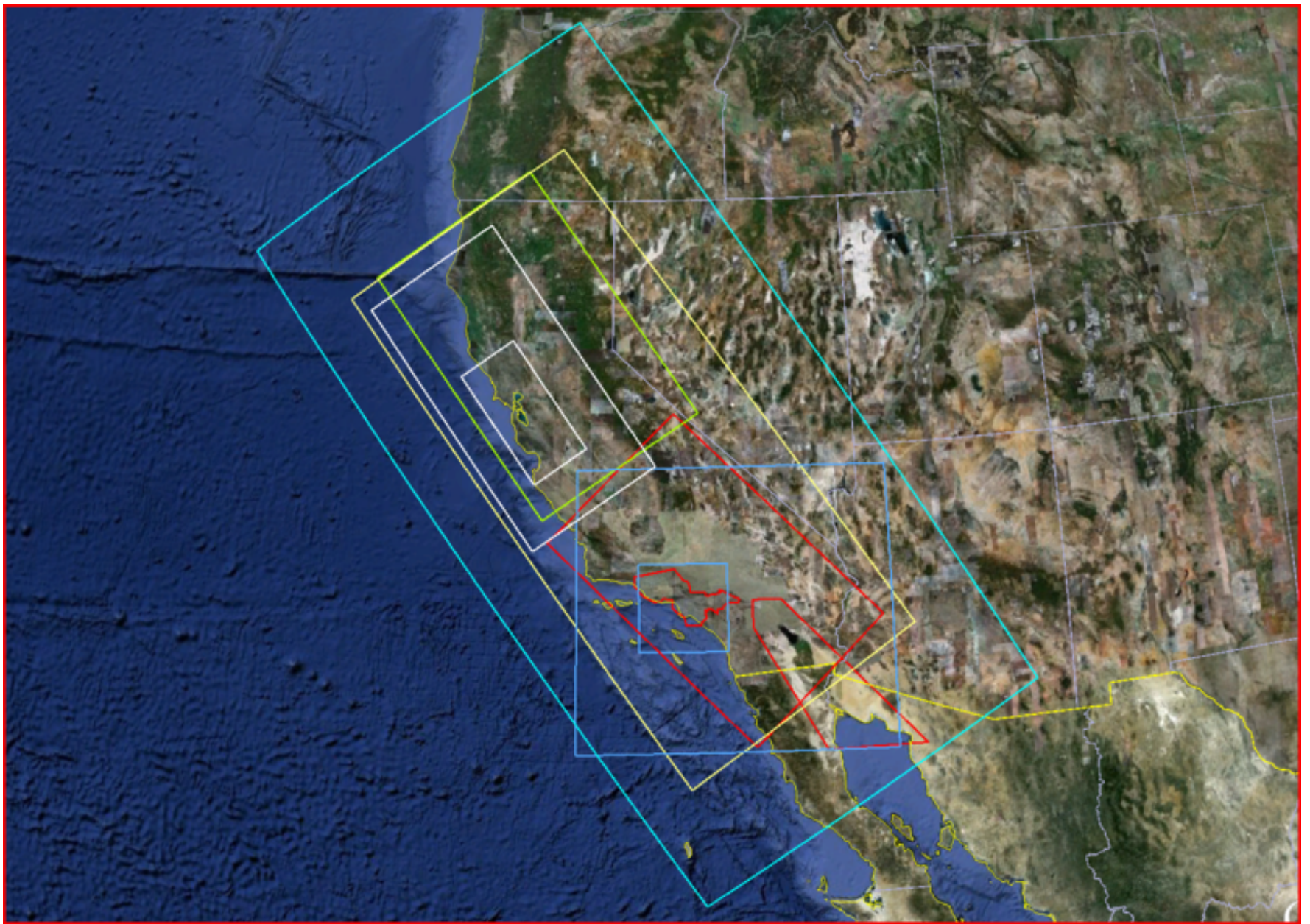


# SCEC CVM Software Overview

SCEC researchers use multiple seismic velocity models including:

- (1) CVM-S4 (SCEC original S. California model)
- (2) CVM-H v15.1 (Harvard-developed S. California model)
- (3) CVM-S4.26 (Tomography improved Southern California velocity models)
- (4) CCA06 (Tomography improved Central California velocity model)
- (5) And others...

Coverage regions may overlap, but material properties differ for each model



Coverage region various California 3D velocity models (CVM-S: red, CVM-H: blue, LinThurber: yellow, Thurber NoCal: green, USGS Bay Area: white)

# SCEC UCVM Software Overview

Each Velocity Model should describe:

1. Coverage Volume
2. Elevation Model
3. Basin Model
4. Geotechnical Layer (0-350m)
5. What material properties the model returns
6. How to query the model

# Seismic Velocity Models Software

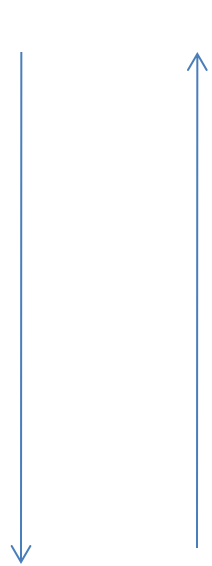
Existing California Seismic velocity models:

- are delivered in a variety of formats (on regular grids, rule-based software, custom software interfaces)
- may use different projections:
- may provide their own query interface.

Examples include:

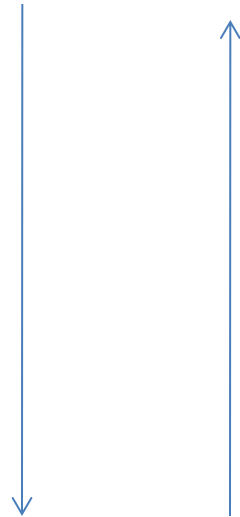
- CVM-S4 – provides btest-in (Fortran) software interface
- CVM-H - provides vx and vx-lite (C-language) software interface)
- CCA06 - provides properties defined on 500m regular mesh

# Scientific CVM Application Programs (Without UCVM)



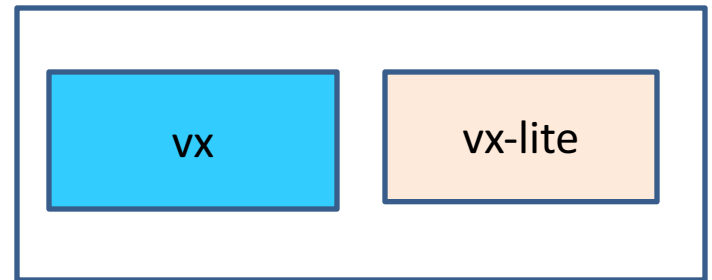
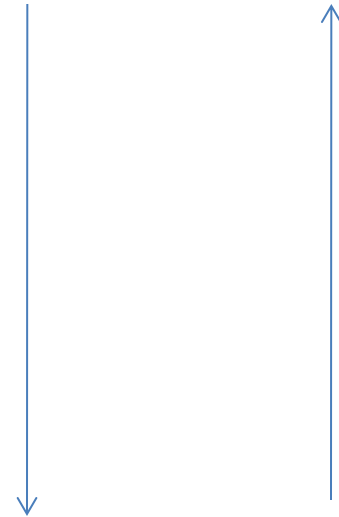
Btest-in

CVM-4.0



BayArea  
cencalvm

BayArea  
Etrees



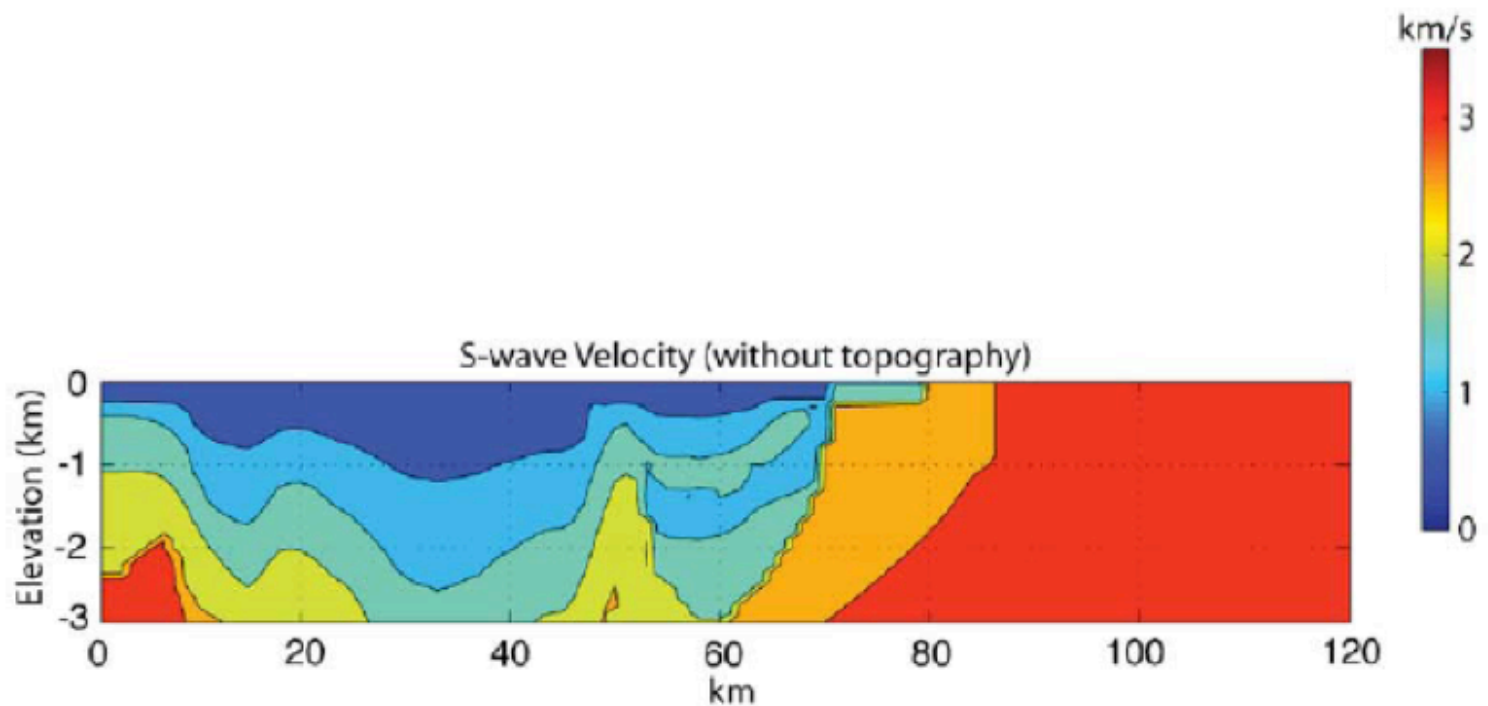
vx

vx-lite

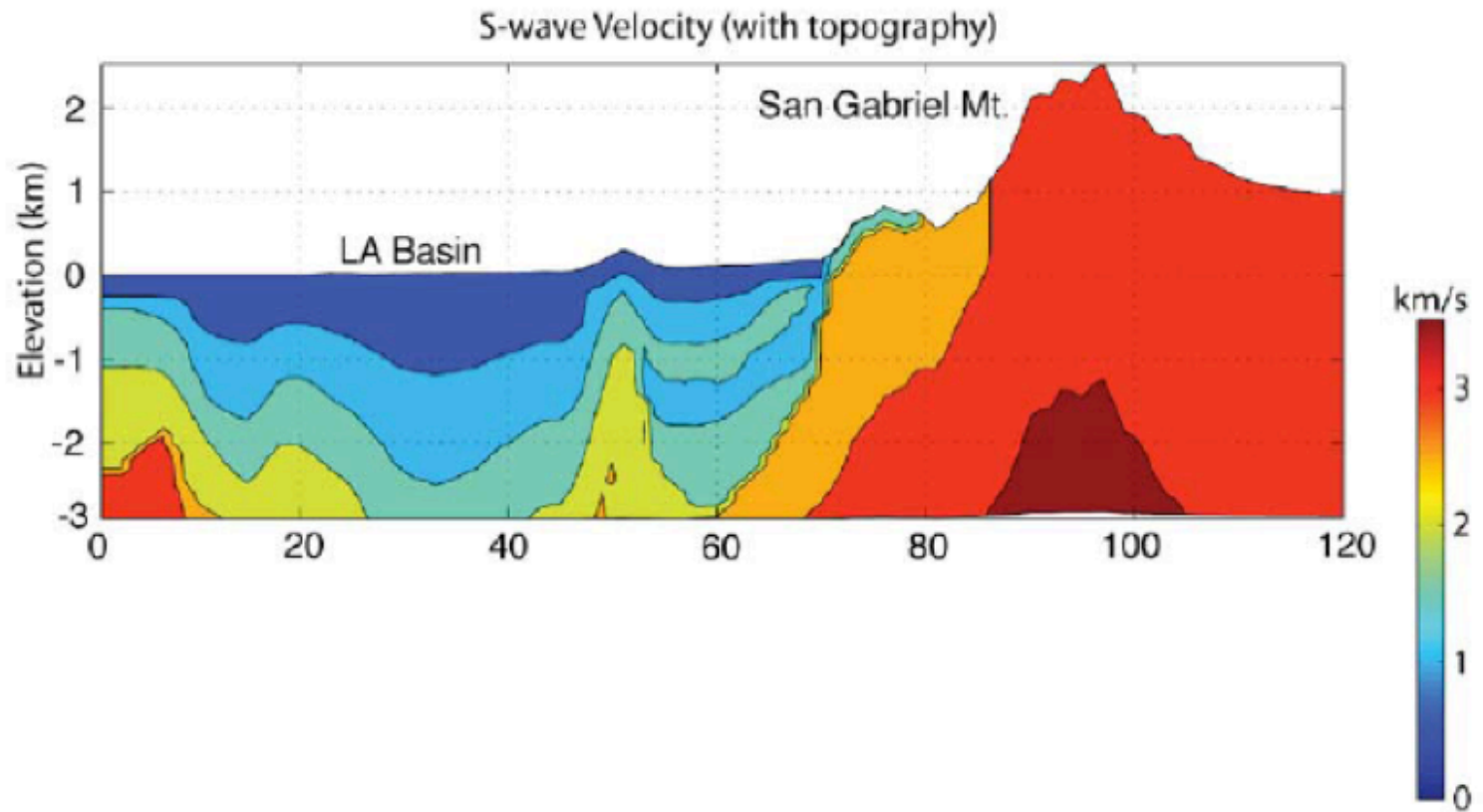
CVM-H  
11.1.0



# SCEC CVM-S4 (No Topography)



# SCEC CVM-H (Topography)





# UCVM is not a Velocity Model

- SCEC's Unified Community Velocity Model (UCVM) software is not a seismic velocity model.
- UCVM is a collection of software tools for working with existing and future seismic velocity models.

# Motivations for UCVM Development

1. Ground motion modelers want to compare ground motion simulations using alternative velocity models.
2. Goal was to create software tools for generating equivalent meshes from different velocity models (e.g. develop a standard way to query by depth for models that are query by elevation)
3. Needed to convert models from one projection to another.
4. Needed to combine CVMs and add background models.
5. Needed tools to query models provided on regular grids, including standard interpolation methods

# UCVM Development Approach

- We designed UCVM to require minimal changes to existing CVMs.
- We want to avoid changing our application software to query each model in its own way.
- We implemented standardized query and projection conversion methods so results are repeatable and comparable

## Scientific CVM Application Programs

List of Latitude, Longitude, Depth



List of Latitude, Longitude, Depth,  
Vp,Vs, Density, Qp, Qs



UCVM\_Query – UCVL Standard Query Interface

vx - CVM-H 6.3 Standard Query Interface

CVM-H Gocad Data Access Libraries

Southern California Material Properties in  
CVM-H 6.3 Voxels Data Files

Wills California Vs30 Map (2006)

# Summary of UCVM Software Features

1. UCVM provides a uniform query interface to several California velocity models. Models may be queried by (lon,lat,depth) or (lon,lat,elev).
  - `ucvm_query`: Linux command-line query tool
  - API: C interface to UCVM
2. UCVM easily combine two or more regional velocity models together into one meta-model. Models are tiled in specified order.
3. Codes to modify top 350 meters as geotechnical layer using Ely-Jordan, and other methods.
4. Allows users to add 1D background models for regions outside CVM coverage
5. Create and populate meshes from any registered CVM in various formats including AWP (Cartesian meshes) and CMU/SCEC-formatted Etrees
6. Support parallel mesh building and population for very large meshes
7. Plotting and visualization scripts

Scientific CVM Application Programs (With UCVM)

UCVM (Meshing / Geotechnical Layer / HPC ) Utilities

UCVM\_Query – UCVM Standard Query Interface

Btest-in

cencalvm

vx

vx-lite

CVM-4.0

USGS-  
NC

CVM-H  
6.2

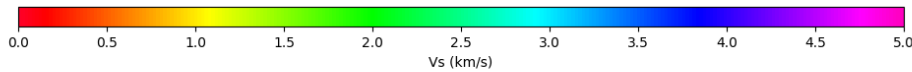
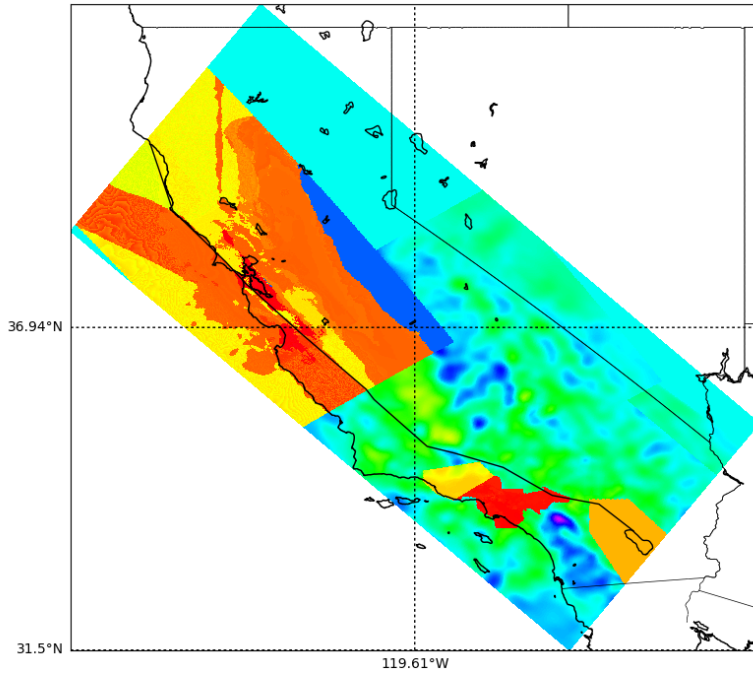
CVM-H  
11.9



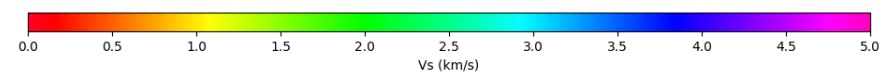
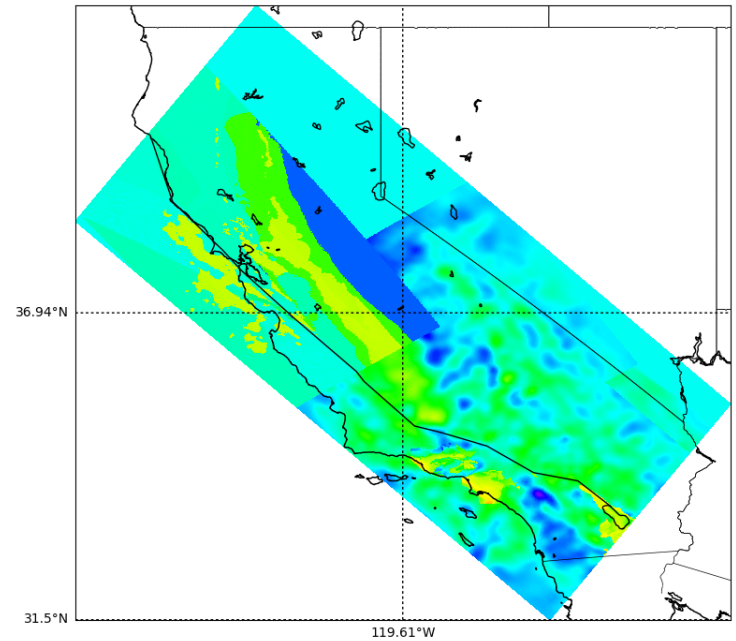
# Example of Tiling Models

(Bay Area, CCA06, CVM-S4.25M01, 1D)  
(0 depth (left), 1k depth (right))

Slice From (-125.00, 32.50)



Slice From (-125.00, 32.50)



# Known SCEC UCVM Issues

- Adding new velocity models (called registering models) requires software developer time.
- Registration of new models lagging behind demand (several pending velocity models including Kohler off-shore, Ben Zion Salton Sea, Central US...)
- Significant installation issues on several computing environments (designed and tested on USC HPC CentOS Linux)
- Feature creep has led to a large number of rarely used but difficult to use and to maintain features.
- UCVM software hard fork produced original C-language codebase (UCVM-C) and beta Python codebase (UCVM-P) with desirable features in each.

# Significant Usage of UCVM

- UCVM used to construct very large meshes for SCEC ground motion simulations (e.g. M8)
- UCVM used to construct Hercules Etrees comparing impact of CVMs on ground motion goodness-of-fit studies (e.g. Chino Hills event)
- UCVM used for to construct meshes for several SCEC CyberShake studies (e.g. 15.3, 17.3)
- Used to support SCEC High Frequency (High-F) ground motion modeling group building high resolution (e.g. 20m resolution) meshes

# Summary

- Currently supported version (described here and in reference) is the C-language version (UCVMC) available at:

<https://github.com/SCECcode/UCVMC>

- UCVM is expected distribution and access software for SCEC-developed velocity models, including tomography improved CVM's and regional-models developed by combining existing CVMs
- Additional details in UCVM reference:

*Small, P., Gill, D., Maechling, P. J., Taborda, R., Callaghan, S., Jordan, T. H., Ely, G. P., Olsen, K. B., & Goulet, C. A. (2017). The SCEC Unified Community Velocity Model Software Framework. Seismological Research Letters, 88(5). doi: 10.1785/0220170082*