SCEC Unified Community Velocity Model (UCVM) Software Framework: Motivation and Overview

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Overview

SCEC's Unified Community Velocity Model (UCVM) Software provides a way to query 3D seismic velocity models for location-specific seismic properties (Vp, Vs, and density) with 8 California models currently supported.

UCVM provides additional utilities for using CVMs in wave propagation simulations including

(a) code to add (or remove) low velocities in top 300m meters,
(b) ability to combine or "tile" multiple small models to increase coverage area
(c) MPI-codes to build very large regular and Etree meshes
(d) basic plotting tools to show characteristics of velocity models

UCVM is not a Velocity Model

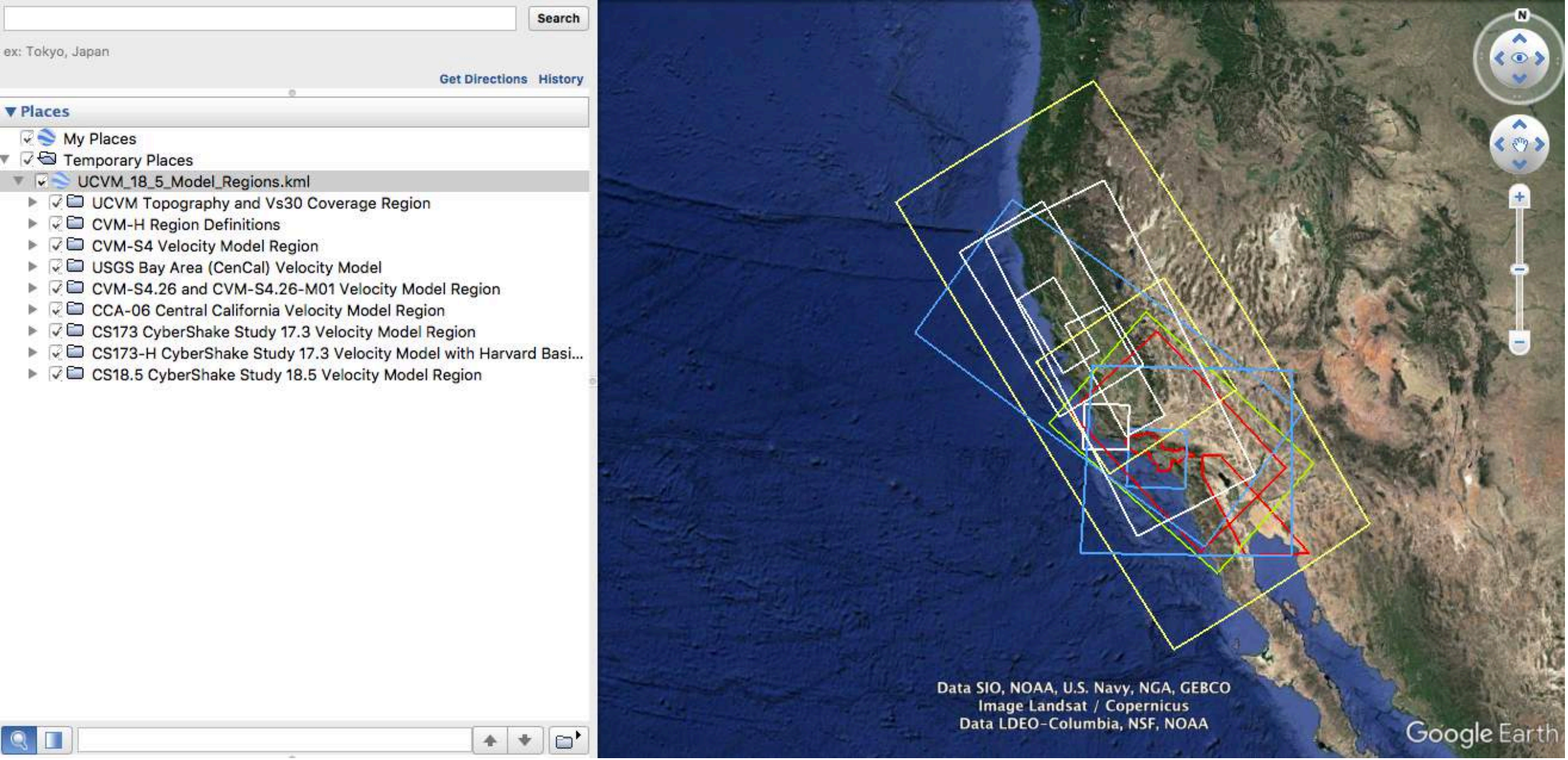
- SCEC's Unified Community Velocity Model (UCVM) software is not a seismic velocity model.
- UCVM is a collection of software tools for working with existing and future seismic velocity models.

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



SCEC Community Velocity Models (CVMs) are distributed using the Unified Community Velocity Model (UCVM) Software Framework. The current version of UCVM provides access to eight California velocity models.

Motivations for UCVM Development

1. Ground motion modelers want to compare ground motion simulations using alternative velocity models.

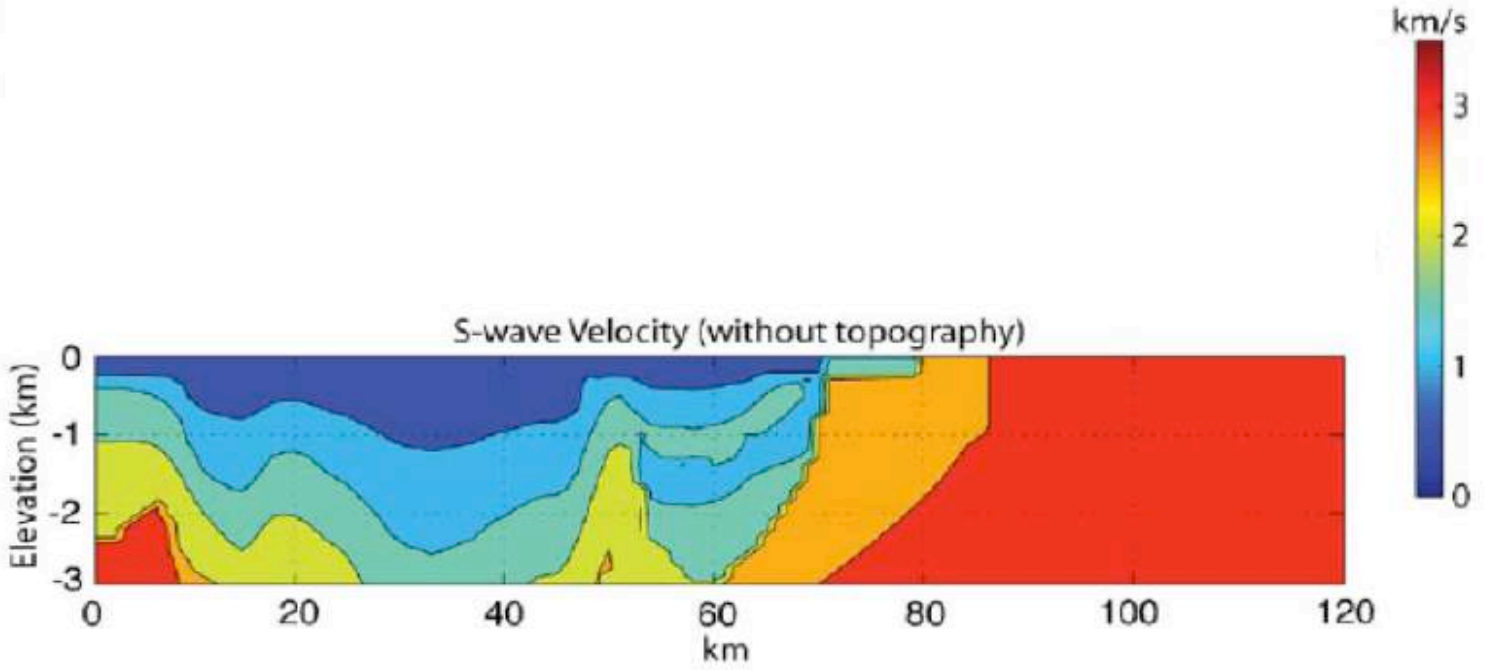
2. Goal was to create software tools for generating equivalent meshes from different velocity models (e.g. develop a standard way to query by depth for models that are query by elevation)

3. Needed to convert models from one projection to another.

4. Needed to combine CVMs and add background models.

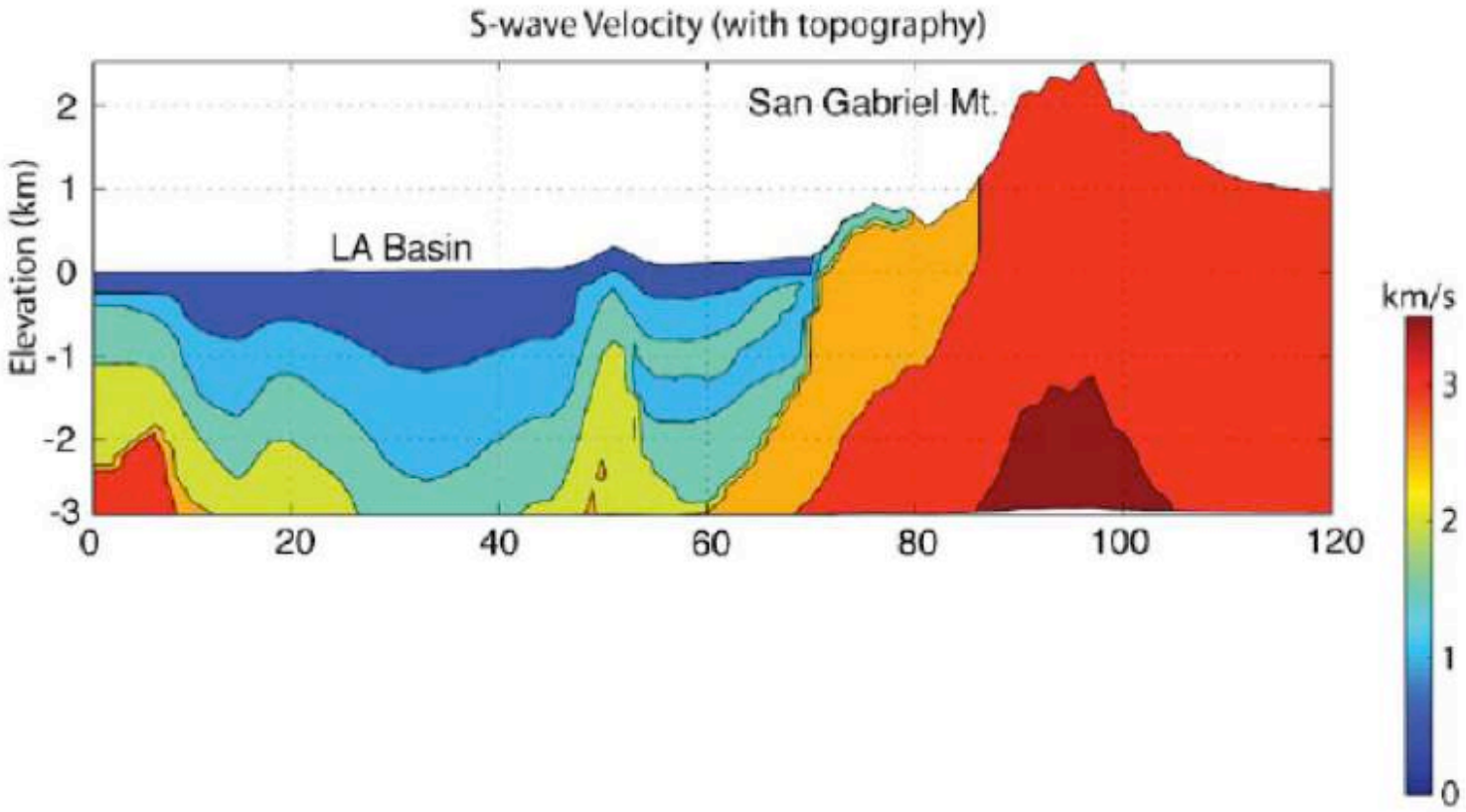
5. Needed tools to query models provided on regular grids, including standard interpolation methods

SCEC CVM-S4 (No Topography)



CVM-S4 native software interface (called btest-in) is based on query by depth. It assumes models are defines as flat volumes.

SCEC CVM-H (Topography)



CVM-H native software interface (called vx-lite) is based on query by elevation. It includes a Digital Elevation Model (DEM) which provide elevation information for every point in supported region

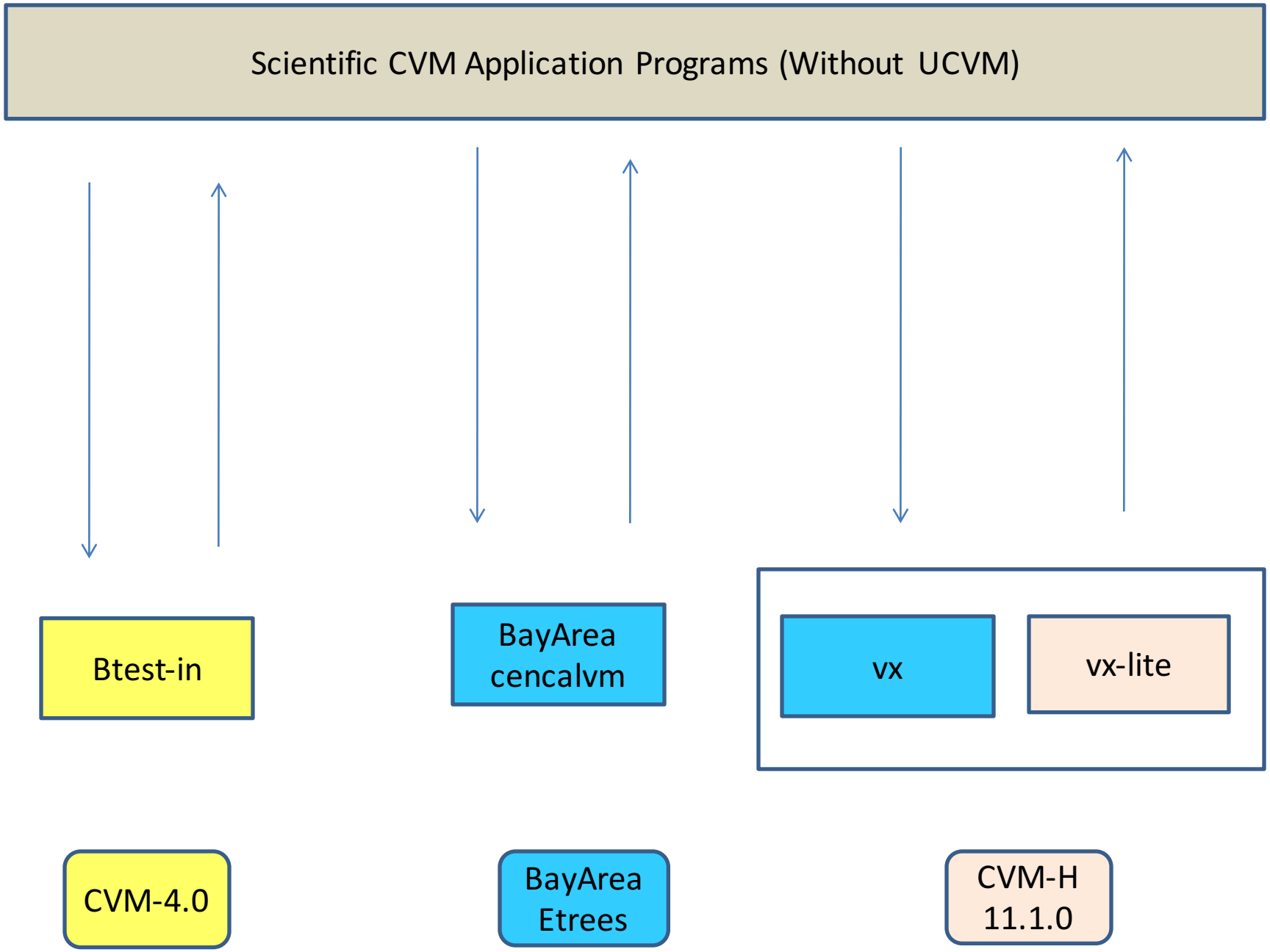
Seismic Velocity Models Software

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
- CenCal (USGS Bay Area Model) – provides properties defined in high and low resolution etree structures.


Scientific CVM Application Programs (Without UCVM)
Btest-in
BayArea cencalvm
vx
vx-lite
CVM-4.0
BayArea Etrees
CVM-H 11.1.0

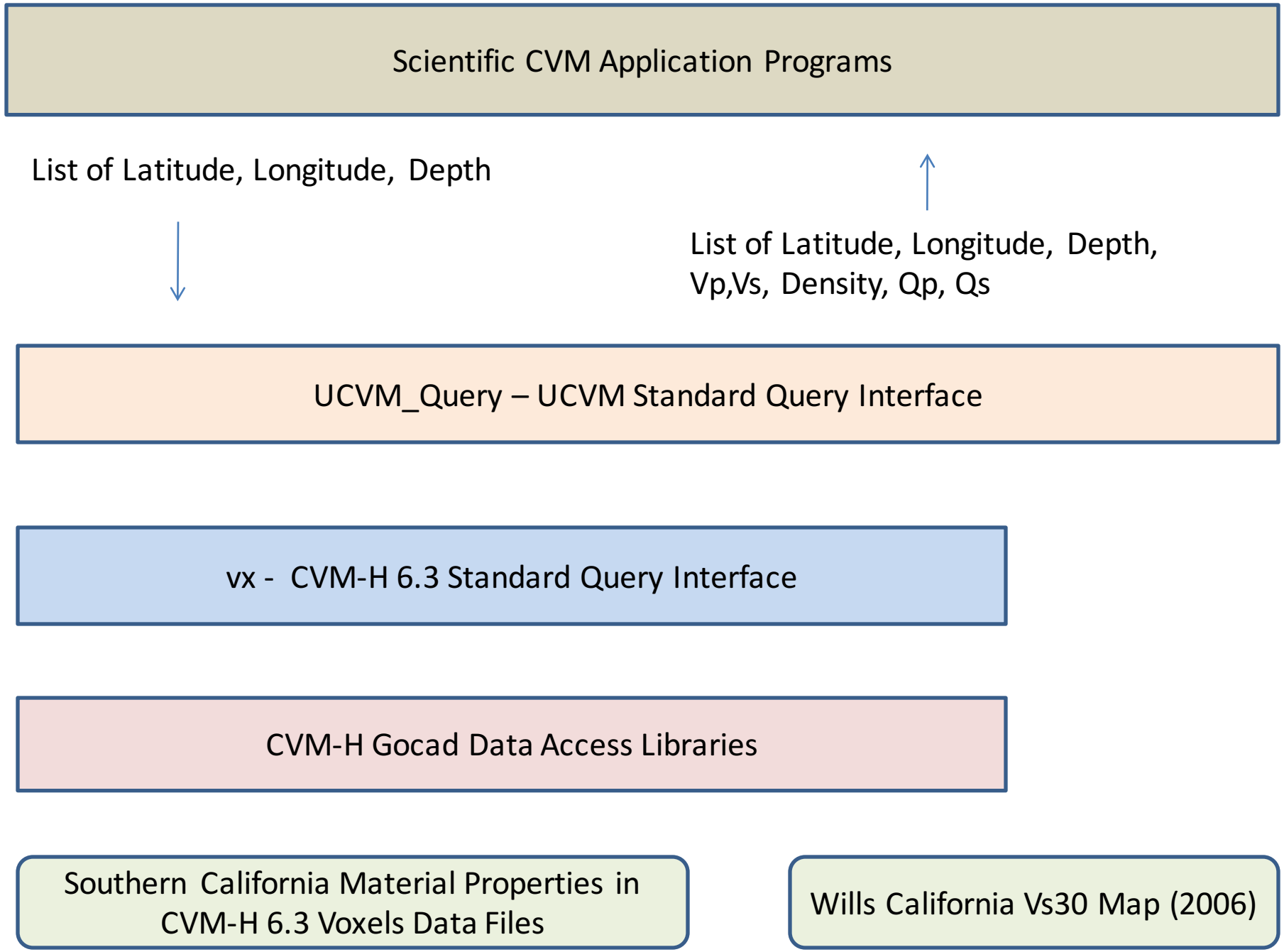
UCVM Development Approach

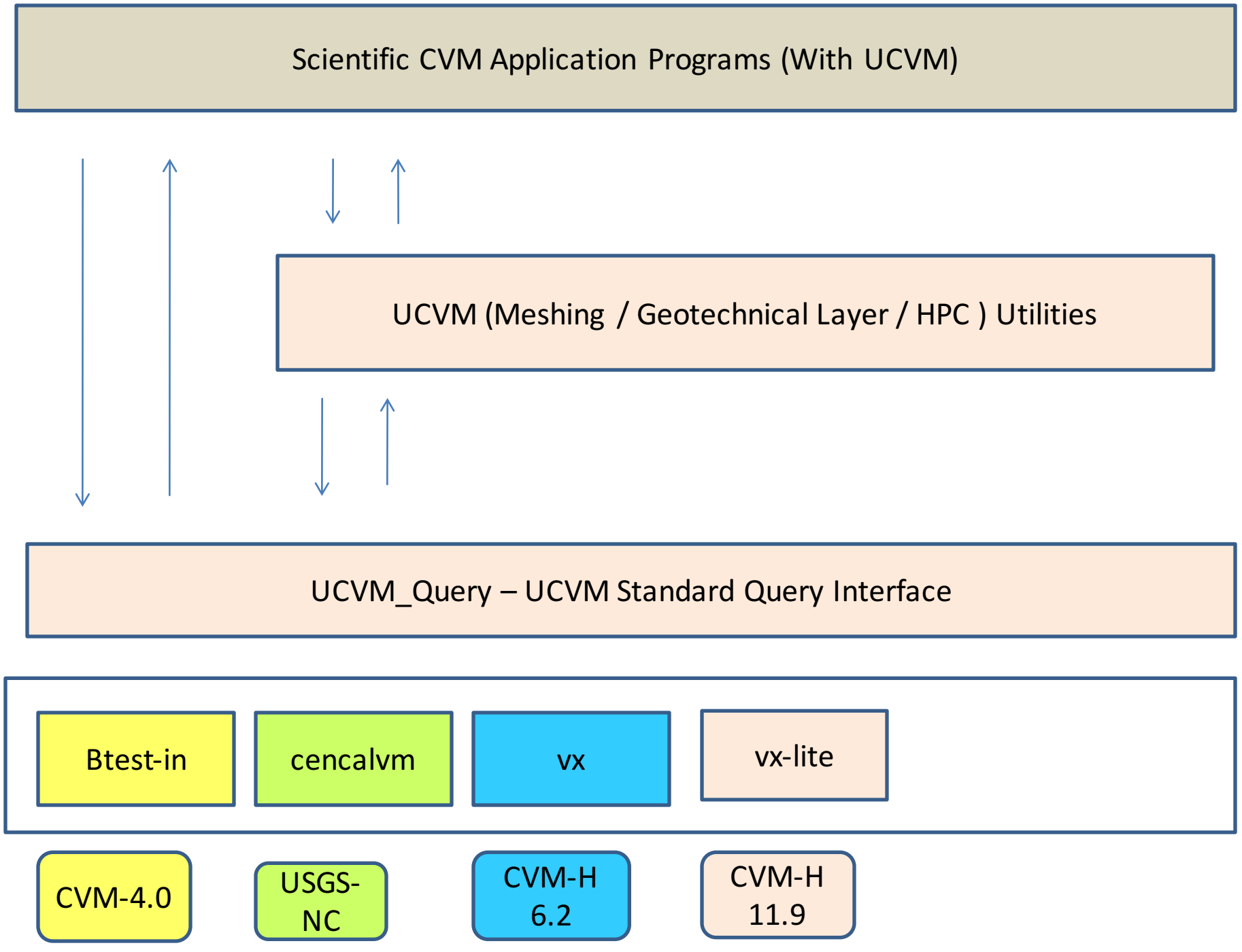
- We designed UCVM to require minimal changes to existing CVMs.
- We want to avoid changing our application software to query each model in its own way.
- We implemented standardized query and projection conversion methods so results are repeatable and comparable

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

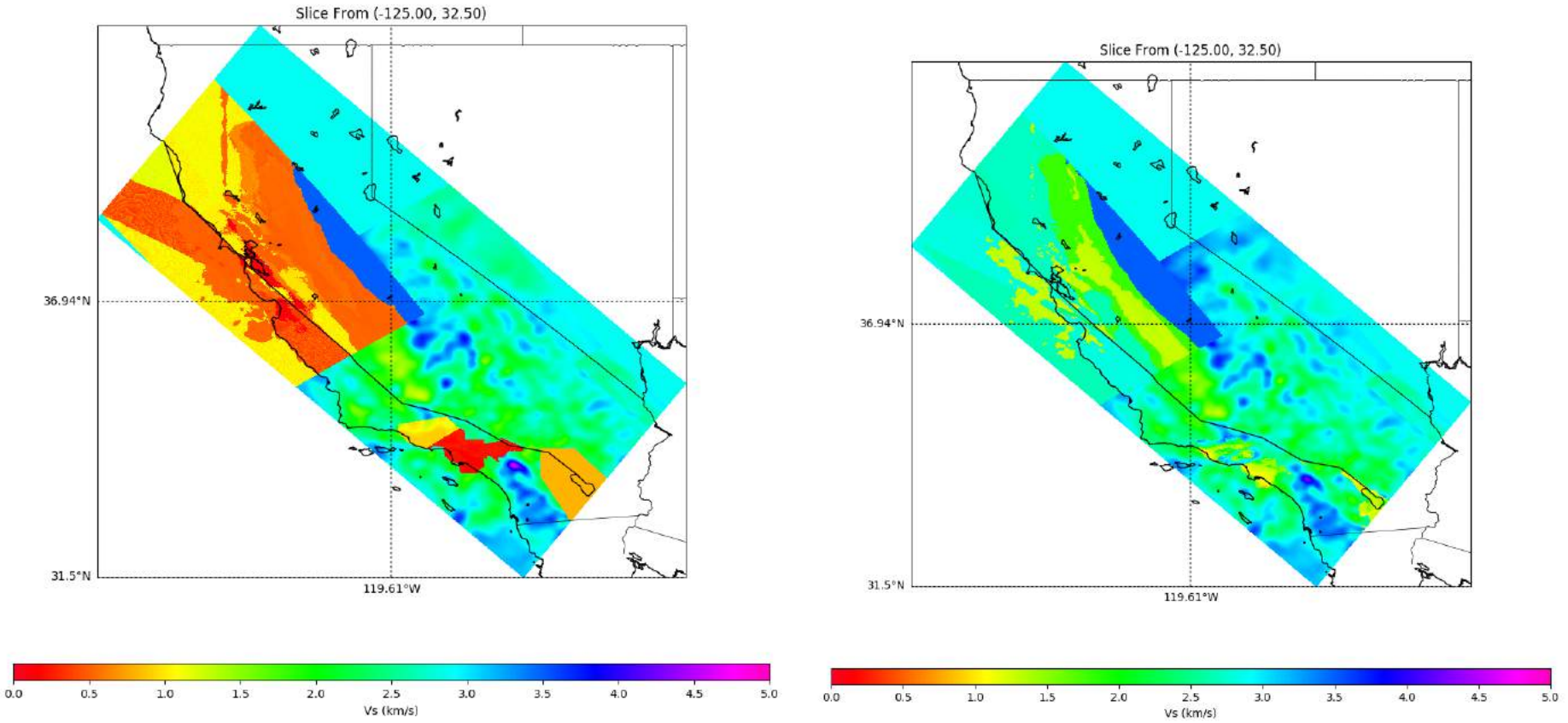

Scientific CVM Application Programs
List of Latitude, Longitude, Depth
List of Latitude, Longitude, Depth,
Vp,Vs, Density, Qp, Qs
UCVM_Query – UCVM Standard Query Interface
vx - CVM-H 6.3 Standard Query Interface
CVM-H Gocad Data Access Libraries
Southern California Material Properties in
CVM-H 6.3 Voxels Data Files
Wills California Vs30 Map (2006)


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

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

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



Significant Usage of UCVM

- UCVM used to construct very large meshes for SCEC ground motion simulations (e.g. M8, CyberShake)
- 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

Known SCEC UCVM Issues

- Software can be difficult to build, has hidden settings, and lacks easy to use interface.
- 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.

Summary

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

  https://github.com/SCECcode/UCVMC

- UCVM is a distribution and access software for SCEC-developed velocity models, including tomography improved CVM's and regional-models developed by combining existing CVMs

Preferred UCVM Reference

If you use the UCVM software in your research, please include a reference to this software. The preferred reference for the UCVM software is:

- 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). https://doi.org/doi:10.1785/0220170082

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