SCEC Community Earth Models: 2025 Updates and New Releases

CEM Co-Leaders:

Scott T. Marshall
Appalachian State University

Patricia Persaud
University of Arizona

SCEC Proposals: will use or contribute to CEMs

2024: 43%
2025: 62%

With Many Contributions From:

CEM Model Developers

Future You??

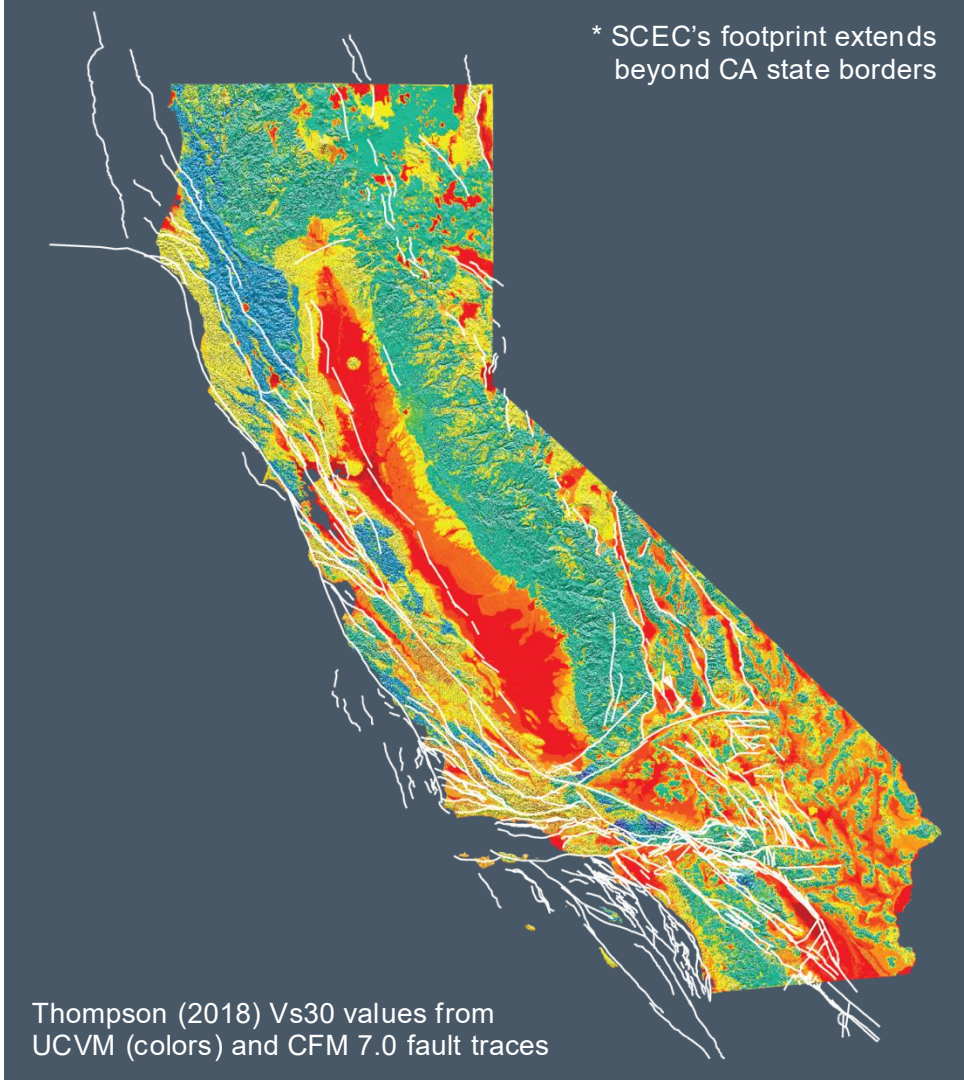
September 7-10, 2025
Hilton Palm Springs, California

CEM Homepage | https://www.scec.org/science/cem

Community Earth Models (CEMs)

The CEM Vision:

Enabling cutting-edge science with community-driven products that quantify key features of the greater San Andreas system

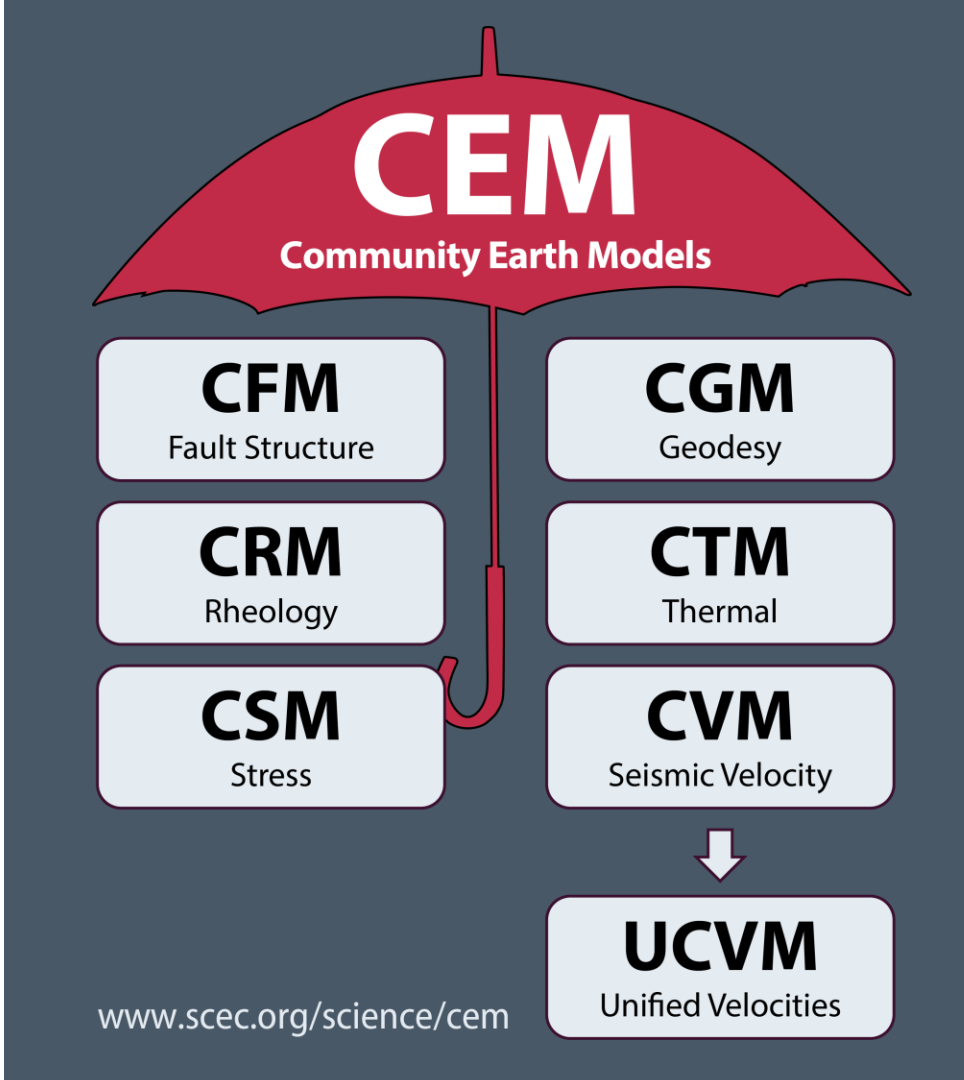


CEM Homepage | https://www.scec.org/science/cem

Community Earth Models

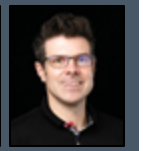
Current Inventory

- **CFM** : Community Fault Model
- **CGM** : Community Geodetic Model
- **CRM** : Community Rheology Model
- **CSM** : Community Stress Model
- **CTM** : Community Thermal Model
- **CVM** : Community Velocity Model
- **UCVM** : Unified Community Velocity Model Framework



Community Earth Models Collaboration

SCEC CEM Developers

…and contributors!

Photo Not Found

*Apologies if I missed anyone

SCEC Software & Web Team

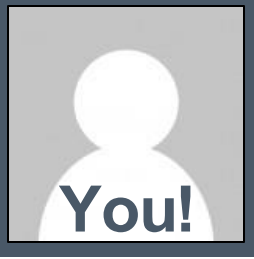

Tran Huynh


Phil Maechling


Mei-Hui Su


Edric Pauk

CEM Users



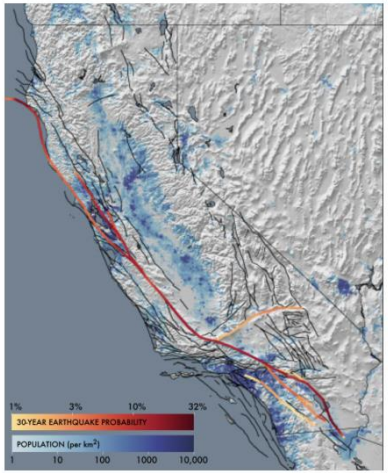
Registration for SCEC2025 is still open! Register Now

SCEC is now Statewide

The Statewide California Earthquake Center builds on SCEC's legacy of leveraging cutting-edge research, interdisciplinary collaborations, and a systems-level approach. SCEC now focuses on the entire San Andreas Fault System which allows us to:

Address key science questions in a broader tectonic context,
Strengthen partnerships across disciplines to improve earthquake science and hazard analysis, and
Engage a wider range of participants, from academia and government to the public.

ABOUT SCEC | NEW BRANDING



Our Natural Laboratory

SCEC's study area now spans the entire Pacific-North American plate boundary, from western Nevada to the Borderlands offshore, and from Baja California to Cape Mendocino. The extensive regional geophysical networks and direct access to major faults of the San Andreas Fault System opens up new research avenues.

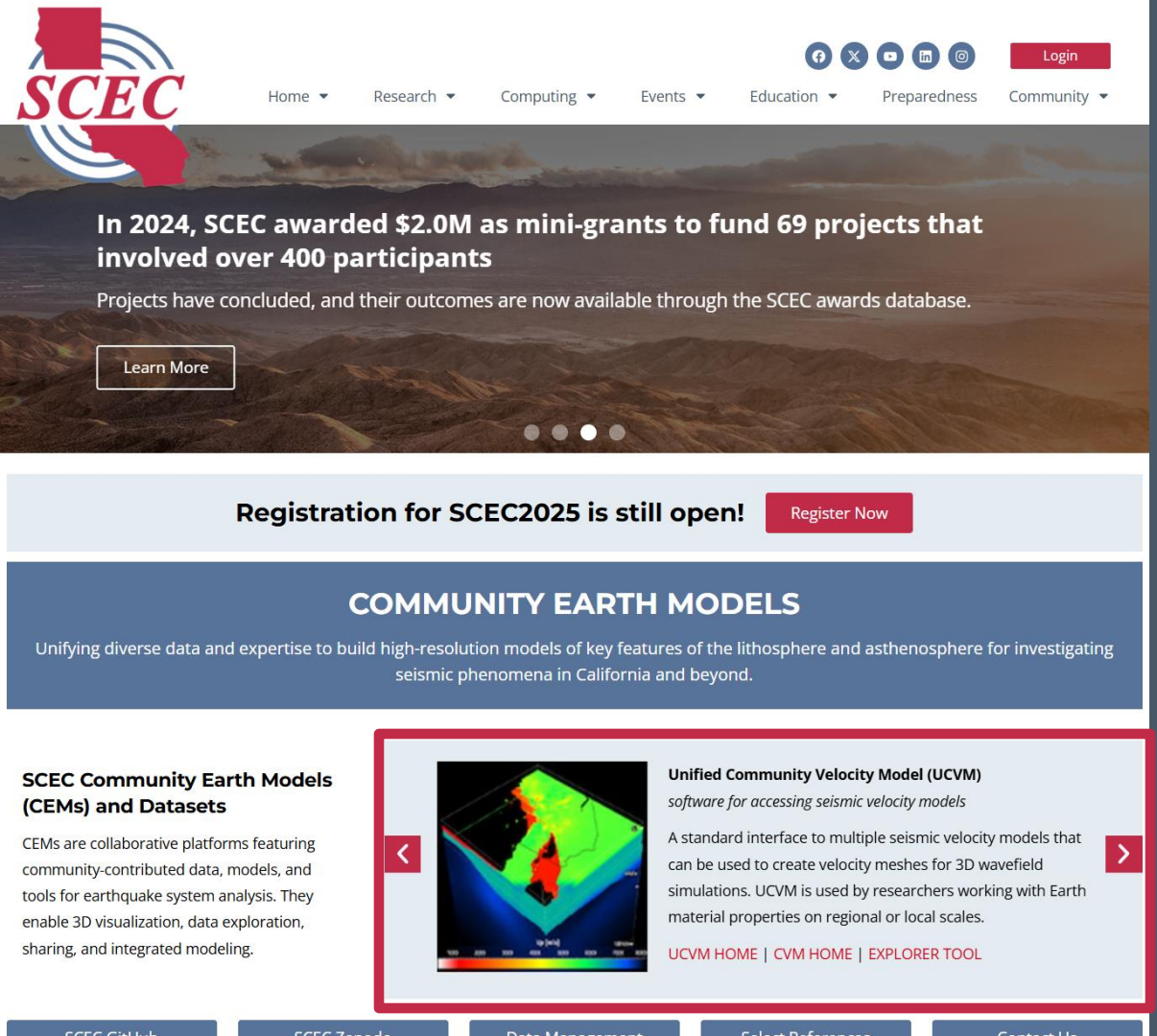
Quick Links

SCEC Business Operations
Hub for proposals, reports, profiles, & more

Southern California Earthquake Center
Archived website for the "Southern" Center

SCEC Homepage

The CEM homepage is linked on the SCEC homepage

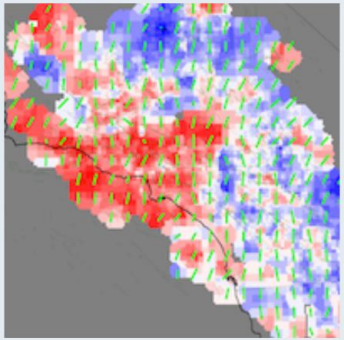


CEM Homepage

CEMs are easily findable and accessible via a the CEM homepage

The CEM widget automatically scrolls through the available CEMs

The CSM Widget



Community Stress Model (CSM)

suite of stress and stressing rate models

The CSM provides estimates of stress and stressing rates for various regions of California. The suite of models, derived using a variety of methods and datasets, are presented on a consistent grid.

CSM HOME | EXPLORER TOOL | CSM ARCHIVE

Link to model homepage

Link to web-based tools "Explorer"

Link to citable Zenodo archive

Findable

Accessible

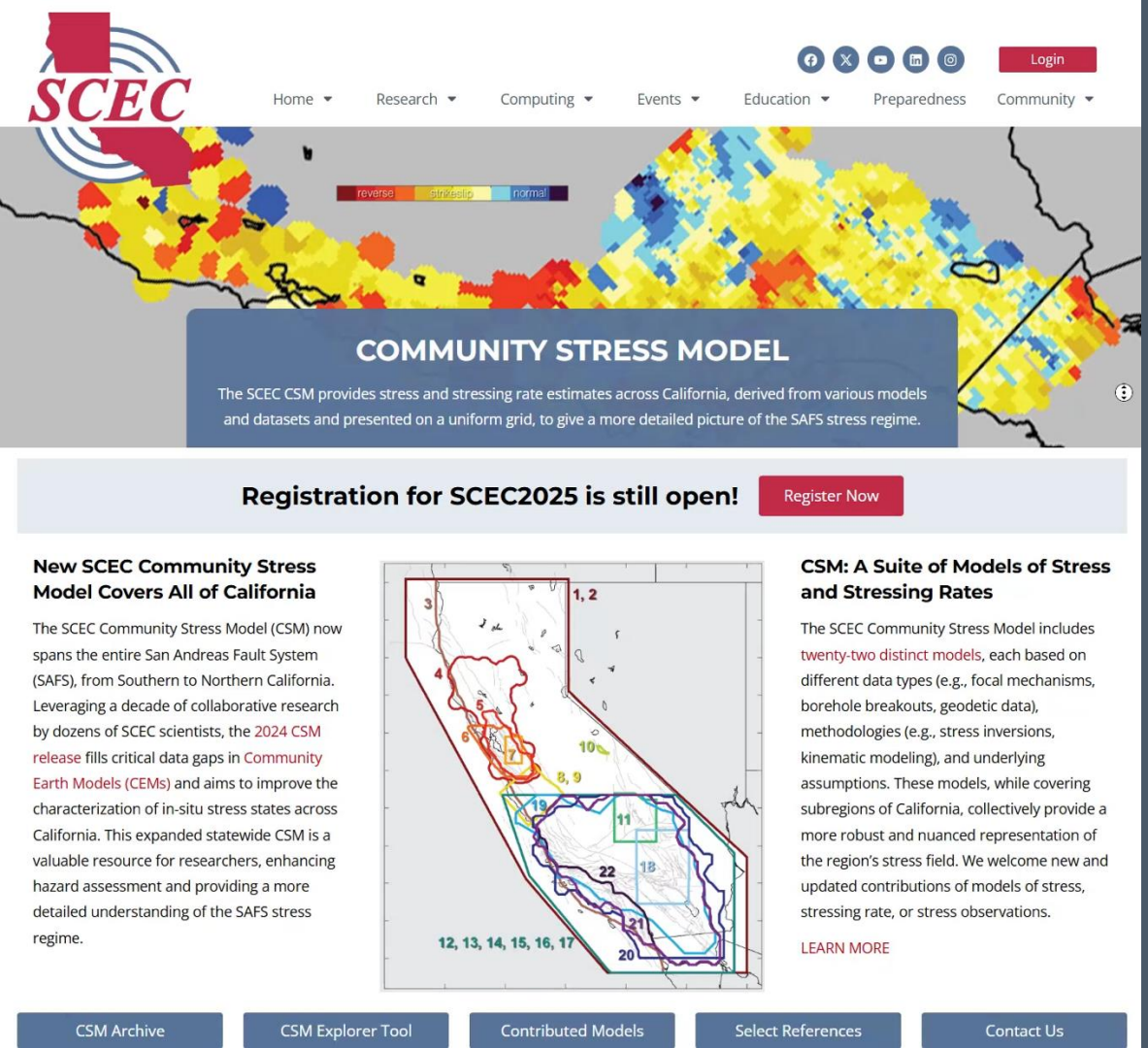
Interoperable

Reusable

CSM Group Leaders

Karen Luttrell (LSU)

Jeanne Hardebeck (USGS)

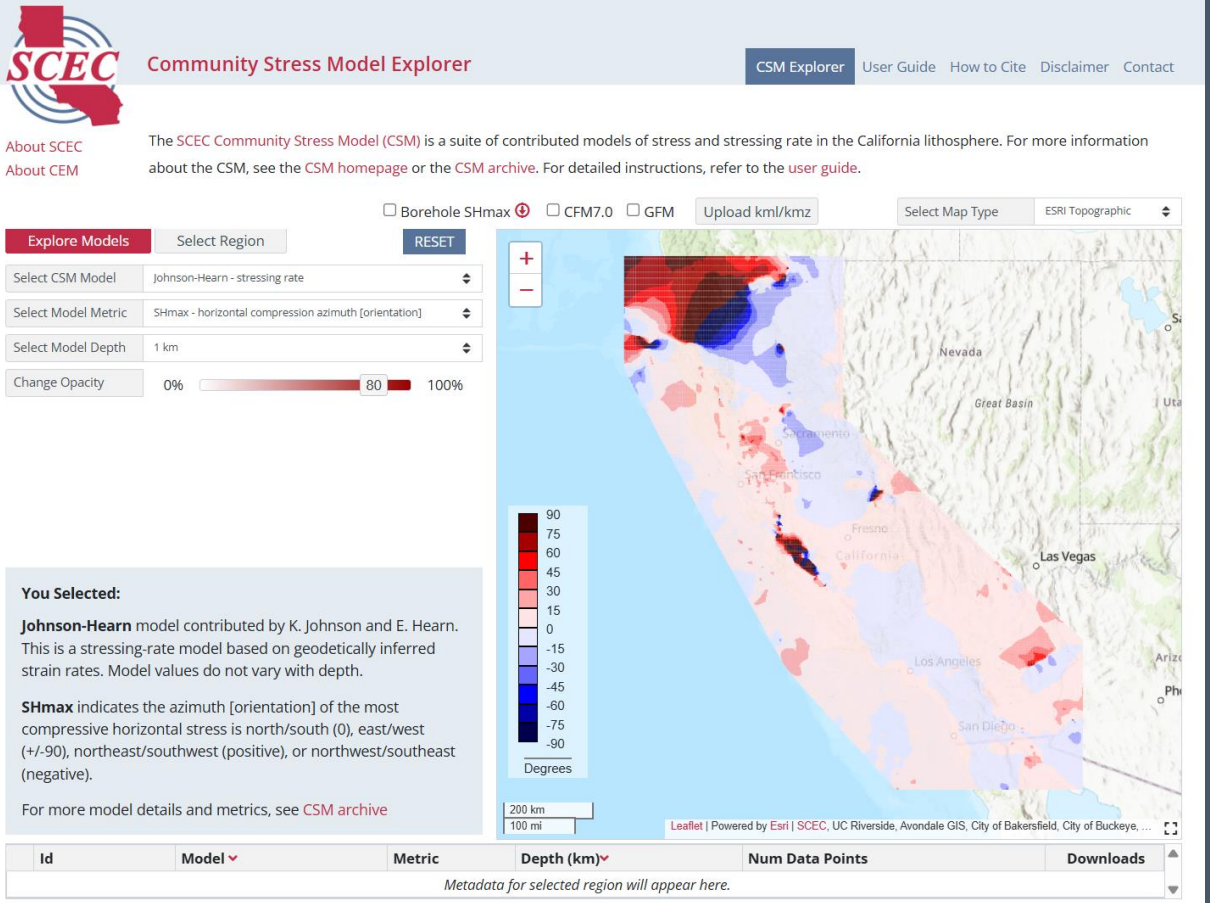


CSM Homepage

CSM is first to employ the new CEM homepage style

Model background page provides details of how models are constructed

Other CEM homepages targeted by end of 2025



CEM Explorers

Web-based tools for Community Earth Models

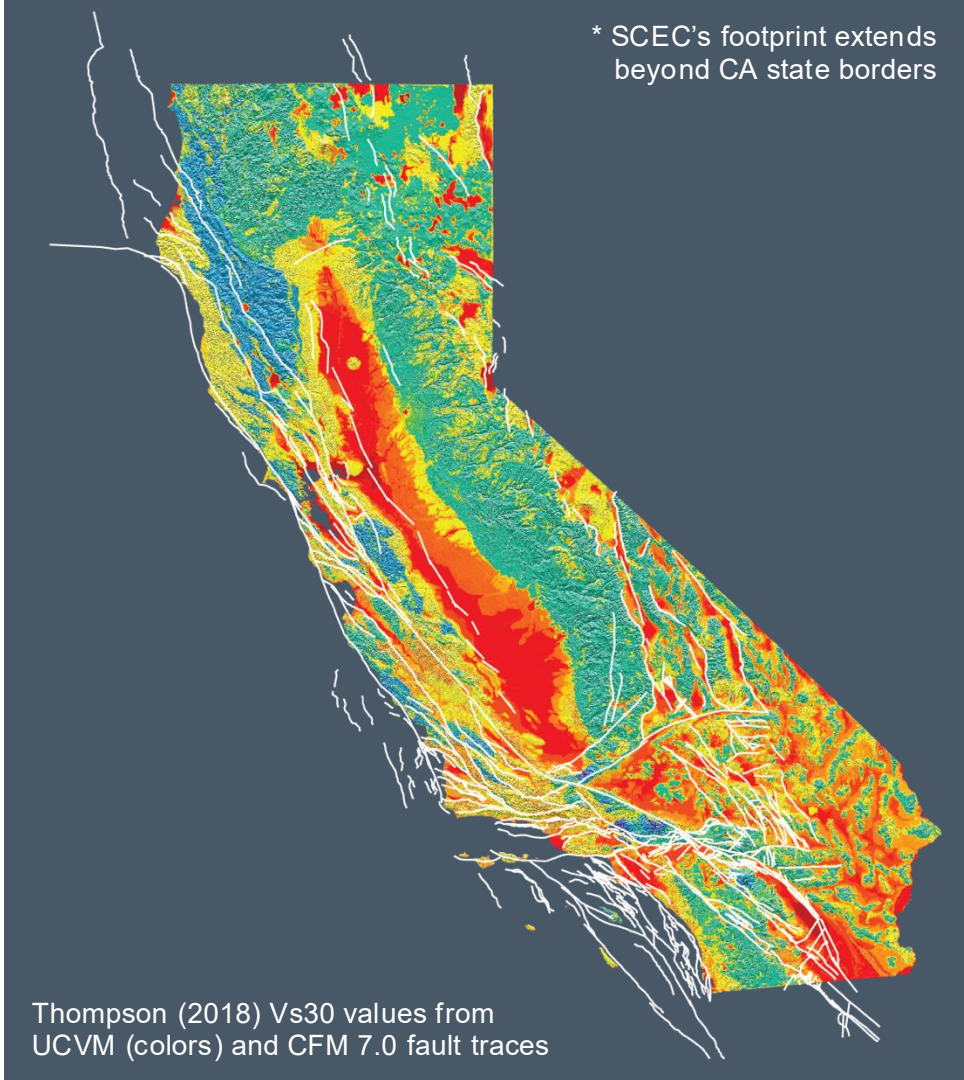
All CEMs have an “Explorer” that helps users explore the model (leaflet-based map)

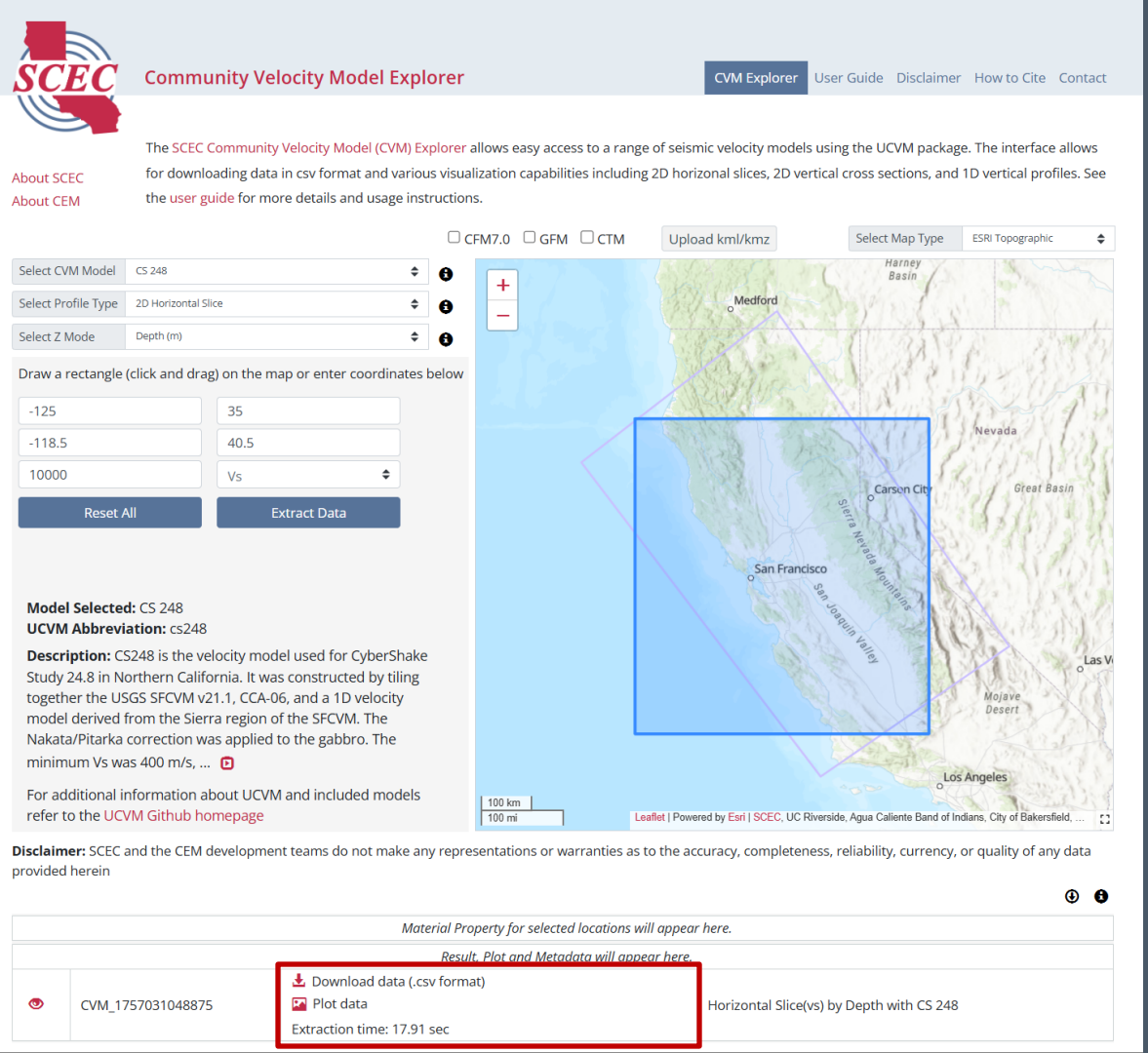
Some are still “Provisional”
moho.scec.org

If you have any issues, let us know! **Drop by our CEM helpdesk!**

Community Earth Model Explorer Updates

1. **New CVM Explorer**
2. **CFM Explorer Updates**
   - **Integration with Earthquake-to-fault Association Service**





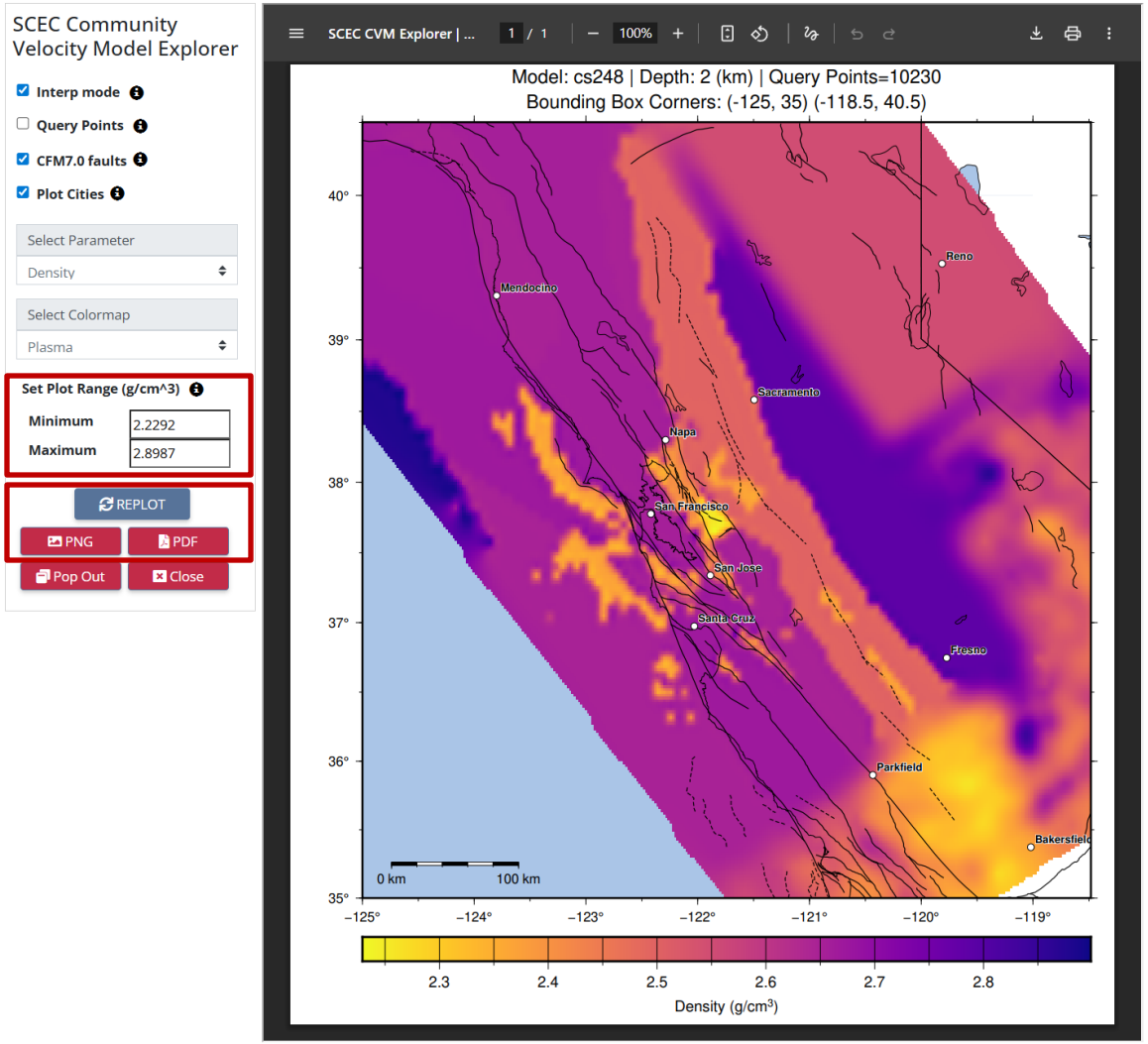
NEW!

CVM Explorer

Web-based tools for Community Velocity Models

What does the Explorer do?

- Search/Query/Download
  - Uses UCVM software & GMT scripts
  - 24 CVMs; 6 tiled models
  - Extract data in .csv format
- Extract Interpolated Profiles
  - 2D horizontal slices
  - 2D cross sections
  - 1D profiles
  - 0D point extraction
- Plots saved in pdf/png formats
- No specialized software needed



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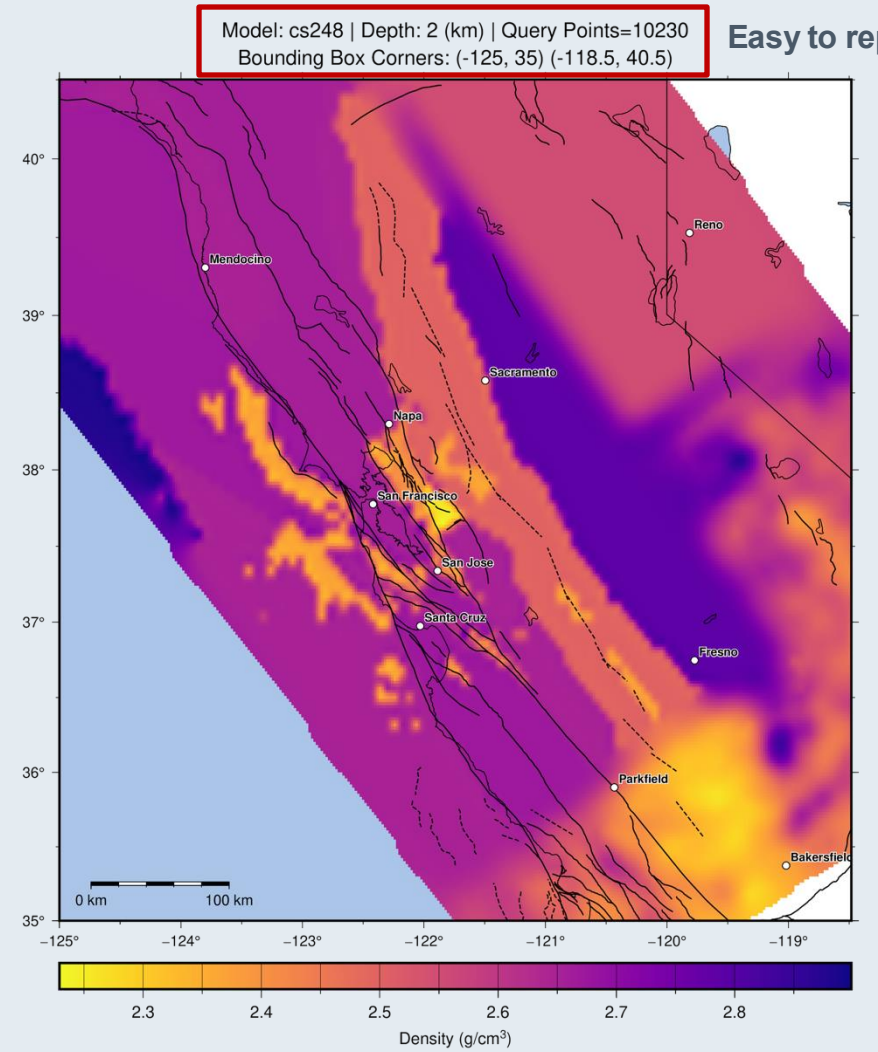

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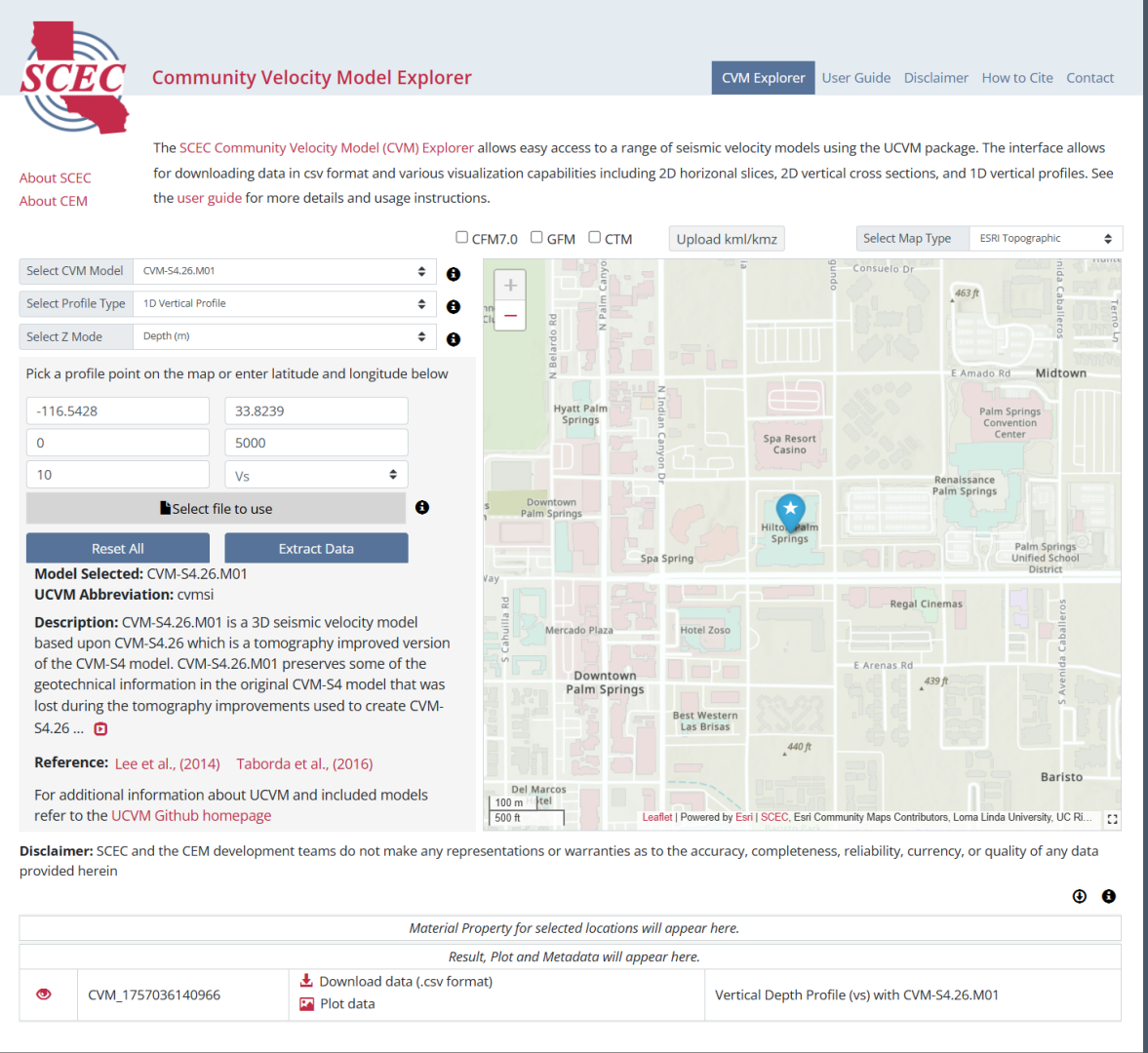

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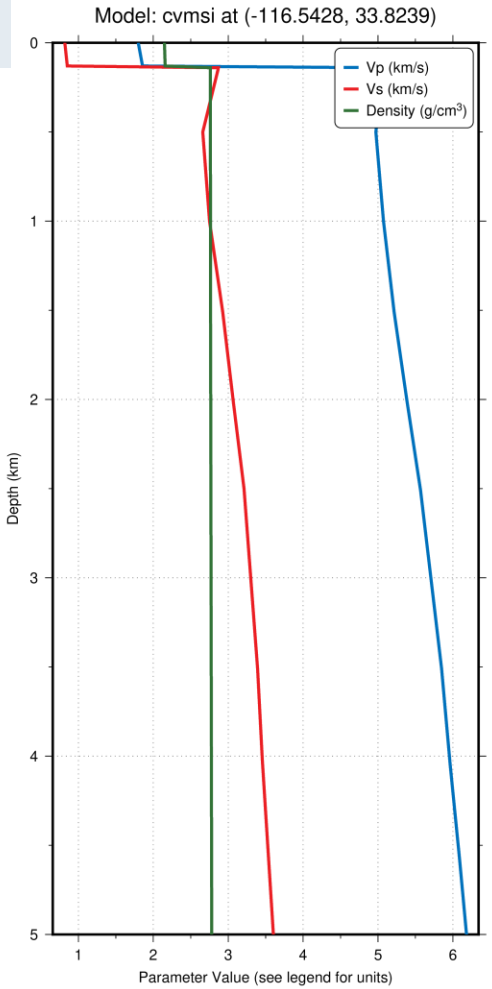
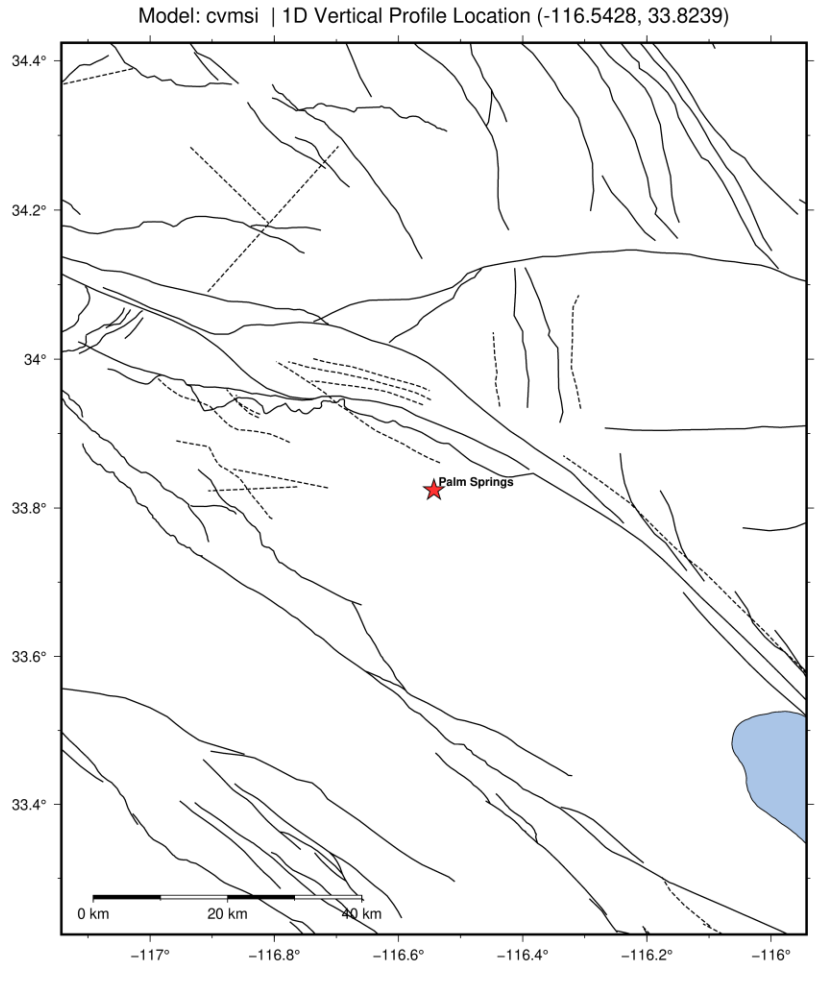
1D Profile

1D Vertical Profile Plot

CVM: CVM-S4.26.M01
Lee at al., (2014)
Taborda et al., (2016)

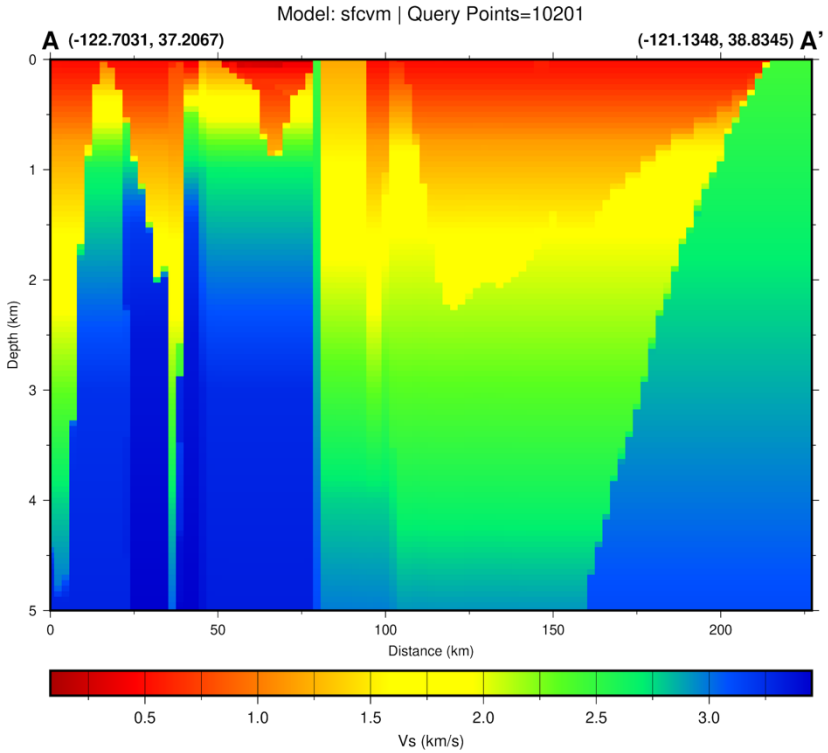


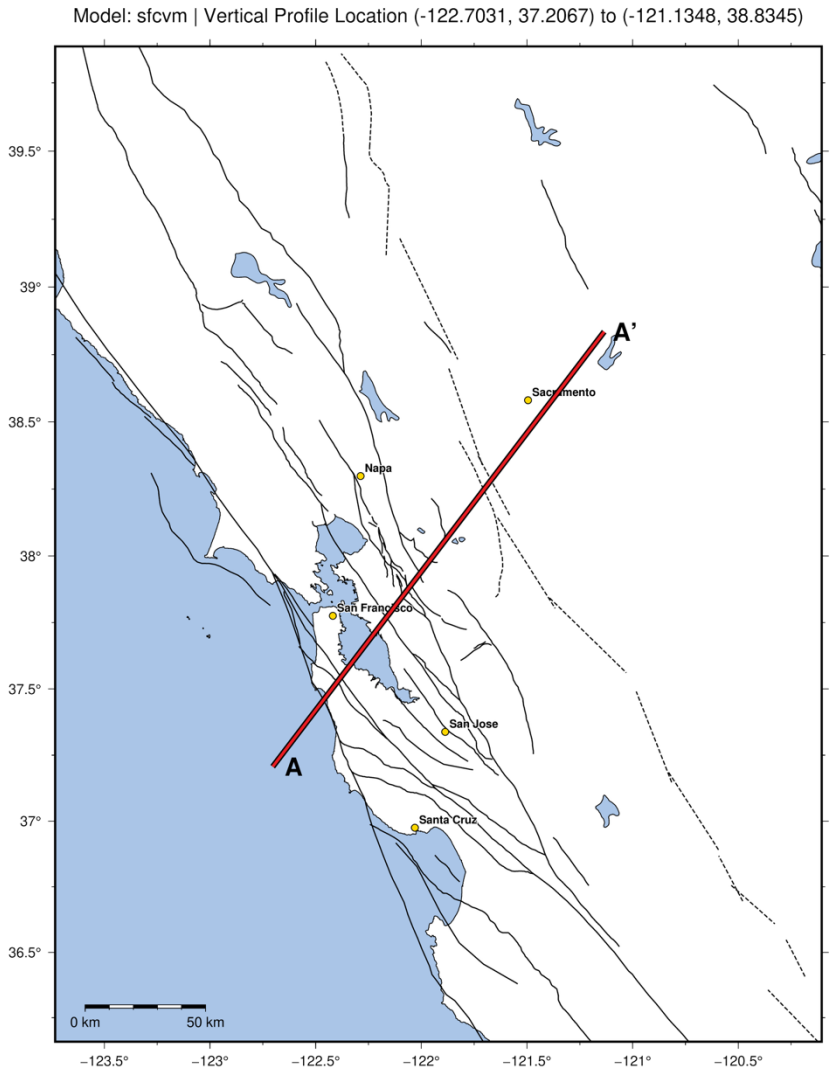


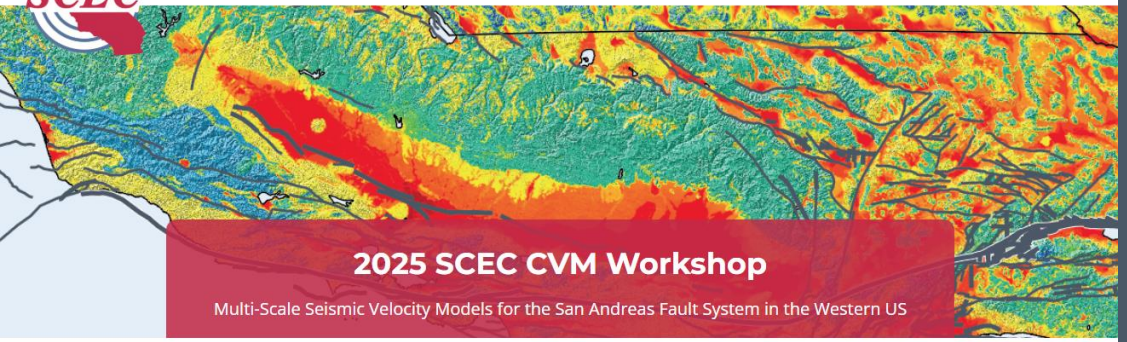
CVM Explorer Plots

Vertical Cross Section Plot

CVM: SF Bay Model (Aagaard et al., 2021)







Date: April 4, 2025 (08:30am – 4:30pm Pacific)
Location: Online via Zoom
Workshop Organizers: Patricia Persaud (U Arizona), Kim Olsen (SDSU), Artie Rodgers (LLNL), Phil Maechling (USC), Yehuda Ben-Zion (USC)

View Workshop Report

Summary

SCEC hosted a workshop to accelerate the development and improvement of multi-scale seismic velocity models that are essential for accurate ground motion simulations and seismic hazard assessments in California and beyond. While significant progress has been made, challenges remain in integrating new data, improving resolution, merging models, and assessing uncertainties. This workshop focused on planning a coordinated research approach to develop multi-scale P- and S-wave velocity models for the San Andreas fault system in the Western US, targeting seismic wavefield simulations up to 5-10 Hz, a frequency range critical for engineering applications. Participants discussed tomography workflows, strategies for merging high-resolution local models and regional models, integrating diverse geophysical data, and developing robust uncertainty quantification methods. The workshop also addressed the development of essential IT tools for model management and access, ensuring practical implementation of workshop recommendations. Discussions at the workshop will guide the development of the next generation of SCEC CVMs, which will advance our understanding of crustal structures and seismic hazards.

Workshop Objectives

Community Velocity Models (CVMs) provide foundational information for many basic and applied topics including the determination of earthquake locations and other source properties, imaging of the subsurface, and simulations of ground motions for use in seismic hazard models. However, current large-scale velocity models within the state of California lack the deterministic information needed for ground motion simulations at the high frequencies required in engineering applications. To address this limitation, the next generation of CVMs should resolve fine-scale seismic structure, in particular in basins, the shallow crust, and around fault zones to allow simulations of ground motion in areas of high population density and critical infrastructure to

2025 Workshop

Multi-Scale Seismic Velocity Models for the San Andreas Fault System

Focused on issues facing CVMs and multi-scale merging methods


Patricia Persaud (Arizona)

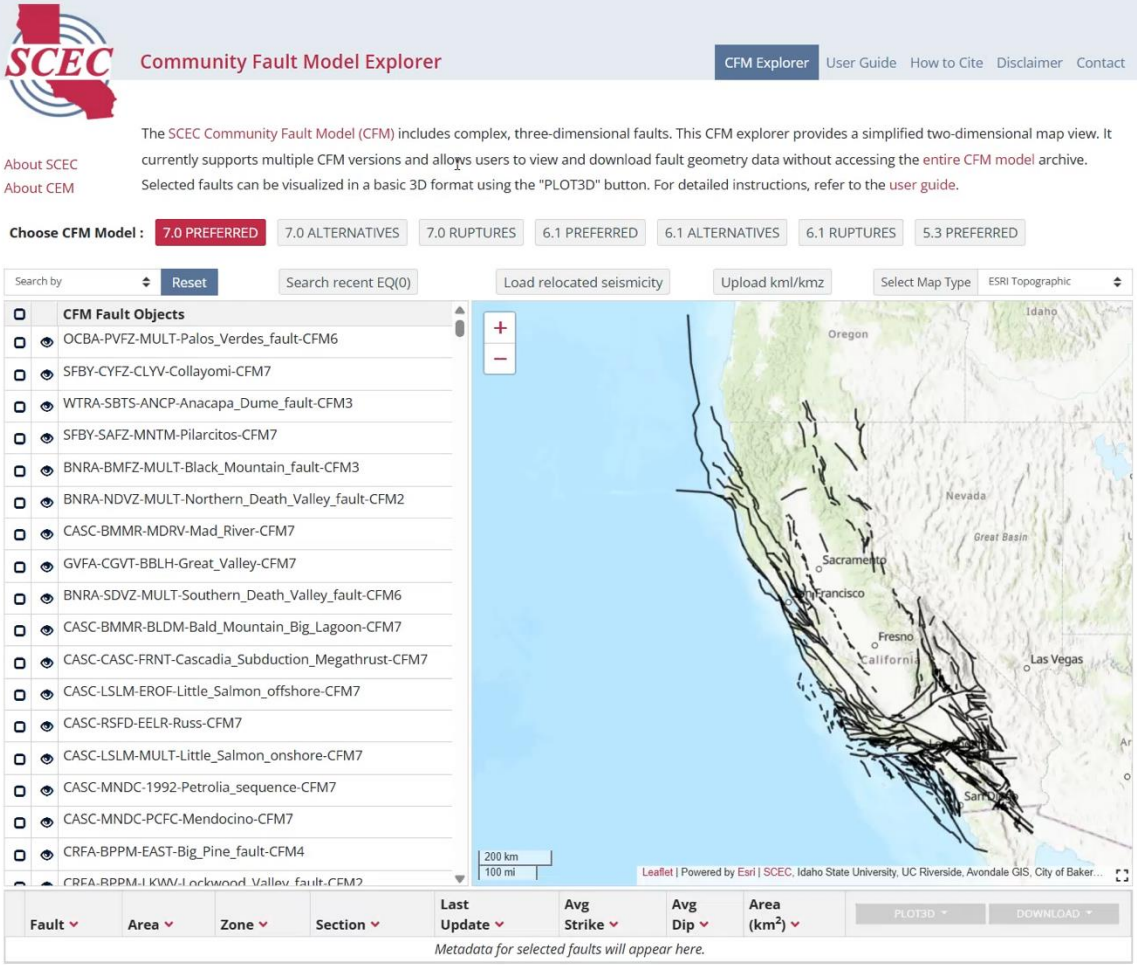

Philip Maechling (SCEC)


Kim Olsen (SDSU)


Yehuda Ben-Zion (SCEC)


Artie Rodgers (LLNL)

https://www.scec.org/events/2025-scec-cvm-workshop/



CFM Explorer

New tools for searching and displaying recent EQs

New “Search recent EQ”

What can it do?

- Search/Query/Download
  - Uses USGS API to query near real-time ComCat catalog
  - Can download event data in .csv
- Links to ComCat
- Visualize EQs in 2D and 3D
- Compare to CFM faults in 2D and 3D!!

A Statistical Method for Associating Earthquakes with Their Source Faults in Southern California

Walker S. Evans[1], Andreas Plesch[*1], John H. Shaw[1], Natesh L. Pillai[2], Ellen Yu[3], Men-Andrin Meier[3], and Egill Hauksson[3]

ABSTRACT

We present a new statistical method for associating earthquakes with their source faults in the Southern California Earthquake Center's 3D Community Fault Models (CFMs; Plesch *et al.*, 2007) in near-real time and for historical earthquakes. The method uses the hypocenter location, focal mechanism orientation, and earthquake sequencing to produce the probabilities of association between a given earthquake and each fault in the CFM as well as the probability that the event occurred on a fault not represented in the CFM. We used a set of known likely associations (the Known Likely Sets) as training or testing data and demonstrated that our models perform effectively on these examples and should be expected to perform well on other earthquakes with similar characteristics including the full catalog of southern California earthquakes (Hauksson *et al.*, 2012). To produce near-real-time associations for future earthquakes, the models have been implemented as an R script and connected to the Southern California Seismic Network data processing system operated by the California Institute of Technology and the U.S. Geological Survey to automatically produce fault associations for earthquakes of M ≥ 3.0 as they occur. To produce historical associations, we apply the method to the most recent CFM version (v.5.2), yielding modeled historical associations for all events of M ≥ 3.0 in the catalog of southern California earthquakes from 1981 to 2016. More than 80% of these events and 99% of moment within the geography covered by the CFM had a primary association with a CFM fault. The models can help identify clusters of small earthquakes that indicate the onset of activity associated with major faults. The method will also assist in communicating objective information about the faults that source earthquakes to the scientific community and general public. In the event of a damaging southern California earthquake, the near-real-time association will provide valuable information regarding the similarity of the current event to forecast scenarios, potentially aiding in earthquake response.

KEY POINTS

- Identifying source faults is difficult, time consuming, and subjective but critical for earthquake response.
- We develop and implement an automated method for associating earthquakes with known faults.
- The method can improve operational response, hazard assessments, and fault model completeness assessments.

providing several options for the earthquake source. Finally, our knowledge of the fault structure is generally incomplete, and thus earthquakes may occur on faults that have not been previously recognized or do meet criteria (e.g., fault size) that warrant their inclusion in regional fault maps or models.

Today, source fault determinations are typically produced by expert examination of earthquake and fault-related data to manually identify source faults using information such as

CFM

Earthquake-to-Fault Associations

Evans et al. (2020)

What can this do?

- Runs real-time on all EQs in SoCal >M3
- Associates EQs with CFM faults (or not in CFM)
- Valuable for rapid response and talking to media
- Now updated to CFM 7.0
- Integrated with CFM Explorer

To faultalarm71@beryl2.gps.caltech.edu 8/29/2025, 7:52 PM

Subject [External] SCSN quake (M3.8): Association with SCEC CFM 7.0 Faults (ci41156568)

Caltech/USGS SCSN Event Information

Magnitude:	3.8
Time (PT -||- UTC):	2025/05/19 12:09:19 ---||--- 2025/05/19 19:09:19
Coordinates (lat,lon):	35.048, -119.039
Location:	15.3 km (9.5 mi) NW from Grapevine, CA
Depth (km/miles):	6.0/3.7
USGS ComCat URL:	ci41156568

CFM 7.0 Fault Association Probability

Most Likely

White Wolf fault (79%)

2D Event-Fault view

3D Event-Fault view

Alternates

Not associated with a CFM modeled fault (17%)

Other CFM faults (4%)

Probability Summary

Fault Name	Distance (km)	Probability (%)	CFM Object Name
White Wolf fault	2.29	79	GVFA-WWFZ-MULT-White_Wolf_fault-CFM5
Not in CFM. See below.	NA: Not in CFM	17	Not in CFM
Pleito fault	9.28	4	GVFA-PLFZ-MULT-Pleito_fault-CFM2

Background Information

Earthquakes can occur both near or on known faults and in places where no clear fault zones are known. Using the statistical method of Evans et al. (2020) doi.org/10.1785/0120190115 the location and focal mechanism of this earthquake suggest the above association with modeled faults and their surroundings in the Community Fault Model (CFM) doi.org/10.5281/zenodo.4651667 provided by a partnership with the Statewide California Earthquake Center (SCEC), Harvard University, Appalachian State

CFM

Earthquake-to-Fault Associations

Evans et al. (2020)

What can this do?

- Runs real-time on all EQs in SoCal >M3
- Associates EQs with CFM faults (or not in CFM)
- Valuable for rapid response and talking to media
- Now updated to CFM 7.0
- Integrated with CFM Explorer

To faultalarm71@beryl2.gps.caltech.edu 9/1/2025, 5:20 PM

Subject **[External] SCSN quake (M3.7): Association with SCEC CFM 7.0 Faults (ci40186202)**

Caltech/USGS SCSN Event Information

Magnitude: 3.7
Time (PT -||- UTC): 2025/02/14 23:44:05 ---||--- 2025/02/15 07:44:05
Coordinates (lat,lon): 34.041, -118.91
Location: 10.1 km (6.3 mi) WNW from Malibu, CA
Depth (km/miles): 15.4/9.6
USGS ComCat URL: ci40186202

CFM 7.0 Fault Association Probability

Most Likely

Anacapa-Dume fault (35%)
2D Event-Fault view
3D Event-Fault view

Alternates

Not associated with a CFM modeled fault (11%)
Other CFM faults (54%)

Probability Summary

Fault Name	Distance (km)	Probability (%)	CFM Object Name
Anacapa-Dume fault	4.43	35	WTRA-SBTS-ANCP-Anacapa_Dume_fault-CFM3
Malibu Coast fault-east	3.62	30	WTRA-SFFS-SMMT-Malibu_Coast_fault_east-CFM6
Malibu Coast fault-west	4.01	24	WTRA-SFFS-ANCP-Malibu_Coast_fault_west-CFM5
Not in CFM. See below. NA: Not in CFM	11		Not in CFM

Background Information

Earthquakes can occur both near or on known faults and in places where no clear fault zones are known. Using the statistical method of Evans et al. (2020) doi.org/10.1785/0120190115 the location and focal mechanism of this earthquake suggest the above association with modeled faults and their surroundings in the Community Fault Model (CFM) doi.org/10.5281/zenodo.4651667 provided by a partnership with the Statewide California Earthquake Center (SCEC), Harvard University, Appalachian State University, and the Southern California Earthquake Data Center. This information is subject to change as more up-to-date data become available. For more information, see https://www.scec.org/article/619.

CFM Fault: SCEC CFM Fault name and closest segment when relevant;
The CFM is developed and maintained by Andrew Plesch and John H Shaw at Harvard University, Dept of Earth & Planetary Sciences and Scott T. Marshall at Appalachian State University, Dept of Geological and Environmental Sciences.

CFM

Earthquake-to-Fault Associations

Evans et al. (2020)

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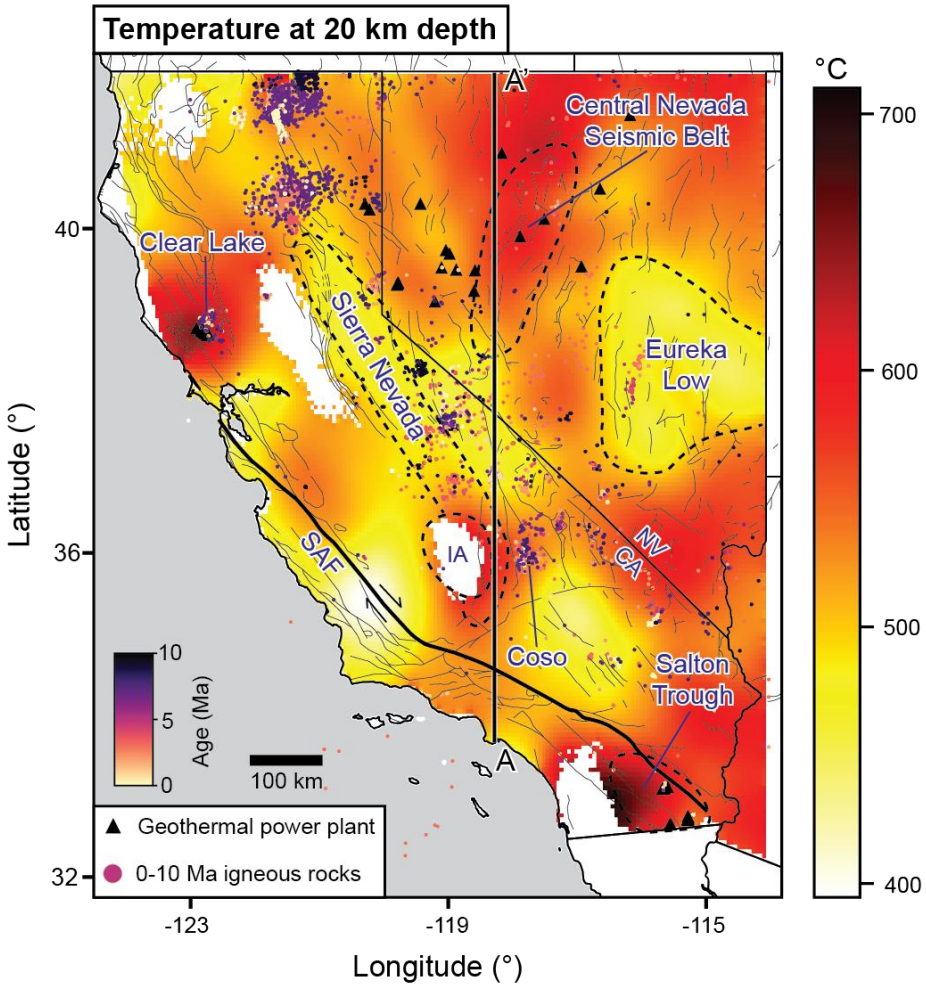
- Integrated with CFM Explorer



Lee et al., in review

Community Thermal Model Explorer

Coming Soon!

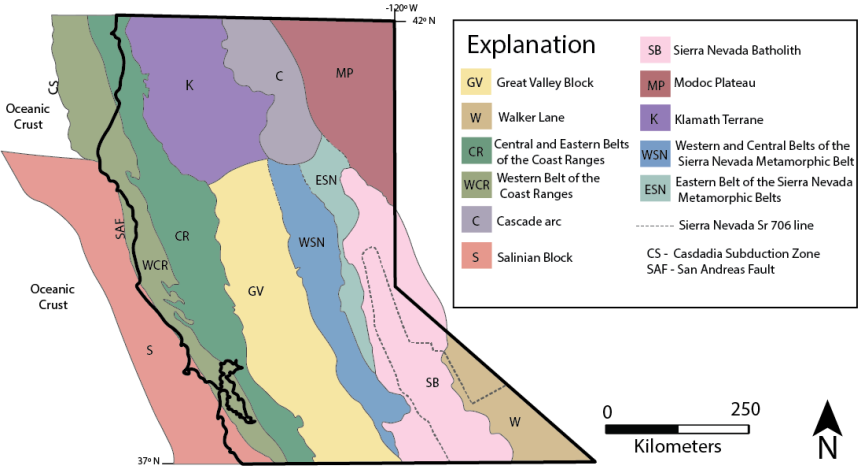
The CTM Explorer will have similar functionality to the CVM Explorer

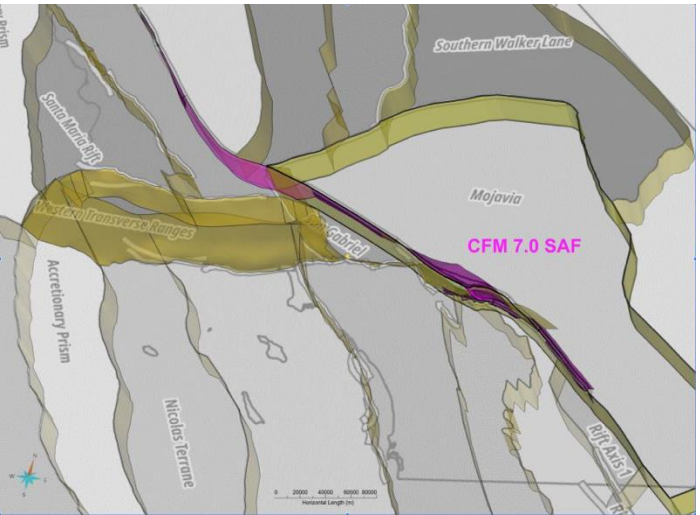

Terry Lee
(UNR)


Andrew Zuza
(UNR)


Daniel Trugman
(UNR)

Major Geologic Provinces of NorCal (Mike Oskin)





Reconciling the GFM with CFM faults (Andreas Plesch)

Geologic Framework Model (GFM)

The GFM is going statewide!

SCEC Statewide GFM/CTM Workshop
August 14-15, 2025 @ UC Davis

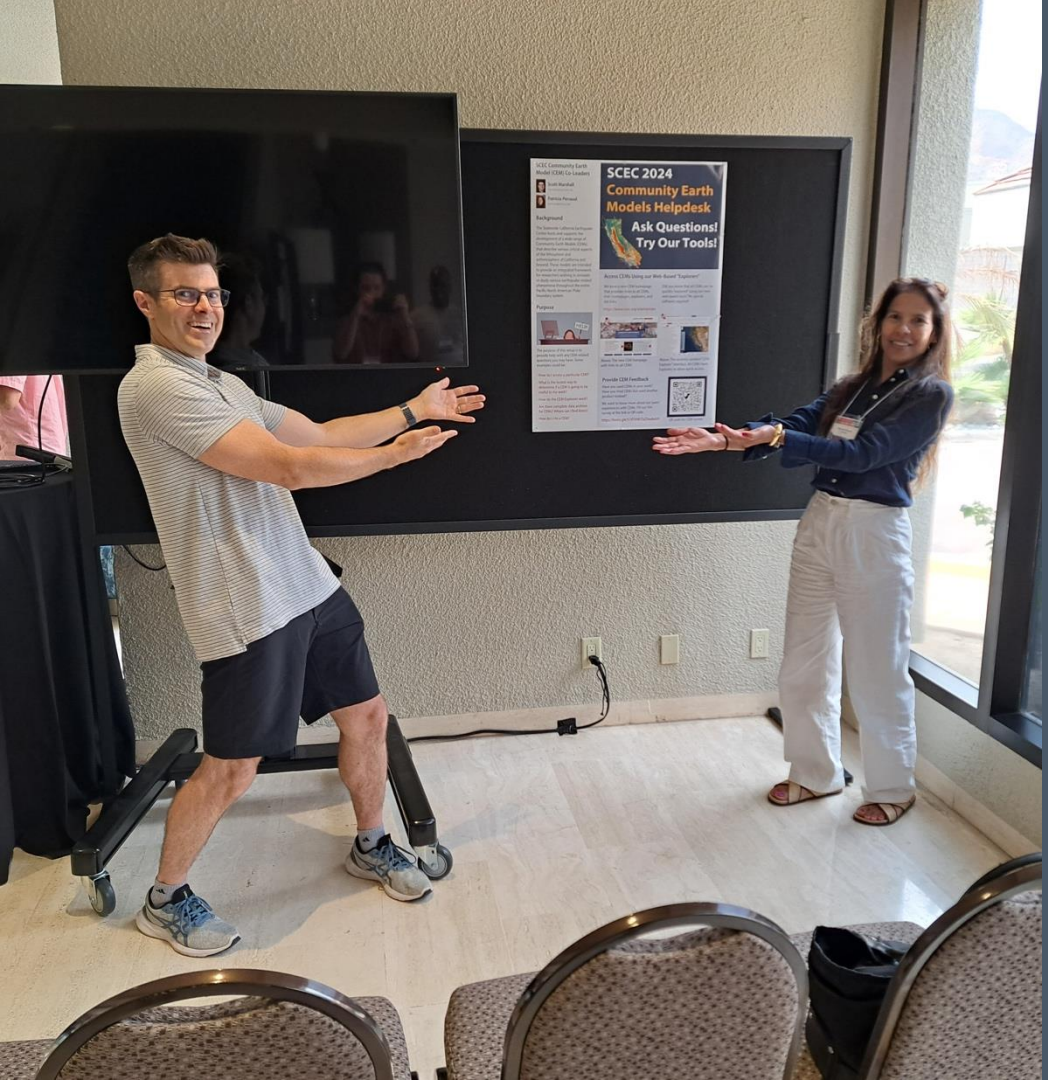
Mike Oskin, Andrew Zuza, Terry Lee, Laurent Montesi, Oliver Boyd, Yuehua Zeng, Sierra Rack

SCEC Community Rheology Model Workshop, Integrating friction into the CRM,
September 6, 2025 @ Hilton Palm Springs

Alexis Ault, Sylvain Barbot, Caroline Seyler

Plenary Talk by Mike Oskin
Tues 2:30pm @ SCEC 2025

California's Geological Framework and Consequent Fault-System Behavior



SCEC 2025

Community Earth Models Helpdesk

We can help!

Available During Poster Sessions

- **Ask questions!**
- **Try our CEM “Explorers”**
- **Meet CEM developers**

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Sunday Sept 7	SCEC Product Name
8:00 PM - 9:00 PM	Tandem and SeisSol
9:00 PM - 10:00 PM	Community Geodetic Model
Monday Sept 8	
10:00 AM - 11:00 AM	Community Fault Model
11:00 AM - 12:00 PM	UCERF3/BBP/pyCSEP
4:30 PM - 5:30 PM	MOOSE-FARMS/QuakeWorx
8:00 PM - 9:00 PM	Unified Community Velocity Model
9:00 PM - 10:00 PM	Community Stress Model
Tuesday Sept 9	
10:00 AM - 11:00 AM	Community Rheology Model / GFM
11:00 AM - 12:00 PM	Community Thermal Model
4:30 PM - 5:30 PM	OneSciencePlace