2025 SCEC Report
Evaluation and Expansion of the statewide SCEC Community Fault Model

Scott T. Marshall
Department of Geological and Environmental Sciences
Appalachian State University
marshallst@appstate.edu

Andreas Plesch
Department of Earth and Planetary Sciences
Harvard University
andreas_plesch@harvard.edu

John H. Shaw
Department of Earth and Planetary Sciences
Harvard University
shaw@eps.harvard.edu

Philip Maechling (unfunded Co-PI)
Southern California Earthquake Center
University of Southern California
maechlin@usc.edu

SCEC Science Milestones Addressed

A3-1: Establish a SAFS-wide Community Fault Model (CFM) that includes more realistic 3D geometry and reconciles inconsistencies between the existing CFM and the lower-resolution National Seismic Hazard Model (NSHM) faults.

A1-1: Assess availability and quality of Community Earth Models (CEMs) for different regions of the SAFS.

C1-1: Develop and utilize existing and emerging cyberinfrastructure to allow for 3D visualization and data (and model data) access. Work towards integration of different Community Earth Models into an integrated web-based Community Earth Model Framework.

SCEC Community Earth Models Used: CFM

1. Abstract

SCEC's Community Earth Models (CEMs) are integral to its earthquake science mission as impactful earthquake scenarios, ground motion simulations, next-generation computational models, and post-earthquake investigations all rely on a comprehensive 3D fault model. In 2024, we delivered the first statewide SCEC Community Fault Model, CFM 7.0. The new model covers the full state of California using uniform guidelines on inventory, fault hierarchy, documentation, and model access. This first statewide CFM provides 556 fault objects (113 new in central and northern California), in the preferred model. While the CFM has existed since 2001, the northern California portion of the CFM is in its infancy. In 2025, we organized an open community evaluation of the northern California portion of the CFM which yielded a large volume of overall positive and constructive feedback including identification of 45 missing faults and > 100 suggestions for improvement in specific fault representations. We have shared this feedback with colleagues at CRESCENT, as they are also working to produce a fault model of northern California. We have plans in place to share the work involving the needed fault updates. In the last year, we have created new fault representations along the California-Oregon border and a new subduction interface which will be included in the next CFM release. During 2025, we also significantly updated the web presence of the CFM with a new homepage (https://www.scec.org/science/community-fault-model/), released significant functionality updates to the CFM Explorer (https://central.scec.org/research/cfm-explorer/), and deployed a major update to the earthquake-to-fault association service, which is now directly linked to the CFM Explorer and provides interactive 2D and 3D visualizations for users. We aim to release the next major CFM version in the next year, once the northern California evaluation feedback has been addressed. Finally, we published a peer reviewed manuscript covering the well-established southern California portion of CFM 7.0.

2. CFM Progress During 2025

CFM 7.0 Community Evaluation: On June 2nd, 2025, we hosted the CFM Evaluation kickoff meeting on Zoom. Given the early stage of the northern California model, we recruited group leaders to focus on regional sections of the CFM to facilitate the evaluation. Each group leader was in charge of finding appropriate reviewers for the faults in their region. For this evaluation, we subdivided the previously unreviewed portions of the model into five areas following the CFM naming hierarchy (CASC-NCRA-NCST, KLMT-GVFA, SFBY, SNLV, OCCA, Figure 1). Each region included between 18 and 38 faults. For each area, the expert groups utilized updated 2D and 3D tools provided by the CFM Explorer and were guided in their evaluation by a set of questions both for each individual fault and for the overall fault area. In total, 132 faults were reviewed, with significant feedback provided. A large majority of the faults received detailed suggestions for updates and 45 faults were recommended to be added to the model. Due to the volume of comments, we plan to continue addressing the evaluation feedback in 2026. The results will be included in the next CFM release.

New CFM Faults and Collaboration with CRESCENT: We continued our ongoing collaboration with the CRESCENT CFM group and worked to ensure the southern portion of the CRESCENT CFM remains continuous and compatible with the northern SCEC CFM, both within the onshore forearc and the offshore splay fault region of the accretionary wedge. To achieve this, we synthesized the USGS National Seismic Hazard Model (NSHM) fault section database, the USGS Quaternary Fault and Fold database, and the California Geological Survey Fault Activity Map, alongside primary data from the National Archive of Marine Seismic Surveys, hypocentral catalogs, and CASIE21 (Carbotte et al., 2024). This

effort resulted in a set of 3D fault representations for the CRESCENT-SCEC southern border that are geometrically and kinematically compatible with the latest SCEC CFM. Beyond fault geometry, the model is constrained by contiguous surfaces such as topography and the base of seismicity (seismogenic thickness) which have been shared with the CRESCENT CFM group to ensure regional consistency. We also produced an updated subduction zone interface which will be included in the upcoming SCEC CFM revision. Specifically, we developed a single, contiguous surface of the Cascadia megathrust below the accretionary wedge and the deeper subduction zone plate interface by merging datasets developed for the CASIE21 imaging project and by Hayes et al. (2018). Since there is overlap at the transition between the base of the accretionary wedge and the seismologically characterized upper limit of the subduction zone, we computed the misfit of the interpolated surface with the input data. The misfit is generally small (median of 138 m for the CASIE21 mapping) and reaches maximum values of 2 km to 5 km in a small area offshore northern Oregon (Figure 2) following the 20 km depth contour of Hayes et al. (2018).

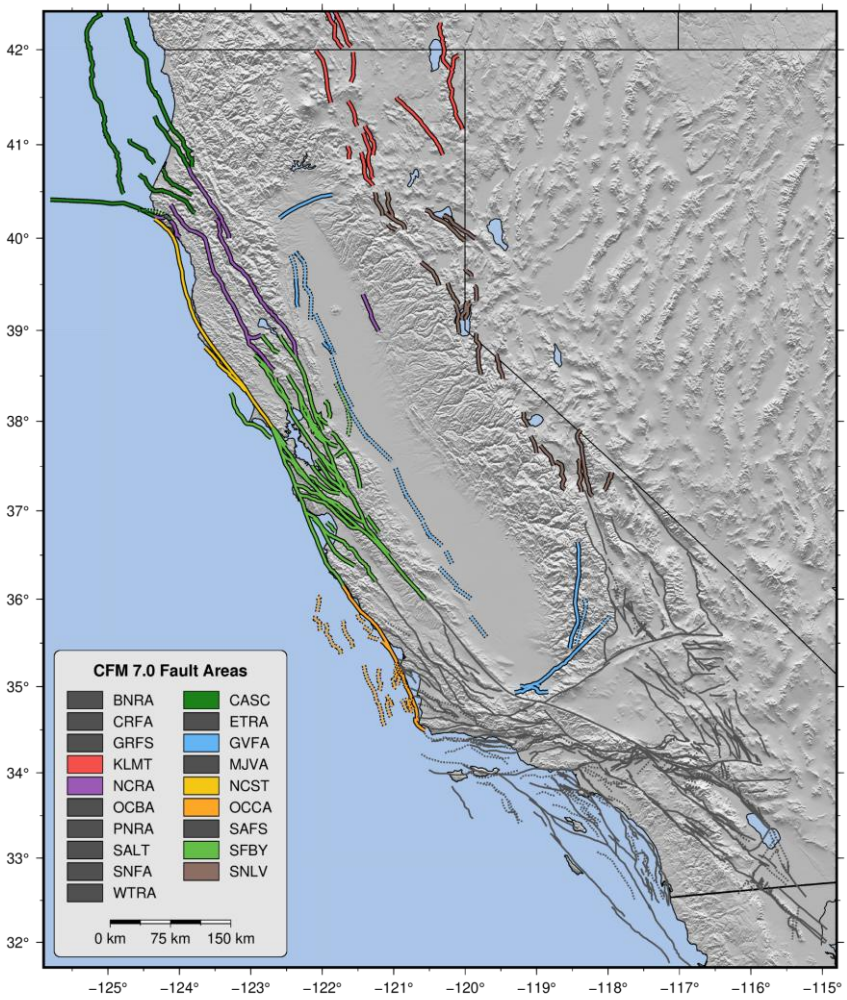

Figure 1: *CFM 7.0 fault traces colored by the major fault area in the CFM hierarchy. Each peer review group was in charge of providing feedback for one or more fault areas. All faults in gray were part of previous southern California CFM evaluations, and were not included in the 2025 community evaluation.*

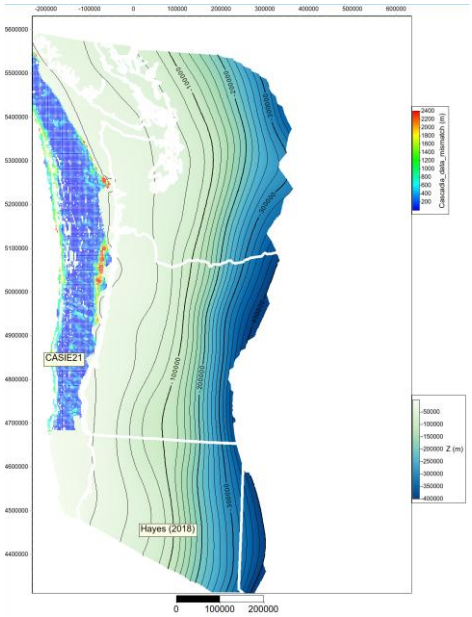

Figure 2: *Map of contoured Cascadia subduction interface. Colored dots show the misfit to CASIE21 mapping of the base of the accretionary wedge.*

The New CFM Home: With the transition to the statewide center, the scec.org homepages were redone in a new visual style with a focus on statewide efforts. Keeping with our longstanding collaboration with SCEC IT and Web groups, we collaboratively worked to create and deploy a new redesigned homepage and background page for the CFM. This new CFM homepage provides information about the model and its key technical developments along with links to the CFM Explorer, the full model archive on Zenodo, and a background page that has information about model changes, how users can contribute to the CFM, downloadable maps, and information about software and scripts to visualize the model components. We hope that this new CFM homepage will provide the information needed by both model users and the broader community.

Updates to the CFM Explorer: In 2025, in collaboration with SCEC IT, we made a significant update to the CFM Explorer by adding the ability to directly query and visualize near realtime seismicity from the USGS ComCat. The USGS ComCat includes API access, which we used to feed data directly into the CFM Explorer. The query process is nearly instantaneous, but is limited by the USGS API to < 20,000 events. The new "Search recent EQ" tool button provides the user with options to filter by magnitude, date/time, and geographic region. The results are interactively visualized on both the 2D map view and can also be viewed in 3D using the plot3d option.

Updates to the Earthquake-to-fault Association Service: In collaboration with the Southern California Earthquake Data Center at Celtech, and SCEC IT, we collaborated to release a major update to the Community Fault Model (CFM) Earthquake-to-Fault Association Service. Launched in 2020, the service was designed to help researchers quickly identify which faults are most likely associated with recent earthquakes greater than magnitude 3, information which is crucial when briefing the public right after shaking is felt. The service utilizes three-dimensional spatial relationships between event locations and fault geometries to generate probabilistic associations, based on methods described in Evans et al. (2020).

Most notably, the updated service now utilizes CFM 7.0 in southern California and integrates with the SCEC CFM Explorer to provide interactive 2D and 3D visualizations of earthquake epicenters, hypocenters, and fault surfaces (Figure 3). Notification emails now include direct hyperlinks to these interactive visualizations of fault traces, the most likely fault surfaces associated with each event, and the hypocenter location (Figure 3). Since releasing this update, usage of the CFM Explorer has significantly increased suggesting that users are making use of these near real time visualization tools. Importantly, we have also produced scripts that automatically create the necessary data files from the CFM archive for use with the association service, thus simplifying the process for updating this critical service in the future.

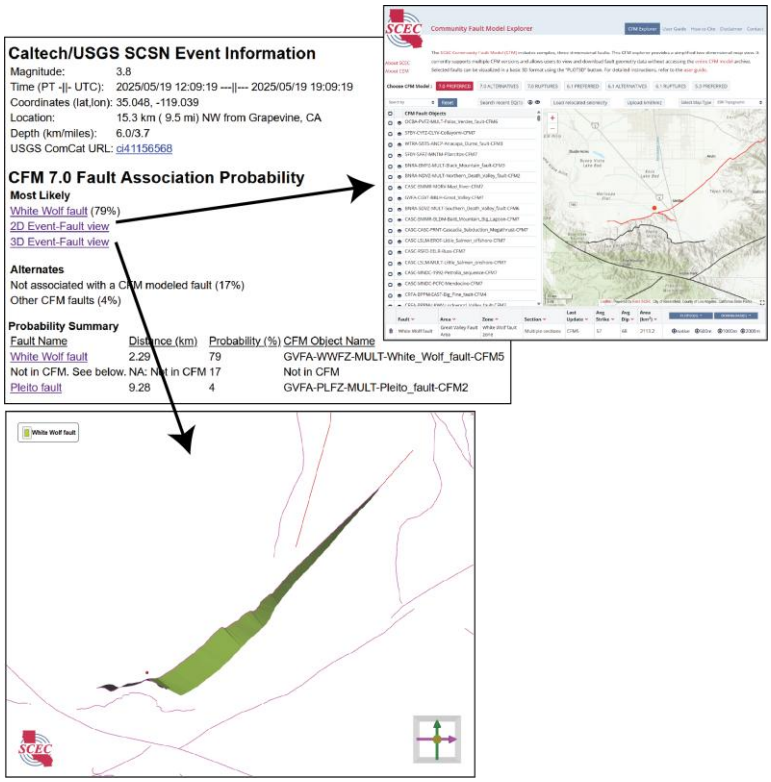

Figure 3: *Screenshot of the updated CFM Explorer used in the earthquake-to-fault association service. Top left: email notification from the service with links to 2D and 3D visualizations using the CFM Explorer. The earthquake-to-fault association service is available to all users with a scec.org account.*

3. Publication of CFM Manuscript

Publishing community models in peer-reviewed journals is essential for ensuring scientific rigor, transparency, reproducibility, and broad usability within the seismic hazards community. We focused significant effort in 2025 on producing a manuscript detailing the well-established southern California portion of the CFM (Plesch et al., 2026). This manuscript was accepted for publication in the Bulletin of the Seismological Society of America in December of 2025 and will serve as a peer-reviewed reference for the CFM. The CFM manuscript not only outlines the construction methods used in the CFM and how the model has changed since the last peer-reviewed manuscript (Plesch et al., 2007), it also provides quantitative analyses of the model that demonstrate changes in completeness and geometric complexity of the model over time. We anticipate a future publication on the statewide CFM, after we have made a series of improvements to the model based on community input.

References

Carbotte S.M. et al., (2024). Subducting plate structure and megathrust morphology from deep seismic imaging linked to earthquake rupture segmentation at Cascadia.Sci. Adv.10,eadl3198. DOI:10.1126/sciadv.adl3198

Evans, W. S., A. Plesch, J. H. Shaw, N. L. Pillai, E. Yu, M. A. Meier, and E. Hauksson (2020). A Statistical Method for Associating Earthquakes with Their Source Faults in Southern California, Bulletin of the Seismological Society of America 110 213-225. doi: 10.1785/0120190115.

Hayes, G. P., Moore, G. L., Portner, D. E., Hearne, M., Flamme, H., Furtney, M., Smoczyk, G. M. (2018). Slab2, a comprehensive subduction zone geometry model. Science 362, 58–61. DOI:10.1126/science.aat4723

Plesch, A., J. H. Shaw, C. Benson, W. A. Bryant, S. Carena, M. Cooke, J. Dolan, G. Fuis, E. Gath, L. Grant, et al. (2007). Community Fault Model (CFM) for Southern California, Bull. Seismol. Soc. Am. 97, no. 6, 1793–1802, doi: 10.1785/0120050211.

Plesch, A., S. T. Marshall, and J. H. Shaw (2026). The Community Fault Model (v. 6.1) for Southern California, Bull. Seismol. Soc. Am. XX, 1–22, doi: 10.1785/0120250247.