2016 SCEC Report

Enhancements to the SCEC CFM: Database & delivery, earthquake simulator formats, & Statewide CFM

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Science Objectives: 4A, 4C

Summary

We continued our efforts to develop a new system for distributing the Community Fault Models (CFM's) (Plesch et al., 2007; Shaw et al., 2015), and to make a series of improvements that will help support their use in earthquake simulators and a variety of other science and hazard assessment projects. This was a collaborative effort between the lead development team for the CFM at Harvard University and SCEC's Community Modeling Environment (CME) group, led by Phil Maechling.

Specifically, we:

1) Released a new version of the CFM (5.1) at the 2016 Annual Meeting. This model incorporates significant revisions to fault representations based on refined fault traces, and new hypocentral and focal mechanism catalogs;
2) Continue development of a database for the latest CFM model release (CFM 5.1), which will be used to support implementation of a new relational database and web interface through CME that will allow users to search and access model components;
3) Generated a set of rectilinear (CFM-R) and regularly gridded CFM representations for the most recent CFM model (version 5.1) at resolutions that are targeted by SCEC investigators for fault system modeling and earthquake simulators;
4) Produced a set of fault trace shape files from the latest CFM and Statewide Community Model models, including blind sources, for use maps and other SCEC activities;
5) Made a series of improvements to the Statewide Community Model (SCFM) that were recommended by participants in a 2015 workshop to evaluate the latest model release.

This project, in conjunction with SCEC sponsored efforts by Craig Nicholson (UCSB), represents the primary effort to support and develop the SCEC Community Fault models (CFM, CFM-R, and SCFM). These models help facilitate probabilistic seismic hazards assessments, fault system modeling, tectonic studies, and earthquake simulators in SCEC.

Project Results

At the 2016 Annual Meeting, we released a new version of the SCEC Community Fault Model (CFM) for southern California (v.5.1, Figure 1). This model represents a substantially enhanced version of the southern California fault representations, which were systematically improved using detailed fault traces from the USGS Quaternary Fault & Fold Database, precisely relocated earthquake hypocenters, and new focal mechanism catalogs (Lin et al., 2007; Yang et al., 2012; Hauksson et al., 2012). This resulted in fault representations that are more precise, and often more highly segmented than in previous model versions. Fault representations were comprehensively improved in the Santa Maria and Ventura basins, Santa Barbara Channel, offshore Continental Borderland, Transverse Ranges, Peninsular Ranges, San Gorgonio Pass area, and the Mojave Desert region. CFM 5.1 also includes the addition of several new faults that were not represented in any previous model versions.

CFM fault representations are organized within an associated hierarchical database that provides unique identifiers (name and number) for each level (that includes fault area, fault system, fault section, fault name & fault strand) of the fault hierarchy within which a fault segment occurs. This hierarchical naming and numbering scheme thus allows for grouping of individual faults as part of geometrically or kinematically linked fault systems. Thus, we developed a corresponding spreadsheet with this information in parallel to releasing the new model version. This information will be provided to the SCEC Community Modeling Environment (CME) team, led by Phil Maechling, to develop a new database architecture that will host this and future CFM model versions and be made accessible through a web-based graphical system. The database architecture that we have designed is structured into tables that define distinct database features (entities). This relational structure allows generalized queries of the database by a database engine. For example, a query for a fault name can provide all database features linked directly or indirectly to the record in the fault table identified by the name. The hierarchical naming system maps into such a relational structure in a natural fashion. In addition to the fault table, linked fault area, fault system, fault section, and fault name tables will be able to systematically reproduce the hierarchy. Systematic numbering will be provided by a number field in parallel to a name field in each table. Eventually, spatial queries can be enabled by embedding geospatially registered geometry into the database.

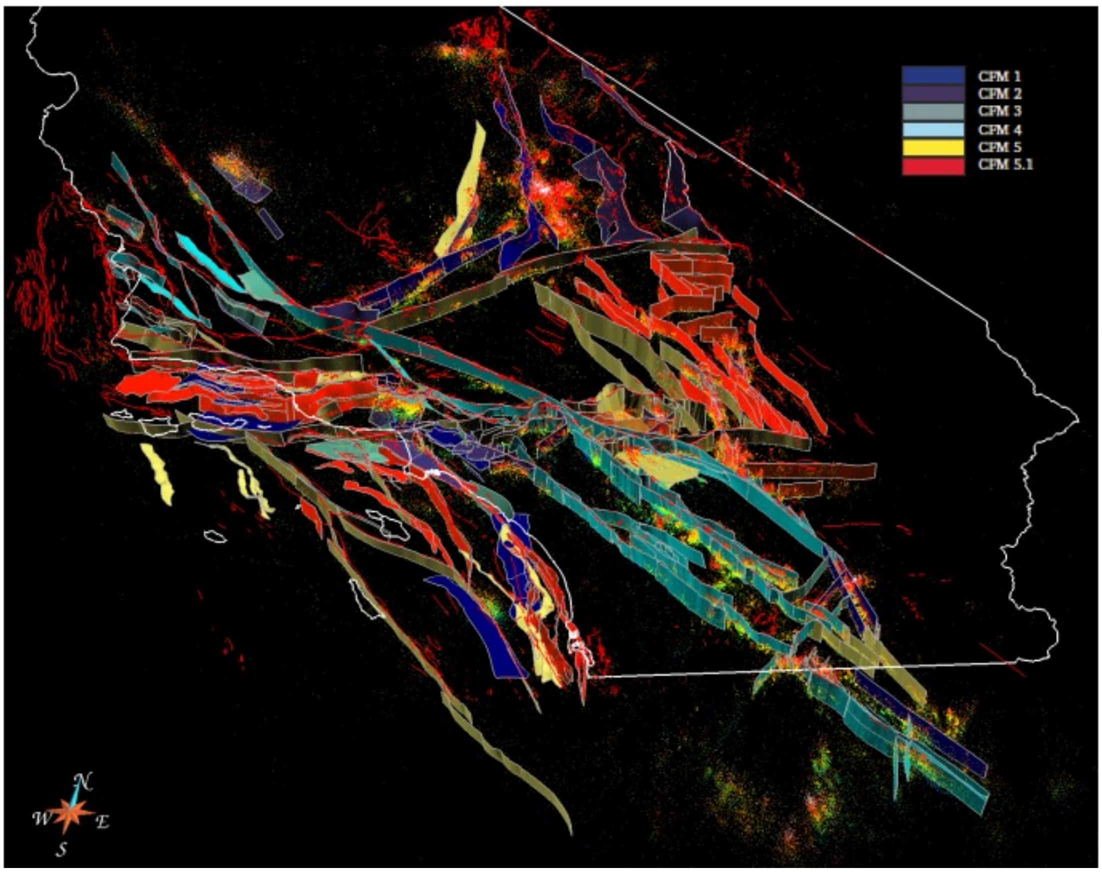

Figure 1: Overview over development history of the CFM. The perspective view shows primary representations for each of the ca. 380 fault and fault sections in the model. The color refers to when the current fault presentation was added or improved during development of the CFM. All phases of development from CFM1 to CFM5.1 are still present in the current model components, highlighting the need for an organized and systematic database to archive the model and access its components. 1981-2011 hypocenter locations by Egill Hauksson.

From inception of the CFM, T-surfaces (Tsurfs) were used as the native format for faults because they provide for more accurate representations of complex, curviplanar surfaces that vary their geometries in depth or along strike. Moreover, the native CFM Tsurfs often have highly varying mesh resolutions, reflecting the amount and quality of data used to constrain each part of the fault representations. This poses a challenge for some model applications, such as earthquake simulators, which require rectangular dislocations (e.g. Okada, 1992) or more evenly meshed Tsurfs. Thus, in cooperation with various SCEC investigators we have developed a set of both rectangular (Figure 2A) and regularly meshed tsurfs for use in earthquake simulators and other applications. We completed the regularly meshed surfaces for faults in CFM 4.0, and currently have a beta version of these surfaces for CFM 5.1 (Figure 2). We anticipate making this available for a planned earthquake simulators workshop in 2017, and will work with this community to plan further refinements and enhancements to these representations that facilitate their use. The goal is to develop file formats and mesh standards that can be implemented and provide by SCEC CME for CFM 5.1 and future model versions.

In a parallel effort, we have also developed a set of fault traces based on the latest CFM release. Traces are one of the simplest but most widely used representations of faults, serving to populate maps and as the basis for some hazard assessments (e.g., for distance calculations used in attenuation relations). To serve these needs, we developed a set of CFM 5.1 fault traces (Figure 2B) by extracting the upper tipline edge of the 3D fault surfaces. The resulting traces are simpler and generally more continuous than USGS Qfault traces, but nevertheless represent a substantial improvement over most trace sets used in published fault maps. The CFM trace set is also unique in that it includes blind sources. Fault traces are provided as standard shape files that can be used in most GIS and other mapping applications, using UTM and geographic coordinate systems.

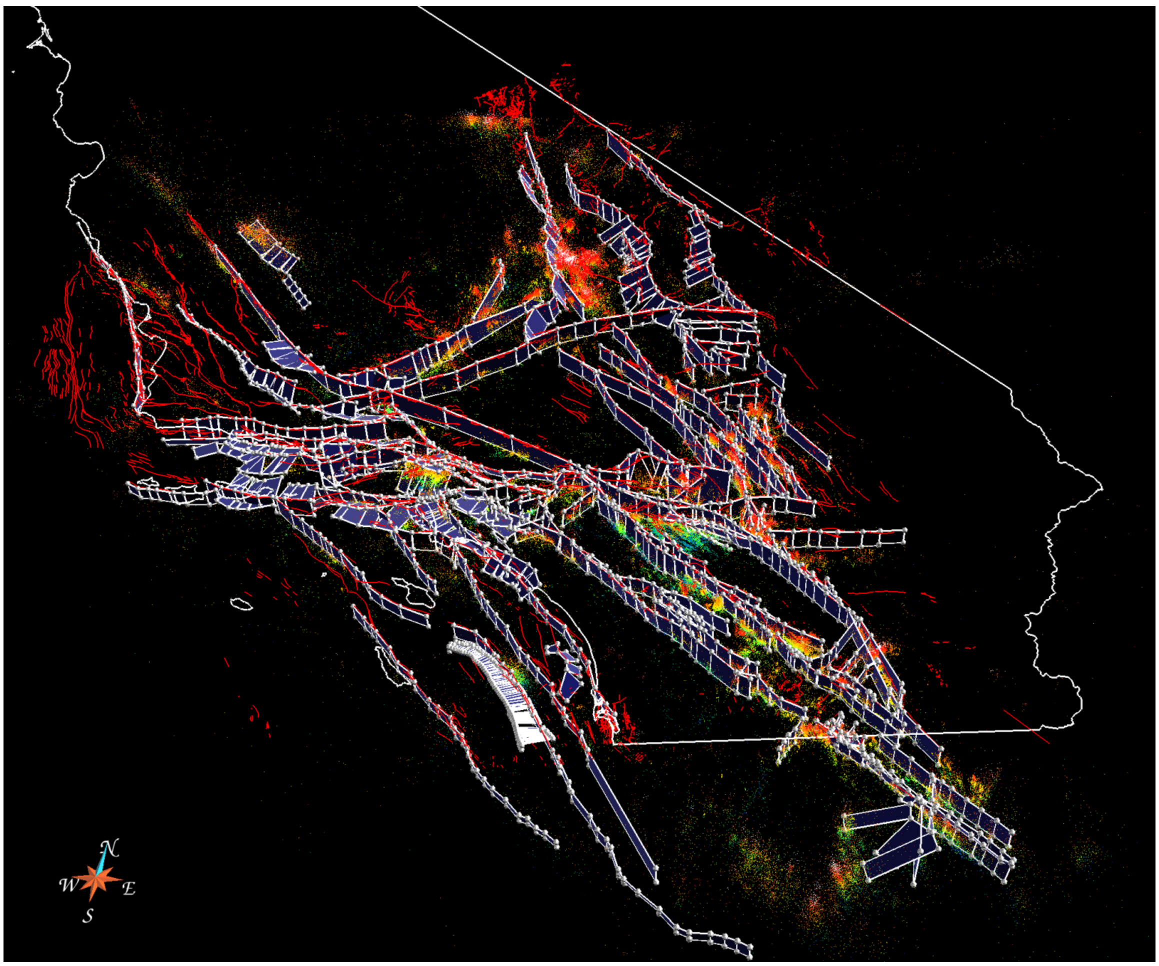

Figure 2A: Perspective view of rectilinear fault representations developed from the Community Fault Model (CFM 5.1).

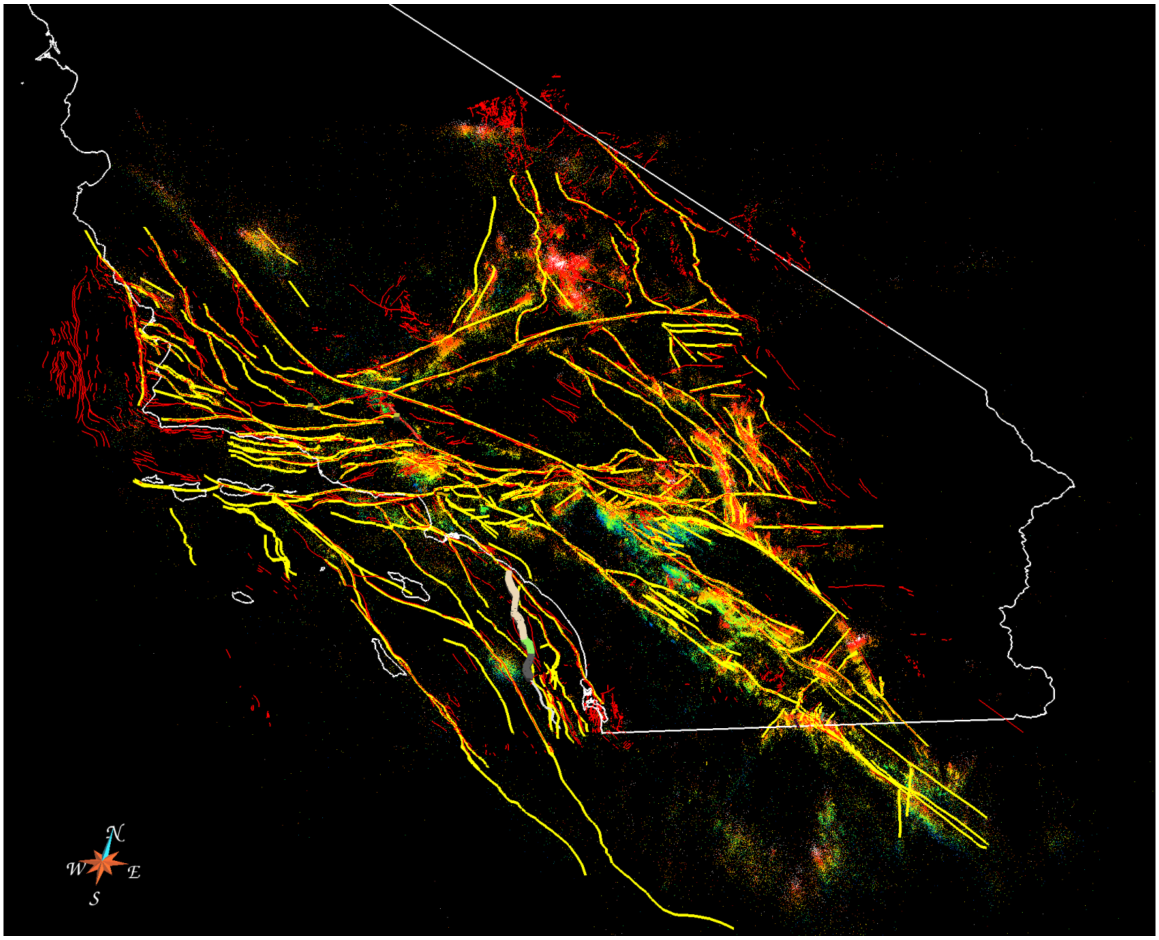

Figure 2B: Perspective view of surface fault traces developed from the Community Fault Model (CFM 5.1).

Finally, we made refinements to the SCFM 3.0 (Figure 3), a statewide model that includes CFM 5.1 representations in southern California along with a comprehensive set of representations for more than 150 fault in northern California. Faults in the San Francisco Bay area (Brocher et al., 2005) are based largely on geological models developed by the USGS (Brocher et al., 2005). New fault representations were generated for the Coast Ranges, Great Valley, southern Cascadia subduction zone, and other areas of northern California. The model was presented for evaluation in a workshop held at the USGS in Menlo Park (5/7/2015). More than 20 participants at the workshop discussed fault representations using 3D visualization software. They were tasked with assigning fault quality rankings and defined a list of targeted improvements to current fault representations. After the workshop, participants continued using SCEC VDO software to evaluate and rank faults. Results from both activities were used to establish preferred fault representations that are represented in the latest statewide model version (SCFM 3.0) and to prioritize a series of improvements to the fault representations for future model releases. This past year, we focused on making refinement to faults in the Santa Maria and San Joaquin basins. These, along with improvements to other faults, will be incorporated in a future model release.

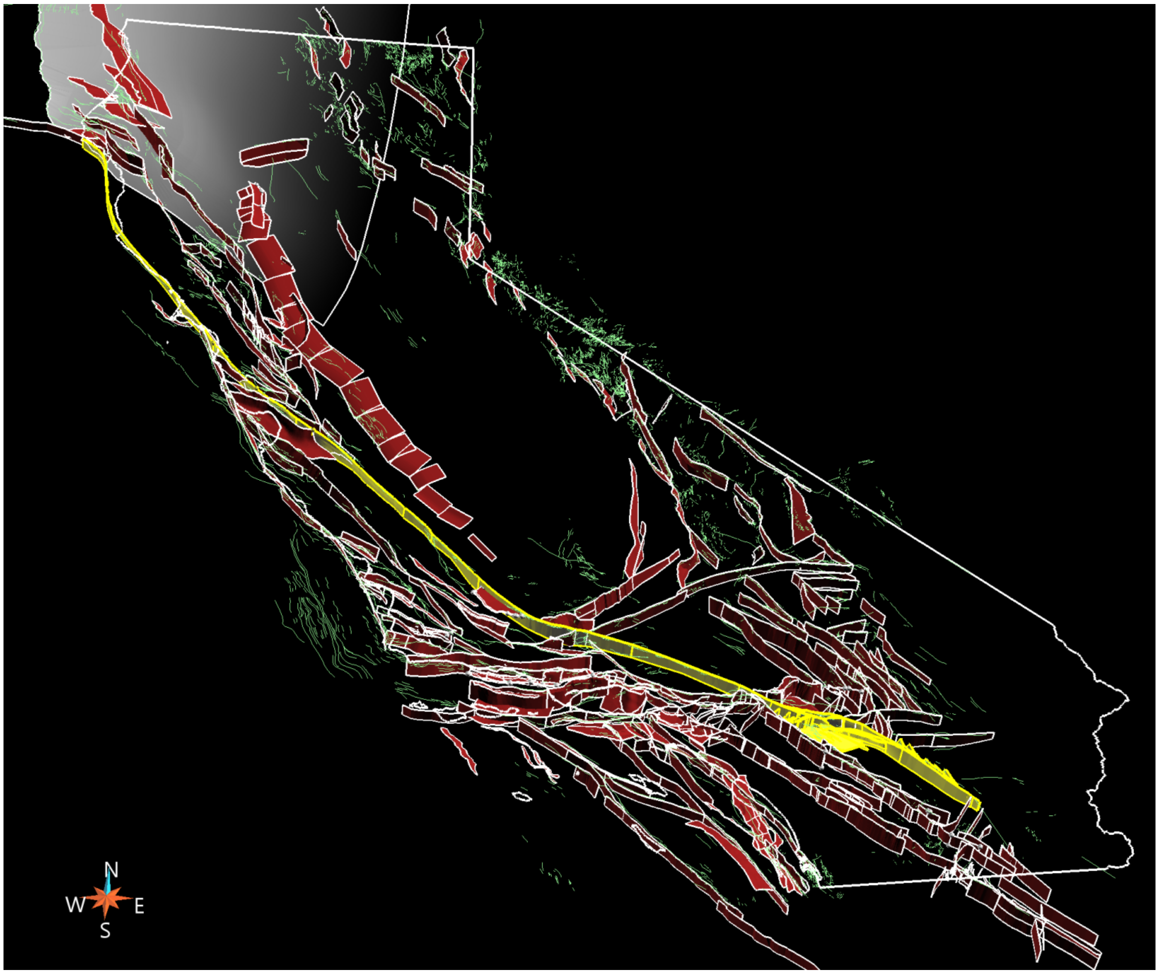

Figure 3: Perspective view of the Statewide Community Fault Model (SCFM 3.0).

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