UPDATING THE 3D FAULT SET FOR THE SCEC COMMUNITY FAULT MODEL (CFM-v4) AND REVISING ITS ASSOCIATED FAULT DATABASE

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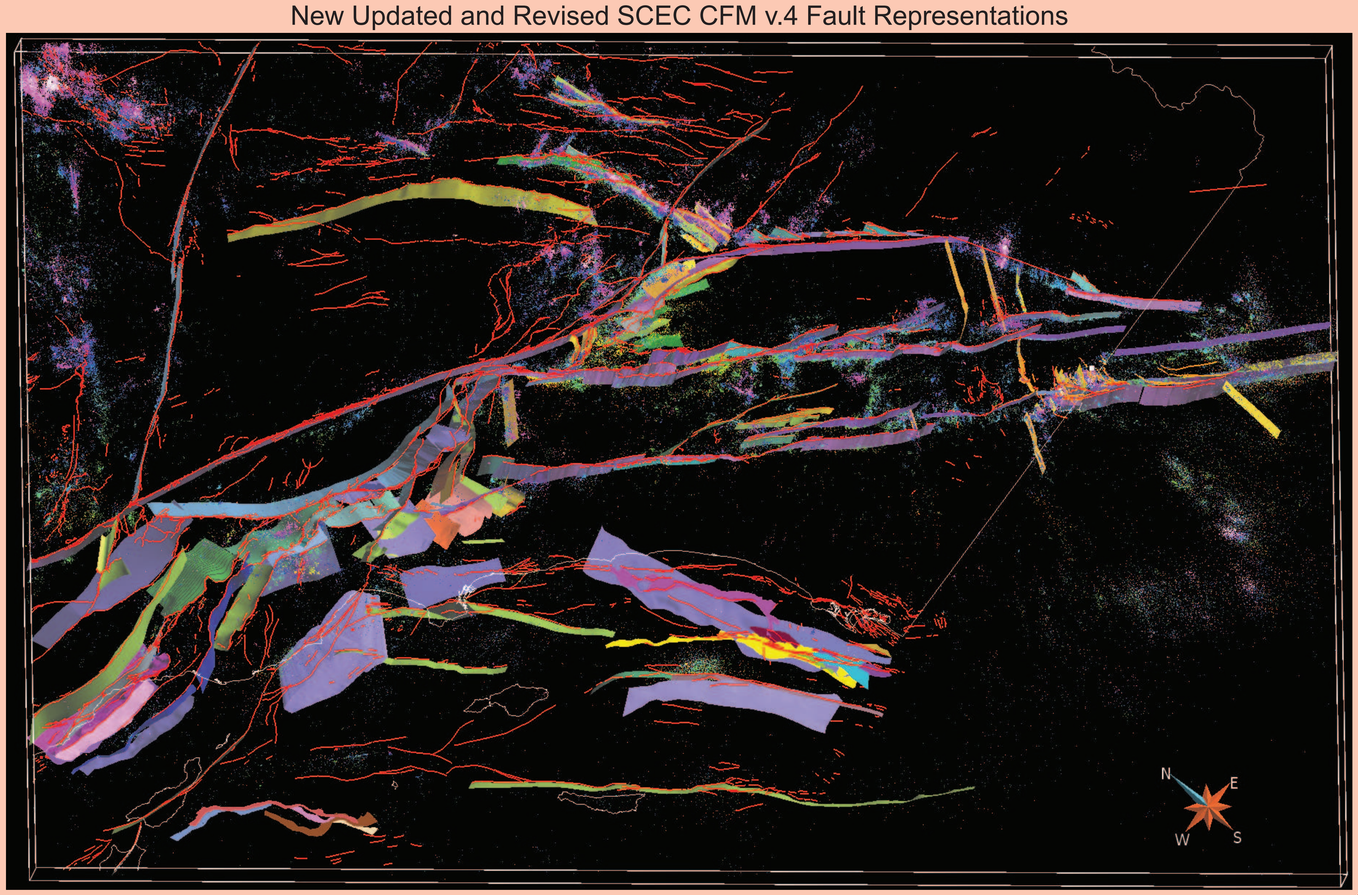
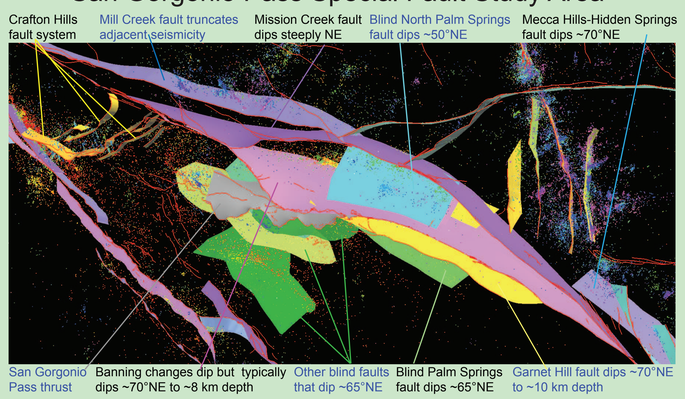
New Updated and Revised SCEC CFM v.4 Fault Representations

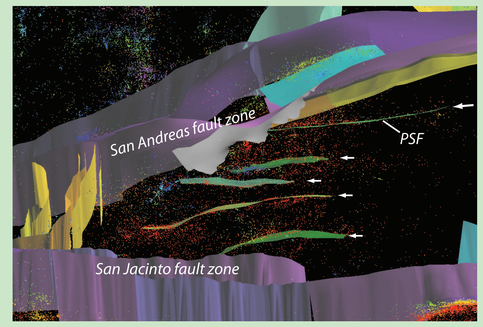
Map 3D view of new elements in CFM v.4 showing detailed USGS Quaternary fault surface traces (red), relocated seismicity (dots) [Hauksson et al., 2012] and new updated 3D fault models for the San Andreas, San Jacinto, Elsinore-Laguna Salada, Agua Tibia-Earthquake Valley, Imperial-Brawley, Hollywood-Raymond, Sierra Cucapah, Lenwood-Lockhart, San Gabriel, San Fernando, Garlock, Oak Ridge-Northridge, Verdugo, Santa Susana, Sierra Madre, Mecca Hills and many other fault systems, as well as for several major cross faults and secondary fault splays. Where they crop out, updated CFM 3D faults are now registered to the Qfault surface traces, and major strike-slip faults are no longer assumed to be vertical, but are now more complex 3D fault surfaces that change dip and dip direction along strike and with depth to better correlate with alignments of relocated earthquake hypocenters and focal mechanism nodal planes. New preliminary 3D models were also added for faults in the offshore Inner Borderland, including the Carlsbad, Coronado Bank detachment, Catalina detachment, Descanso, and Santa Monica Bay faults, as well as others in the onshore and offshore Ventura, Santa Maria and Santa Barbara basins, including the Pitas Point-Ventura, Red Mountain, Lion, San Cayetano, South San Cayetano, Lompoc, Los Alamos, and Casmalia faults.



San Gorgonio Pass Special Fault Study Area

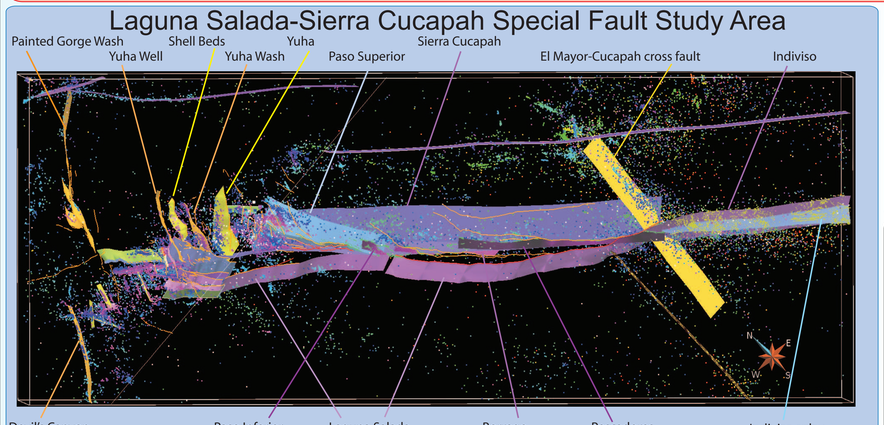


The San Andreas fault in San Gorgonio Pass now consists of multiple, active non-planar fault strands including the Banning, Garnet Hill, and Mission Creek. The North Palm Springs fault may be the down-dip extension of the San Gorgonio Pass thrust offset by the Banning strand.

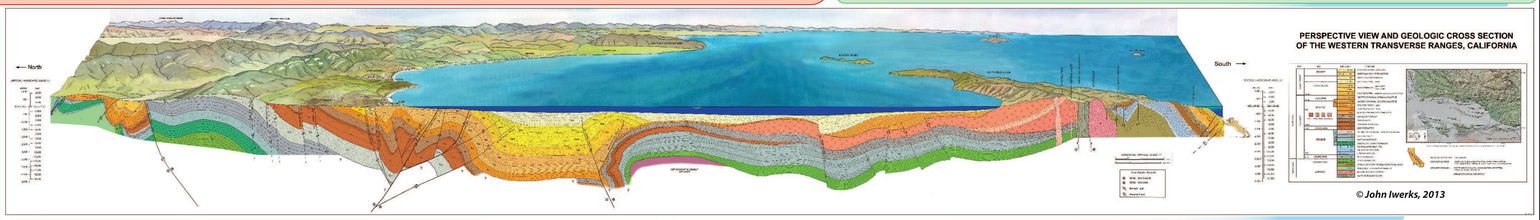


Oblique 3D view looking down-dip and in the plane of slip for the blind Palm Springs fault (PSF). This perspective reveals a set of sub-parallel en echelon oblique-slip faults (arrows) dipping ~65°NE and which also help accommodate plate motion through the pass.

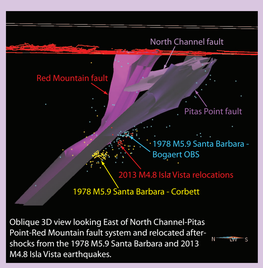
Laguna Salada-Sierra Cucapah Special Fault Study Area



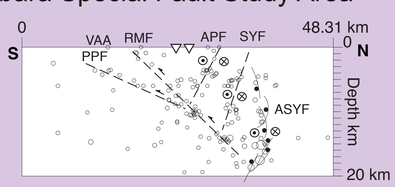
Oblique 3D view looking NE of complex, non-planar, multi-stranded steep-to-West-dipping Laguna Salada-Indiviso fault models with adjacent sub-parallel non-planar, multi-stranded steep-to-East-dipping Sierra Cucaph faults, plus additional secondary fault splays and related cross faults in the Yuha desert and other areas.



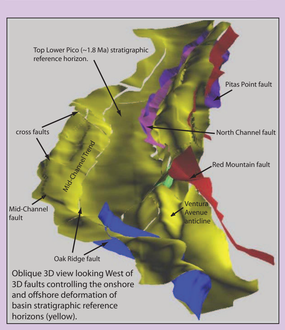
Ventura-Santa Barbara Special Fault Study Area



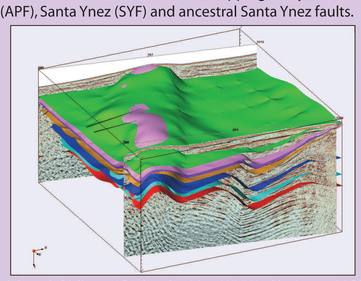
Oblique 3D view looking East of North Channel-Pitas Point-Red Mountain fault system and relocated after-shocks from the 1978 M5.9 Santa Barbara and 2013 M4.8 Isla Vista earthquakes.



Cross section looking West of relocated seismicity that define the principal N-dipping Pitas Point (PPF) and Red Mountain faults (RMF), and the S-dipping Arroyo Parida (APF), Santa Ynez (SYF) and ancestral Santa Ynez faults.

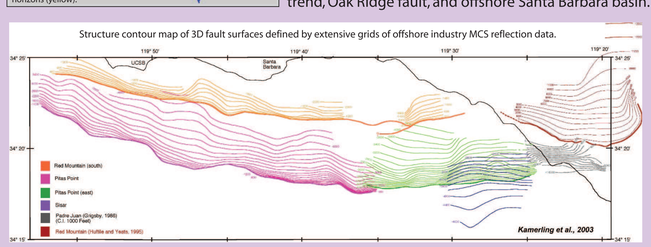


Oblique 3D view looking West of 3D faults controlling the onshore and offshore deformation of basin stratigraphic reference horizons (yellow).



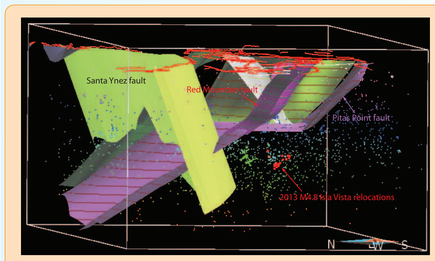
(above) Oblique 3D view looking WNW of industry MCS data used to map stratigraphic reference horizons and active fault geometry (below) across the Mid-Channel trend, Oak Ridge fault, and offshore Santa Barbara basin.

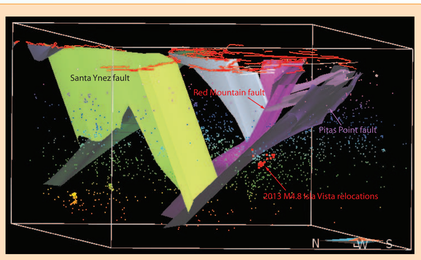
Structure contour map of 3D fault surfaces defined by extensive grids of offshore industry MCS reflection data.

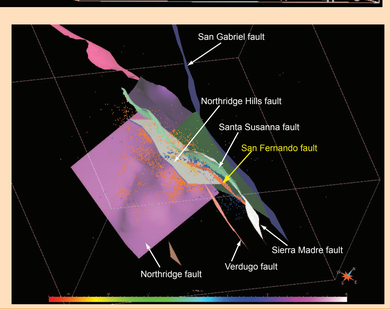


Improvements in CFM for Version 4.0

- New 3D fault representations for major active fault zones, including the San Andreas from Parkfield to the Salton Sea, San Jacinto, Elsinore-Laguna Salada, Agua Tibia-Earthquake Valley, Garlock, Imperial-Brawley, Sierra Cucapah, Hollywood-Raymond, Oak Ridge-Northridge, San Gabriel, Santa Susana, San Fernando, Verdugo, Sierra Madre, Mecca Hills and many other fault systems, have now been added to CFM that allow for more non-planar 3D fault geometry as indicated by the relocated microseismicity, including changes in dip and dip direction along strike and with depth. These new updated and revised 3D fault models and interpretations help characterize a more complex pattern of fault interactions at depth between various fault sets and linked fault systems, and may help to explain some of the more enigmatic fault behavior that is otherwise difficult to understand.
- Special attention was focused on developing new updated fault sets for **Special Fault Study Areas**. This includes new 3D models for the complex geometry of active faults through San Gorgonio Pass; better resolution of the fault splays and secondary strands of the steep-to-west-dipping Laguna Salada-Indiviso fault and their relation to the steep-to-east-dipping Sierra Cucapah fault and cross faults in the Yuha Desert; and more detailed models for offshore Inner Borderland faults and others in the Ventura, Santa Barbara and Santa Maria basins.
- A new surface layer allows 3D fault models in CFM that crop out to be registered to the more detailed, mapped fault surface traces from the USGS/CGS Quaternary Fault and Fold database (Qfaults) and other digital fault maps. This registration process for older CFM v.3 fault surfaces is, however, still on-going and not yet complete.
- A new SCEC CFM fault database hierarchical naming and numbering scheme has been implemented that provides unique identifiers for each level of the fault hierarchy (area, system, section, name, model) under which a particular fault segment is classified. These additional fault identifiers allow for more flexible database searches and easier identification of fault components, alternative representations, and possible system-level associations of linked fault sets that comprise CFM. The database was expanded to include authorship of models provided to CFM and each fault model undergoes further community review and evaluation. We received a number of these rankings and reviews of previous CFM faults, and strongly encourage participation by the SCEC community to help us further review and improve these latest 3D fault models for CFM v.4.
- Digital CFM fault representations and other CFM objects are now referenced to the modern WGS84 datum. A preliminary converted version of CFM is now available at the CFM website (http://structure.harvard.edu/cfm/modelaccess.html), although a complete version of CFM v.4 is still under review and further development.







(above) Oblique 3D views looking East of alternative fault representations in CFM v.4 for the active faults in the Ventura-Santa Barbara area relative to relocated seismicity (dots) and the 2013 M4.8 Isla Vista aftershocks (red squares). top (left) Models from Hubbard et al for the Pitas Point, Lion, Ventura, Red Mountain, San Cayetano, South San Cayetano. S-dpping light green fault at left is the Santa Ynez fault. (top right) Models from Kamerling et al for the Pitas Point, North Channel, Red Mountain, Arroya Parida-Mission Ridge, and Santa Ynez faults. (right) Oblique 3D view looking NW of CFM fault models. Based on relocated aftershocks of the 1971 M6.7 San Fernando (blue) and 1994 M6.7 Northridge earthquakes (orange) , new 3D fault models were developed for CFM v.4.

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