A 3d Community Fault Model (CFM Version 3.0) for Southern California and Associated Models

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Abstract

We present a new three-dimensional model of the major fault systems in southern California that describes the San Andreas fault and associated strike-slip fault systems in the Eastern California shear zone and Peninsular ranges, as well as active blind thrust and reverse faults in the Los Angeles basin and Transverse Ranges. The model consists of triangulated surface representations (t-surfs) of more than 140 active faults, which are defined based on surfaces traces, seismicity, seismic reflection profiles, wells, and geologic cross-sections and models. The majority of earthquakes, and more than ninety-five percent of the regional seismic moment release, occur along faults represented in the model, suggesting that it describes a comprehensive set of major earthquake sources in the region. The model serves the Southern California Earthquake Center (SCEC) as a unified resource for physics-based fault systems modeling, strong ground motion prediction, and probabilistic seismic hazards assessment.

The web interface to the CFM database (http://structure.harvard.edu/cfm) was reengineered to provide a unified storage system in the database that holds both geometry and attribute data, and to distribute the CFM and associated models.

Specifications

Dimensions:
- 32.5° to 36°N latitudes, with extension for large faults to 32.25° and 37°N
- 114.5° to 120.5°W longitudes

Components:
- triangulated surface representation of ca. 160 faults
- regional topographic surface
- base of seismicity surface

Inventory:
- CGS unique fault names and numbers
- additions by CFM Working Group

Resolution:
- variable resolution (ca. 0.5 to 5 km) reflecting current state of knowledge

Projection and datum:
- model was contructed in UTM zone 11, datum NAD27
- completed surfaces to be converted to NAD83 programmatically

Technical information

fault statistics:

171 faults (excluding 8 now retired names)

60 faults with more than one alternative representations
- 40 with one additional alternative
- 16 with two additional alternative
- 3 with three additional alternative
- and 1 with four additional alternative

The 171 preferred representation house 438 tsurfs which contain complete or partial extents. The alternative representations of the 60 faults which have them house 229 such tsurfs. This sums to a total of 667 managed tsurfs.

CFM and alternative fault representations

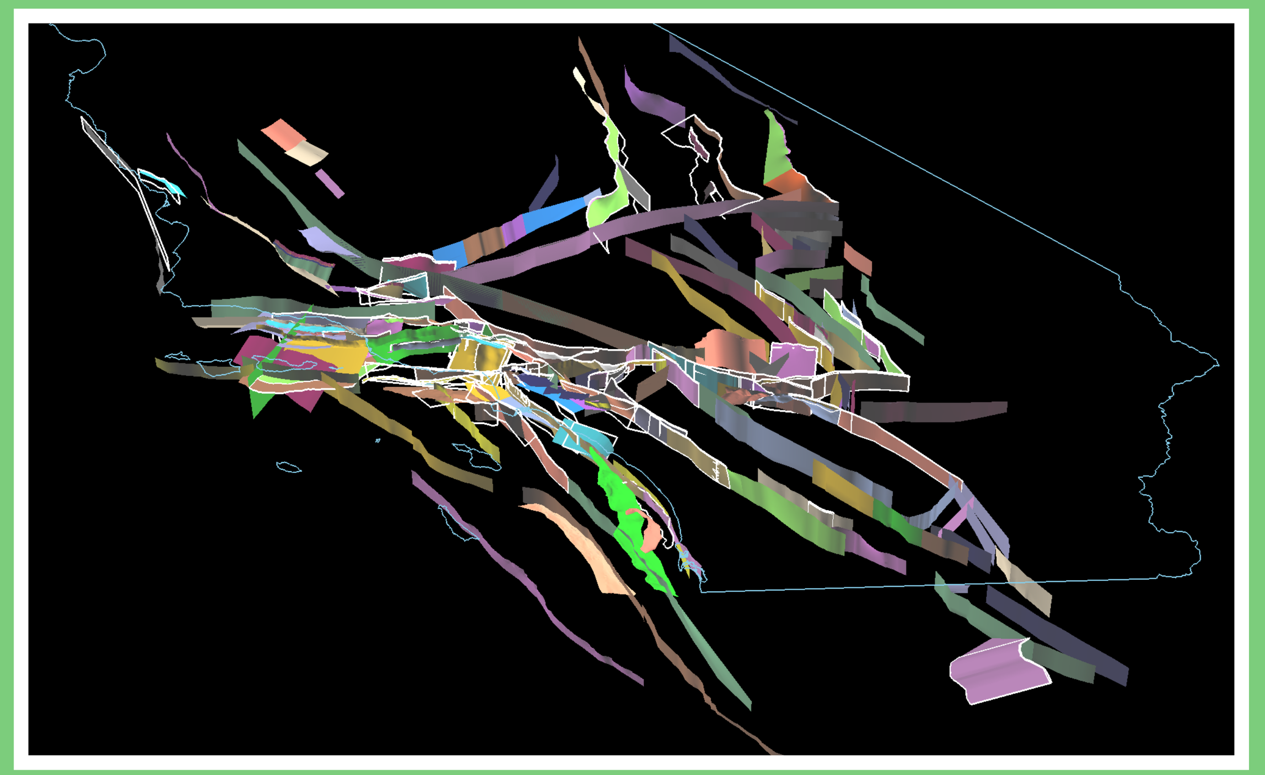

Fig. 1: perspective view of CFM version 3, most highly ranked faults. Colors serve just to distinguish between faults. The white outlines signify faults that have alternative representations.

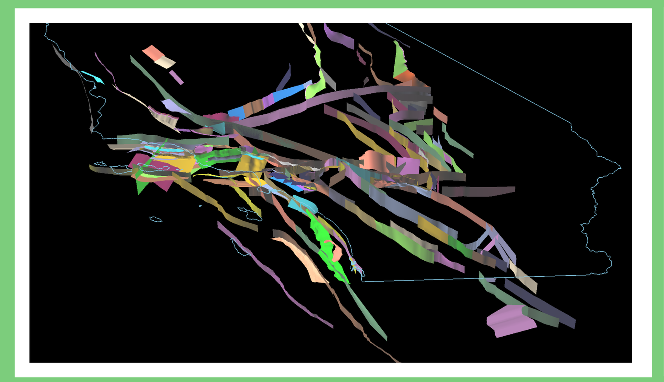

Fig. 2: perspective view of just the most highly ranked alternative representation in CFM version 3.0.

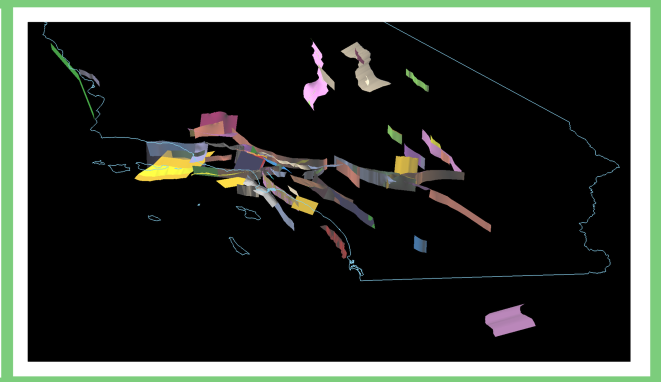

Fig. 3: perspective view of the alternative representation in CFM version 3.0.

Examples of alternative representations

CFM includes multiple representations of faults for which a single representations and its associated spatial uncertainty does not fully describe an existing variety in knowledge. E.g., frequently, intersections of steeply dipping and gently dipping faults give rise to alternative representations.

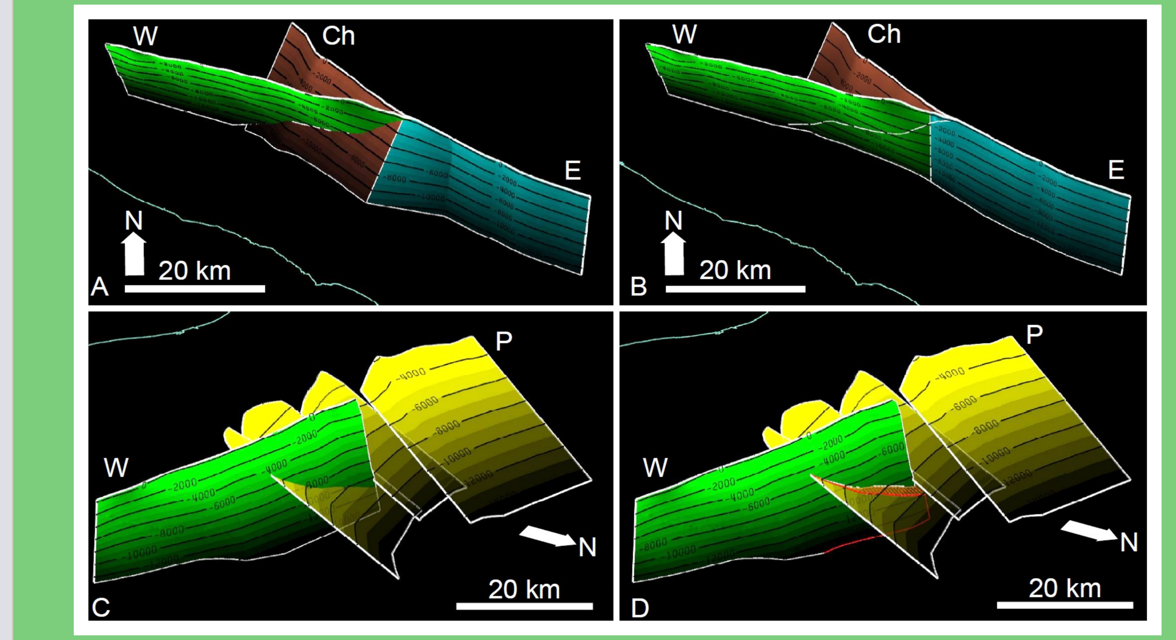

Fig. 4: A is a perspective view of alternative representations of the Whittier (W), Chino (Ch), and Elsinore (E) faults. The depth contour line interval is 2000 m. In A, the Whittier terminates into the Chino at depth; whereas, in B the Chino terminates into the Whittier. Note that the alternative B, deemed the preferred alternative (see text for election procedure) yields a smoother connection between the Whittier and Elsinore faults as well as between the Chino and Elsinore faults which can be clearly seen in the linearity of the contour lines. In C, the Whittier and Puente Hills (P) faults intersect but do not displace each other; whereas in D the Whittier is displaced by increasing slip (red lines connecting fault gap) on the Puente Hills (Shaw et al., 2002). The preferred alternative D respects proposed fault kinematics. The CFM contains these types of alternative representations for many faults, reflecting uncertainties regarding the manner in which dipping faults intersect at depth.

Community Block Model (CBM)

The two layer CBM currently is composed of two sets of 39 blocks. Block boundaries in the upper layer are modified CFM fault representations which were selected based on slip-rate and their role in separating basins and major geologic units. The modifications -included smoothing and planar extrapolation beyond the fault tips. These extensions are necessary to develop a block model, which requires an interconnected set of faults. Precaution was taken to assure that original faults remain as close to their CFM representations as possible and distinguishable from the added extensions. Blocks in the upper and lower layer are separated by a base of seismicity surface and the model has topography and the Moho as upper and lower boundaries, respectively.

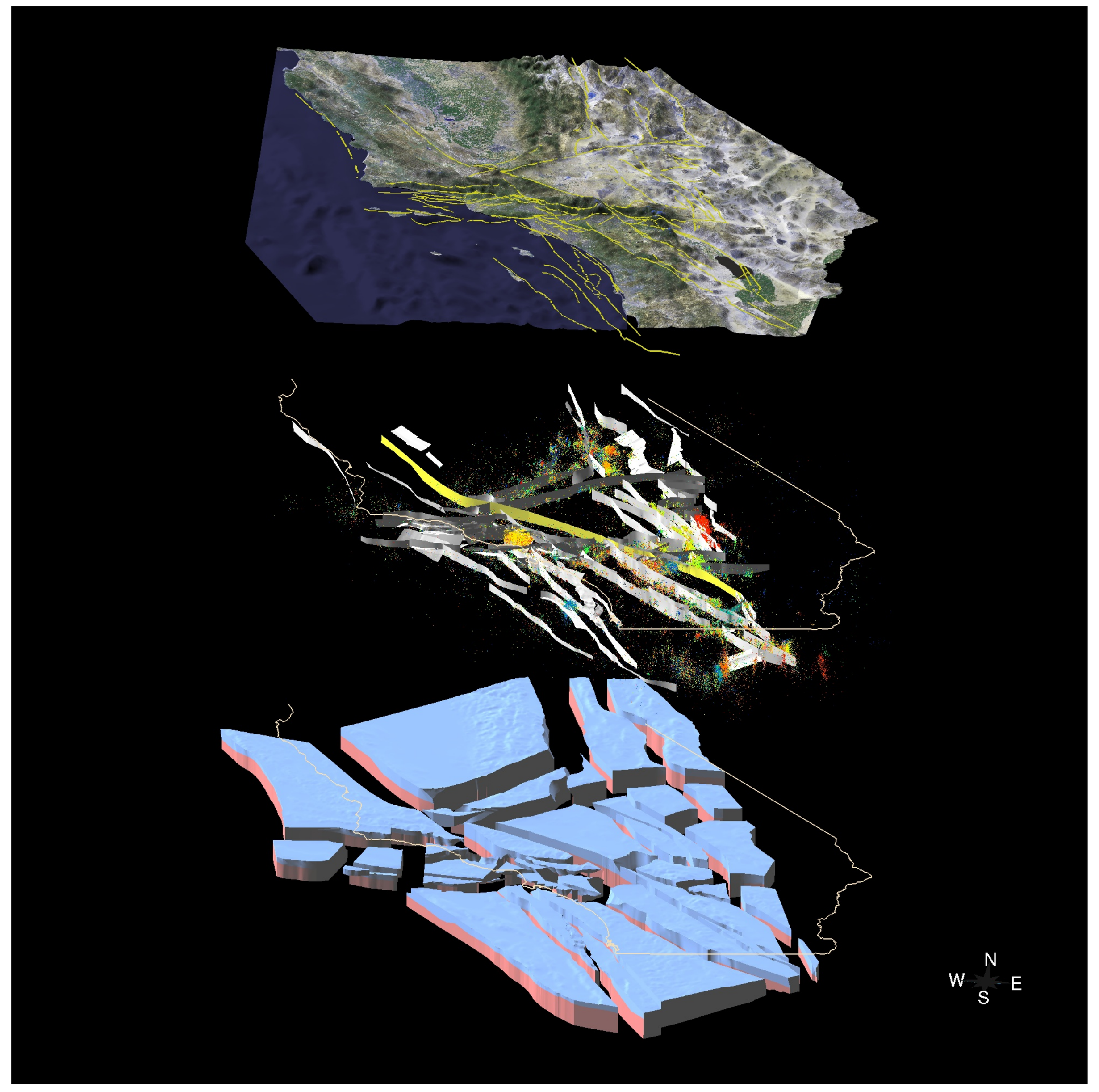

Fig. 5: The top tier displays a Landsat 7 drape over a DEM of southern California with both national database and CGS/CFM fault traces. The second level shows the CFM with seismicity (Hauksson and Shearer, 2005), and the bottom tier presents the CBM in an exploded view. The blue layer of the CBM is above the base of seismicity, and the red is above the Moho.

CFM trace map

We extracted the surface trace or the upper tip line in the case of blind faults from the CFM 2.5 tsurf representations. The resulting trace map is available in DXF and shapefile formats.

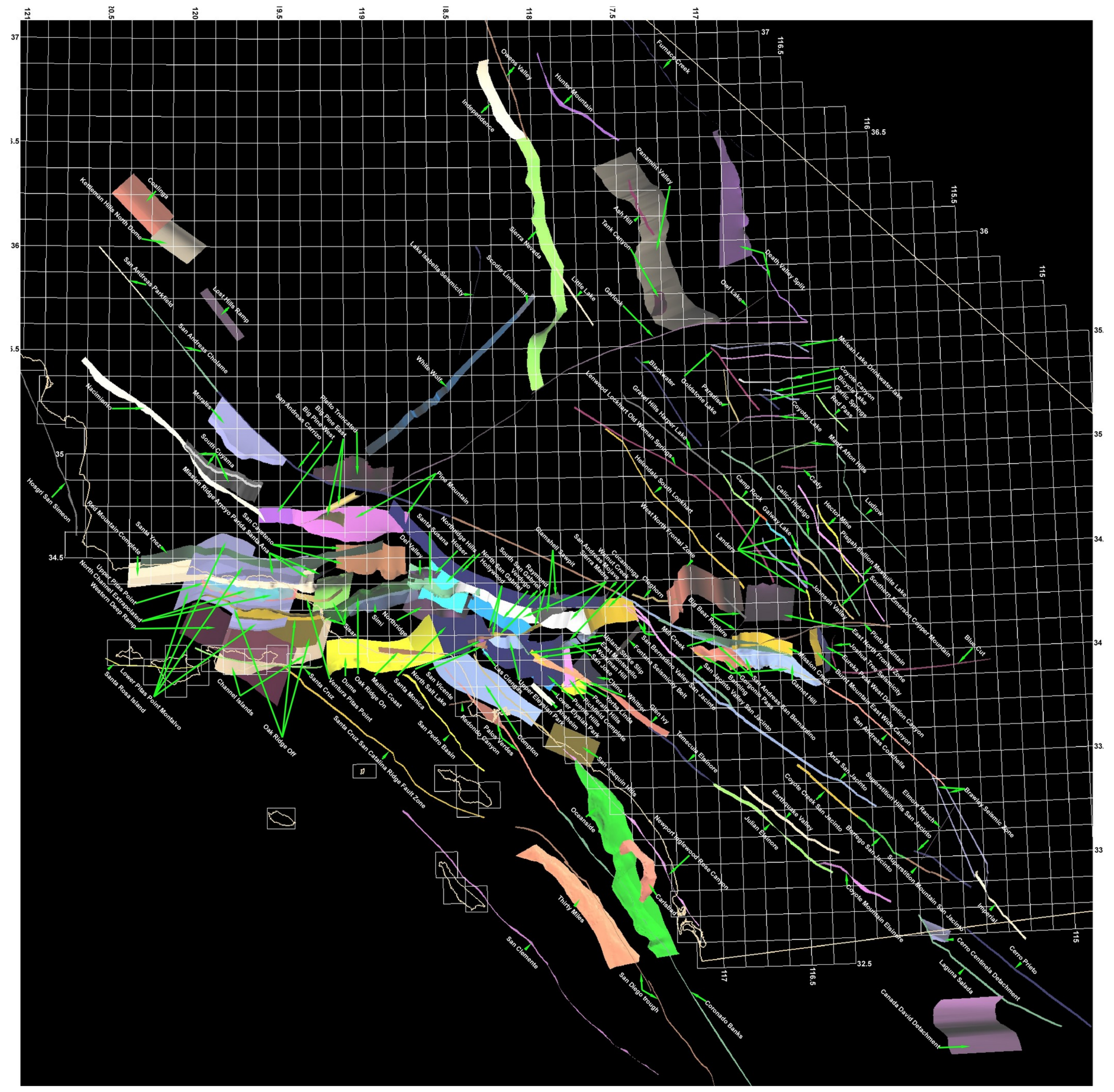

Fig. 6: Map view of labelled CFM (version 2.5) faults. A trace map of this model is available.

Download all models at http://structure.harvard.edu/cfm

CFM-R (rectilinear version)

We generated a rectilinear version of the CFM (version 2.5) for situations where a simplified fault representation is more appropriate. Each fault was subdivided into 5km or longer patches. The downdip sides of each patch are parallel to each other and perpendicular to the strike line (the fault trace in map view). The lower corner points are at the depth of the seismogenic thickness surface used in CFM. Coordinates in all available files are given in the UTM zone 11, NAD 27 projection.

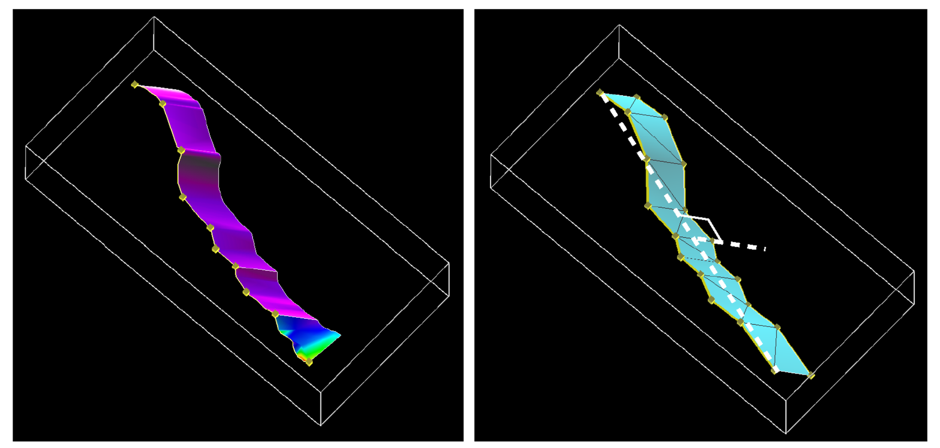

Fig. 7: The basic process of converting the tsurfs of CFM to simplified, rectilinear fault representation is illustrated by the Sierra Madre fault. First, the CFM representation is subdivided along its trace in 5km sections. The color signifies local dip. Then the segmented trace is shifted to depth at an average, constant dip value. Finally the resulting polygons are cut the local seismogenic depth.

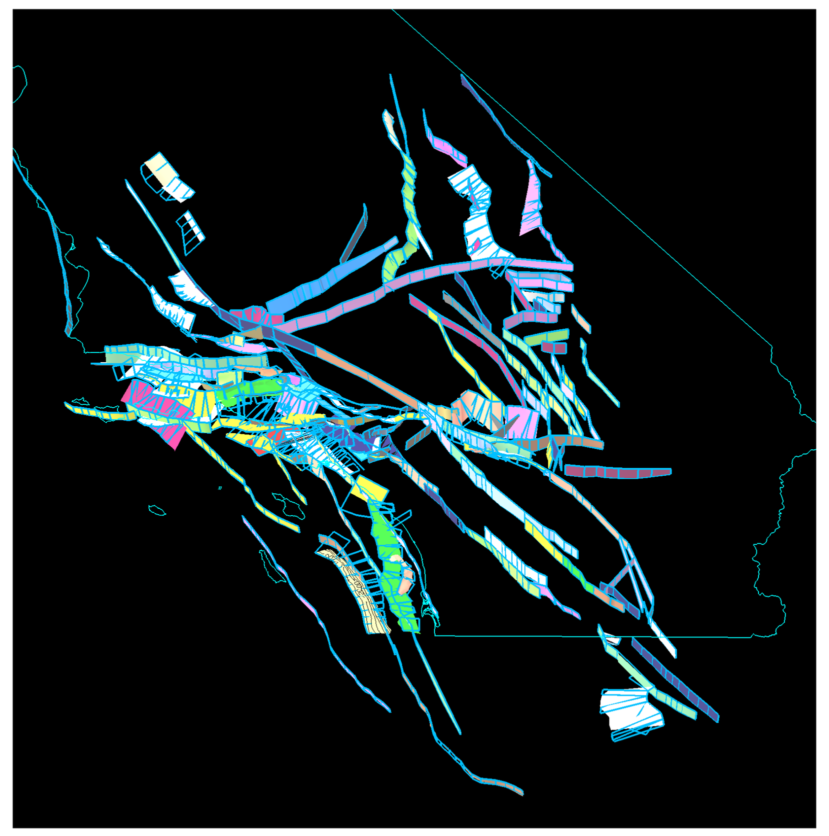

Fig. 8: Comparison of CFM-R with original CFM version used to derive it. Generally the fit is as good as can be expected from the simplification process. For some faults, dip averaging leads to enlarged total surface areas.