The SCEC Community Fault Model: Challenges, Progress, and the Future

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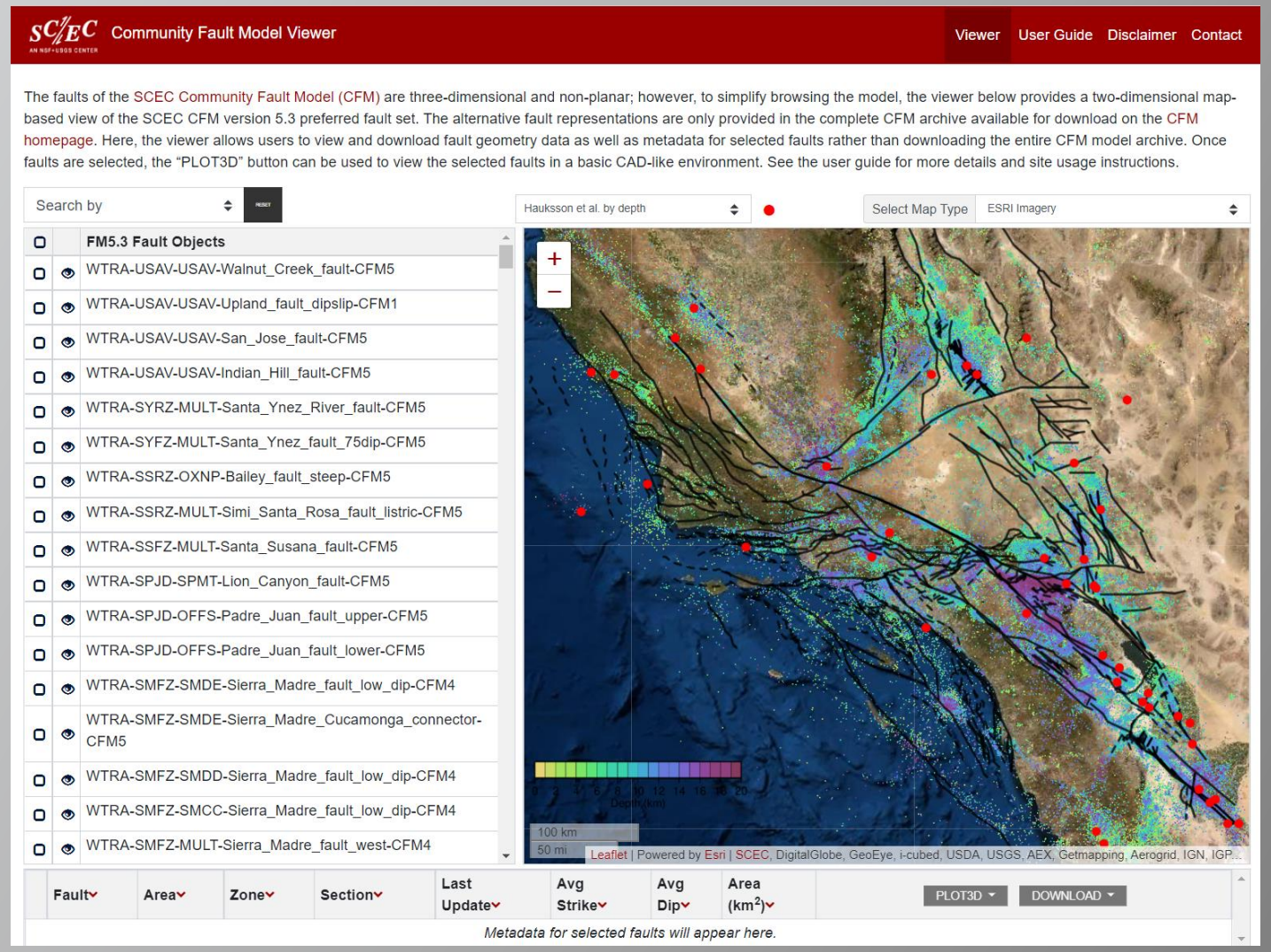
New web-based tools for the CFM!
https://www.scec.org/research/cfm



CFM Association Service

- SCEC collaborators (Harvard & Caltech) developed a statistical method to rapidly identify the most likely CFM fault for earthquakes (Evans et al., 2020)
- Applied to the full SCSN catalog ($M \geq 3.0$) using CFM (5.2),
- Provides probabilities of association between every earthquake and the CFM faults
- Offered as an email service

https://www.scec.org/research/cfm

Caltech/USGS SCSN Event Information

Magnitude: 3.6
Time (PT -||- UTC): 2021/09/13 07:59:35 ---||--- 2021/09/13 14:59:35
Coordinates (lat,lon): 34.229, -118.905
Location: 5.1 km (3.2 mi) NNW from Thousand Oaks, CA
Depth (km/miles): 1.8/1.1
USGS ComCat URL: ci39807135

CFM Fault Association Probability

Most Likely

Simi; Santa Rosa fault segment (70%)

Alternates

Not associated with a CFM modeled fault (24%)
Other CFM faults (6%)

Probability Summary

CFM #	Fault Name	Distance (km)	Probability (%)
319	Simi; Santa Rosa fault segment	2.89	70
329	not in CFM	NA: Not in CFM	24
320	Bailey fault; steep segment	6.65	6
278	Oak Ridge fault; MRSH segment	12.73	0
267	Southern San Cayetano; Ventura segment	17.69	0

Example email from the CFM association service

CFM Acknowledgements

SCEC IT/Software Team

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USC

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CXM Software Engineer
USC

CFM Contributors/Developers

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Christopher C. Sorlien
UC Santa Barbara

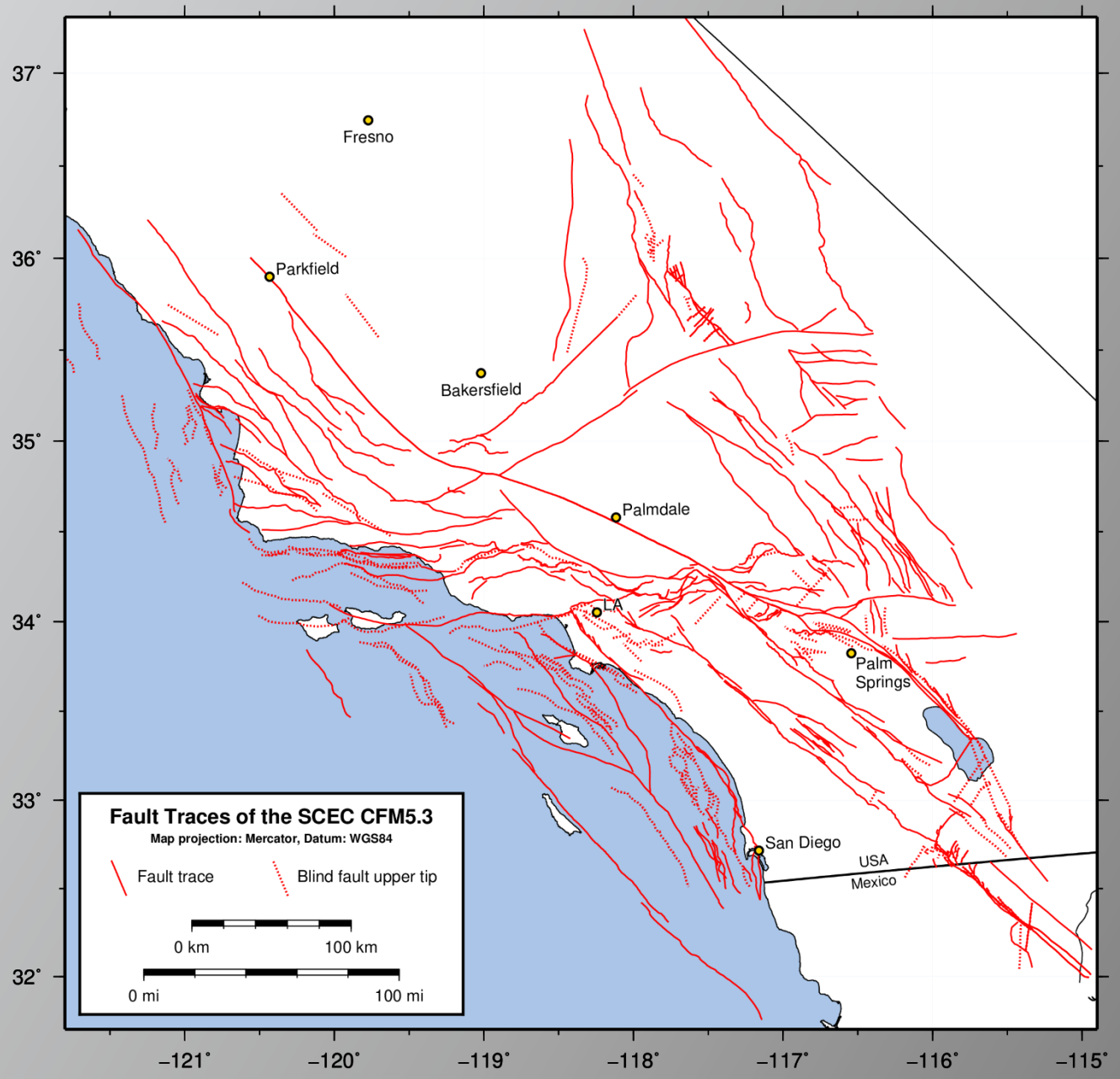
insert your photo here!

…and countless other CFM contributors over the last 25+ years!

What is the CFM?

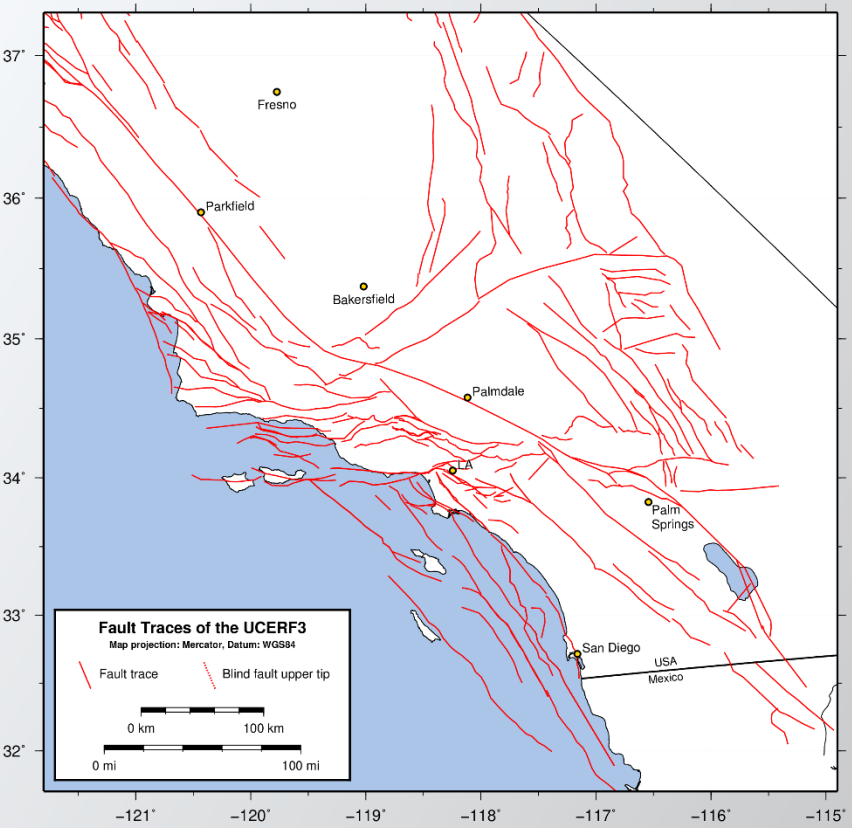
A hierarchically-organized set of 3D fault representations in southern California and adjacent offshore basins.

- Current version: CFM5.3
  - includes 440 individually named fault representations
  - alternative representations are also provided
- Surfaces are based on any/all available data
  - Seismicity
  - Geologic mapping
  - Geophysical and borehole data
  - etc…



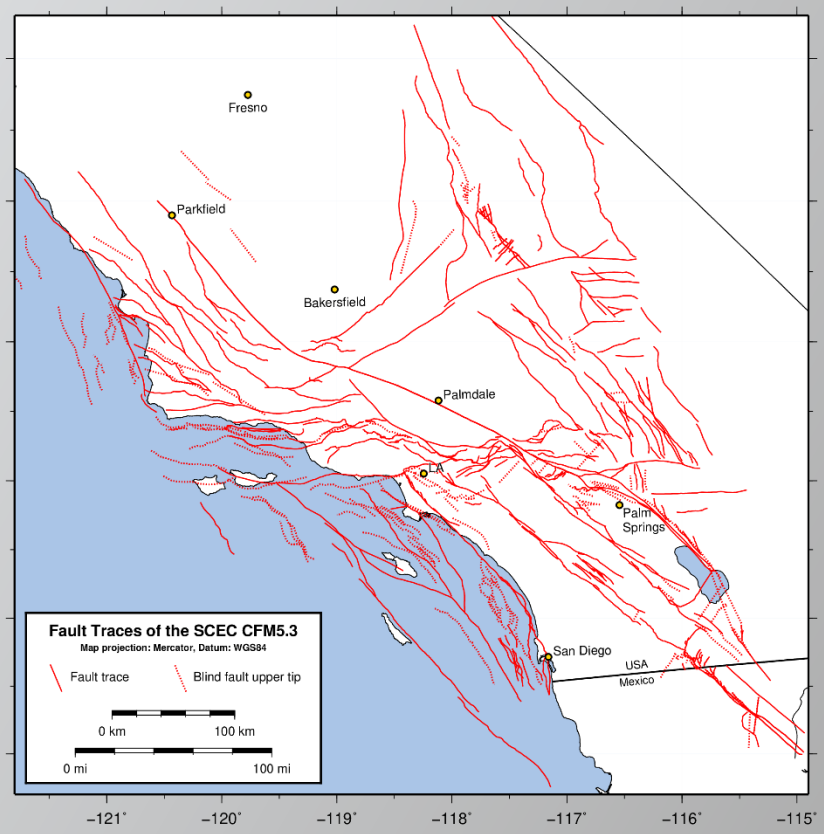
Fault trace maps of CFM5.3 available at the CFM homepage: https://www.scec.org/research/cfm

UCERF3



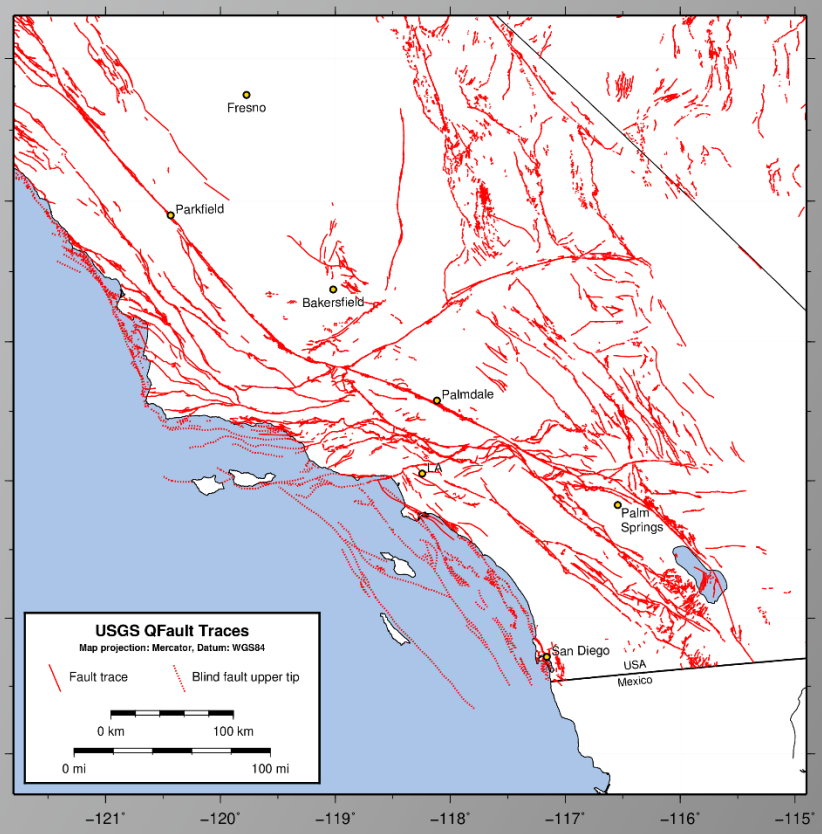
- 3D Model
- Geometrically smooth compared to CFM
- Developed for seismic hazard analyses

CFM5.3



- 3D Model
- Geometrically complex
  - Defined by source data
- Developed for use in a variety of SCEC initiatives

USGS QFaults



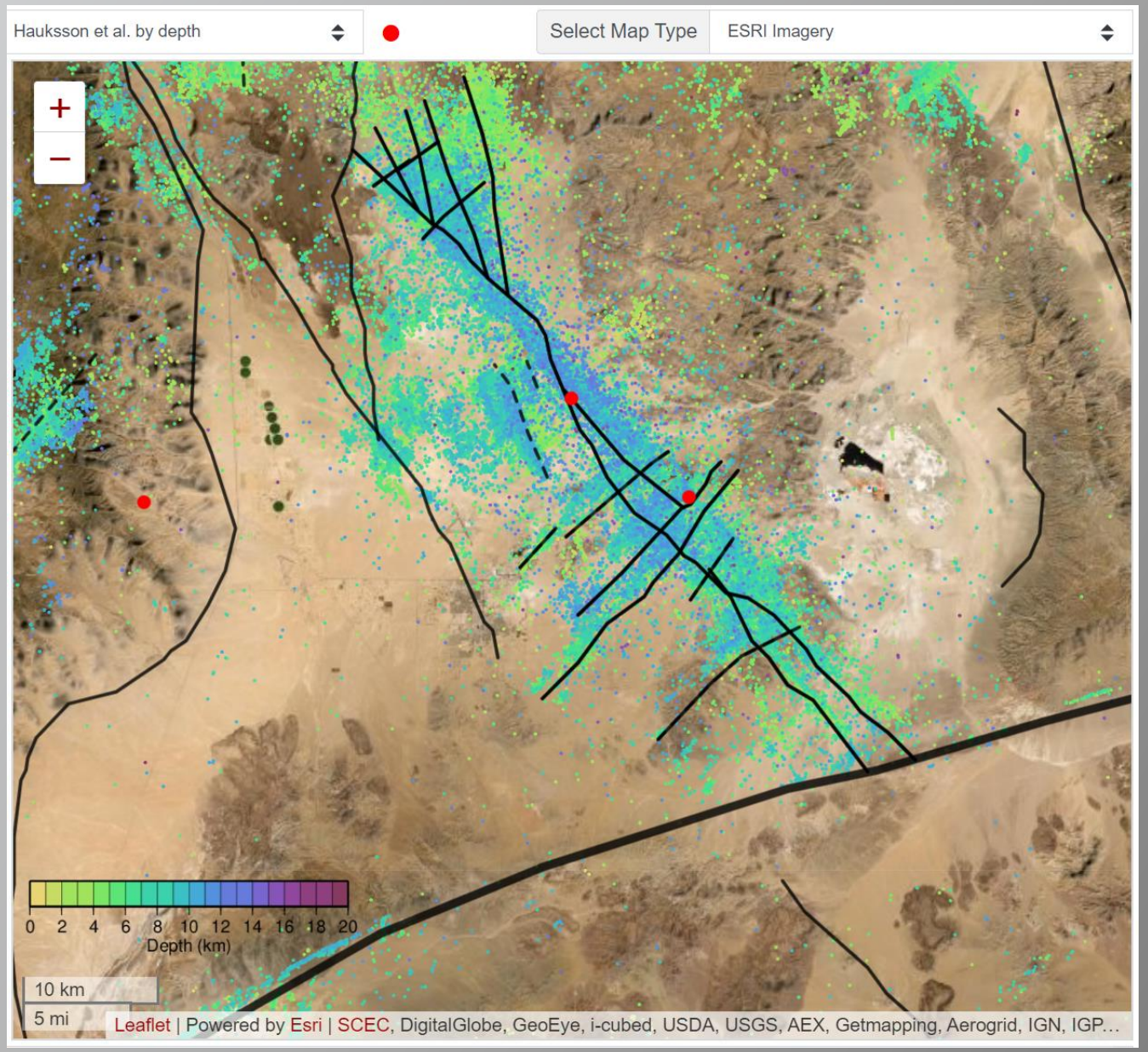
- 2D Model (traces)
- Geometrically complex
  - Defined by mapping
- Identifies activity of faulting

CFM Challenges

Building and maintaining a model like the CFM provides many challenges

Challenges ----> Progress

1. Fault source data is diverse
2. Metadata and file management
3. 3D file format(s)
4. Availability of 3D CAD software
5. What does “Community” mean?

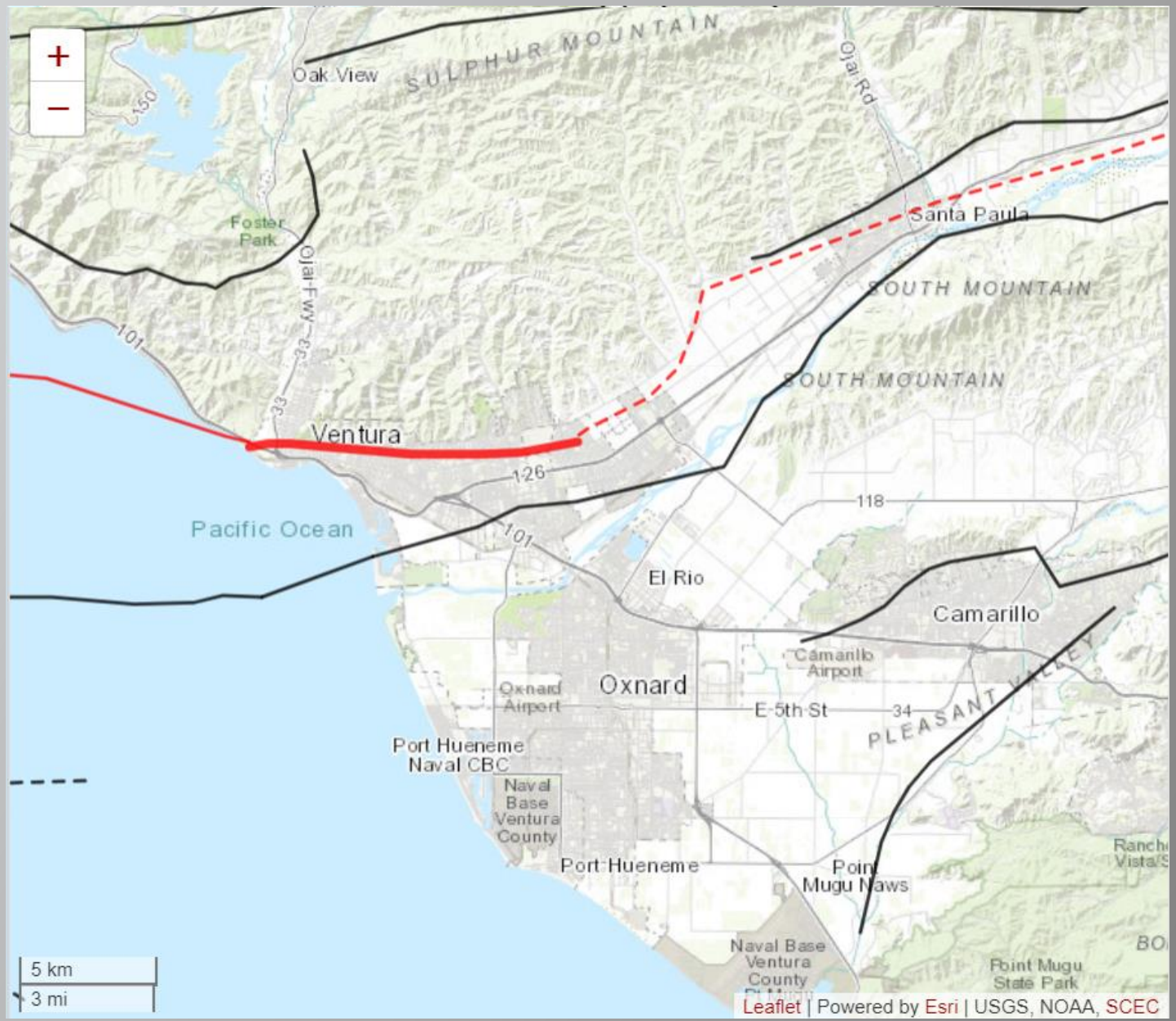


Challenge: Fault Source Data is Diverse

Example: Ventura fault

(Hubbard et al. 2014, BSSA)

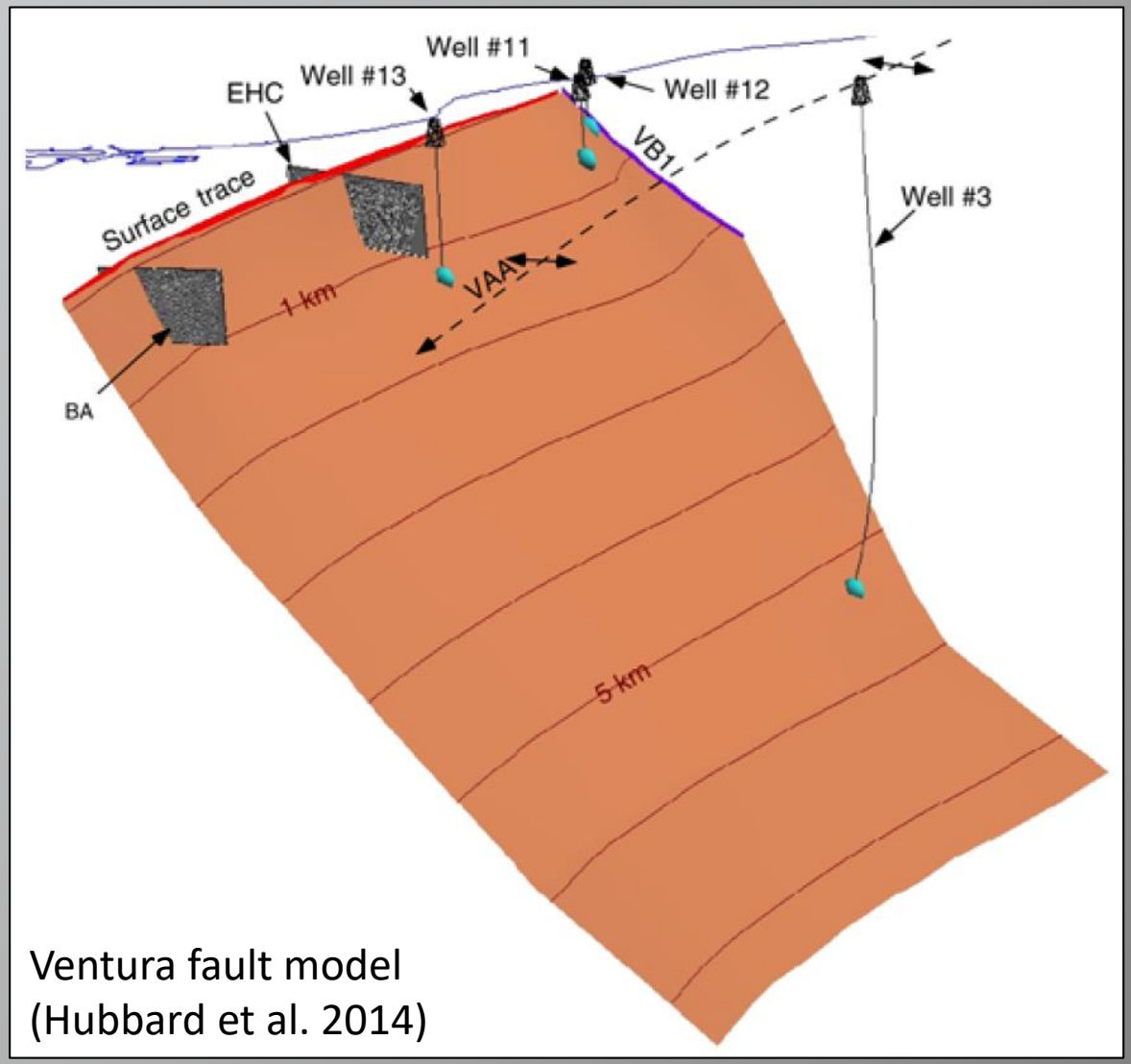
- Reverse fault in Western Transverse Ranges



Challenge: Fault Source Data is Diverse

Implications for Constructing Fault Models

- Most faults are built by hand
  - Time-intensive
  - Not possible to automate (for most faults)
  - Error estimates are not practical

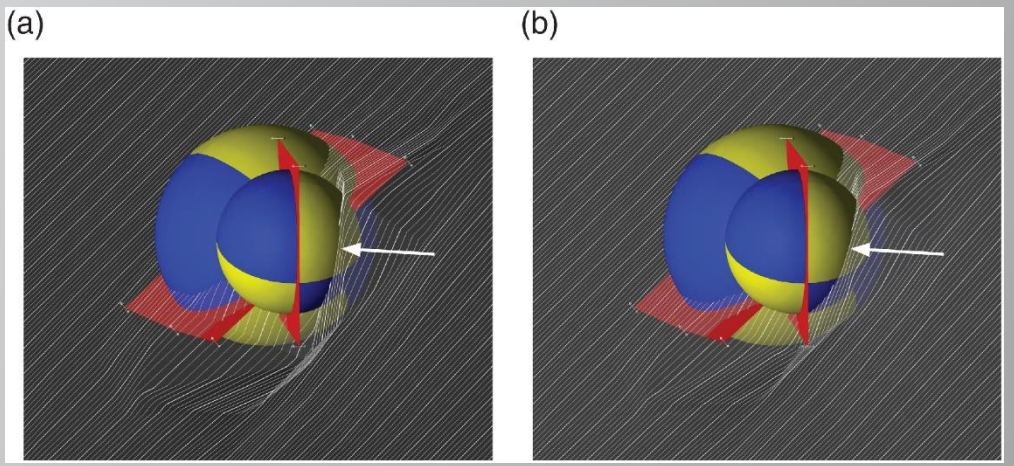


Ventura fault model
(Hubbard et al. 2014)

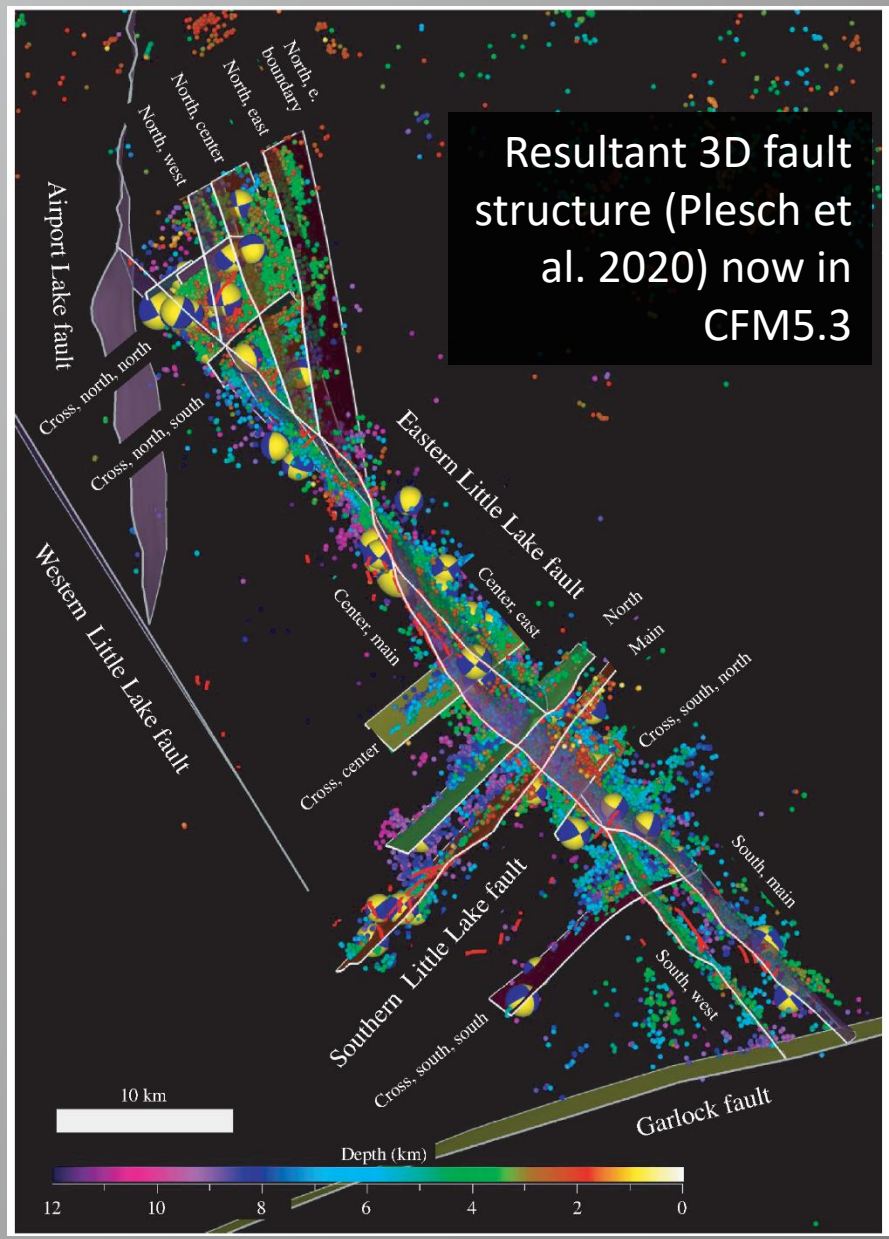
Progress: Semi-Automated Methods

Where sufficient seismicity exists, semi-automated methods have been developed (Reisner et al. 2017, SRL)

- Example: 2019 Ridgecrest faults (Plesch et al. (2020, BSSA)
- This will be used for several other CFM fault systems



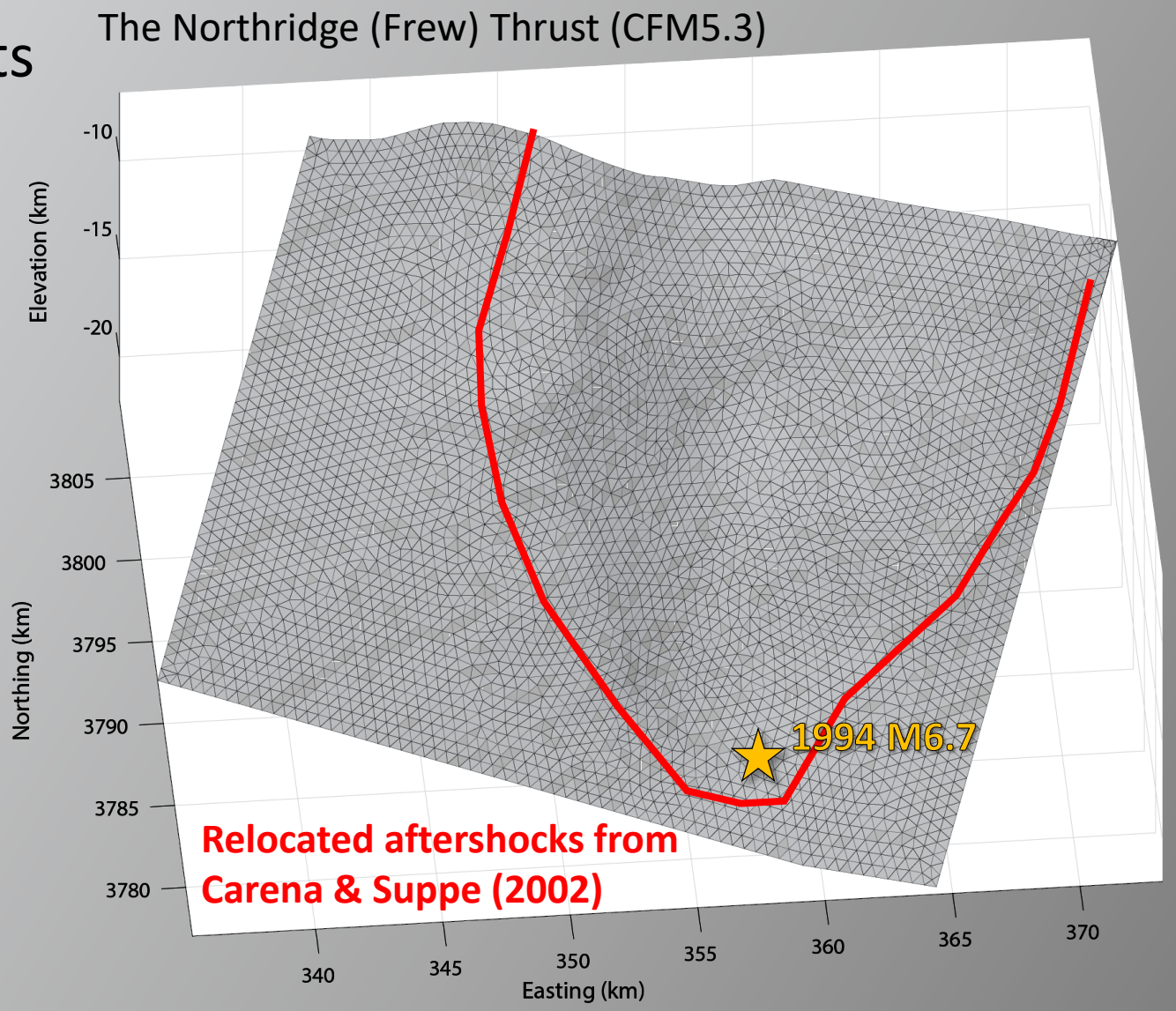
Weighting of focal mechanisms (Plesch et al. 2020)



Challenge: Metadata and File Management

The CFM contains a variety of data in different formats for all 440 fault objects

- Metadata spreadsheet – 26 columns
  - Name
  - Avg Strike/Dip
  - Surf Area
  - References, etc…
- Gocad t-surfs in three resolutions
  - Native, 500m, 1000m, 2000m
- Fault traces (utm and lon/lat)
  - GMT (plain text), and GIS shapefiles, GoogleEarth kml
- Complete references document

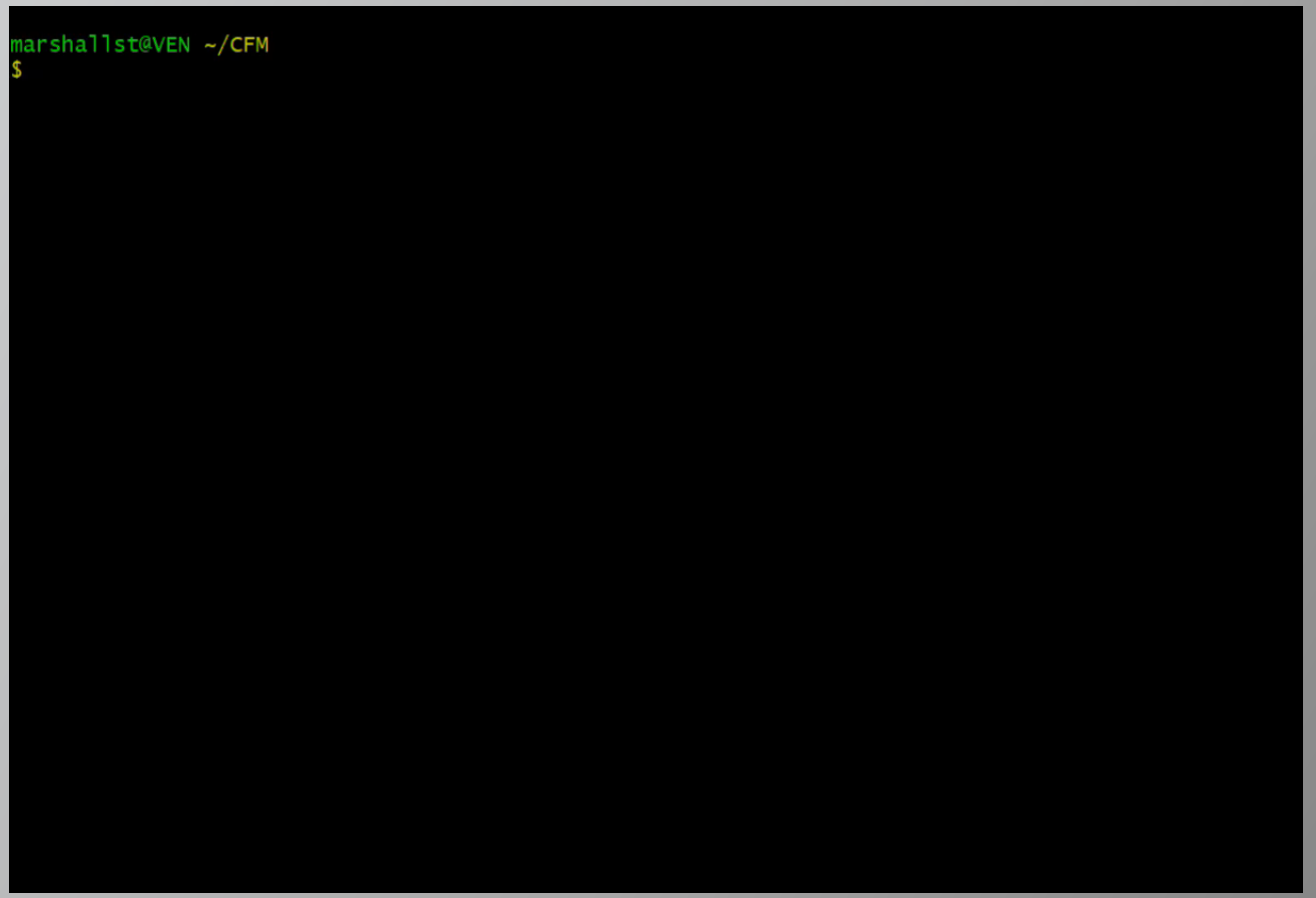


Progress: Semi-Automated Consistency Checks

A series of semi-automated scripts check for consistency

- Metadata
- Fault Object Names
- Filenames
- Fault Trace Names
- Etc…
- Script also calculates avg strike/dip, surface area

First run resulted numerous minor inconsistencies (now fixed)



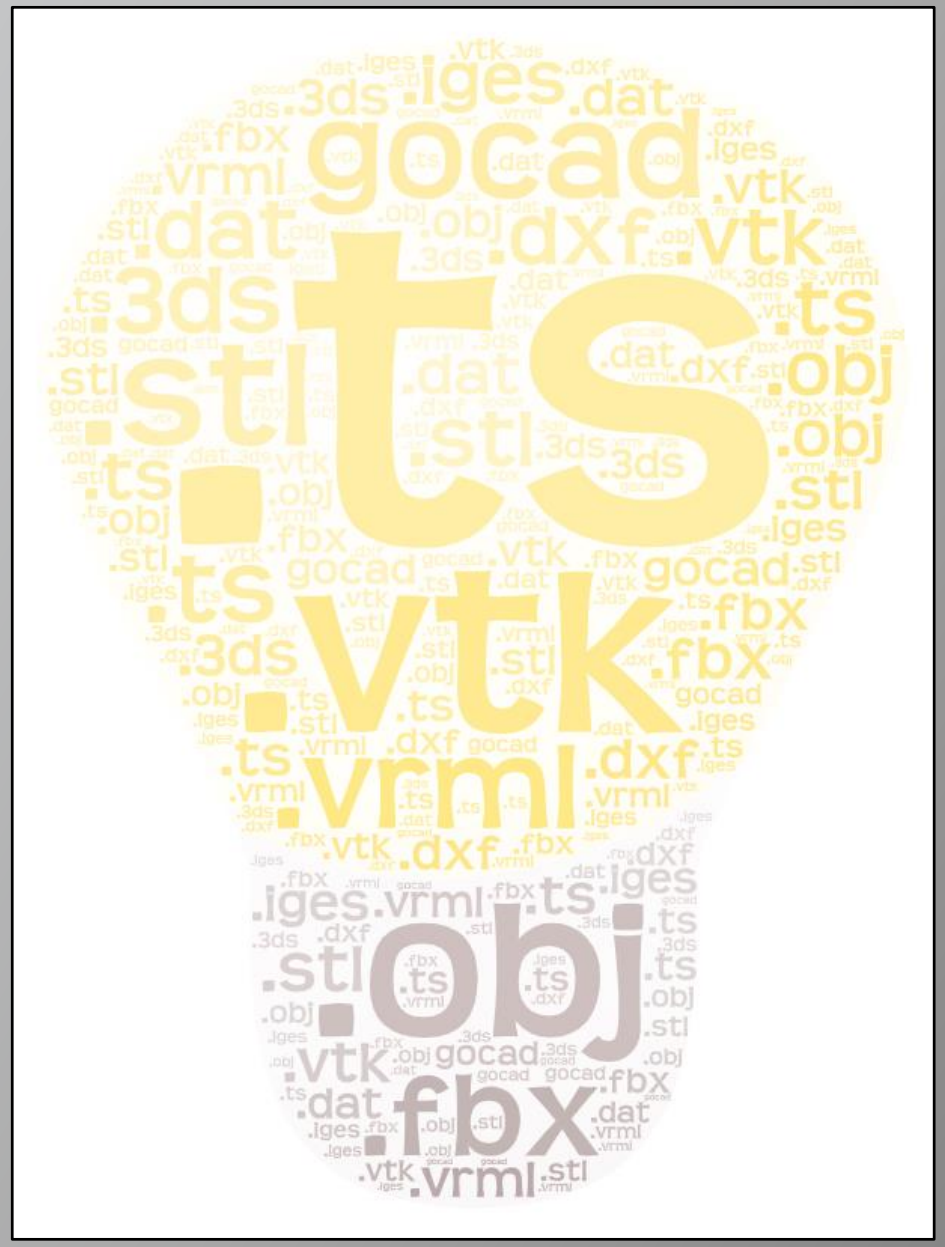
Yes, this is the best visualization I could think of…

Challenge: No Standard 3D File Format

There are numerous 3D object formats

- Some are proprietary / binary
  - We don’t want to limit software choice
  - We want to make scripting easy (ASCII)

- Gocad t-surf files were chosen long ago
  - Why?

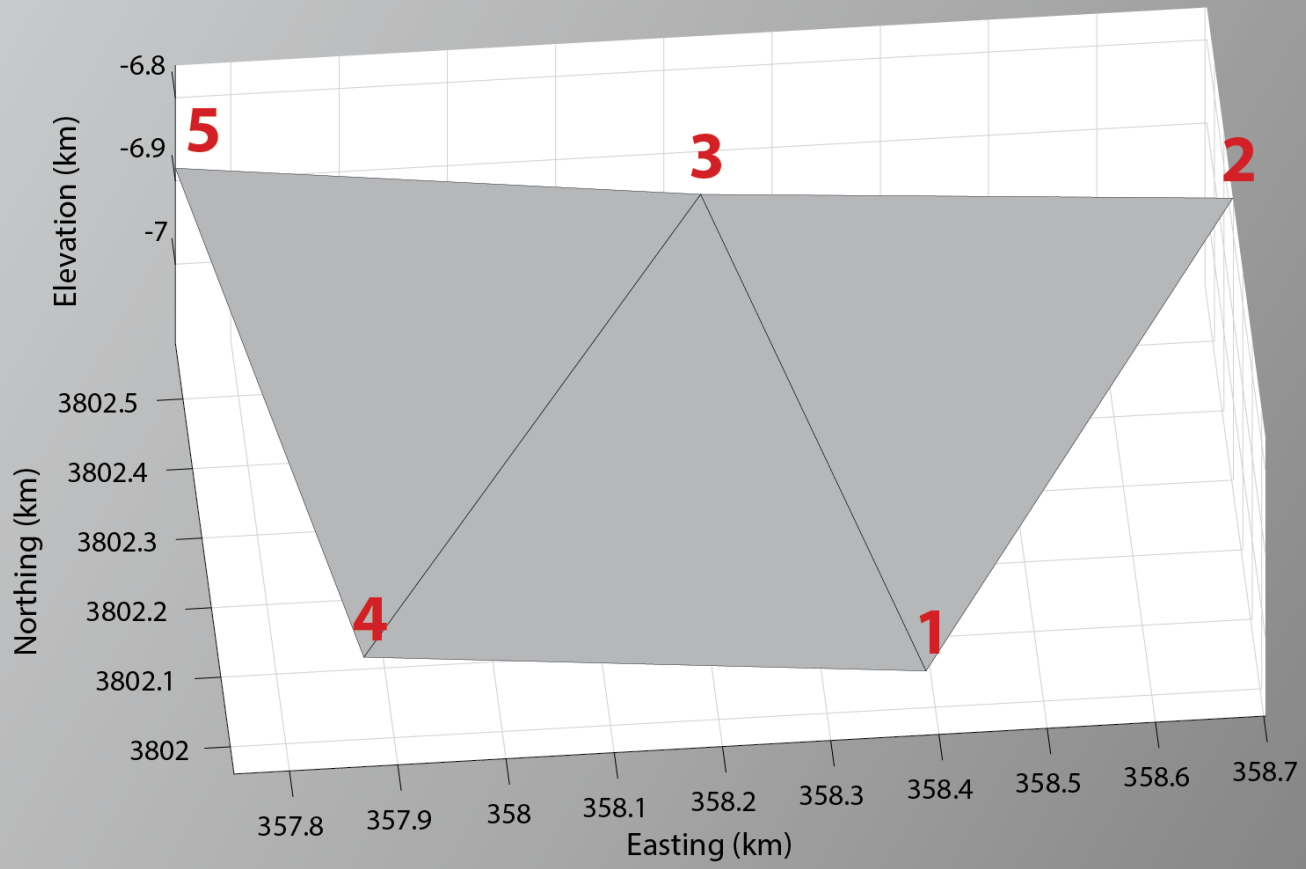


Progress: Gocad T-Surf File Documentation

```
GOCAD TSurf 1
HEADER {
name:WTRA-ORFZ-SFNV-Northridge_Frew_fault-CFM2_500m
*visible:true
*solid*color:0.082353 0.121569 0.858824 1
}
GOCAD_ORIGINAL_COORDINATE_SYSTEM
NAME Default
AXIS_NAME "X" "Y" "Z"
AXIS_UNIT "m" "m" "m"
ZPOSITIVE Elevation
END_ORIGINAL_COORDINATE_SYSTEM
TFACE
VRTX 1  358388.04688000 3801961.01562000 -7017.96484000
VRTX 2  358701.60938000 3802306.12500000 -6761.31885000
VRTX 3  358220.79688000 3802429.00000000 -6824.27686000
VRTX 4  357882.39062000 3802117.23438000 -7095.05664000
VRTX 5  357748.76562000 3802580.10938000 -6884.66162000
TRGL 1 2 3
TRGL 4 1 3
TRGL 4 3 5
END
```

Corresponding Gocad file contents.

More t-surf info on CFM homepage.



3 Randomly-selected elements from the Northridge (Frew) Thrust. Vertices in red.

Challenge: 3D CAD Software is Expensive

Gocad

- Not free
- Reads t-surf files

Petex Move

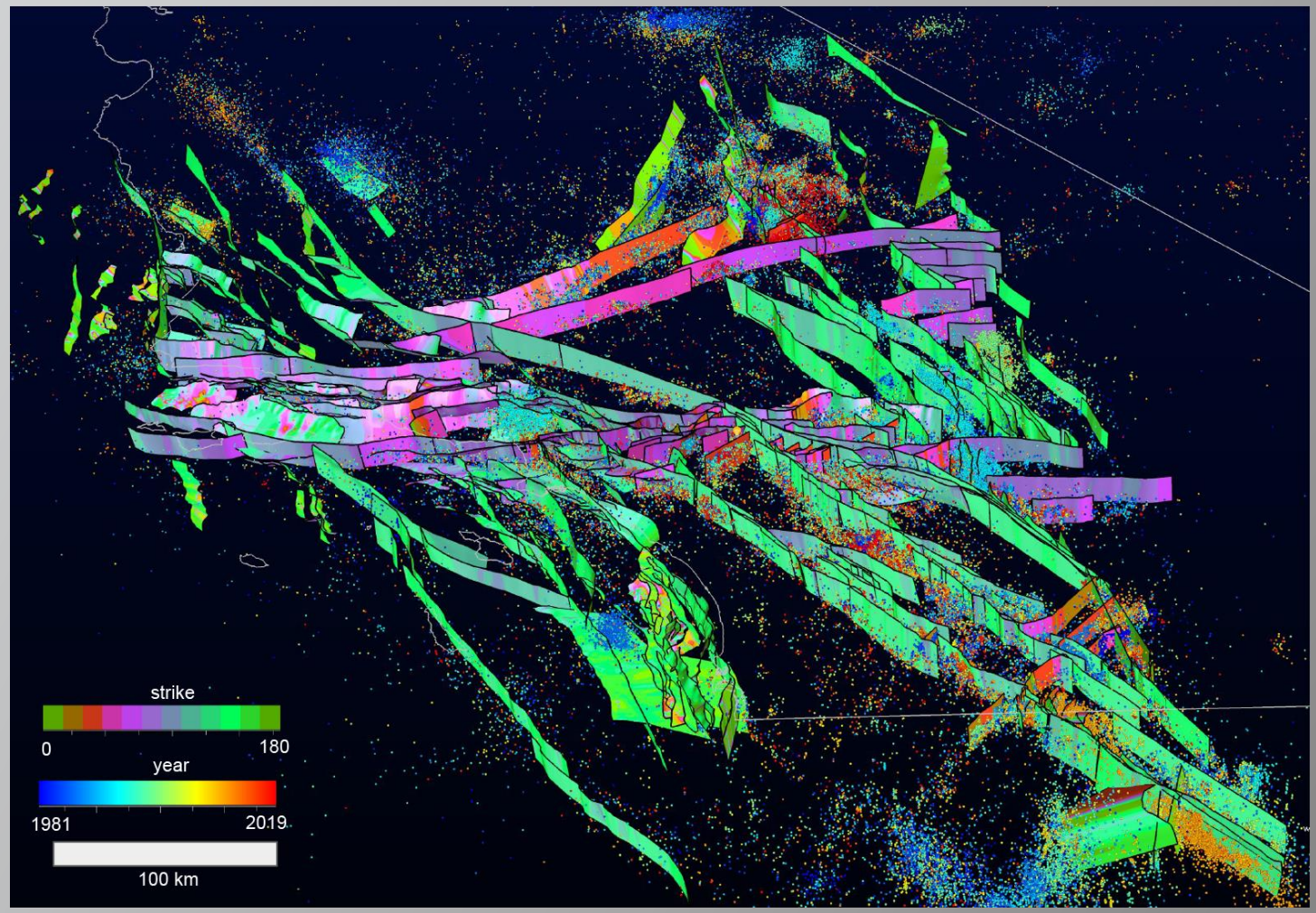
- Free for academic institutes
- Can import t-surf files

Cubit / Coreform Cubit

- Free for government agencies
- Free 1yr trial for others
- We provide conversion scripts to facet format on CFM homepage

MATLAB

- Not free (also, not really CAD)
- We provide conversion scripts on CFM homepage



Oblique 3D view of CFM5.3 visualized with Gocad. Faults are colored by strike and relocated seismicity from Hauksson et al. (2012) colored by time

Progress: New Web-Based Tools

CFM Homepage

- https://www.scec.org/research/cfm

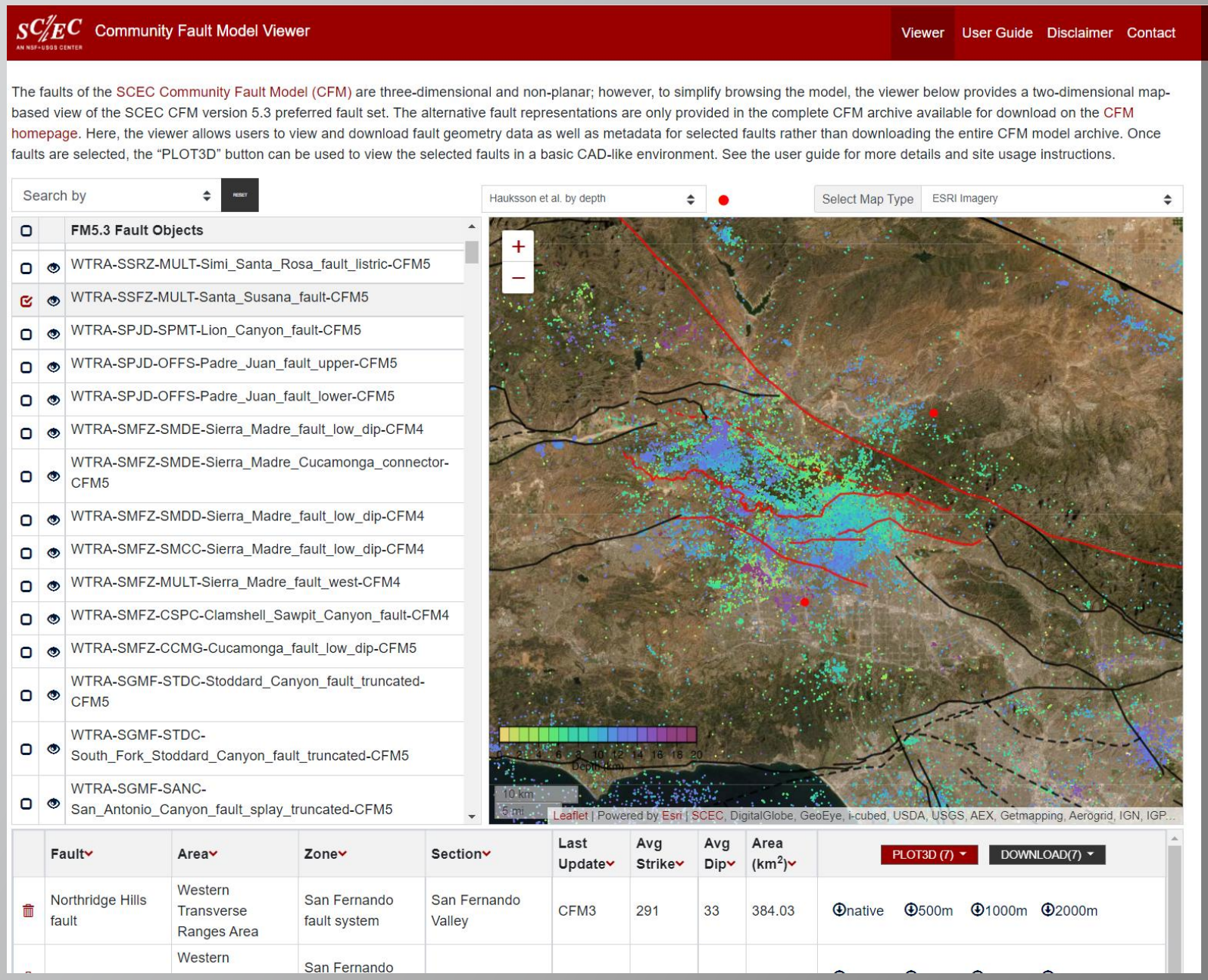
We have a updated CFM web interface

- https://www.scec.org/research/cfm-viewer/

For more information, see posters #005, #020

https://www.scec.org/meetings/2021/am/poster/005

https://www.scec.org/meetings/2021/am/poster/020



Community Fault Model Viewer

scec.org/research/cfm-viewer/

SCEC Community Fault Model Viewer

Viewer | User Guide | Disclaimer | Contact

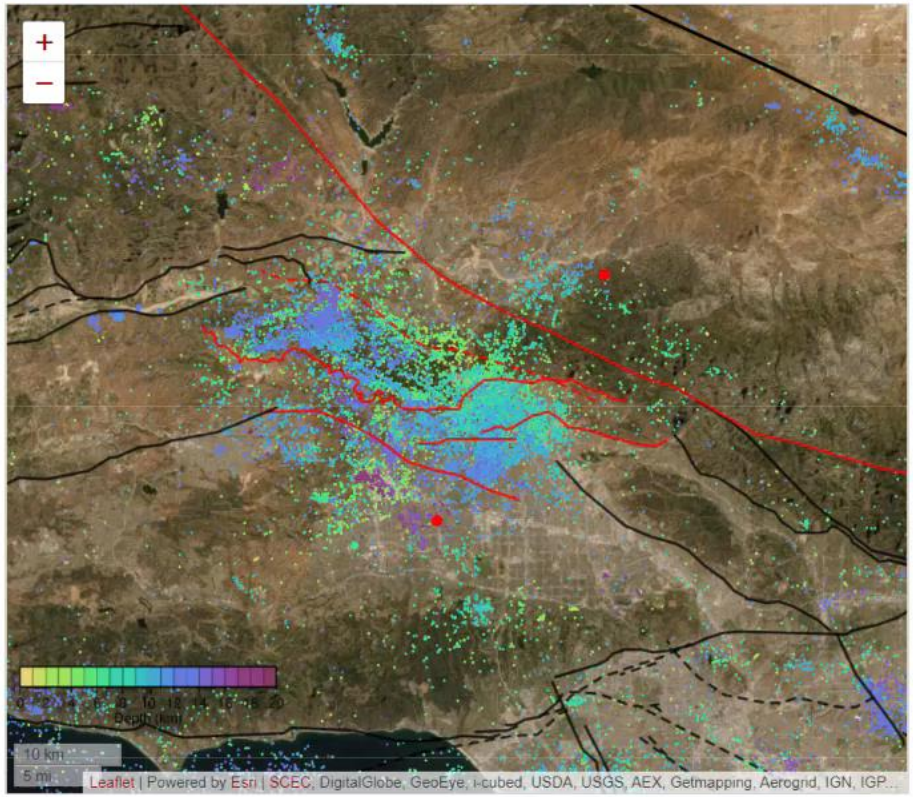
The faults of the SCEC Community Fault Model (CFM) are three-dimensional and non-planar; however, to simplify browsing the model, the viewer below provides a two-dimensional map-based view of the SCEC CFM version 5.3 preferred fault set. The alternative fault representations are only provided in the complete CFM archive available for download on the CFM homepage. Here, the viewer allows users to view and download fault geometry data as well as metadata for selected faults rather than downloading the entire CFM model archive. Once faults are selected, the "PLOT3D" button can be used to view the selected faults in a basic CAD-like environment. See the user guide for more details and site usage instructions.

Search by | RESET

Hauksson et al. by depth

Select Map Type: ESRI Imagery

	FM5.3 Fault Objects
☑	WTRA-SFNS-SFNV-Northridge_Hills_fault_truncated-CFM3
☐	WTRA-SFFS-SRSM-Western_Santa_Cruz_Island_fault_trim-CFM5
☐	WTRA-SFFS-SRSM-Santa_Rosa_Island_fault-CFM5
☐	WTRA-SFFS-SNCZ-Santa_Cruz_Island_fault-CFM5
☐	WTRA-SFFS-SMMT-Santa_Monica_fault_steep-CFM5
☐	WTRA-SFFS-SMMT-Malibu_Coast_fault_east_steep_alt2-CFM5
☐	WTRA-SFFS-SGVS-Raymond_fault_extended-CFM5
☐	WTRA-SFFS-LABS-North_Salt_Lake_blind_fault-CFM3
☐	WTRA-SFFS-LABS-Hollywood_fault-CFM5
☐	WTRA-SFFS-ANCP-Malibu_Coast_fault_west_steep_alt2-CFM5
☐	WTRA-SCFZ-TOPA-San_Cayetano_fault-CFM5
☐	WTRA-SCFZ-SCLV-Holser_fault-CFM2
☐	WTRA-SBTS-SMNB-Santa_Monica_thrust_fault-CFM1
☐	WTRA-SBTS-MULT-Channel_Islands_Thrust_fault-CFM1
☐	WTRA-SBCF-WEST-Hondo_detachment_S_dip-CFM5
☐	WTRA-SBCF-MULT-Western_Deep_fault-CFM5

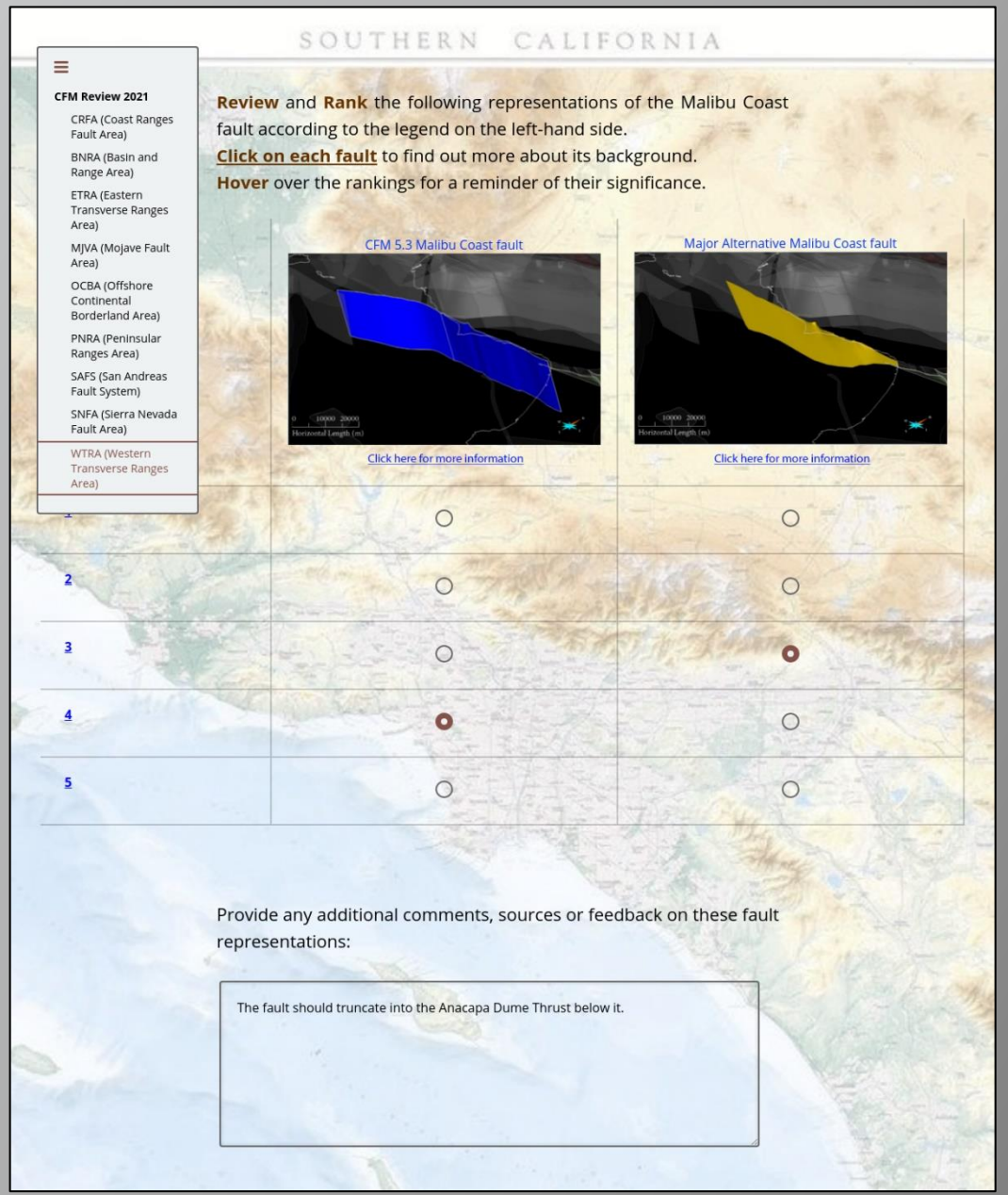


	Fault	Area	Zone	Section	Last Update	Avg Strike	Avg Dip	Area (km^2)	PLOT3D (7) / DOWNLOAD(7)
🗑	Northridge Hills fault	Western Transverse Ranges Area	San Fernando fault system	San Fernando Valley	CFM3	291	33	384.03	native 500m 1000m 2000m
🗑	Mission Hills fault	Western Transverse Ranges Area	San Fernando fault system	Mission Hills	CFM4	268	55	46.87	native 500m 1000m 2000m
🗑	San Fernando	Western	San Fernando	San Fernando					

Challenge: What Does “Community” Mean?

For CFM, the model is periodically evaluated by the SCEC community

- CFM5.3 evaluation planned for late fall early winter
- We developed a web interface that shows alternatives
  - Provides references and a description of the differences



Evaluation Web interface by Ana Luiza Nicolae (Harvard)

For more about the upcoming CFM5.3 evaluation visit poster #005

https://www.scec.org/meetings/2021/am/poster/005

The Future of the CFM…

- CFM5.3 evaluation
  - Will provide data for CFM6.0
  - Alternatives will be reduced to only faults with significant differences
- Scope should increase plate boundary scale
  - A preliminary version of statewide model exists
  - This will require a large effort and resources, but is possible
- Working on a web-based CFM fault submission form