CFM and updates to the CBM

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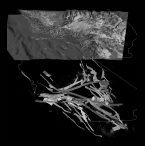
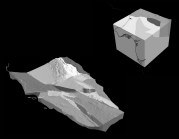
June, 2006

SCEC Community Fault Model CFM



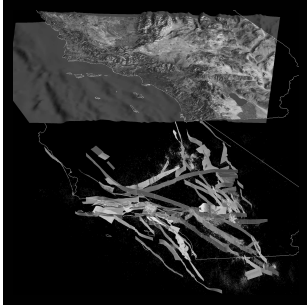
- **Version 2.5** is now available
- website: http://structure.harvard.edu/cfm/

SCEC Community Block Model CBM



- **derived from CFM**
- two layers: seismogenic depth, Moho
- uCBM: 6 blocks in LA
- Mojave: better meshing available
- **Landers update: more detail, additional block**

A 3d Community Fault Model for Southern California



CFM Working Group
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Marc Kamerling
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Scott Lindvall
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Craig Nicholson
Nathan Niemi
Michael Oskin
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Robert Yeats

Harvard Group
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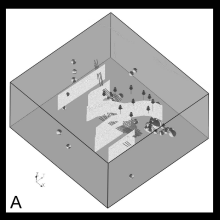
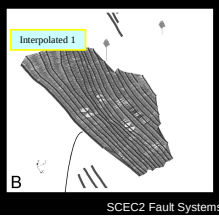
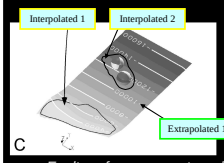
Generating fault surfaces

Data and information are assembled



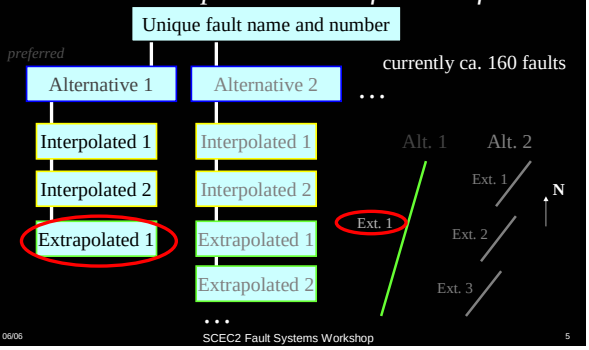
Fault surfaces are interpolated



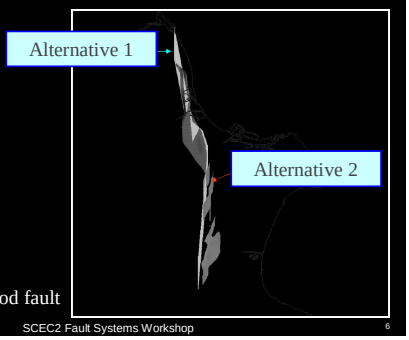


Fault surfaces are extrapolated

Each version of CFM represents a set of specific alternative representations for each fault

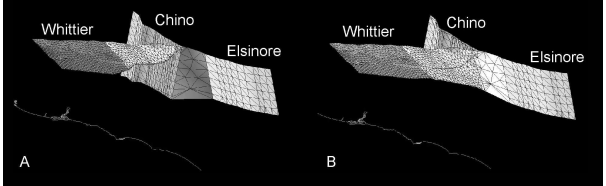


Alternatives represent substantially different geometric definitions of a fault surface



Newport-Inglewood fault

Alternative CFM models …
Sources of alternative fault representations
- simple vs. complex
- interpretation style
- fault linkages



Alternative CFM models …
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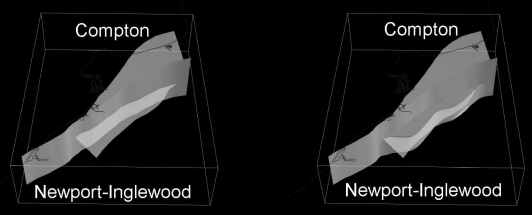
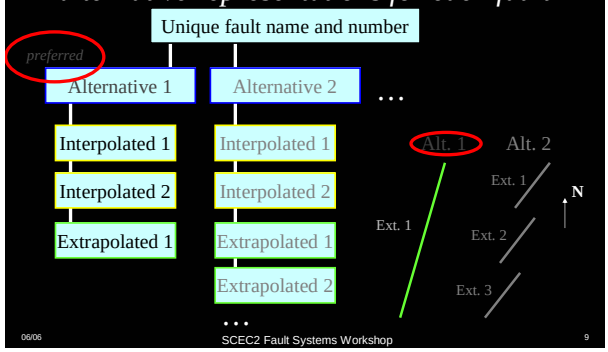


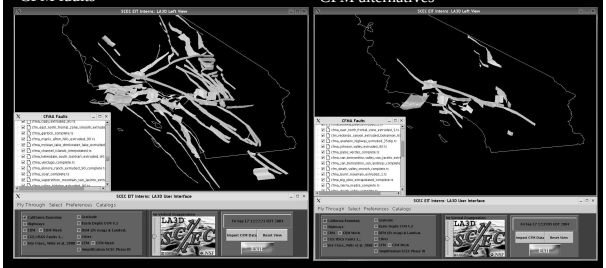
Each version of CFM represents a set of specific alternative representations for each fault



CFM Ranking

CFM faults

CFM alternatives



20+ member CFM Working Group is using LA3D viewer, developed by the SCEC Interns program, to evaluate CFM including the alternative fault representations. Their input is used to rank the alternative fault representations.

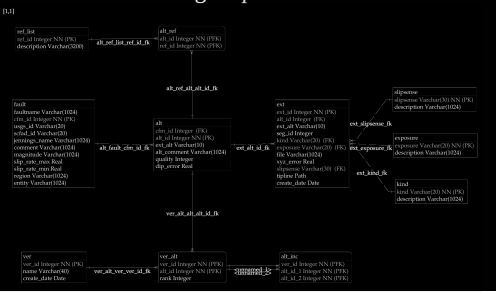
CFM Fault Attributes

In the database, each *alternative representation* will have a unique set of attributes assigned to it, including:
- fault type (rl or ll strike-slip, thrust, normal, oblique …)
- surface or blind designation
- x,y,z average uncertainty
- average dip uncertainty
- qualitative assessment of representation (1-5)
- slip rate range (CGS/SCFAD)
- primary reference list
- date generated

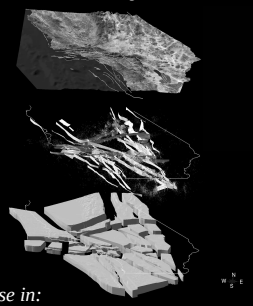
CFM inventory, alternative fault representations, and fault attributes are designated by an SCEC Working Group.

CFM Database

CFM components are stored in a relational database constructed using *Postgresql*, which will be accessed by users via a WWW interface using *MapServer*.



SCEC Community Block Model - 2006



Set of interconnected, closed volumes that are bounded by major faults, as well as topography, base-of-seismicity, and Moho surfaces.

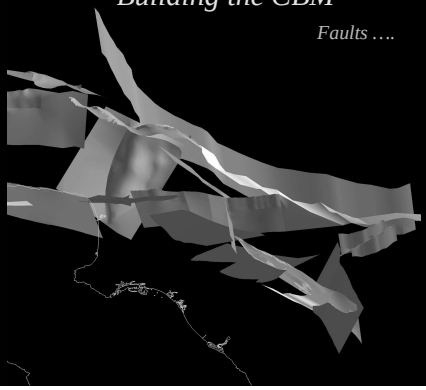
Intended for use in:
- *fault systems analysis (FEM)*
- *property modeling*

Building the CBM

Blocks are defined by a subset of 53 faults from the CFM.

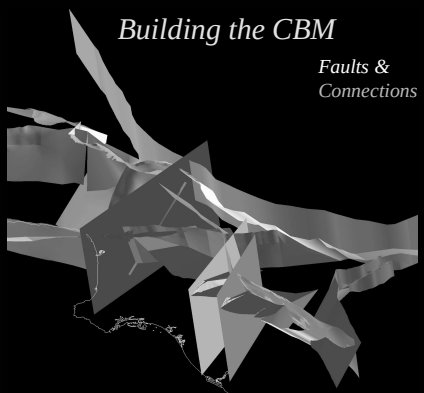
Building the CBM

Faults ….



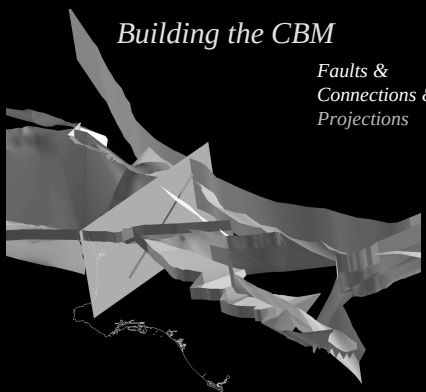
Building the CBM

Faults & Connections



Building the CBM

Faults & Connections & Projections



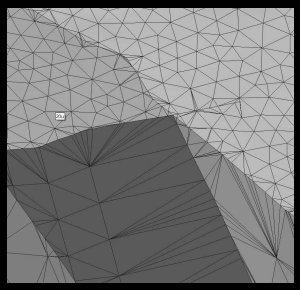
Building the CBM

Trimming at intersections with surfaces

CBM Meshes

Properties

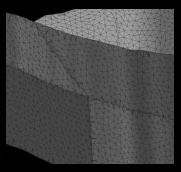
- *one file per block*
- *raw meshes from intersecting tsurfs with widely varying triangle sizes and shapes*
- *each side of a block is identified in file*
- *all faces connect to be watertight*



CBM Meshes

improved meshing on Mojave blocks

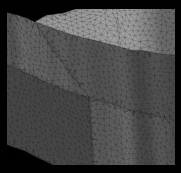
- *all faults and interfaces regridded*
- *intersected regridded tsurfs*
- *uniform triangle sizes*
- *high aspect ratio triangles at edges from intersections*



CBM Meshes

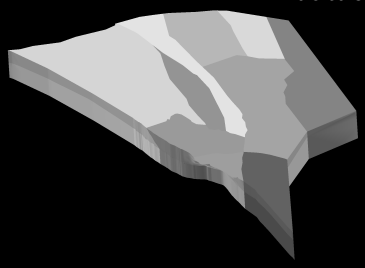
improve meshing on all CBM blocks ?

- *"FrameModel" plugin (F. Lepage, 2003)*
- *meshes lines, surfaces and volumes*
- *expects t-surfs as input*
- *corner-edge, edge-edge, edge-surface relations (macro-topology) need to be explicitly defined*
- *output is self-consistent triangulated and tetrahedralized meshes*

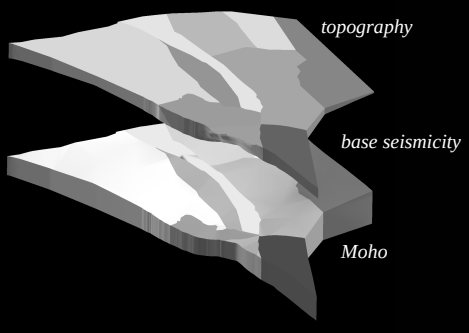


CBM - Mohave region

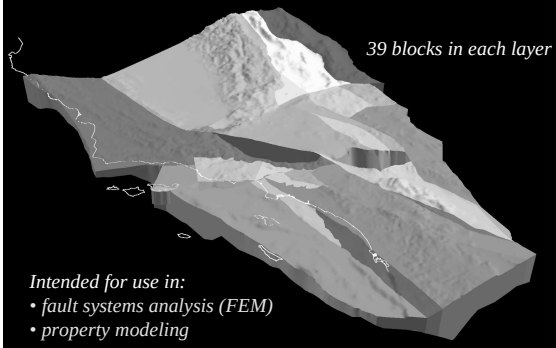
20 blocks



CBM - Mohave region



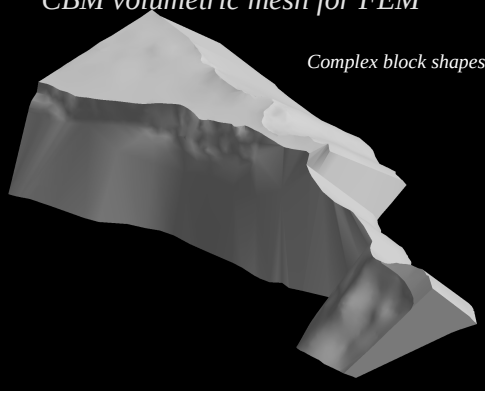
SCEC Community Block Model - 2006



Intended for use in:
- *fault systems analysis (FEM)*
- *property modeling*

CBM volumetric mesh for FEM

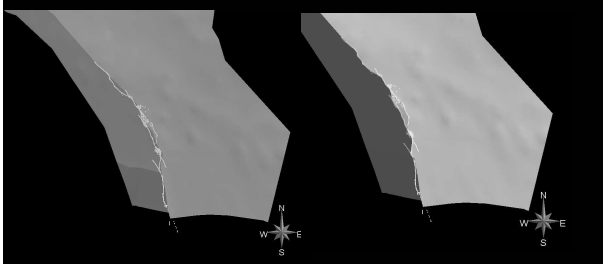
Complex block shapes



CBM Landers update

original

update

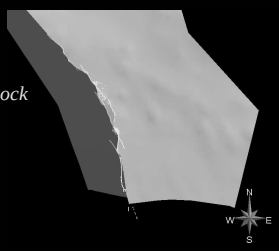


available from: http://structure.harvard.edu/cfm/additionalproducts.html

CBM Landers update

update

updated block 20 and 24:
- *better fit to rupture trace*
- *more detail along rupture*
- *optional small block at central rupture branch separated from block 24*



CBM Landers update

update

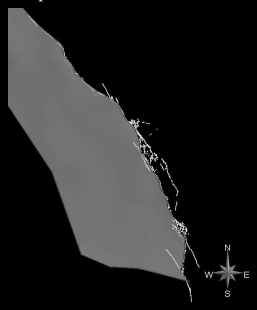
better fit to rupture trace
- *based on detailed CFM alternative from manually registered data*
- *translated to match digital rupture data*

original

CBM Landers update

update

more detail along rupture
- *increased linear sections from 7 to 27*
- *southernmost section (Southern Johnson Valley F.) remains at original representation*



CBM Landers update

update

optional small central block (38)
- *defines area between northern termination of Homestead Valley F. and southern Emerson F.*
- *an optional representation of the block to the east (24) exists which incorporates this small block*

CBM availability

- **available from http://structure.harvard.edu/cfm/addtionalproducts.html**
- **paraview (.vtk) files available as well**
- **short ts to vtk awk conversion script**

```
BEGIN{
print "# vtk DataFile Version 3.0"
print "vtk output"
print "ASCII"
print "DATASET POLYDATA"
nv =0; nt = 0;}
$1 ~ "VRTX" {vr[nv] = $3" "$4" "$5; nvv[$2]=nv; nv++}
$1 ~ "TRGL" {tr1[nt] = $2; tr2[nt]=$3; tr3[nt]=$4; nt++}
END{
print "POINTS", nv,"float"
for (n=0;n<nv;n++) {
 print vr[n] }
print "POLYGONS", nt, nt*4
for (n=0;n<nt;n++) {
 print 3,nvv[tr1[n]],nvv[tr2[n]],nvv[tr3[n]] }
}
```


CBM summary

- **derived from 56 CFM faults**
- **two layers with 37 blocks each: seismogenic thickness, Moho**
- **Landers update: more detail, additional block**
- **available from http://structure.harvard.edu/cfm/addtionalproducts.html**

gocad

- used widely in academia and industry
- visualisation, construction and evaluation
- uses DSI which allows for weighted or fuzzy constraints on interpolation
- native ascii format
- imports shapefile, dxf, xyz, images, others

gocad (it)

- multi-platform: xp, linux, irix, solaris, no macs
- likes lots of RAM
- object-oriented
- c++ with qt
- open api for developers
- scriptable: command scripts, visual wizards
- supports plugins

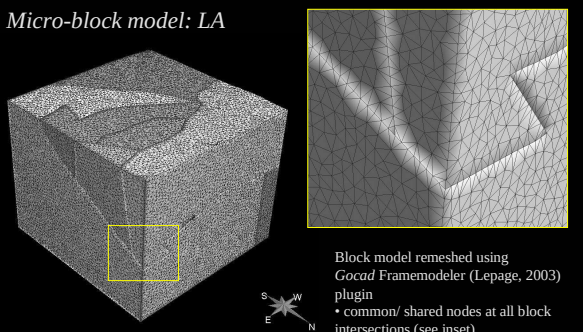
gocad (org)

- academic research branch: www.gocad.org
- gocad consortium: ca 90 universities, 20 companies
- members have access to research plugins
- commercial branch: www.earthdecision.com
- maintains, polishes
- fees/year: now EUR4.2k for 4 licenses

gocad (?)

- minus
  - expensive, commercial
  - no GIS functionality
- plus
  - flexible - structured, unstructured grids
  - works well
  - fairly open

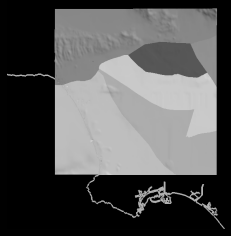
Micro-block model: LA



Block model remeshed using *Gocad* Framemodeler (Lepage, 2003) plugin
- common/ shared nodes at all block intersections (see inset)
- variable mesh density (here 500 m)

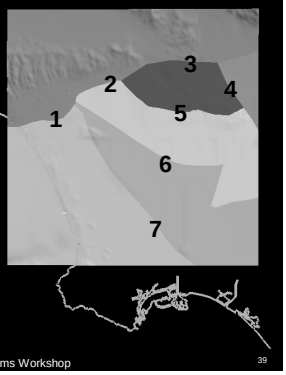
Area of Interest

- north-western boundary of LA basin
- several faults meet to define small blocks
- Santa Monica fault, Hollywood fault, Raymond fault
- Alhambra Wash fault
- Upper Elysian Park thrust
- Puente Hills thrust
- Newport-Inglewood fault



Area of Interest

1. Santa Monica fault
2. Hollywood fault
3. Raymond fault
4. Alhambra Wash fault
5. Upper Elysian Park thrust
6. Puente Hills thrust
7. Newport-Inglewood fault



Fault Specification

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

Resolution
- variable resolution (≈0.5 to 5km) reflecting current state of knowledge about faults.

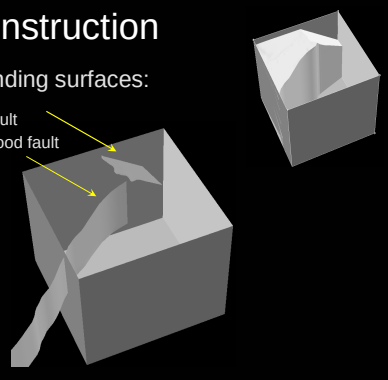
Projection and datum
- Model was constructed in UTM Zone 11 w/ NAD27 datum.
- Completed surfaces will be converted to NAD83.

Block construction

- collect bounding surfaces
- evaluate resulting block bounding surfaces
- extend surfaces when required (tears, connectors)
- intersect surfaces, produce shared edges
- use framemodeler to assemble and mesh blocks

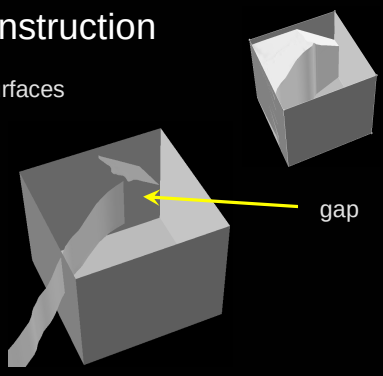
Block construction

- collect bounding surfaces:
- Santa Monica fault
- Newport-Inglewood fault



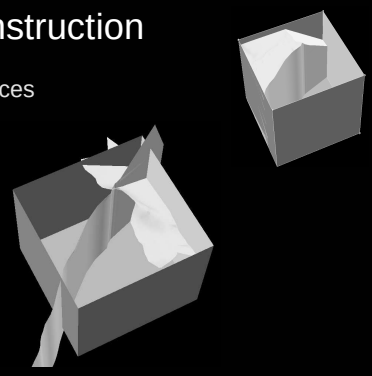
Block construction

- evaluate surfaces



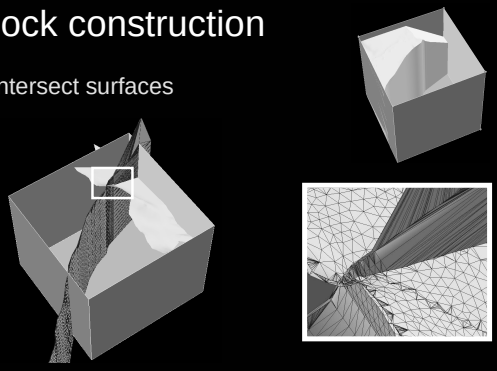
Block construction

- extend surfaces



Block construction

- intersect surfaces



Block construction

- assemble block