The SCEC Community Stress Model (CSM) Project

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Community Stress Model (CSM):

- New project starting in SCEC4.

- Long-term goal: a model or set of models of stress and stressing rate in the southern California lithosphere.

- The CSM will probably not be a single model, but a (hopefully small) set of models.

- Any branches in the CSM will be based on clearly-defined differences in data or assumptions.
Who are the users of the CSM and what do they need?

**External users:** Rupture dynamics, geodynamics, seismic hazard, stress triggering, others?
**Needs:** You tell us!
**Provide:** One or more reference stress and stressing rate models, accessible through an interface developed jointly with the user communities.

**Internal users:** Researchers working on problems directly related to stress.
**Needs:** Access to existing data and models, easier ways to integrate and compare models and observations.
**Provide:** A modeling environment with tools that will enable researchers to develop and test candidate models against suites of data and/or quantitatively compare their models with other models.
Community Stress Model (CSM) strategy:

• Long-term goal: a model or set of models of stress and stressing rate in the southern California lithosphere.

• First step (ongoing) is to collect and compare existing stress and stressing rate models from the SCEC community.

• Validate models with available observations and physical constraints.

• Plan to construct the final CSM model by choosing a preferred model, combining the models and/or using them to form branches.

• Differences between contributed models:
  1. Reconcile through further work.
  2. Consider their variation to represent the uncertainty.
  3. Choose a preferred model, or relative weighting of models.
  4. Become CSM model branches.
Contributed Models:

Stress:

1) Inversion of focal mechanisms for stress orientation. – Wenzheng Yang and Egill Hauksson (Caltech).

2) Finite element model including topography, depth-dependent rheology, frictional faults, and long-term deformation model. – Peter Bird (UCLA).

3) Inversion for stress field that fits topography, fault loading from dislocation model, tectonic loading, and focal mechanisms. – Karen Luttrell (USGS), Bridget Smith-Konter (Texas), and David Sandwell (UC San Diego).

4) Smoothing of World Stress Map. – Peter Bird (UCLA); Jeanne Hardebeck (USGS).

5) Global model from density-driven mantle flow, plus lithosphere gravitational potential energy, fit to geoid and global plate motions. – Attreyee Ghosh and Thorsten Becker (USC).
Average Stress Model: average normalized deviatoric stress tensor.

* Average of Bird; Luttrell, Smith-Konter & Sandwell; and Yang & Hauksson models, everywhere at least two of these models are defined.
Stress Models: differential stress ($\sigma_1$-$\sigma_3$) versus depth.

Solid line/symbol: median. Dashed line: middle 68%.
Contributed Models:

Stressing Rate:

1) Block model fit to geodetic data. – Jack Loveless (Smith) and Brendan Meade (Harvard).

2) Fault loading from dislocation model using geologic and geodetic slip rates. – Bridget Smith-Konter (Texas), and David Sandwell (UC San Diego).

3) Fault loading from dislocation model plus static stress changes from earthquakes. – Anne Strader and David Jackson (UCLA).

4) 3D local boundary element model fit to slip rates (LA, Ventura, San Gregorio). – Michele Cooke (UMass) and Scott Marshall (Appalachian State).

5) UCERF3 deformation models translated to stressing rate. - Models of Bird, Johnson, and Zeng, translated by Liz Hearn.
Average Stress Rate Model: average differential stressing rate: $\delta(\sigma_1 - \sigma_3)/\delta t$.

* Average of Loveless & Meade; Smith-Konter & Sandwell; and Strader & Jackson models, everywhere at least two of these models are defined.
Average Stress Rate Model: average normalized deviatoric stress tensor – orientation only.

* Average of Loveless & Meade; Smith-Konter & Sandwell; and Strader & Jackson models, everywhere at least two of these models are defined.
The CGM may be used to (1) develop or refine contributed stress and stressing rate models, and/or (2) validate contributed and final CSM stressing rate models.

Contributed stressing rate models are fault based (block models, deep dislocations) so any features of the CGM geared toward these types of models would benefit the CSM.

Strain rate and stressing rate more difficult to constrain from geodetic data than slip rate, need to constrain the shape of the “S” across the fault zone. Requires finer spatial resolution, especially near important faults.

Fine spatial resolution also required because we observe sharp changes in the stress field over scales of ~10 km.

Most contributed stressing rate models are limited to strike-slip loading. Vertical motion will be important as models progress to include dip-slip loading.

We hope to eventually develop time-dependent stress and stressing rate models, so feasibility of time dependent CGM is of interest.