

**Workshop Report for
“Community Stress Model (CSM) Workshop”**

SCEC Award #13002

PIs:

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CSM Progress to Date:

Crustal stress is a fundamental quantity that is relevant to many aspects of the earthquake problem. SCEC4 has committed to the development of the Community Stress Model (CSM) to provide the SCEC community with better constraints on the stress field, and with a means to formally test physical connections between observations and stress models. The intended CSM end-product, a model or suite of models for the 4D stress tensor in the California lithosphere, will be useful for numerous SCEC core science issues. These include a better understanding of how faults are loaded, redistribute strain via earthquakes, and evolve over time. There is a range of potential uses for the CSM, including seismic hazard estimates, crustal seismicity studies, dynamic earthquake rupture models and earthquake simulators. Moreover, even the discussions of the issues involved in the construction of a CSM (such as the completeness of physical models, noise, and uncertainties) are expected to lead to scientific progress.

The first step of the CSM project has been to attempt to compile and compare all of the existing relevant data and models held by the SCEC community. A call went out for contribution of data and models, and to date 16 models have been submitted, primarily models of stress or stressing rate in the upper crust. Unfortunately, not much data has been submitted. At the October 2012 CSM Workshop we compared the submitted models, and discovered an encouraging agreement between models on the stress orientations throughout southern California, and on the stressing rate and its orientation along the major faults of the San Andreas system. Since that workshop, we have begun developing a website for collaboration, where the submitted models can be accessed, compared, and validated against data.

Workshop Discussions and Identified Next Steps:

At this workshop, held May 29-30 in Menlo Park, we discussed a range of topics, focusing on geodetic-based stressing rate models, geodynamic models, and data and validation.

Geodetic-based Stressing Rate Models:

Holding the CSM workshop in conjunction with the CGM workshop was successful in increasing the participation of geodesists in the CSM workshop. This led to productive discussions of the strengths and limitations of geodetic-based stressing rate models. One of the primary drawbacks of these models is that they are based on observed horizontal motions, and therefore may poorly model the vertical strain rates and stressing rates. We reported on the importance of vertical geodetic data to the CSM efforts at the CGM workshop.

Geodynamic Models:

This year's CSM workshop also had increased participation from the geodynamic modeling community, and there are plans for more geodynamic models to be submitted to the CSM. This is quite important, because most of the models submitted so far are limited to the upper crust, and many are data-driven rather than physics based. Geodynamic models will contribute significantly to the CSM because of their deeper extent and their more physics-based approach. At the workshop, plans were made for collaborative work where global geodynamic models would be used to provide boundary conditions for regional models of southern California.

Data and Validation:

Data, and validation of the submitted models against data, was identified as a key need for the CSM that has been lacking up to this point. We discussed our needs to collect identified datasets, including borehole observations and anisotropy measurements, and the need to validate models against these data. We also discussed the need to validate submitted models using other physical constraints, for example ensuring that stress projected onto faults would result in reasonable rake directions.

Identification of "Model 0":

The workshop participants felt it was appropriate to identify and release a CSM "version 0", reflecting what can be learned from the contributed models to date. The release of initial models will allow the larger SCEC community to engage with the CSM process through actual models. Hopefully this will result in feedback that can be used in further model development, as well as feedback on user needs, preferred

model formats, etc. The CSM web site, under initial development, will have clarifying sub-labels, for example CSM-stress model A version 0 the “A” label would indicate stress derived from focal mechanism, and various other types of version 0 stress models may be provided. We have identified the Yang and Hauksson [GJI, 2013] model as stress model “A version 0”, and a committee of geodesists has been charged with identifying or constructing stressing rate model(s) “version 0”.

Summary of Workshop Action Items

- ⤴ Release “Model 0” at the annual meeting in September comprised of
 - Yang and Hauksson stress model A
 - Stressing rate model from strain rate model(s)
- ⤴ Request additional metadata from currently contributed models and, with author permission, make models available on the SCEC website
- ⤴ Begin development of quantitative tests for stress models
 - Comparison with World Stress Map
 - Consistency of projected stresses and fault slip directions
- ⤴ Begin cataloging data sources for stress models on the SCEC website
- ⤴ Encourage further model development via the SCEC Collaboration Plan and contact with potential contributors
 - Incorporate constraints on vertical stress tensor components
 - Extend model coverage into the lower crust and upper mantle
 - Constrain regional geodynamic stress models with global dynamic models
 - Acquire additional available borehole data from various sources and make it accessible to the SCEC community for model development and validation

Agenda:

Community Stress Model Workshop Agenda
May 29-30, 2013

Wednesday, May 29

- 8:00-9:00 Breakfast
- 9:00-9:15 Welcome and Introductions - Thorsten Becker
- 9:15-9:30 Overview of CSM plans and goals - Thorsten Becker
- 9:30-9:50 Review of submitted CSM models - Jeanne Hardebeck
- 9:50-10:10 Review of CSM Workshop 2 model comparisons - Jeanne Hardebeck
- 10:10-10:50 Stressing rate from UCERF3 deformation models
Discussion - moderator Liz Hearn
- 10:50-11:10 Break
- 11:10-12:00 Reconciling deformation/stressing rate models
Discussion - moderator David Sandwell
- 12:00-13:00 Lunch
- 13:00-13:50 Bringing geodynamic models into CSM
Discussion - moderator Bill Holt
- 13:50-14:20 Reconciling stress models
Discussion - moderator Jeanne Hardebeck
- 14:20-14:40 Break
- 14:40-15:30 Moving forward - Models
Discussion - moderator Brad Aagaard
- 15:30-16:00 Plans for CSM web site - Thorsten Becker
- 16:00-18:00 Free Time
- 18:00-19:00 Dinner

Thursday, May 30

8:00-9:00 Breakfast

9:00-9:50 Existing data and data needs
Discussion - moderator Egill Hauksson

9:50-10:40 Validating CSM models against data
Discussion - moderator Jeanne Hardebeck

10:40-11:00 Break

11:00-11:50 Moving forward - Data and Validation
Discussion - moderator Brad Aagaard

11:50-12:00 Wrap-up

12:00 Adjourn

Participants:

In-Person -- Brad Aagaard (USGS), Thorsten Becker (USC), Greg Beroza (Stanford), Yuri Fialko (UCSD), Mike Floyd (MIT), Lucy Flesch (Purdue), Tom Hanks (USGS), Jeanne Hardebeck (USGS), Egill Hauksson (Caltech), Liz Hearn (USGS contractor), Bill Holt (SUNY at Stony Brook), Tran Huynh (USC), Kaj Johnson (Indiana), Eric Lindsey (UCSD), Mian Liu (Missouri), Karen Luttrell (USGS), Betsy Madden (UMass), Jessica Murray (USGS), Tom Parsons (USGS), Fred Pollitz (USGS), David Sandwell (UCSD/SIO), Wayne Thatcher (USGS), Xiaopeng Tong (UCSD), Wenzheng Yang (AIR Worldwide, Boston), and Jiyang Ye (Missouri)

Remote -- Attreyee Ghosh (Bangalore Institute of Technology)