

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

**SCEC Award #14024**

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 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, earthquake stress interaction studies, dynamic earthquake rupture models and earthquake simulators. Moreover, even the discussions of the issues involved in the construction of a CSM are leading to scientific progress.

The initial effort of the CSM was to compile and compare all of the existing relevant models held by the SCEC community. A call went out for contribution of data and models, and 16 models were submitted, primarily models of stress or stressing rate in the upper crust. At the 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. Recognizing that most of submitted models were crustal models derived from focal mechanism and/or geodetic data, for the 2013 CSM workshop we invited members of the geodynamics community to encourage them to submit physics-based models of stress in the southern California lithosphere. Geodynamic modeling projects are underway, some supported by SCEC grants to individual PIs.

Observations are needed to constrain and/or validate the stress and stressing rate models. The most direct measurement of stress is in boreholes: the CSM currently has the borehole data compiled by the World Stress Map project, as well as some

additional contributed borehole observations. Work is underway to compile additional data from industry. Additional sources of indirect stress measurements, such as seismic anisotropy, are currently being compiled. These data-collections efforts are also supported by SCEC grants to individual PIs.

A web site for the CSM has been developed where the community can find information about the CSM, join the mailing list, view and download many of the submitted models, view comparisons between submitted models, and obtain information about how to submit models and data. The website can be found at: <http://sceczero.usc.edu/projects/CSM>.

### **Workshop:**

While previous CSM workshops were organized around group discussions, for 2014 we used a more standard talk-based workshop format. The talks focused on the two areas of current effort: (1) physics-based models of stress in the lithosphere, and (2) identifying and obtaining the data needed to constrain and/or validate stress models. In these talks, the PIs of CSM-related, SCEC-funded projects, as well as others from the SCEC community, updated the group on the progress of their model development or data-gathering activities. Each talk generated lively discussion.

### **Identified Next Steps:**

The stress and stressing rate models that have been contributed to the CSM are ready for use by SCEC researchers, and are available for download from the CSM website in a standardized format. At the 2014 CSM workshop, we discussed that these models may be under-utilized by the SCEC community because there is not general awareness that they are available. We decided we need to “advertise” the CSM models to the broader SCEC community. We are therefore proposing that the CSM workshop for 2015 focus on introducing potential users to the CSM models that are currently available and how to access these models.

Another outcome of the discussion at the 2014 CSM workshop was an endorsement of the formation of a SCEC Community Rheology Model effort. Linking kinematics (e.g. strain/strain-rate) with dynamic indicators (e.g. stress) requires a constitutive law, which in the case of the southern California crust will consist of the complex, spatio-temporally dependent rheological behavior of the lithosphere. Like the CSM itself, rheology is subject to much debate and large uncertainties, but also accessible to geological, geophysical, and rock mechanics inquiry. A Community Rheology Model workshop is being proposed for 2015, and we will encourage the CSM modeling community to participate in that workshop. This would support physics-based modeling directed towards the CSM as well as other efforts within SCEC.

## **Workshop Agenda:**

**OVERVIEW:** The fourth annual workshop of the SCEC Community Stress Model (CSM) project will focus on (1) incorporating the stress predicted by physics-based models into the CSM, and (2) new sources of data to inform and validate CSM models. The workshop format will include formal presentations on recent progress in physics-based modeling and data compilation, and focused discussion on the future direction of the CSM.

**PARTICIPANTS (23 total, 3 remote):** Brad Aagaard (USGS), Thorsten Becker (USC), Peter Bird (UCLA), Michele Cooke (UMass Amherst), Thomas Goebel (Caltech), Jeanne Hardebeck (USGS), Egill Hauksson (Caltech), Liz Hearn (Consulting Geophysicist), Tran Huynh (USC), Nadia Lapusta (Caltech), Eric Lindsey (UCSD), Karen Luttrell (LSU), Patricia Persaud (Caltech), Fred Pollitz (USGS), Margarita Segou (GeoAzur/CNRS), Bruce Shaw (Columbia), Peter Shearer (UCSD), Debbie Smith (USGS), Bridget Smith-Konter (Hawaii), Joann Stock (Caltech), Wayne Thatcher (USGS), Wenzheng Yang (AIR Worldwide), and Jiyang Ye (Missouri)

### **MONDAY, October 27, 2014**

9:00-9:15 Introductions

9:15-9:30 Jeanne Hardebeck - Current status of the CSM

9:30-9:45 Jeanne Hardebeck for CGM Group - SCEC Community Geodetic Model workshop report

9:45-10:00 Brad Aagaard - SCEC/CIG Crustal Deformation Modeling workshop report

#### **CSM Modeling Updates, part 1:**

10:15-10:45 Peter Bird - Stress equilibrium in southern California from Maxwell stress function models

10:45-11:00 Break

11:00-11:30 Liz Hearn - A physics-based lithosphere deformation model for the SCEC CSM: Progress and challenges

11:30-12:00 Bridget Smith-Konter - 4-D earthquake cycle modeling of the San Andreas Fault System: Stress rates, historical stress accumulation, and uncertainties

12:00-13:00 Lunch

#### **CSM Modeling Updates, part 2:**

13:00-13:30 Karen Luttrell - Earthquake cycle influence on the plate boundary stress budget, as constrained by seismology, geodesy, and topography

13:30-14:00 Michelle Cooke - Influence of fault geometry on deformation partitioning within southern California

14:00-14:30 Discussion: Modeling needs (2015 proposals, goals for SCEC5)

14:30-14:45 break

**CSM Data Compilation Updates:**

14:45-15:15 Peter Shearer - Earthquake stress drop estimates: what are they telling us?

15:15-15:45 Joann Stock - Calibration of Stress Field Models Using Borehole Data

15:45-16:15 Thorsten Becker - Anisotropy Observations and Implications for Stress

16:15-16:45 Discussion: Data needs (2015 proposals, goals for SCEC5)

16:45-17:00 Wrap-up