February 27, 2007

This is the 2006 SCEC Progress Report for SCEC Proposal # 06127. It is written by and submitted by co-PI, Ruth Harris.

3D Rupture Dynamics Code Validation 2006 Workshop

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Please note that our workshop was held in early 2007.

The goal of our group is to compare and better understand the computer codes that are currently being used by SCEC scientists to simulate earthquake rupture dynamics. The results have significant ramifications for research findings in the SCEC science groups Earthquake Source Physics, Ground Motions, Fault Systems, Fault and Rock Mechanics, in the SCEC NGA project, and in the SCEC ITR projects Pathway3, TeraShake and Cybershake because all of these projects rely on the assumption that the numerical simulations are working similarly and correctly.

Code comparers in 2006 prepared for and participated in the February 2007 SCEC Code Workshop, which is covered in this report. We had 16 SCEC researchers, including postdocs and students, tackling our sixth and seventh benchmarks, The Problem, Version 6 (TPV6) and The Problem, Version 7 (TPV7). The definitions of these benchmarks and instructions to the modelers are in Appendix I of the Report for our Collaborative Project, 06123.

The workshop was held on February 12, 2007 at SCEC at USC. The agenda is Table 1. The workshop had 30 attendees, including the 16 modelers (SCEC students, postdocs, faculty, USGS researchers, and 1 researcher from Japan). The list of attendees is Table 2. Presentations and discussions at the workshop were related to the invited talks and to the comparisons of the codes. The list of modelers and their codes is Table 3. Among the attendees were numerous students, postdocs, and, senior researchers, including members of the SCEC CME project. Our invited speakers also spanned the range from student to postdoc to senior researcher.

At the workshop we unveiled to the SCEC community our newly developed online web comparison tools developed by Michael Barall. For all previous code comparison workshops the comparisons were painstakingly prepared manually by unlucky coordinating PI Harris. In contrast, for this workshop the modelers were able to submit their results to the new SCEC website, check to make sure that they were submitting results that made sense (e.g. sign-convention was correct, scale was correct), and also compare with the results of other SCEC modelers using different dynamic rupture codes.

At the workshop talks were followed by ample discussion time so that all of the participants were easily able to discuss the issues brought up specifically by each speaker, as well as being able to discuss related topics.

Our main finding was that the new SCEC website is a huge plus compared to our previous labor-and time-intensive techniques, especially for the coordinating PI. Parts of the website will likely be borrowed by the SCEC CME project, if they haven't already been borrowed by the time of this writing.

Scientifically we learned that the bimaterial problem, with the parameters that we selected for TPV6 and TPV7 is a tricky case of needing to use finer grid spacing than some of the codes are capable of using at this time. We also learned that subsets of the codes produced similar results, whereas other codes produced different results, using the coarser 100 m spacing, but that it was difficult to tell which code was the most accurate due to the resolution issue. In particular, even for the "well-posed" TPV6, it is likely that the grid spacing would need to be on the order of 25-50 m for an accurate comparison. A conclusion from this exercise is that the results from each code should be examined with a convergence test to determine how fine a grid spacing is needed for each specific code.

We also had good discussions regarding the use of various types of regularization parameters in the spontaneous rupture codes, for the bimaterial problem. Some authors (SCEC and outside-of-SCEC) use various forms of regularization of the friction, whereas at least one SCEC code author uses viscous damping with slip-weakening friction. How these different types of regularization affect the timing and amplitude of rupture on a highly detailed level may lead to slightly different results for the bimaterial problem, and so convergence seems a bit more challenging than our previous benchmarks where we were dealing with a homogeneous medium.

The following pages list the workshop schedule, including the invited speakers, the workshop attendees, and the modelers who tackled the benchmarks for the workshop.

Table 1. The Workshop Schedule

SCEC 3D Rupture Dynamics Code Validation Workshop

February 12, 2007
USC

10:00 Workshop Introduction
(Ruth Harris)

10:20 Discontinuum Modeling of Dynamic Ruptures
(*Matt Purvance)*

10:50 A New Finite Volume Approach for Modeling Dynamic Rupture along Non-Planar Faults
(Victor Cruz Atienza)

11:20 A Support-Operator Method for Dynamic Rupture Modeling
(Geoff Ely)

11:50 DynaShake
(Steve Day)

12:15 Lunch

1:00 Slip between Dissimilar Materials:
Instabilities, Ill-posedness, and Implications for Numerical Modeling
(Eric Dunham)

1:30 The New SCEC Code Comparison Website
(*Michael Barall)*

2:00 The Benchmarks:
The Problem Versions 6 and 7 Comparisons and Discussion
(*Ruth/All)*

3:00 General Discussion about Benchmarks and Future Plans
(*All)*

Table 2. List of Attendees

Aagaard	Brad	United States Geological Survey
Ampuero	Jean Paul	ETH Zurich
Barall	Michael	Invisible Software
Ben-Zion	Yehuda	University of Southern California
Bhat	Harsha	Harvard University
Cruz Atienza	Victor	SDSU
Custodio	Susana	University of California, Santa Barbara
Dalguer	Luis	San Diego State University
Day	Steven	San Diego State University
Duan	Benchun	San Diego State University
Dunham	Eric	Harvard University
Ely	Geoffrey	University of California, San Diego
Harris	Ruth	United States Geological Survey
Huynh	Tran	University of Southern California
Kaneko	Yoshi	California Institute of Technology
Kase	Yuko	Active Fault Research Center, AIST
Lavallee	Daniel	University of California, Santa Barbara
Liu	Yi	California Institute of Technology
Ma	Shuo	Stanford University
Maechling	Philip	University of Southern California
McRaney	John	University of Southern California
Rojas	Otilio	San Diego State University
Oglesby	David	University of California, Riverside
Okaya	David	University of Southern California
Olsen	Kim	San Diego State University
Pitarka	Arben	URS Corporation
Purvance	Matthew	University of Nevada, Reno
Schmedes	Jan	University of California, Santa Barbara
Templeton	Elizabeth	Harvard University

Table 3. Codes and Code Users for The February 12, 2007 Workshop

The Problem, Versions 6, 7
(January – February 2007)

(Results Submitted by February 8, 2007)

3D Code	Code User(s)	TPV6 Spacing (m)	TPV7 Spacing (m)	Code Description
EqSim	Aagaard	100	100	Aagaard Finite Element
AWM-Olsen	Cruz Atienza/Olsen	100	100	Olsen Finite Difference
dfm	Dalguer/Day	100	100	Day Finite Difference
dfm	Day/Dalguer	50	50	Day Finite Difference
EQdyna	Duan	100	100	Duan Finite Element
MDSBI	Dunham	100	100	Dunham Spectral Bounday Integral
SGFD	Dunham2	100	100	Dunham Finite Difference
SORD	Ely	100	100	Ely Irregular-grid Support-Operator
Kase	Kase	100	100	Kase Finite Difference
BI	Liu/Lapusta	100	100	Lapusta/Liu Spectral Bounday Integral
MAFE	Ma	100	100	Ma Finite Element
DYNA3D	Oglesby	150	150	Oglesby Finite Element
FDMSPLIT	Pitarka	100	100	Pitarka Finite Difference
ABAQUS	Templeton/Bhat	100	100	ABAQUS Finite Element/Explicit