

Project 12177: Rupture Dynamics Code Validation 2012 Workshop (convened March 15, 2013)

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The 2012 SCEC Dynamic Rupture Code Comparison Workshop was held March 15, 2013, at the U.S. Geological Survey in Menlo Park, California. 37 people participated, including 8 remotely, and 29 in the meeting room. This year's workshop included at least 6 new people, among them 3 new students and 2 new postdocs. Our attendees this year included scientists from 4 countries (Japan, New Zealand, Switzerland, U.S.A.), with outside-U.S. attendees participating remotely. At least 13 of our 37 participants were either students or postdocs. Many thanks to Tran Huynh for all of her dedicated work that helped make this workshop happen.

The workshop agenda and participant list are on the last page of this report.

Ruth Harris (USGS) introduced the workshop to the participants, who learned for the first time (or remembered, if they were code workshop veterans) about the previous science that has been done to test our computer codes that simulate earthquakes as spontaneous ruptures. A quick summary of all of the computer code benchmarks performed to date was presented. There was mention of the successes and challenges from last year's benchmarks, in particular that the heterogeneous initial stresses planar-fault benchmark worked very well, and that the fault branch benchmark worked less well, and therefore had been reintroduced for this year's modeling exercises.

The participants then learned about the SCEC Community Stress Model, in a talk by Brad Aagaard (USGS), who presented information about the progress and plans of the CSM Technical Activity Group.

Michael Barall (Invisible Software) then presented a comprehensive talk explaining the details of the newest completed SCEC Dynamic Rupture group's benchmarks, the case of the fault stepover (TPV22-23), and the case of the fault branch (TPV24-25). The fault stepover benchmarks were successfully achieved by the codes that did the simulations with appropriate resolution. The fault branch in previous years had provided the modelers with challenges, and this year was the third try by our group with this fault geometry. Fortunately, this time around the codes that simulated the benchmarks and that also implemented the requested element-sizes, did successfully match each other well.

Ossian O'Reilly (Stanford) then gave a brief presentation about theoretical modeling approaches to friction-free fault branches.

The workshop attendees next joined workshop co-convenor Harris in a discussion about how our group should frame our 2013 benchmarks, cases of the fault bend/curve. Proposed ideas included sinusoidal faults, circular faults of varying radii, planar faults with single bumps, and fault bends. Upcoming email conversations among the group's members will pinpoint the exact desired parameters for this 2013 study of non-planar fault geometry that will likely first be implemented in 2D. Workshop time ran out before the group was able to discuss another activity

that is planned for 2013, development of comparison metrics, but this theme is likely to be continued and enhanced in email dialogues among our group members. It was also suggested by workshop co-convenor and Dynamic Rupture Code Comparison group project-lead Harris that this theme of comparison metrics could serve as a topic for our next big group paper.

Following lunch, USGS scientists Brian Kilore and Greg McLaskey presented the workshop in-person attendees with a tour of the big-block and one of the smaller rock friction machine setups in the USGS rock mechanics labs. Attendees were able to experience a laboratory earthquake, and view where rate-state history and empirically-based hypotheses about rate-state friction in both rock and plastic occurred over the past 30 years.

The workshop attendees then returned to the conference room where Norm Abrahamson (PG&E) gave a talk about upcoming deadlines for big projects that are related to engineering implementation. He discussed how computationally-based dynamic rupture simulations might be able to contribute to these implementation efforts. Among the topics that Abrahamson presented as needing better solutions are methodologies for simulating hanging wall vs. footwall ground motion effects, and representation of large earthquake sources on creeping faults and their resulting ground motions. Actual implementation in a robust framework would however require validation of the ground motions predicted by spontaneous rupture simulations. This validation could be accomplished by comparing the computational simulation results with ground motion recordings from actual events. The desired frequency range is up to 5 Hz.

After a short break, the workshop attendees next heard four talks about spontaneous rupture models of the 2011 Tohoku earthquake. Benchun Duan (Texas A&M University) and Yihe Huang (Caltech) presented talks about their models that primarily implemented slip-weakening-type friction, Junle Jiang (Caltech) presented Hiroyuki Noda's (JAMSTEC) and Nadia Lapusta's (Caltech) work that implemented thermal pressurization, and Shuo Ma (San Diego State University) presented his models that implemented slip-weakening but set the fault in an elastoplastic setting.

For more information about our group, to download our group's papers, for descriptions of our group's benchmarks that we use to compare our codes' results, and to view many of our workshop presentations, please see our SCEC website: scecddata.usc.edu/cvws.

Thank you to SCEC for funding this workshop.

SCEC Rupture Dynamics Code Comparison Workshop

Conveners: *Ruth Harris and Ralph Archuleta*

Location: USGS Menlo Park (Building 3, Room 3-237)

SUMMARY: The purpose of the SCEC Rupture Dynamics Code Comparison Workshop is to discuss the results for our group's most recent benchmarks, TPV22-23, and 24-25, which are fault stepovers and fault branches, respectively, and to plan our next science steps for 2013-2014. We will also see laboratory earthquakes on the USGS's 'big block', learn about how our work fits into the big picture of earthquake engineering application, and learn about spontaneous rupture models of the 2011 Tohoku earthquake. For more information about our code comparison group and the benchmarks, please see the SCEC/USGS Spontaneous Rupture Code Verification Project website: <http://scecddata.usc.edu/cvws>.

FRIDAY, MARCH 15, 2013

	<u>Presenter(s)</u>
10:00 Introduction	Ruth Harris
10:15 The SCEC Community Stress Model	Brad Aagaard
10:35 The Benchmark Assignments and Results/Discussion	Michael Barall / All
11:35 Discussion of Future Plans	Ruth Harris / All
12:15 <i>Lunch</i>	
13:15 Laboratory Tour of the Big Block	Brian Kilgore / Greg McLaskey
14:20 Use of Dynamic Rupture Modeling in Earthquake Engineering Applications: User Needs and Schedule	Norm Abrahamson
14:40 <i>Break</i>	
15:00 Tohoku Earthquake Dynamic Rupture Models	
15:00 Tohoku: Slip-Weakening Friction in an Elastic Model	Benchun Duan
15:30 Tohoku: What can a simple slip-weakening model of the Tohoku earthquake tell us?	Yihe Huang
16:00 Tohoku: Thermal Pressurization in an Elastic Model	Junle Jiang
16:30 Shallow Subduction Earthquakes: Slip-Weakening Friction in an Elastoplastic Model	Shuo Ma
17:00 Additional Workshop Comments / Discussion	Ruth Harris / All
17:30 <i>Adjourn</i>	

37 PARTICIPANTS (8 of them Remote):

Brad Aagaard (USGS), Norm Abrahamson (PG&E), Pablo Ampuero (Caltech), Ralph Archuleta (UCSB), Michael Barall (Invisible Software), Sam Bydlon (Stanford), Luis Dalguer (ETHZ, Switzerland, *remote*), Steve Day (SDSU), Kenneth Duru (Stanford), Ben Duan (Texas A&M), Eric Dunham (Stanford), Percy Galvez (ETHZ, *remote*), Tom Hanks (USGS), Ruth Harris (USGS), Evan Hirakawa (UCSD, *remote*), Yihe Huang (Caltech), Tran Huynh (USC), Junle Jiang (Caltech), Yuko Kase (GSJ, Japan, *remote*), Yoshi Kaneko (GNS, New Zealand, *remote*), Brian Kilgore (USGS), Jeremy Kozdon (NPS), Qiming Liu (UCSB), Julian Lozos (UCR), Shuo Ma (SDSU), Greg McLaskey (USGS), Morgan Moschetti (USGS, *remote*), Ossian O'Reilly (Stanford), David Oglesby (UCR), Ryan Payne (Texas A&M), Arben Pitarka (LLNL), Daniel Roten (ETHZ, Switzerland, *remote*), Surendra Somala (Caltech), Seok Goo Song (ETHZ, Switzerland, *remote*), Lucas Wilcox (NPS), and Shiqing Xu (USC), Mystery Person (Stanford?).