Workshop on Dynamic Faulting Parameters: What Do We Know, and Where Do We Go?

Workshop Report

Introduction

This SCEC-funded workshop was organized by Brad Aagaard, Steve Day, David Oglesby, and Kim Olsen as a way to leverage to the ongoing success of the 3D Rupture Dynamics Code Validation project. As dynamic rupture modelers have gained confidence in the numerical validity of their methods, we now can start addressing whether there is any consensus on the parameterization of fault physics in these codes, and what we can do to make our modeling efforts more useful to the wider SCEC community. Because dynamic earthquake modelers in SCEC are actively researching a wide variety of physical question, we also take a number of different approaches to solving fault dynamics problems, and make a number of different assumptions about which dynamic parameters to include in our models and what the values of these parameters should be. For example, some researchers use slip-weakening friction while others use rate-and-state; some researchers include thermal effects and some do not; some researchers assume that perturbations in normal stress are significant in fault friction while others do not. This diversity of approaches is a great strength of the group, but it is important to determine if some sort of consensus on at least some of the physical processes and parameterizations. Some of the questions motivating this workshop were:

- How can we constrain the physics in spontaneous rupture models?
- What are the physical processes we need to model?
- What are the parameters and initial conditions for the processes?
- What additional knowledge would be helpful to constrain the parameters and characterize the variability (probability density functions) of the parameters?
- Is there a consensus on what we need to do to make our spontaneous rupture models more realistic?
- What additional observations could be made to resolve conflicting viewpoints?
- What state of knowledge do we need to reach in order to use spontaneous rupture modeling in ground motion scenarios?

To help answer these questions, we invited Bill Ellsworth, Charlie Sammis, and Chen Ji to give short presentations on their research and related topics at the workshop. These presentations were designed to spur conversations that would lead toward answers to the above questions and related issues. The conversations were the guided by the workshop conveners toward addressing the specific questions of the workshop, and were the focal point of the meeting.

Agenda

Dynamic Faulting Parameters Workshop

Tuesday, March 11, 2008

Kellogg West Conference Center, Pomona, CA

Valley Vista Room

Conveners: *Brad Aagaard, Steve Day, David Oglesby, Kim Olsen*

8:30-9:00	Opening remarks and background on spontaneous rupture modeling (*David Oglesby)*
9:00-9:45	SAFOD results and their implications for Dynamic Faulting Parameters (*Bill Ellsworth)*
9:45-10:30	Discussion: SAFOD observations
10:30-10:45	*Break*
10:45-11:15	Effects of off-fault damage on earthquake rupture propagation (*Charlie Sammis)*
11:15-11:45	Discussion: fault materials and damage rheologies
11:45-12:30	*Lunch*
12:30-1:00	Source parameters for dynamic rupture modeling from experimental fault and rock mechanics (*Nick Beeler)*
1:00-1:30	Discussion: frictional experiments and theory
1:30-2:00	Finite fault inversions: uncertainty, resolution, and fun (*Chen Ji)*
2:00-2:30	Discussion: kinematic slip inversions
2:30-2:45	*Break*
2:45-3:30	Discussion: all issues
	How can we constrain the physics in spontaneous rupture models?
	What are the physical processes we need to model?
	What are the parameters and initial conditions for the processes?
	What additional knowledge would be helpful to constrain the parameters and characterize the variability (probability density functions) of the parameters?
3:30-4:00	Discussion: Where do we go from here?
	Is there a consensus on what we need to do to make our spontaneous rupture models more realistic?
	What additional observations could be made to resolve conflicting viewpoints?
	What state of knowledge do we need to reach in order to use spontaneous rupture modeling in ground motion scenarios?
4:00	Adjourn

Attendance

Last Name	First Name	Organization
Aagaard	Brad	USGS
Archuleta	Ralph	UCSB
Avant	Travis	Cal Poly Pomona
Barall	Michael	Invisible Software
Beeler	Nick	USGS
Beroza	Greg	Stanford
Bhat	Harsha	USC
Biegel	Ron	USC
Boettcher	Margaret	USGS
Brune	Jim	UNR
Chen	Ting	Caltech
Cruz Atienza	Victor	UNAM
Dalguer	Luis	SDSU
Daub	Eric	UCSB
Day	Steve	SDSU
Duan	Ben	Texas A&M
Dunham	Eric	Harvard
Ellsworth	Bill	USGS
Ely	Geoff	UCSD
Goldsby	David	Brown
Hanks	Tom	USGS
Harris	Ruth	USGS
Huynh	Tran	SCEC
Ji	Chen	UCSB
Jordan	Tom	USC
Kaneko	Yoshi	Caltech
Kase	Yuko	AIST Japan
Kroll	Kayla	Cal Poly Pomona
Lapusta	Nadia	Caltech
Liu	Yi	Caltech
Ma	Shuo	Stanford
Oglesby	David	UC Riverside
Olsen	Kim	SDSU
Pitarka	Arben	URS Corp
Polet	Jascha	Cal Poly Pomona
Ramirez Guzman	Leo	CMU
Roten	Daniel	SDSU
Sammis	Charlie	USC
Schmedes	Jan	UCSB
Smith	Deborah	UCR
Song	Seok Goo	URS Corp
Star	Lisa	UCLA
Templeton	Elizabeth	Harvard

Results

The participants and conveners agreed that the combination of short talks and guided discussion was very successful in moving toward answers for at least some of the questions listed above, and in helping to further define the questions we need to answer in the future. The following are some general statements that we believe capture the general consensus of the workshop participants.

Lessons learned

- Confining pressure is roughly lithostatic/hydrostatic.
- The San Andreas Fault corresponds to a "strong crust, weak fault" model.
- Friction: Many mechanisms may lead to low sliding friction at high slip rates; thermal effects, in particular may be quite important.
- Depth of slip: Most slip is in the middle of the seismogenic zone.
- Kinematic inversions determine the velocity of an apparent rupture front that is radiating seismic energy; this may not correspond to the rupture velocity in our dynamic models.
- Kinematic inversions resolve some parameters, but they may be event and data specific.
- Off-fault damage is an energy sink; it reduces rupture velocity.

Where do we go from here?

- We need good near-source data; such data could help differentiate between crack-like and pulse-like rupture.
- We need to drill faults right after earthquakes to observe the materials right afterwards in order to measure the extent of damage, temperature, and other fault and material properties.
- We need to understand the shallow rheology better; it affects rupture propagation as well as radiation.
- We need to move away from simple slip-weakening to some sort of generalized rate/state formalism. It should include standard rate/state behavior at low slip speeds, and it should include some sort of parameterization of other weakening mechanisms at high slip rates, such as thermal and/or chemical effects.
- Another workshop will help to further explore what sort of friction law(s) is/are required to better capture the physics of fault rupture and slip, and perhaps to work toward comparable scenario models for ground motion estimation.