November 18, 2008

Summary Report for the 2008 SCEC 3D Rupture Dynamics Code Workshop

Submitted by Ruth Harris

The SCEC 3D Rupture Dynamics Code Workshop was held at the Kellogg West Conference Center, Pomona, CA, on November 17th. There were 33 invited attendees who participated in the workshop, including senior scientists, junior scientists, postdoctoral associates and students. Seven of these participants were also invited speakers.

The agenda for the one-day meeting was as follows:

07:30-08:30	Breakfast (dining room)
09:00-09:40	Review of the goals, summary of the latest benchmark results (Ruth)
09:45-10:25	Invited Talk + Discussion (Ralph Archuleta)
10:25-10:40	Break
10:45-11:25	Invited Talk + Discussion (Jim Rice)
11:30-12:10	Invited Talk + Discussion (Ben Duan)
12:15-01:00	Lunch
13:05-13:45	Invited Talk + Discussion (Pablo Ampuero)
13:50-14:30	Invited Talk + Discussion (Shuo Ma)
14:30-14:50	Break
14:55-15:35	Invited Talk + Discussion (Joe Andrews)
15:40-16:20	Invited Talk + Discussion (Jan Schmedes)
16:20-17:00	Overall Comments and Conclusions

There were two objectives for the meeting. The first objective was to observe and discuss the results of earthquake rupture benchmark simulations performed by the users of SCEC and USGS spontaneous rupture computer codes. The second objective was to discuss and come to consensus on which type of physical parameters should be used in the next phase of the Extreme Ground motion project's spontaneous rupture simulations.

I. First we discussed the benchmarks. For this workshop, the modelers were assigned two types of benchmarks, with the expectation that at least one type would be completed in time for the meeting. Our main priority for the ExGM project was completion of the dipping fault, slip-weakening benchmarks, but at the same time it was recognized that some of the codes could not simulate rupture on a non-vertical fault. Fortunately since members of our community also wanted to test variations of fault friction relations, this worked out well, as the vertical-fault modelers were able to work on the second type of benchmark, the rate-state friction vertical-fault benchmarks.

This meeting and the dipping-fault benchmarks were the first time that non-vertical fault geometry was tested in our exercise, and also the first time that 2D modeling efforts were

allowed in our code verification exercise. Therefore for this workshop we were able to view not only how well the 3D codes simulations of rupture on a dipping fault compared, but we were also able to view the differences and similarities between 3D and 2D simulations of spontaneous earthquake rupture dynamics.

Our findings:

a) Benchmarks TPV10 and TPV11 were cases of subshear and supershear rupture on a 60-degree dipping normal fault, respectively (please see our group's website http://scecdata.usc.edu/cvws/benchmark_descriptions.html for the exact details of the benchmark descriptions). These benchmarks were developed in consultation with Joe Andrews.

We observed that most of the seven 3D codes that ran TPV10 were able to match each others' rupture front contour plots, and similarly the synthetic seismograms also matched well. We also observed that most of the six 2D codes that ran TPV10 were able to match each others' synthetic seismograms. Interestingly however, there was a lack of agreement between the 2D and 3D rupture front contour plots or synthetic seismograms.

It was decided at the workshop that this lack of match between the 2D and 3D results was due to the increased sensitivity of the 2D to the nucleation patch size, that was held constant between the 2D and 3D simulations. The effect of the large nucleation patch size in 2D was to send TPV10, that was subshear in 3D, into supershear territory in 2D. This resulted in highly contrasting behavior between 2D and 3D simulations for TPV10.

TPV11 also showed a mismatch between the 2D and 3D results. Although both 2D and 3D had supershear rupture speeds, once again the 2D case appears to have demonstrated the sensitivity to the nucleation zone size.

Fortunately for this workshop our goal was to have the code results match in 3D, for both TPV10 and TPV11, and this goal was achieved for most of the participating codes, reassuring the community that we can continue in 3D to the next stage of the ExGM dynamic rupture modeling project.

b) TPV103 and TPV104 were rate-state benchmarks developed by Eric Dunham. They involved a slip law and strong rate-weakening. Four modelers using four different codes simulated TPV103, the wholespace benchmark, and two modelers using two different codes simulated TPV104, the halfspace benchmark. For TPV103, three out of the four codes produced excellent agreement of both the rupture front contour plots and the synthetic seismograms.

II. Next we heard from Ralph Archuleta about the timeline for the Extreme Ground motion project's transition from spontaneous rupture simulations to kinematic efforts.

III. Five invited talks followed. These speakers were requested to talk about whether or not we can use slip-weakening and elastic off-fault behavior to simulate earthquake rupture dynamics. The consensus from the talks was that we really do need to pay attention to other physical mechanisms that are likely to be active during real earthquakes. These include other forms of friction (Jim Rice and Jean-Paul Ampuero), and the interaction between off-fault yielding mechanisms and the rupture itself (Pablo Ampuero, Ben Duan, Shuo Ma, Joe Andrews). The concept that off-fault yielding helps limit the ground motion during extreme events was emphasized by speakers Joe Andrews and Ben Duan.

IV. Ralph Archuleta then presented Jan Schmedes and his strategy on how to construct realistic pseudodynamic rupture simulations from spontaneous rupture runs.

V. We then finished the meeting with a one-hour group discussion and debate about whether or not we can satisfy our state of the art scientific awareness about earthquake rupture dynamics mechanisms and at the same time perform short-time-frame assignments of spontaneous rupture simulations for the ExGM project. There was concern among the participants that we might be ignoring significant features of real earthquakes by simplifying our assumptions to slip-weakening and off-fault elastic behavior, and it was recommended that more sophisticated formulations not be abandoned within our SCEC science framework for research in 2009 and beyond. All agreed on this point. We then came to consensus that it would be satisfactory to use slip-weakening and off-fault elastic behavior for the short-time-frame ExGM simulations, since these are the main assumptions that have been benchmark tested within our group's codes to date. It was also recommended that a few cases with off-fault plastic yielding be included in these ExGM simulations, to test if the off-fault yielding has a big effect on the synthetic seismograms.

Workshop Participants List

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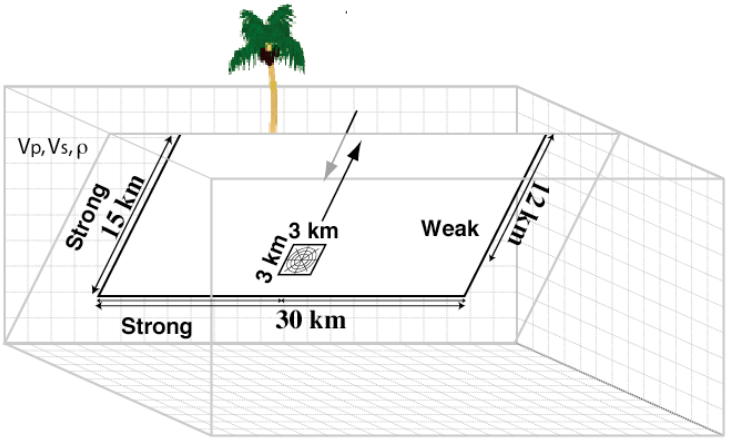
*Couldn't attend that day, but participated in activities leading up to the workshop

For more information about our group efforts, please also look at our SCEC website, scecdata.usc.edu/cvws and read our paper (Harris et al., SRL, 2009).

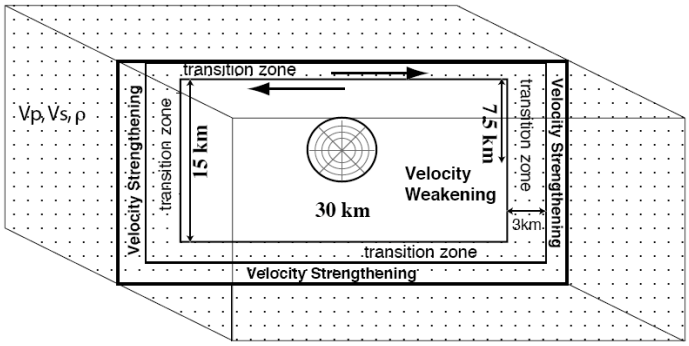
The October-November 2008 benchmarks

Slip-weakening

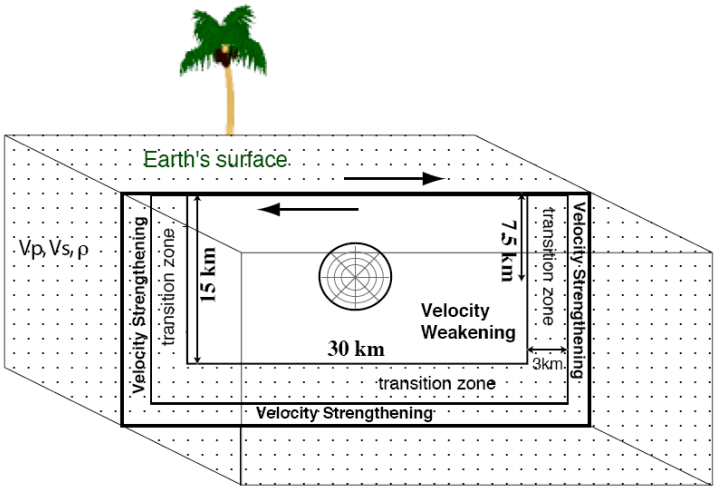


TPV10 and 11
Normal faulting on a dipping fault set in a half-space

Rate-State Friction using a slip law with strong rate-weakening



TPV103
Strike-slip faulting on a vertical fault set in a whole-space



TPV104
Strike-slip faulting on a vertical fault set in a half-space