Presentation for November 20, 2009
Pomona, CA

The 2009 SCEC Rupture Dynamics Code Validation Workshop

Ruth A. Harris
(U.S. Geological Survey)

SCEC Rupture Dynamics Code Validation Workshop

Friday November 20, 2009
Kellogg West Conference Center, Pomona, CA

09:00	**Introduction**	Ruth Harris
09:30	**Extreme Ground Motion Benchmarks TPV12/13**	Joe Andrews and Michael Barall
10:45	Break	
11:00	**Convergence Benchmarks TPV205/210**	Eric Dunham and Michael Barall
12:15	Lunch	
13:15	**Misfit Metrics**	Kim Olsen
14:00	**CIG Benchmark Tool**	Brad Aagaard
14:15	**The Source Inversion Validation Exercise**	Morgan Page
14:40	Break	
15:00	**Rupture Propagation on Branching Faults**	Nora DeDontney
16:00	**Group Discussion**	All

Introduction to Our Group's Activities

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Project Coordinator: Ruth Harris, *USGS*
Software Engineer: Michael Barall, *Invisible Software*

Current Modelers

Brad Aagaard, *USGS*
Jean Paul Ampuero, *Caltech*
Joe Andrews, *USGS*
Ralph Archuleta, *UCSB*
Michael Barall, *Invisible Software*
Victor Cruz-Atienza, *UNAM, Mexico*
Steve Day, *SDSU*
Ben Duan, *TAMU*
Eric Dunham, *Stanford*
Geoff Ely, *USC*
Alice Gabriel, *ETH, Switzerland*
Yoshihiro Kaneko, *UCSD*
Yuko Kase, *GSJ, Japan*
Jeremy Kozdon, *Stanford*
Nadia Lapusta, *Caltech*
Shuo Ma, *SDSU*
Hiroyuki Noda, *Caltech*
David Oglesby, *UCR*
Kim Olsen, *SDSU*
Daniel Roten, *SDSU*
Mohammad Sasani, *TMU, Iran*
Seok Goo Song, *URS*

Alumni

Harsha Bhat, *USC*
Luis Dalguer, *ETH, Switzerland*
Yi Liu, *Ph.D. at Caltech*
Arben Pitarka, *QTSI*
Matt Purvance, *UNR*
Elizabeth Templeton-Barrett, *ExxonMobil*

http://scecdata.usc.edu/cvws/participants.html

Overall Goal of our Code Verification Group

Compare the methods
currently being used by SCEC and USGS scientists to
simulate (spontaneous) earthquake rupture dynamics

Some Specific Objectives

Understand if our methods are producing the same results when using
the same assumptions about friction, crustal structure, fault geometry, etc.

Learn which methods are best suited for which type of problem, for example,
heterogeneous stress, heterogeneous materials, dipping faults, complex friction.

Funding

This project has been funded by the Southern California Earthquake Center,
the U.S. Geological Survey, and the U.S. Dept. of Energy/PG&E-USGS Extreme Ground Motion Project

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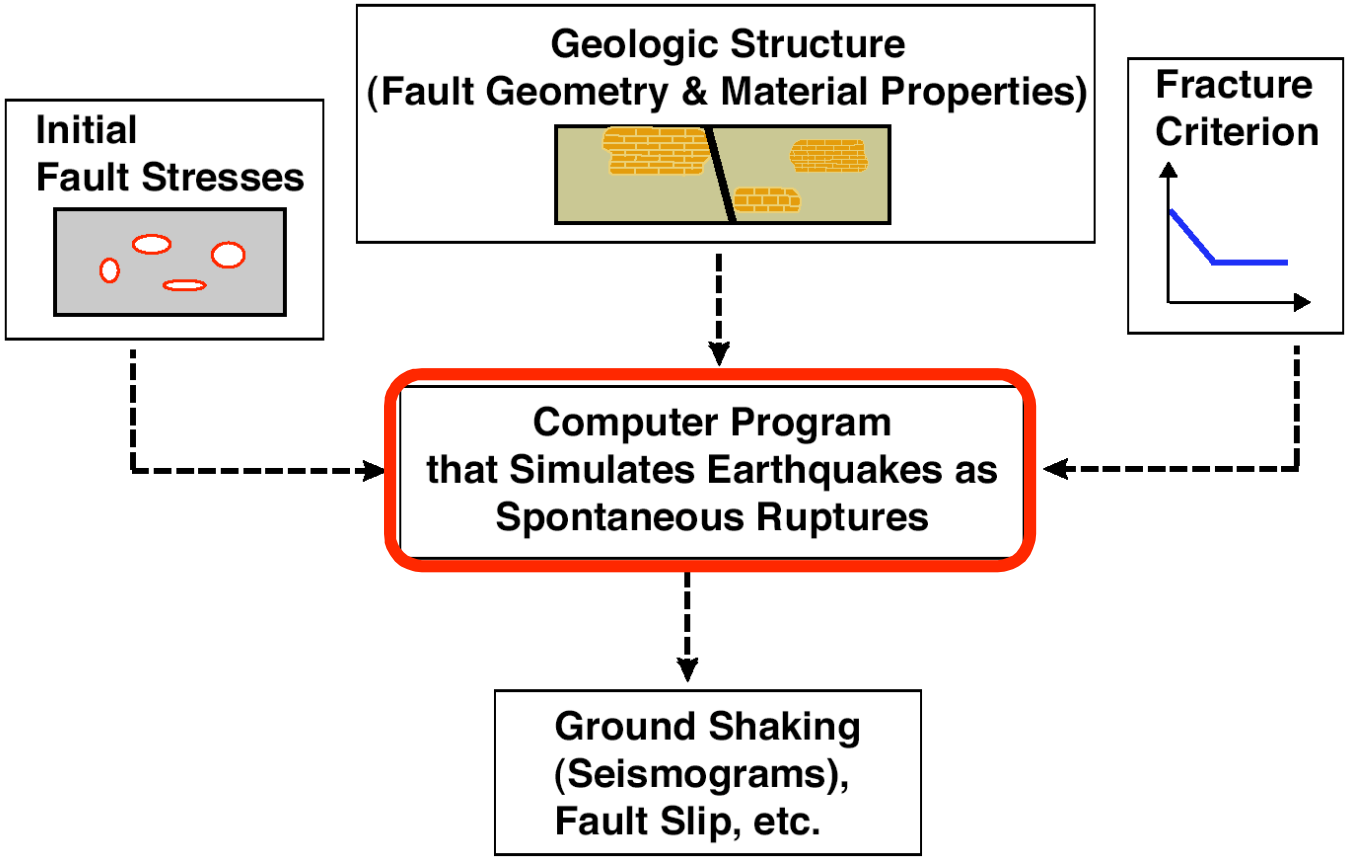

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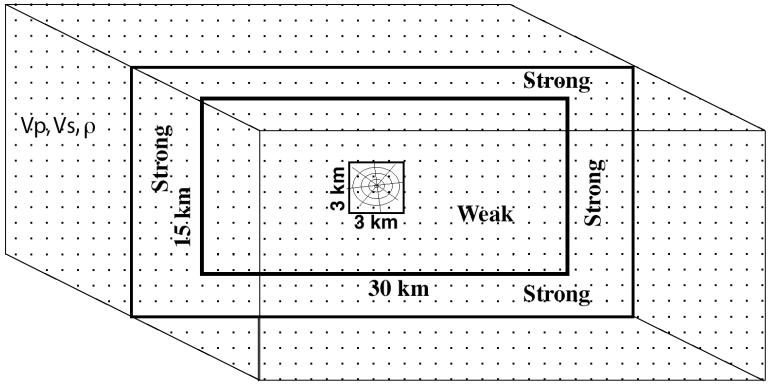
Code Comparison Strategy

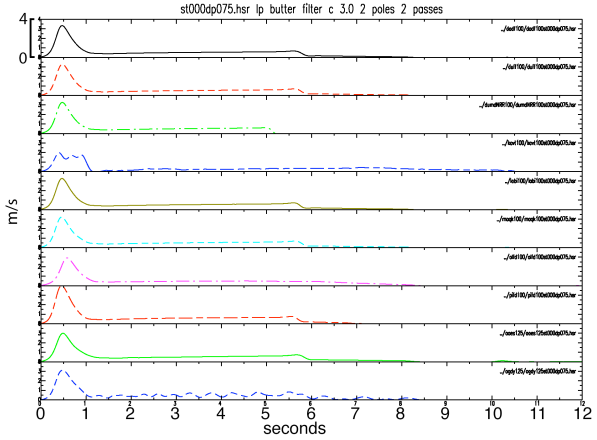
Start simply

Spontaneous rupture on a **vertical strike-slip fault set in a homogeneous elastic Fullspace**

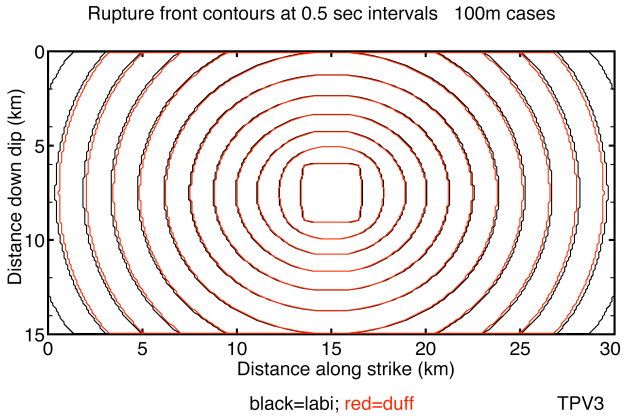


homogeneous initial stresses

slip-weakening friction



Some Results



Code Comparison Strategy

Incrementally add complexity

Rupture on a Vertical Strike-Slip fault set in an elastic **Halfspace**, homogeneous initial stresses, slip-weakening friction

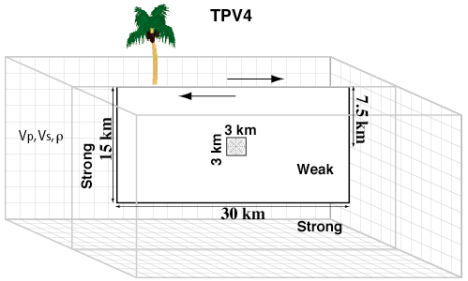
→

Rupture on a Vertical Strike-Slip fault set in elastic material, **Heterogeneous Initial stresses**, slip-weakening friction

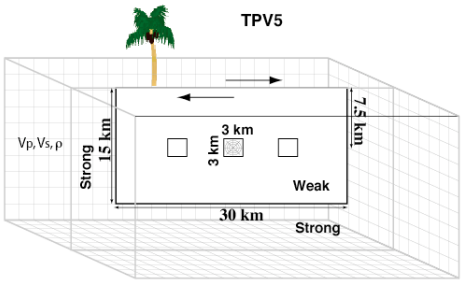
→

Rupture on a Vertical Strike-Slip fault set in elastic **Heterogeneous material**, homogeneous initial stresses, slip-weakening friction

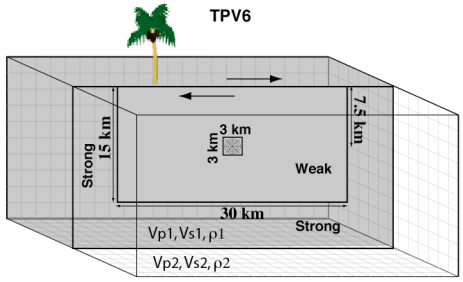
→



TPV4



TPV5



TPV6-7

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Code Comparison Strategy

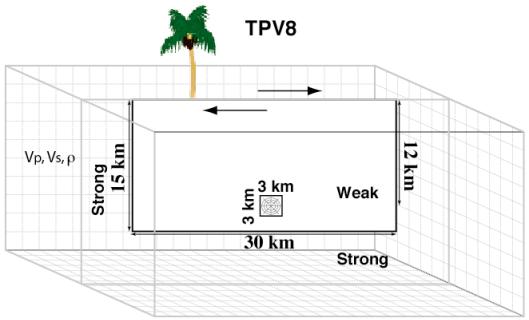
Incrementally add complexity

Rupture on a Vertical Strike-Slip fault set in elastic material, **Depth-dependent Initial Stresses**, Slip-weakening friction

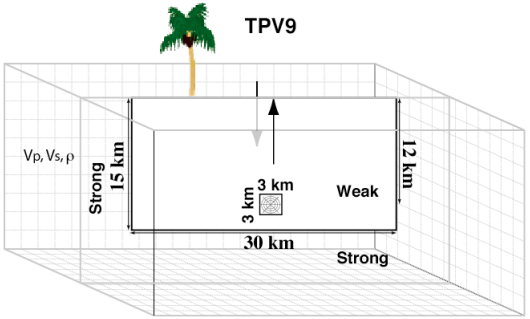
→

Rupture on a Vertical **Dip-Slip** fault set in elastic material, Depth-dependent initial stresses, Slip-weakening friction

→



TPV8



TPV9

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Code Comparison Strategy

Incrementally add complexity

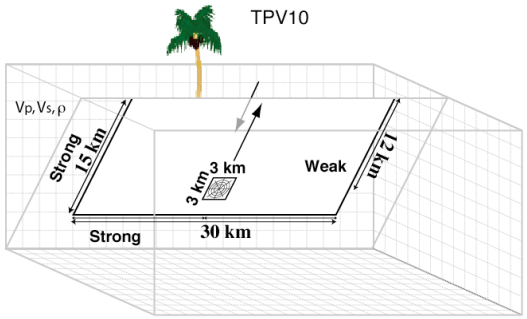
Rupture on a **Dipping** Dip-slip fault set in elastic material, Depth-dependent initial stresses, slip-weakening friction

→

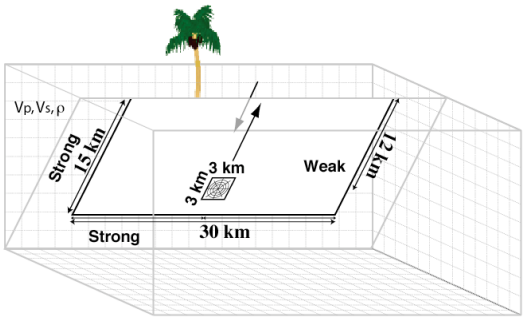
Rupture on a Dipping Dip-slip fault set in elastic material, Depth-dependent **Supershear** initial stresses, slip-weakening friction

→

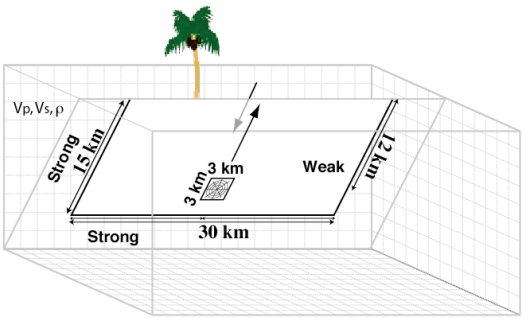
Rupture on a Dipping Dip-slip fault set in **Plastic** material, Depth-dependent supershear initial stresses, slip-weakening friction



TPV10



TPV11-12



TPV13

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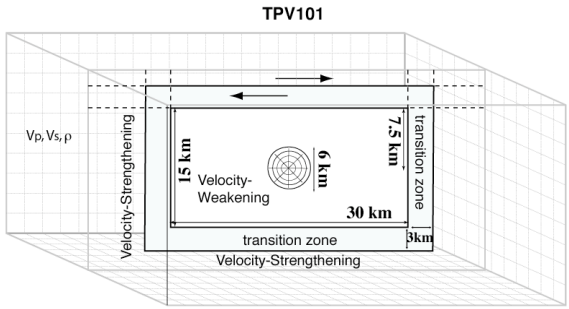
Code Comparison Strategy

Incrementally add complexity

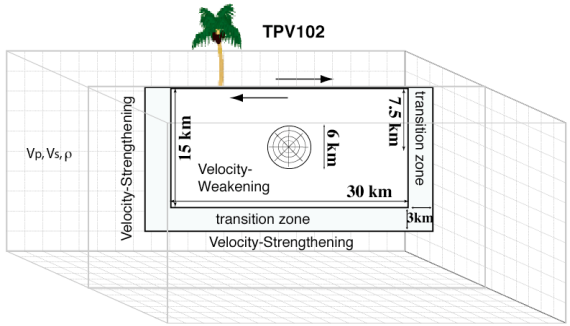
Rupture on a vertical strike-slip fault set in a homogeneous (materials) **Fullspace,** Homogeneous initial stresses, **Rate-state friction, Ageing law**

→

Rupture on a vertical strike-slip fault set in a homogeneous (materials) **Halfspace** Homogeneous initial stresses, Rate-state friction, Ageing law



TPV101

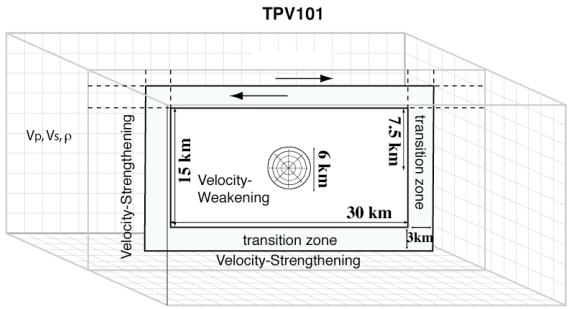


TPV102

Code Comparison Strategy

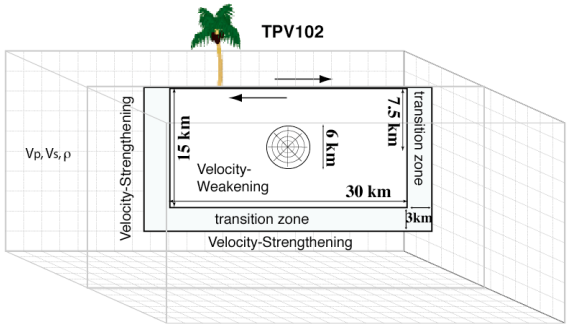
Incrementally add complexity

Rupture on a vertical strike-slip fault set in a homogeneous (materials) **Fullspace,** Homogeneous initial stresses, Rate-state friction, **slip law, strong rate-weakening**



TPV103

Rupture on a vertical strike-slip fault set in a homogeneous (materials) **Halfspace** Homogeneous initial stresses, Rate-state friction, slip law, strong rate-weakening



TPV104

Today's Benchmarks

The Problem,
Versions 12 and 13
The Problem,
Versions 205 and 210

Courtesy of Joe Andrews and Michael Barall

The Problem, Versions 12 and 13 (September-November 2009)

Andrews et al., BSSA, 2007 Figure 7

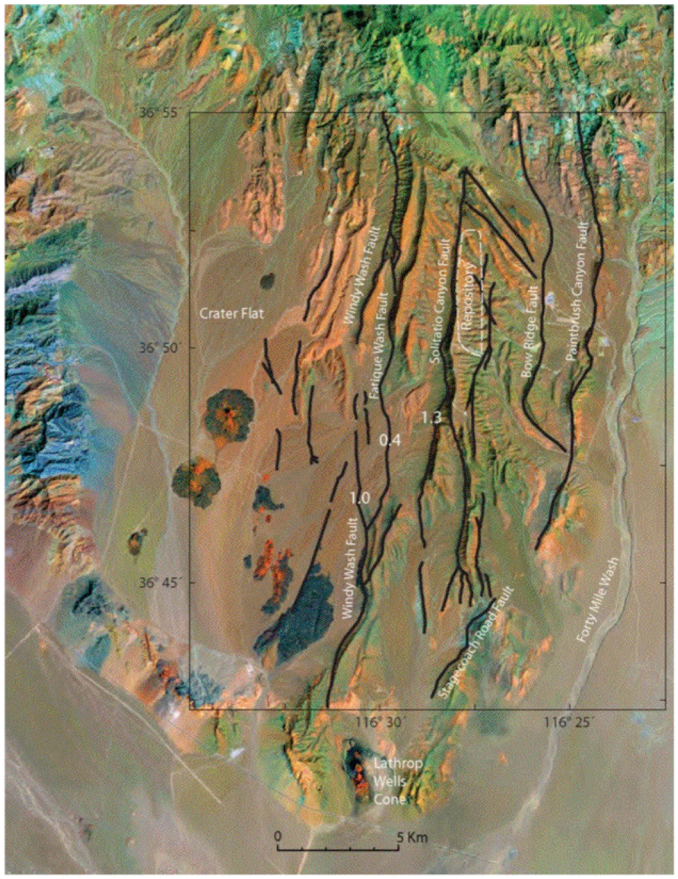
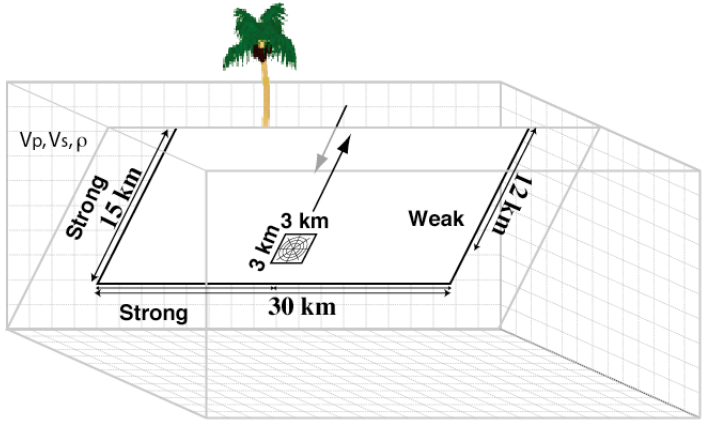


Figure 7. Color orthophoto map of the Yucca Mountain area with surface fault traces from figure 2 of Whitney, Taylor, and Menges, 2004 shown in the smaller boxed area. Numbers show locations of observed maximum-slip values of 1.3 m on the Solitario Canyon fault, 0.4 m on the Fatigue Wash fault, and 1.0 m on the Windy Wash fault at the time of the Lathrop Wells eruption. The footprint of the proposed repository is approximate.

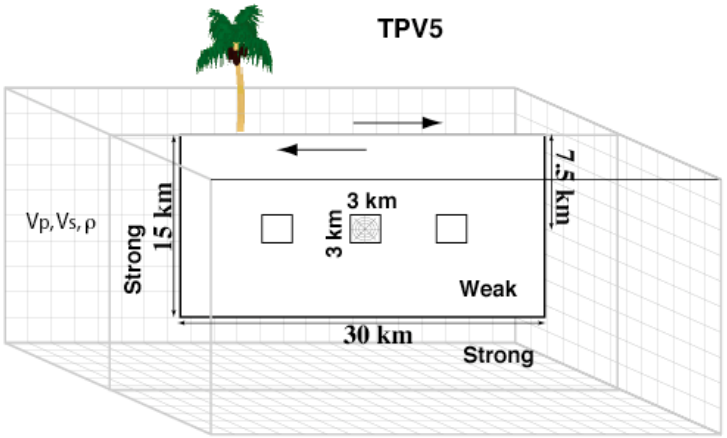
Extreme Ground Motion



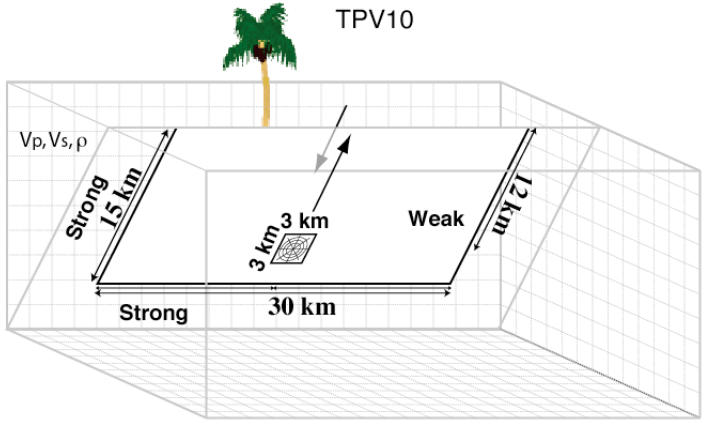
Courtesy of Eric Dunham and Michael Barall

The Problem, Versions **205 and 210** (October-November 2009)

Code-convergence testing with TPV5 and TPV10



TPV5, 205



TPV10, 210

SCEC/USGS Spontaneous Rupture Code Verification Project

SCEC/USGS Spontaneous Rupture ...

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The SCEC/USGS Spontaneous Rupture Code Verification Project

Quick Link to Description of TPV12 and TPV13

Quick Link to Description of TPV205 and TPV210

Benchmark Comparison Tool

Benchmark Descriptions

Code Descriptions

Workshop Presentations

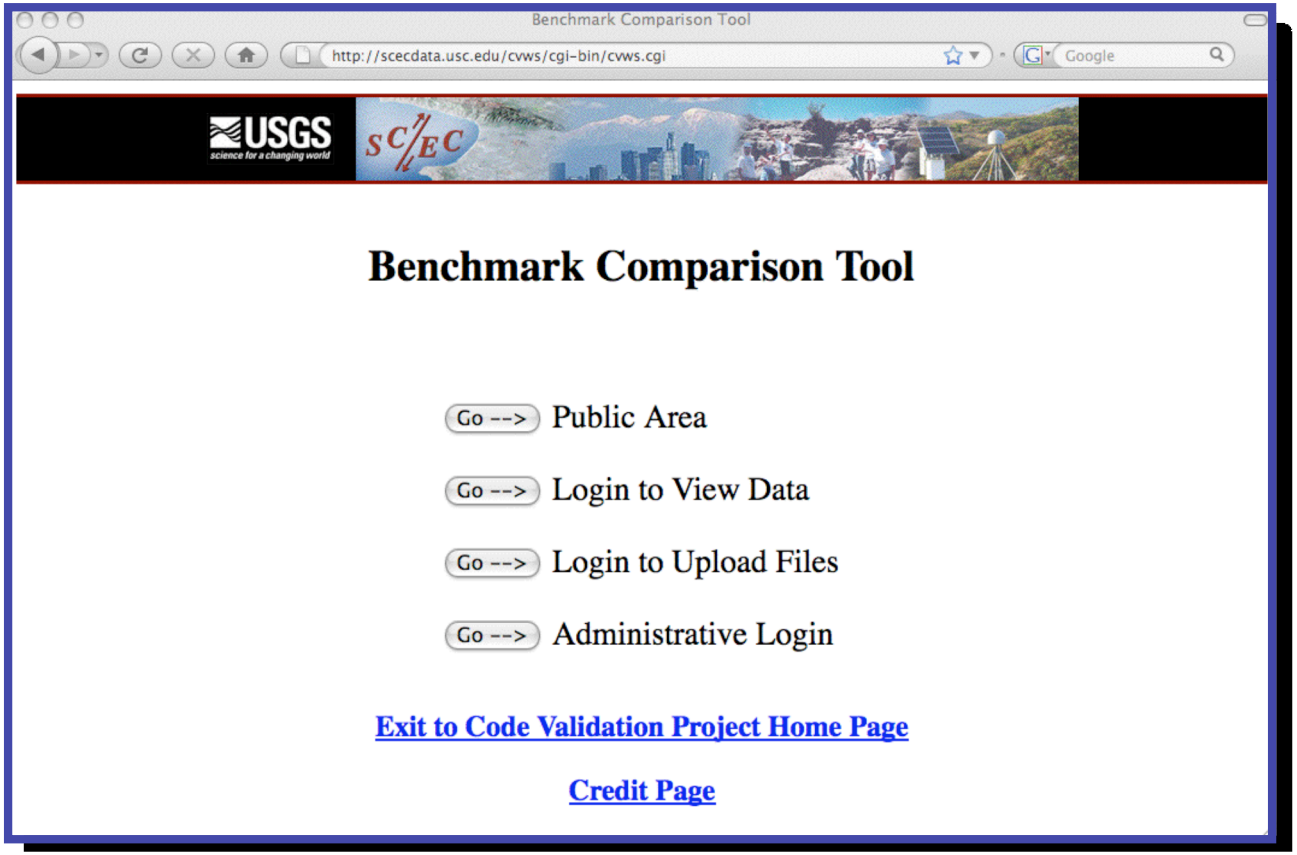
Participants

References

Credit Page

If you use our SCEC/USGS Code Verification Web Server (CVWS) or benchmarks in research you submit for publication, please cite our paper:

Harris, R.A., M. Barall, R. Archuleta, B. Aagaard, J.-P. Ampuero, H. Bhat, V. Cruz-Atienza, L. Dalguer, P. Dawson, S. Day, B. Duan, E. Dunham, G. Ely, Y. Kaneko, Y. Kase, N. Lapusta, Y. Liu, S. Ma, D. Oglesby, K. Olsen, A. Pitarka, S. Song, and E. Templeton, The SCEC/USGS Dynamic Earthquake Rupture Code Verification Exercise, *Seismological Research Letters*, vol. 80, no. 1, pages 119-126, doi:10.1785/gssrl.80.1.119, 2009.


Benchmark Comparison Tool
http://scecdata.usc.edu/cvws/cgi-bin/cvws.cgi
Google
USGS
science for a changing world
SCEC
Benchmark Comparison Tool
Go --> Public Area
Go --> Login to View Data
Go --> Login to Upload Files
Go --> Administrative Login
Exit to Code Validation Project Home Page
Credit Page

Goals for this workshop :

Some Items to discuss today

Extreme Ground Motion - Do our code comparisons look o.k.?

Code convergence testing - How are we doing?

Misfit Metrics - How should our group proceed?

Collaborations with other groups - How should we interact, teach, and learn?

2010 Fault Branch Benchmarks - What are the important issues?

Our SRL article

link available on our website

http://scecdata.usc.edu/cvws

Harris, R.A., M. Barall, R. Archuleta, B. Aagaard, J.-P. Ampuero,
H. Bhat, V. Cruz-Atienza, L. Dalguer, P. Dawson, S. Day,
B. Duan, E. Dunham, G. Ely, Y. Kaneko, Y. Kase, N. Lapusta, Y. Liu,
S. Ma, D. Oglesby, K. Olsen, A. Pitarka, S. Song, and E. Templeton,
The SCEC/USGS Dynamic Earthquake-Rupture Code Verification Exercise,
Seismological Research Letters, vol. 80, no. 1, 2009.

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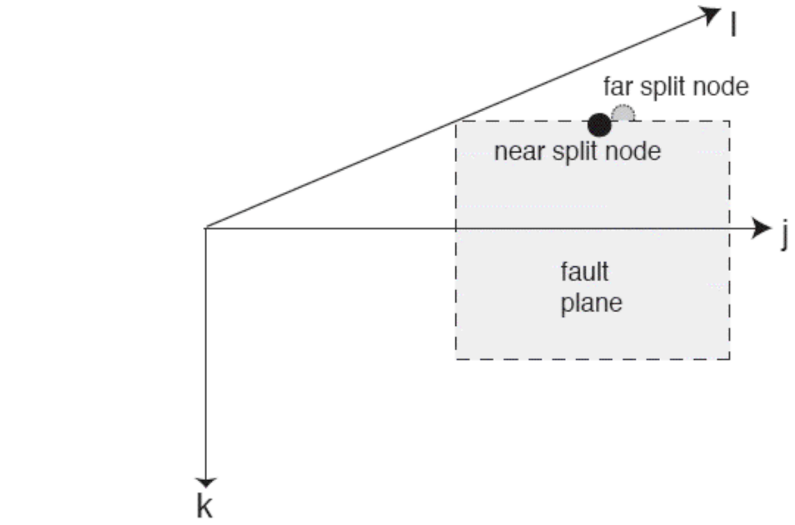

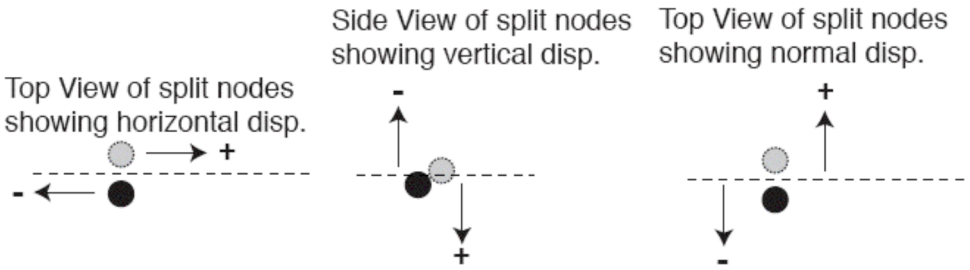

horizontal displacement of split node on far side of fault = $u(j,k,l^+)$
horizontal displacement of split node on near side of fault = $u(j,k,l^-)$
horizontal slip = $u(j,k,l^+) - u(j,k,l^-)$ (>0 for right-lateral strike-slip)

vertical displacement of split node on far side of fault = $v(j,k,l^+)$
vertical displacement of split node on near side of fault = $v(j,k,l^-)$
vertical slip = $v(j,k,l^+) - v(j,k,l^-)$ (>0 for downward slip)

normal displacement of split node on far side of fault = $w(j,k,l^+)$
normal displacement of split node on near side of fault = $w(j,k,l^-)$
normal slip = $w(j,k,l^+) - w(j,k,l^-)$ (>0 for extension)

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