Presentation for February 25, 2011
Cal Poly Pomona, Pomona, CA

February 2011 SCEC Rupture Dynamics Code Validation Workshop

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

Plans for this workshop

*See a quick overview of our group’s activities to date

*Learn about related SCEC Technical Activity Groups

*Learn about a new code

*Examine the results from the latest benchmarks

*Learn about fault intersections

*Plan our next steps

SCEC Rupture Dynamics Code Validation Workshop

Friday February 25, 2011
Kellogg West Conference Center, Cal Poly Pomona, Pomona, CA

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17:00	Adjourn	

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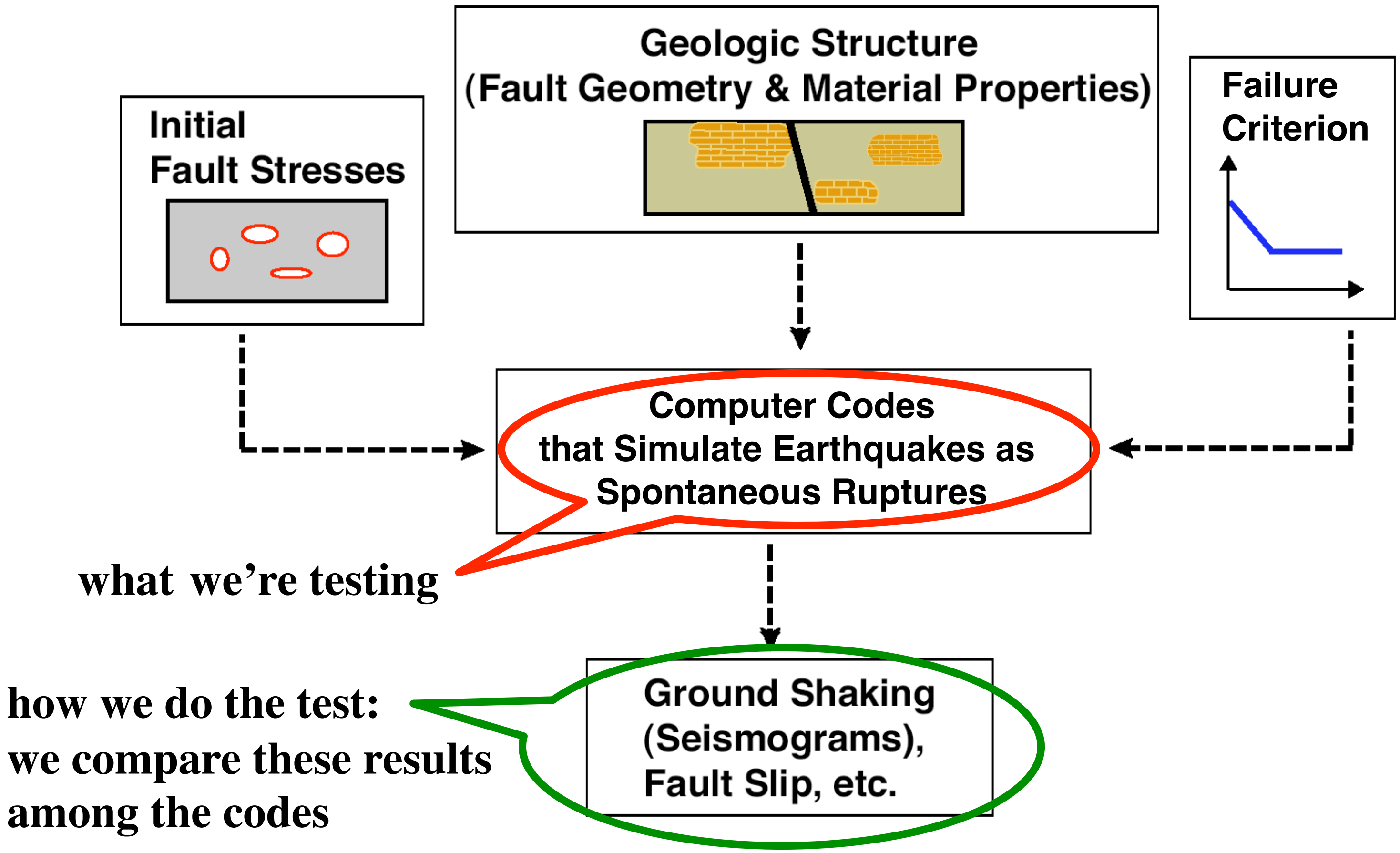
What our Group Does – Computer Code Testing



Please see our website http://scecdata.usc.edu/cvws

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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.

Overall Goal of our Code Verification Group

Compare the computational 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.

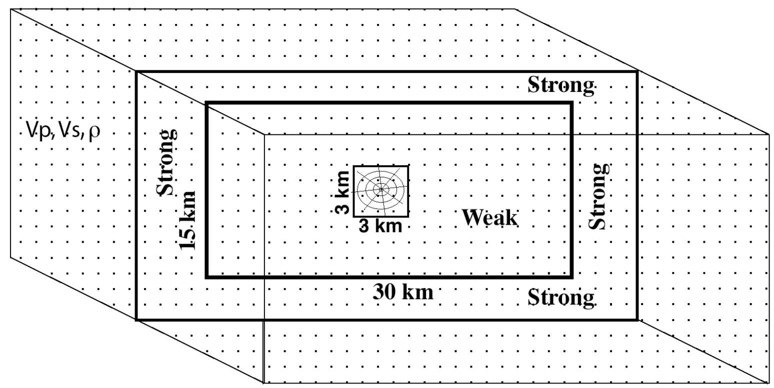
Funding

This project has been funded by the Southern California Earthquake Center, the U.S. Geological Survey, the U.S. Dept. of Energy, and the PG&E Company

Code Comparison Strategy

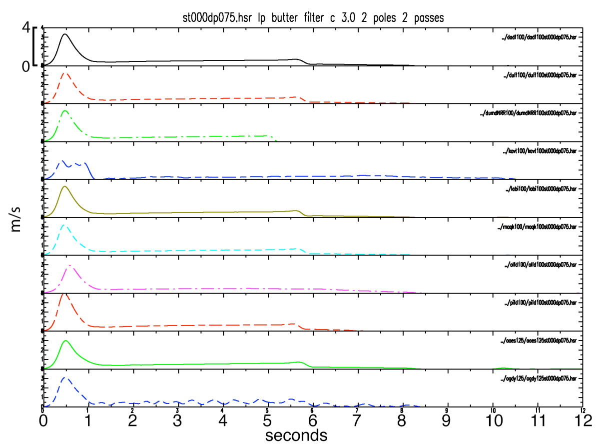
Start simply

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

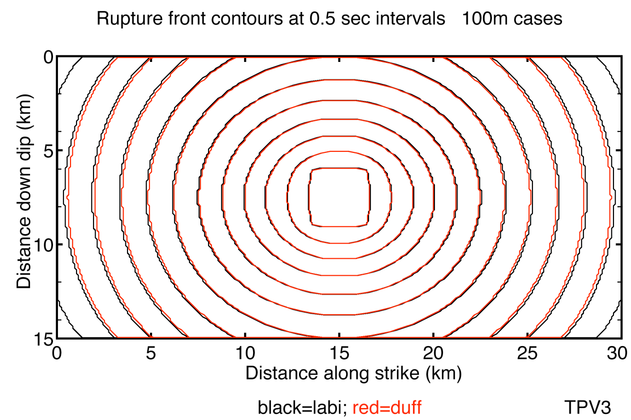


homogeneous initial stresses

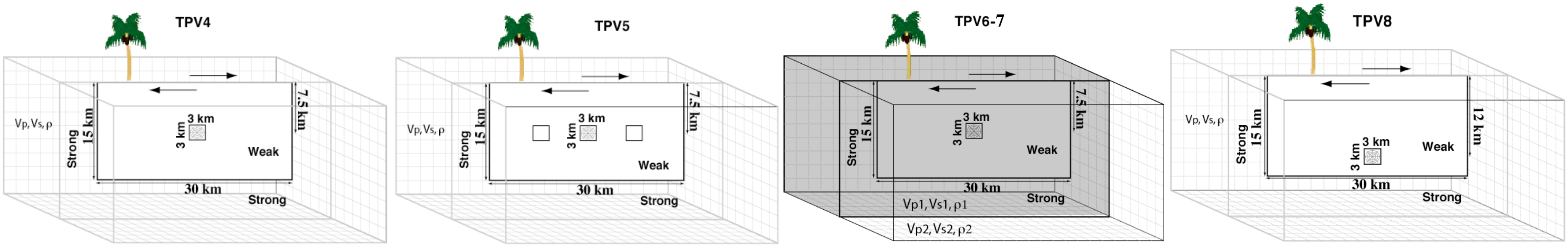
slip-weakening friction



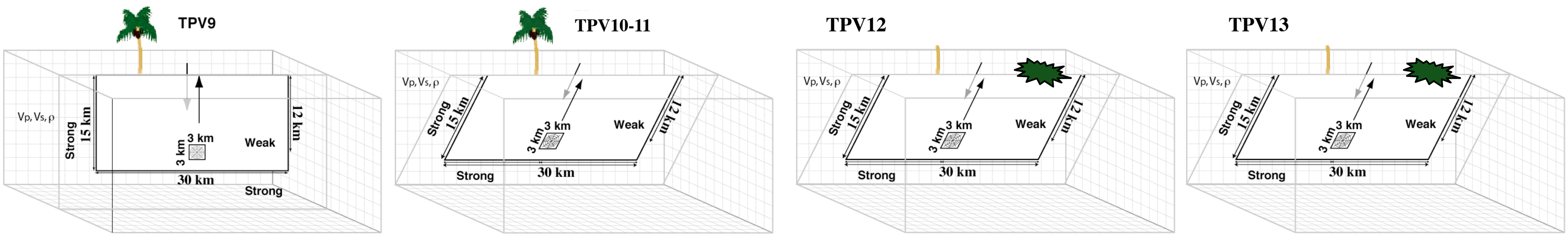
Some Results

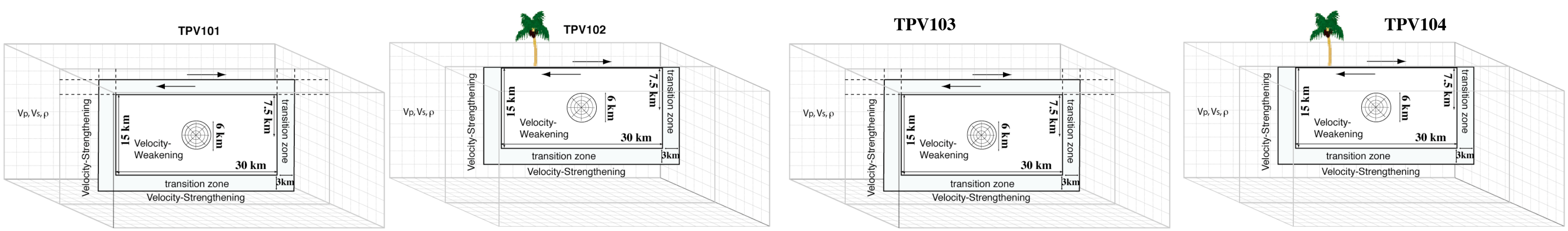


Code Comparison Benchmarks – Incrementally add complexity



Slip-weakening friction





Rate-state friction using an ageing law

Rate-state friction using a slip law with strong rate-weakening

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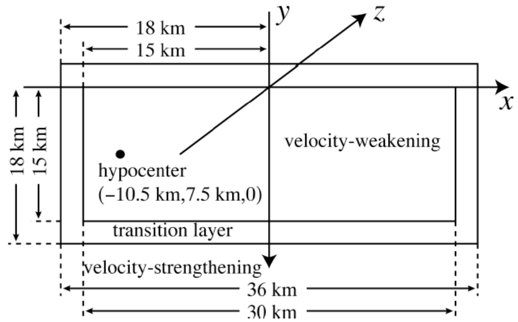
Code Comparison Strategy

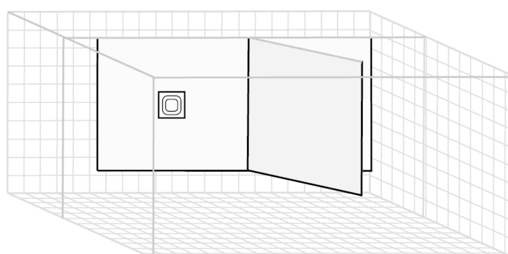
Incrementally adding complexity: friction, fault geometry

→ Rupture on a Vertical strike-slip fault set in a homogeneous materials elastic halfspace, **Thermal pressurization** with rate-state friction, slip-law, strong rate-weakening



TPV105-2D

→ Rupture on a **Branching** strike-slip fault set in a Homogeneous (materials) elastic halfspace, homogeneous initial stresses, Slip-weakening friction



TPV14-15

Recently Completed Work – ExGM project

New multi-author (TPV12-13 modelers) paper about to be submitted to SRL

Extreme Ground Motion Produced by an **Extreme Event**

Andrews et al., BSSA, 2007 Figure 7

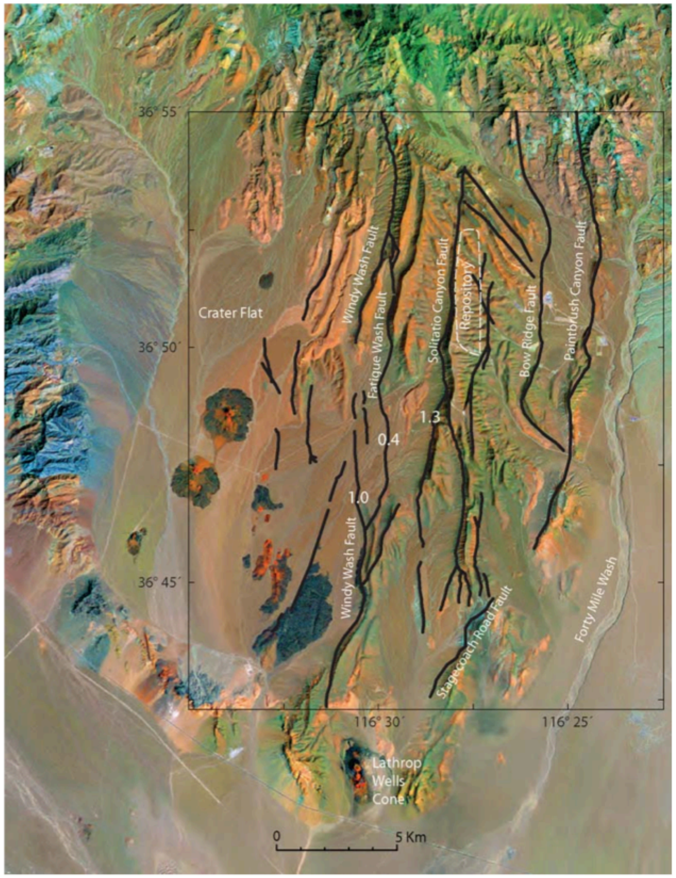
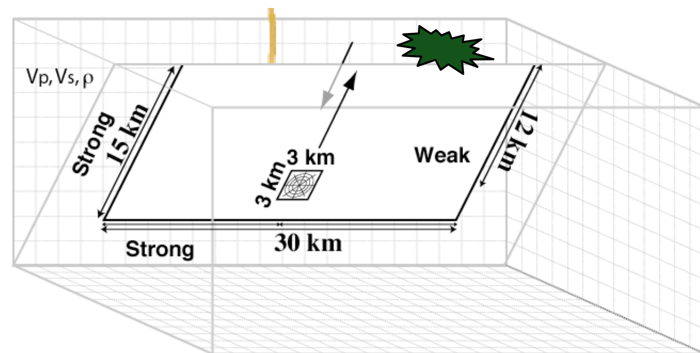


Figure 7. Color orthophoto map of the Yucca Mountain area with surface fault traces from figure 2 of Whitney, Taylor, and Menges, 2004 shown in the smaller boxed area. Numbers show locations of observed maximum-slip values of 1.3 m on the Solitario Canyon fault, 0.4 m on the Fatigue Wash fault, and 1.0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



Benchmarks TPV12 and 13

TPV12 = elastic
TPV13 = plastic

elastic / plastic

3D

elastic

Benchmark: tpv12 (The Problem, Version 12)

Users — Select Checked | Select All

	Name	Description	Action
☑	aagaard	Brad Aagaard - Finite Element - EqSim	Select
☑	barall	Michael Barall - Finite Element - FaultMod	Select
☑	duan	Benchun Duan - Finite Element - EQdyna	Select
☑	kaneko	Yoshihiro Kaneko - Spectral Element - SPECFEM3D	Select
☑	kase	Yuko Kase - Finite Difference	Select
☑	ma2	Shuo Ma - MAFE	Select
☑	oglesby	David Oglesby - Finite Element - DYNA3D	Select

Select Checked | Select All

plastic

Benchmark: tpv13 (The Problem, Version 13)

Users — Select Checked | Select All

	Name	Description	Action
☑	barall	Michael Barall - Finite Element - FaultMod	Select
☑	duan	Benchun Duan - Finite Element - EQdyna	Select
☑	kaneko	Yoshihiro Kaneko - Spectral Element - SPECFEM3D	Select
☑	ma2	Shuo Ma - MAFE	Select

Select Checked | Select All

2D

elastic

Benchmark: tpv12-2d (2D Version of TPV12)

Users — Select Checked | Select All

	Name	Description	Action
☑	andrews	Joe Andrews - 100 m	Select
☐	andrews.2	Joe Andrews - 50 m	Select
☐	andrews.3	Joe Andrews - 25 m	Select
☑	barall	Michael Barall - FaultMod - 100 m	Select
☐	barall.2	Michael Barall - FaultMod - 50 m	Select
☑	duan2	Benchun Duan - 2D Finite Element -100 m	Select
☐	duan2.2	Benchun Duan - 2D Finite Element - 12.5 m	Select
☐	dunham3	Eric Dunham - FDMAP (2D) 6.25 m	Select
☑	dunham3.2	Eric Dunham - FDMAP (2D) 100 m	Select
☐	dunham3.3	Eric Dunham - FDMAP (2D) 25 m	Select
☑	gabriel	Alice Gabriel - 2D Spectral Element - SEM2DPACK - 100m	Select
☐	ma2	Shuo Ma - MAFE (2D) - 50m	Select
☐	ma2.2	Shuo Ma - MAFE (2D) - 25m	Select
☑	ma2.3	Shuo Ma - MAFE (2D) - 100m	Select
☑	oglesby	David Oglesby - Finite Element - DYNA3D	Select

Select Checked | Select All

plastic

Benchmark: tpv13-2d (2D Version of TPV13)

Users — Select Checked | Select All

	Name	Description	Action
☑	andrews	Joe Andrews - 100 m	Select
☐	andrews.2	Joe Andrews - 50 m	Select
☐	andrews.3	Joe Andrews - 25 m	Select
☑	barall	Michael Barall - FaultMod - 100 m	Select
☐	barall.2	Michael Barall - FaultMod - 50 m	Select
☑	duan2	Benchun Duan - 2D Finite Element - 100 m	Select
☐	duan2.2	Benchun Duan - 2D Finite Element - 12.5 m	Select
☐	duan2.3	Benchun Duan - 2D Finite Element - 3.125 m	Select
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☐	ma2.3	Shuo Ma - MAFE (2D) - 25m	Select

Select Checked | Select All

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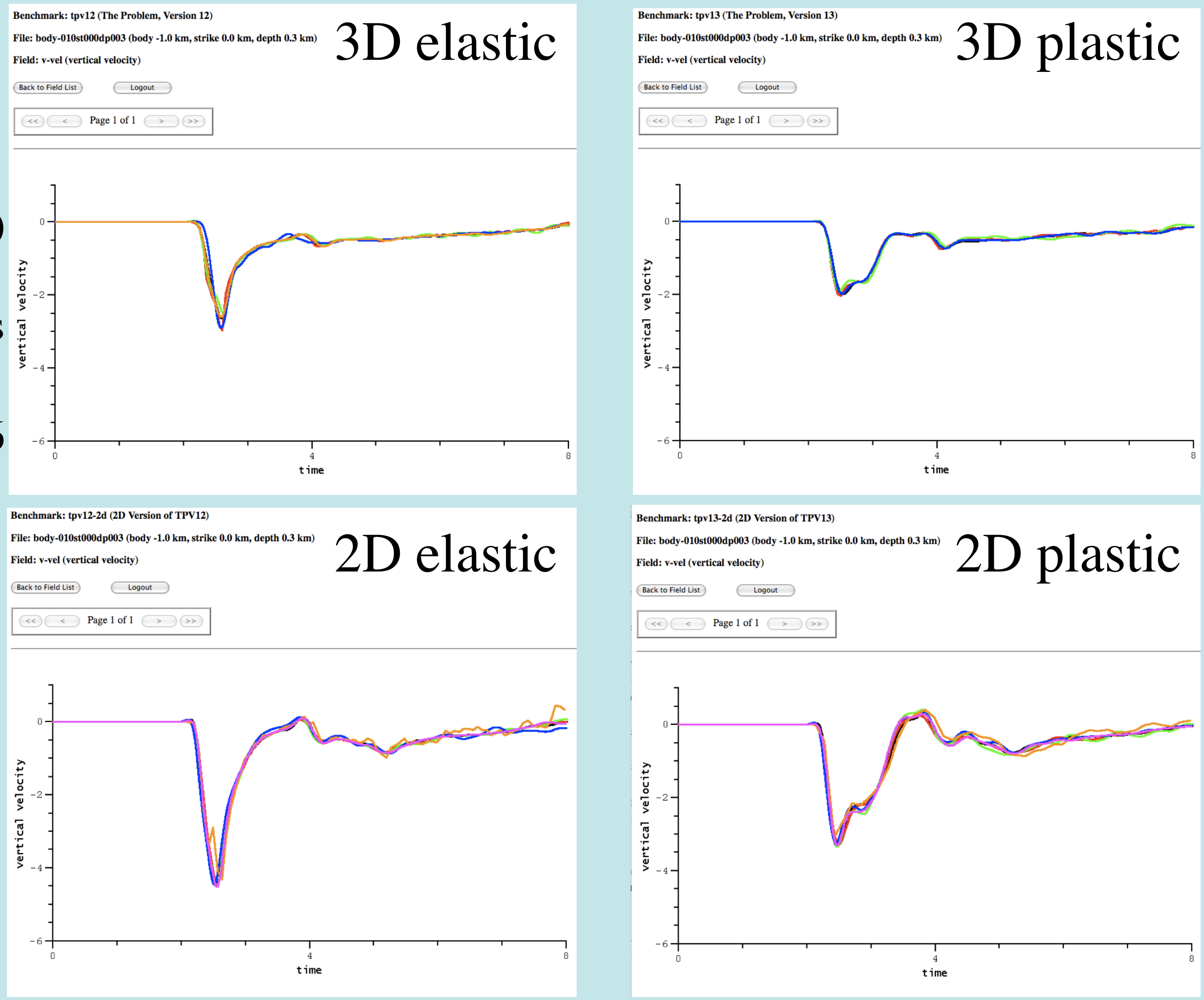
Vertical Velocity at Station 1-km from fault, 0.3 km-depth, footwall side of the fault

(3 Hz filter)

0

m/s

-6



0 seconds 8

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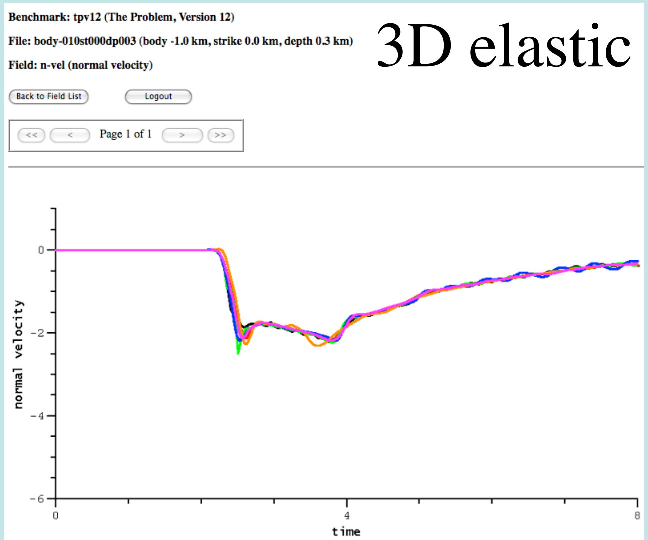
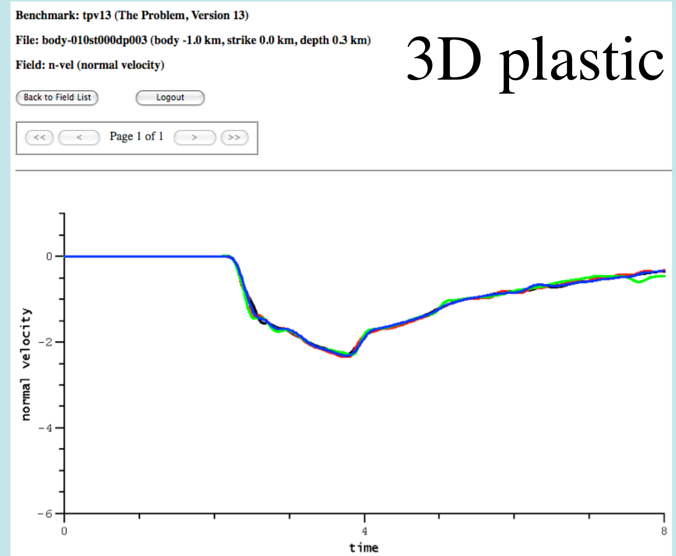
S O U T H E R N   C A L I F O R N I A   E A R T H Q U A K E   C E N T E R

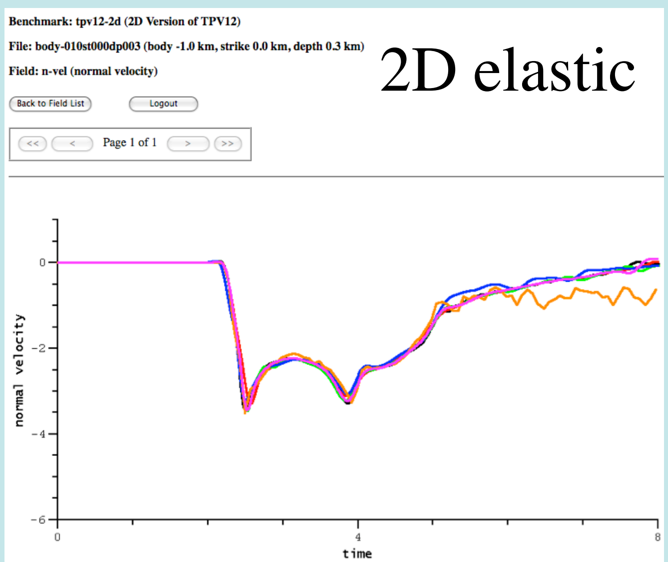
Horizontal
(Fault-trace
Perpendicular)
Velocity
at
Station
1-km
from fault,
0.3 km-depth,
footwall side
of the fault

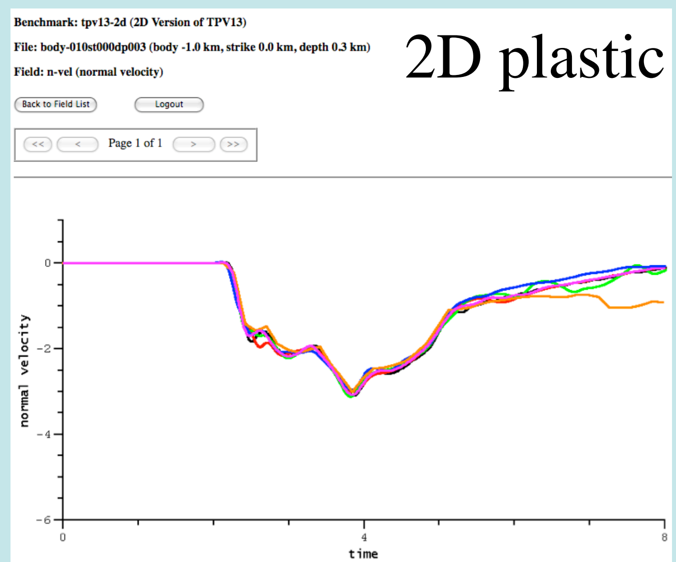
(3 Hz filter)

0
m/s
-6









0 seconds 8

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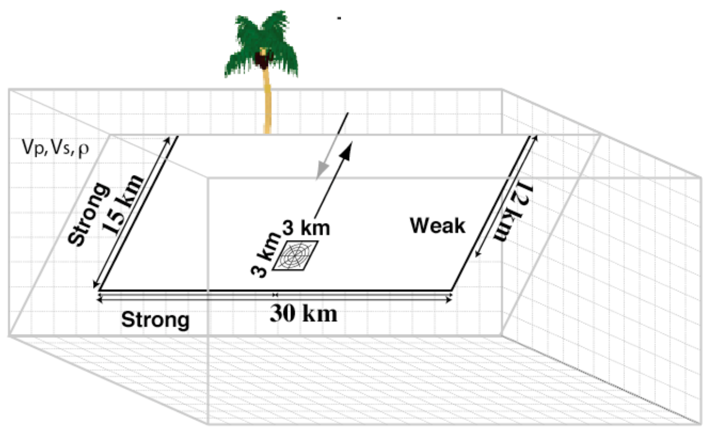
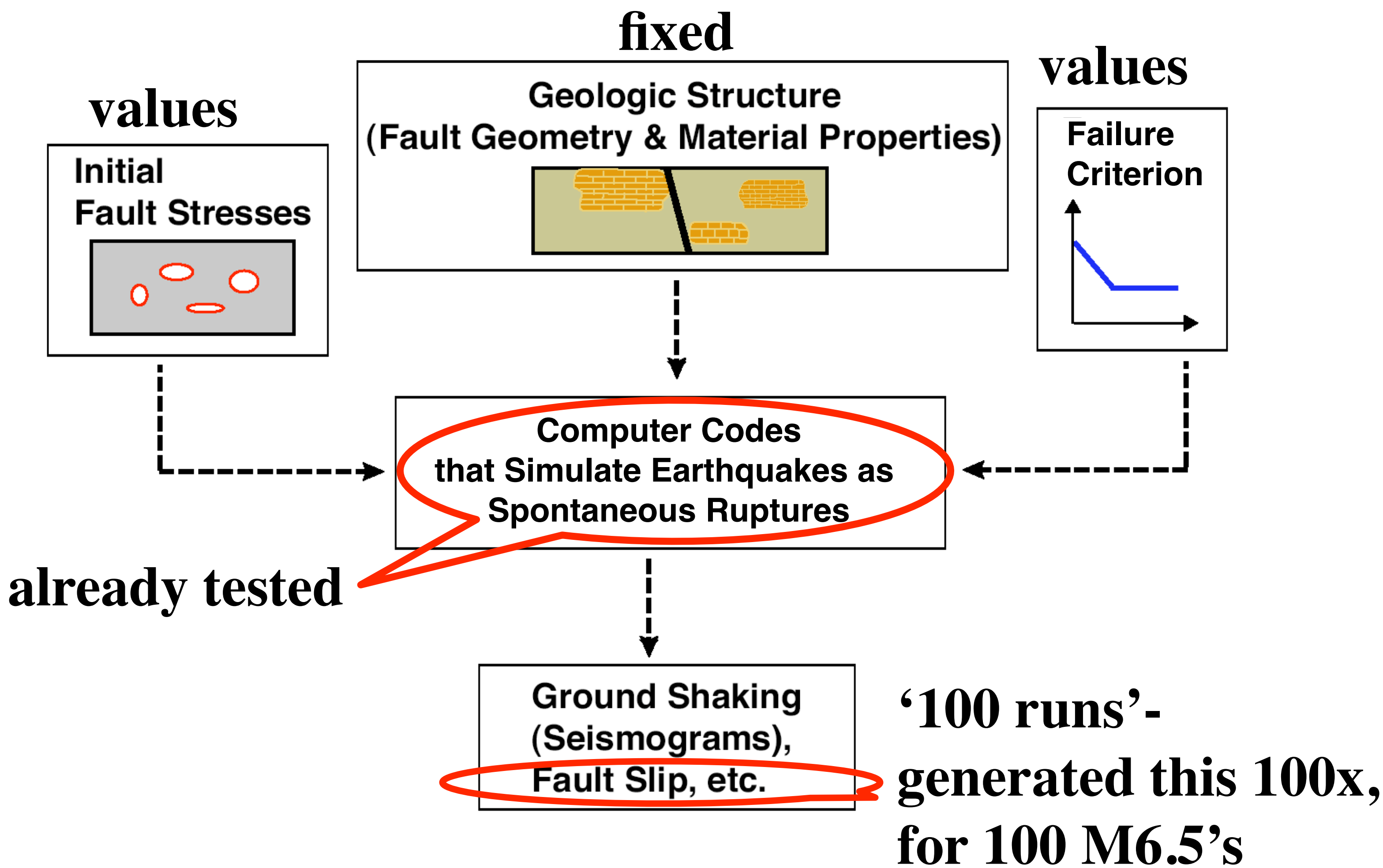
‘100 Runs’ Exercise

Regular ground motion produced by **regular M6.5’s**



used spontaneous rupture simulations
to produce ‘100’ **M6.5 sources**

Work done for '100 runs' – Assigned 100 different 'values'

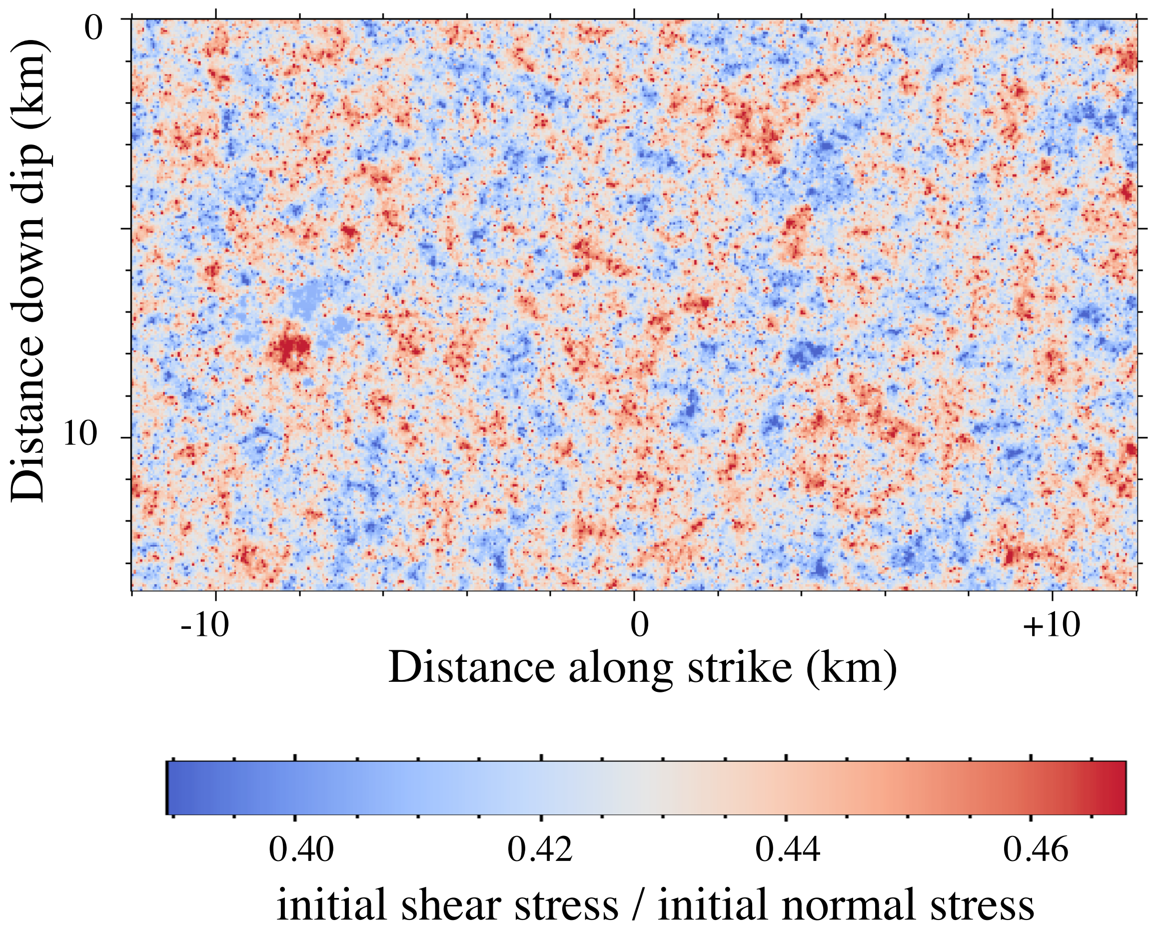


Developed Hybrid Initial-Conditions Method and Received Committee Approval

<u>Features</u>:

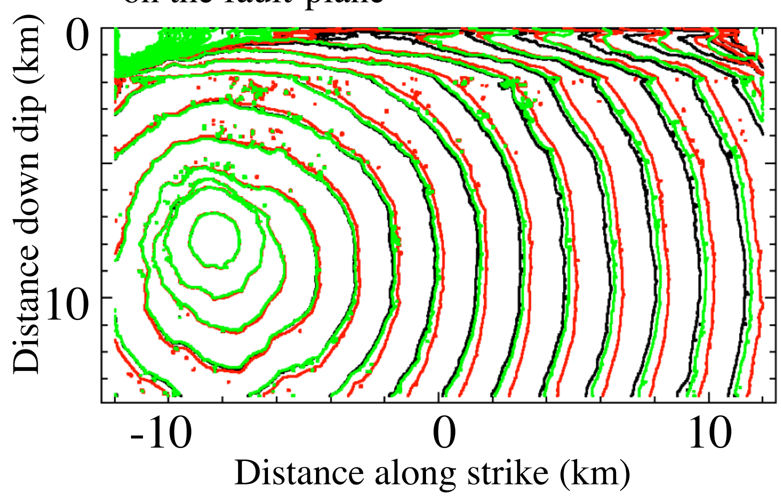
*Gradual Forced Nucleation
*Slip-weakening failure criterion
*Rigid barriers at fault edges
*24 km x 13.6 km fault plane with constant dip
*Initial normal stress distribution:
  depth dependent
*Initial shear stress distribution:
 1-point statistics = Levy distribution
 2-point statistics = von Karman power spectrum
*M6.5
*1-D 3-layer shear-modulus (and velocity) model
*Elastic behavior

One Initial Stress-Conditions Realization from the '100 Runs' Exercise

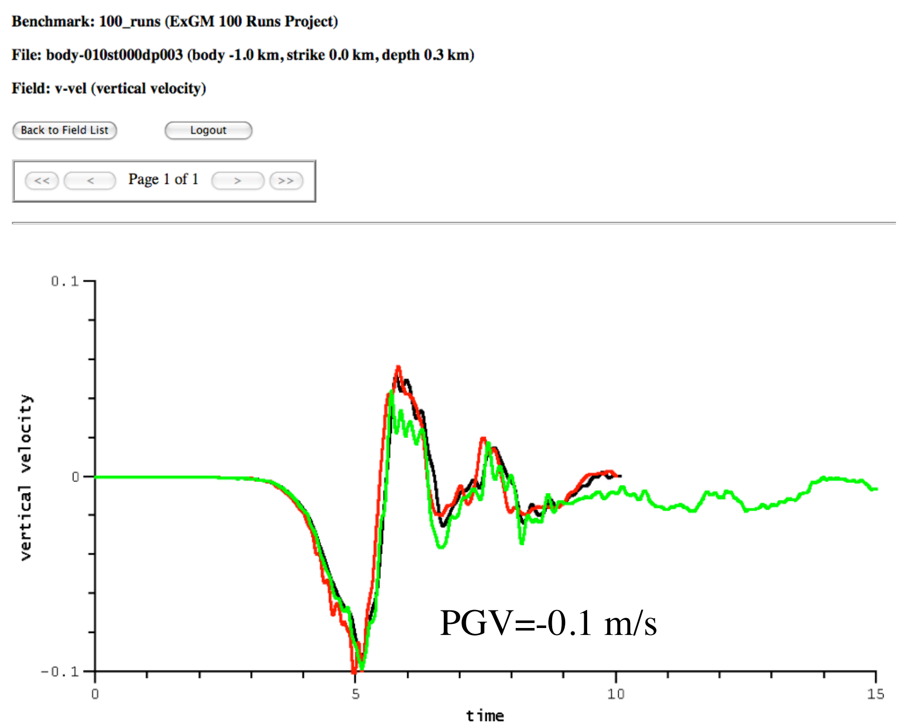


Rupture front contour plot and ground motion from this one realization

Rupture-front contours (0.5 sec intervals) on the fault-plane



Unfiltered motion at YM station
Vertical-velocity (0.1 to -0.1 m/s) vs. time (0-15 secs)



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