TPV5

Part I. SOME DEFINITIONS:

Displacement = motion relative to its initial position. Since all of the calculations start with this position at zero, Displacement = Absolute motion.

Velocity = Absolute motion with respect to time.

Slip = Relative motion across the fault plane (e.g., for split nodes).

Slip-Rate = Relative motion across the fault plane (e.g., for split nodes), with respect to time.

Rupture Front = Location of the leading edge of the rupture. Here we define this region as where (and when) slip-rate first changes from zero to greater than 1 mm/s.

Part II. MODEL DESCRIPTION - THE PROBLEM, VERSION 5 (August 4, 2005)

Please note that this is **THE 3D** model that we are investigating for TPV5. Although variations are of course interesting, our goal is to follow the description precisely. If the code you're using will not run with Version 5's parameters, please contact Ruth ASAP. *Please feel free to point out to me as soon as possible, if I have omitted some critical details that you and others may need to run the simulations, or if there are any mistakes in the descriptions/requests.*
Note: All units are in MKS.

1) Material properties are homogeneous throughout the medium and set to:
vp=6000. m/s
vs=3464. m/s
density=2670. kg/m3

2) The fault within the three-dimensional medium is a vertical right-lateral strike-slip planar fault that resides in a **<u>halfspace</u>**. The fault reaches the Earth's surface.

3) The rupture is allowed within a rectangular area that is 30000 m long x 15000 m deep.

4) The bottom boundary of the allowed 30000m x 15000m rupture area is defined by a strength barrier*.

5) The right and left ends of the allowed 30000 m x 15000 m rupture area are defined by a strength barrier*.

6) The nucleation point is centered both along-dip and along-strike of the 30000m x 15000m rupture area, on the fault plane, at 15000m along-strike and 7500m depth.

7) Nucleation occurs because the initial shear stress in a 3000 m x 3000 m square nucleation patch is set to be higher than the initial static yield stress in that patch. Failure occurs everywhere on the fault plane, including in the nucleation patch, following a linear slip-weakening fracture criterion. The square patch has a side-length of 3000m. The square nucleation patch is centered on the nucleation point. <u>The initial shear stress in this square area is equal to 81.6 MPa</u>.

Within the entire 3000 m x 3000 m nucleation patch, at zero seconds:
Static coefficient of friction = 0.677
Dynamic coefficient of friction = 0.525
Initial shear stress in the along-strike-direction (at t = 0) = 81.6 MPa
Initial shear stress in the along-dip direction (at t = 0) = 0 MPa
Initial normal stress (at t = 0) = 120 Mpa
Initial static yield stress (at t = 0) = 0.677 x 120 MPa = 81.24 MPa
Initial dynamic friction stress (at t = 0) = 0.525 x 120 MPa = 63.00 Mpa
Initial stress drop (at t = 0) = 81.6 MPa – (0.525 x 120 MPa) = 18.6 Mpa
Slip-weakening critical distance = 0.40 m

TPV5 Description, continued

8) Halfway between the nucleation patch's center and the **right** end of the fault, there is a square patch of lower initial shear stress. The square patch has a side-length of 3000m. This patch has the same depth as the nucleation patch and is centered on a point 7.5 km along-strike distance from the center of the nucleation patch, so that the new patch's center is at along-strike, along-depth coordinates (+7.5, 7.5).
Friction is governed by the linear slip-weakening fracture criterion.
The initial shear stress in this square area is equal to **62.0 MPa.**

Within the entire 3000 m x 3000 m right patch, at zero seconds:
Static coefficient of friction = 0.677
Dynamic coefficient of friction = 0.525
Initial shear stress in the along-strike-direction (at t = 0) = 62.0 MPa
Initial shear stress in the along-dip direction (at t = 0) = 0 MPa
Initial normal stress (at t = 0) = 120 MPa
Initial static yield stress (at t = 0) = 0.677 x 120 MPa = 81.24 MPa
Initial dynamic friction stress (at t = 0) = 0.525 x 120 MPa = 63.00 MPa
Initial stress drop (at t = 0) = 62.0 MPa – (0.525 x 120 MPa) = -1.0 MPa
Slip-weakening critical distance = 0.40 m

9) Halfway between the nucleation patch's center and the **left** end of the fault, there is a square patch of higher initial shear stress. The square patch has a side-length of 3000m. This patch has the same depth as the nucleation patch and is centered on a point 7.5 km along-strike distance from the center of the nucleation patch, so that the new patch's center is at along-strike, along-depth coordinates (-7.5, 7.5).
Friction is governed by the linear slip-weakening fracture criterion.
The initial shear stress in this square area is equal to **78.0 MPa**.

Within the entire 3000 m x 3000 left patch, at zero seconds:
Static coefficient of friction = 0.677
Dynamic coefficient of friction = 0.525
Initial shear stress in the along-strike-direction (at t = 0) = 78.0 MPa
Initial shear stress in the along-dip direction (at t = 0) = 0 MPa
Initial normal stress (at t = 0) = 120 MPa
Initial static yield stress (at t = 0) = 0.677 x 120 MPa = 81.24 MPa
Initial dynamic friction stress (at t = 0) = 0.525 x 120 MPa = 63.00 MPa
Initial stress drop (at t = 0) = 78.0 MPa – (0.525 x 120 MPa) = 15.0 MPa
Slip-weakening critical distance = 0.40 m

TPV5 Description, continued

10) Outside of the nucleation patch, and the right and left patches, friction is governed by the linear slip-weakening fracture criterion, but the initial shear stress is once again different (but the same as for TPV3, **70 MPa**).

Within the 30000 m x 15000 m faulting area, but outside of the 3000 m x 3000 m nucleation patch, right patch, and left patch:

Static coefficient of friction = μ_s = 0.677
Dynamic coefficient of friction = μ_d = 0.525
Initial shear stress in the along-strike-direction (at t = 0) = 70 MPa
Initial shear stress in the along-dip-direction (at t = 0) = 0 MPa
Initial normal stress (at t = 0) = 120 MPa
Initial static yield stress (at t = 0) = 0.677 x 120 MPa = 81.24 MPa
Initial dynamic friction stress (at t = 0) = 0.525 x 120 MPa = 63.00 MPa
Initial stress drop (at t = 0) = 70 MPa – (0.525 x 120 MPa) = 7.00 MPa
Slip-weakening critical distance = d_0 = 0.40 m

11) *On the fault plane, but outside of the 30000 m x 15000 m faulting area, there is a strength barrier.
This is accomplished by setting the static coefficient of friction to the high value of 10000. so that the rupture is not able to propagate on the fault plane beyond 30000 m x 15000 m:

Static coefficient of friction = μ_s = 10000.
Dynamic coefficient of friction = μ_d = 0.525
Initial shear stress in the along-strike direction (at t = 0) = 70 MPa
Initial shear stress in the along-dip direction (at t = 0) = 0 MPa
Initial normal stress (at t = 0) = 120 MPa
Slip-weakening critical distance = d_0 = 0.40 m

End of TPV5 Description

<u>Helpful tip</u>:

The website file "Diagram showing locations of on-fault stations, for TPV5"
is a sketch of the TPV5 benchmark.

Just note that the figures in the above file only show the on-fault stations, and that you'll also need to also look at the website file "Diagram showing locations of off-fault stations, for TPV5" to see the off-fault station locations.

Part III. RESULTS TO PROVIDE

Note 1.

The requested output files are:

1) A rupture- time contour plot

2) *Time-series files in ascii format*

Please provide the results in raw form (no filtering). Don't worry about oscillations.

Note 2.

The requested stations are located both on and off the fault plane.

Note 3.

Computations should be run using the following element-size/node-spacing
(please provide a complete output-file set for each of these):

100m

If the code you are using cannot run with 100m spacing, due to memory/processor constraints, please run using 150m instead and please note that you used 150m in the files and accompanying information that you send me.

Part III. *RESULTS TO PROVIDE, CONTINUED:*

1) A 2D contour plot of the rupture front, as defined by the locations where (and when) fault slip-rate first changes from zero to greater than 1 mm/s, contoured at 0.5 second intervals. This plot information should be in ascii format
(**see website directions**
"Required file formats, and instructions for uploading files, for TPV5"
for specific formatting information)

2) ASCII Time Series Files
(**see website directions**
"Required file formats, and instructions for uploading files, for TPV5"
for specific formatting information)

Please provide the time series results
for the times **0.0 to 12.0 seconds after nucleation**.

There are stations located on the fault. These are shown in the website file
"Diagram showing locations of on-fault stations, for TPV5"

There are stations located off the fault. These are shown in the website file
"Diagram showing locations of off-fault stations, for TPV5"

Part IV. *TIME-SERIES FILE FORMAT AND FILE NAMING CONVENTION*

see website directions
"Required file formats, and instructions for uploading files, for TPV5"

Part V. *SIGN-CONVENTIONS*

see website file
"Diagram showing coordinate system and sign conventions, for TPV5"