TPV16 and TPV17
Heterogeneous Initial Stress Benchmarks

November 24, 2011

These benchmarks use heterogeneous initial stress conditions, which are randomly generated.

In addition to this written description, you will need the input files which give the initial stresses and friction parameters for every point on the fault surface.
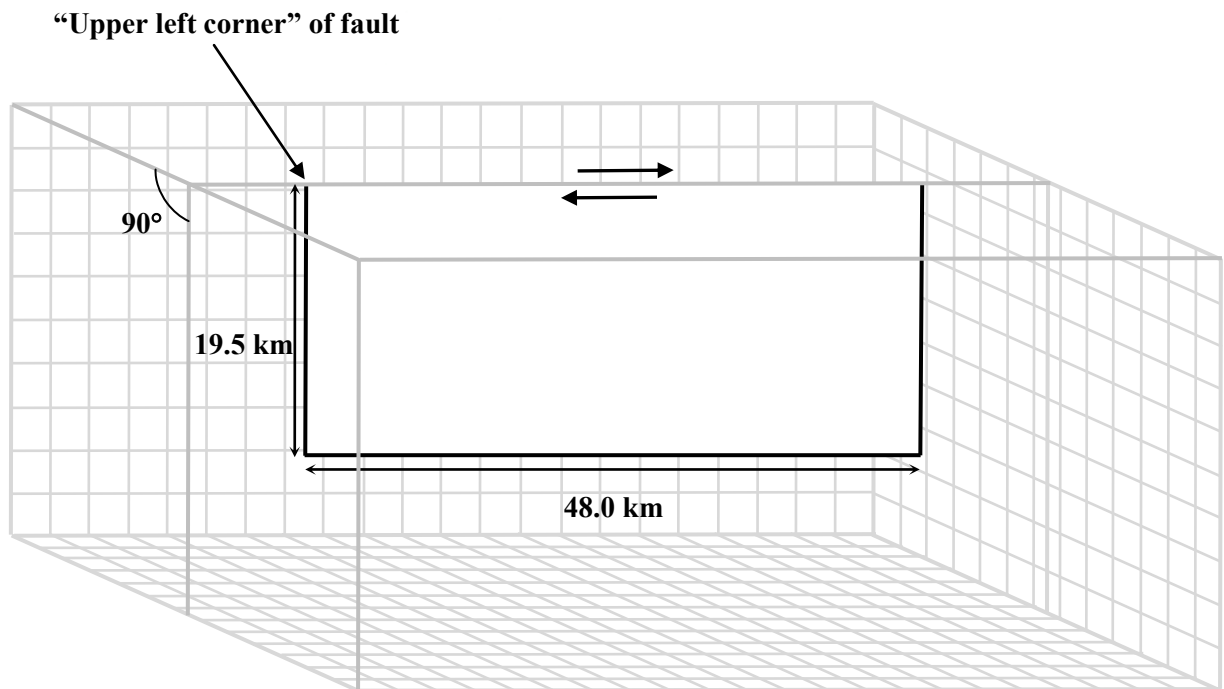
The benchmarks use a vertical strike-slip fault set in an elastic halfspace.

Benchmarks TPV16 and TPV17 are identical except for the initial stress conditions. Each benchmark has its own input file, which gives the initial stress conditions for that benchmark.

Contents

1. Fault Geometry

"Upper left corner" of fault

90°

19.5 km

48.0 km

The model volume is an elastic half-space.

The fault is a vertical, planar, right-lateral, strike-slip fault. The fault reaches the earth's surface.

Rupture is allowed within a rectangular area measuring 48000 m along-strike and 19500 m down-dip. A node which lies exactly on the border of the 48000 m × 19500 m rectangle is considered to be inside the rectangle, and so should be permitted to slip.

The portions of the fault below, to the left of, and to the right of the 48000 m × 19500 m rectangle are a strength barrier, within which the fault is not allowed to rupture.

Note: For TPV16-17, we expect the rupture to stop spontaneously before it reaches the edges of the fault.

2. Material Properties

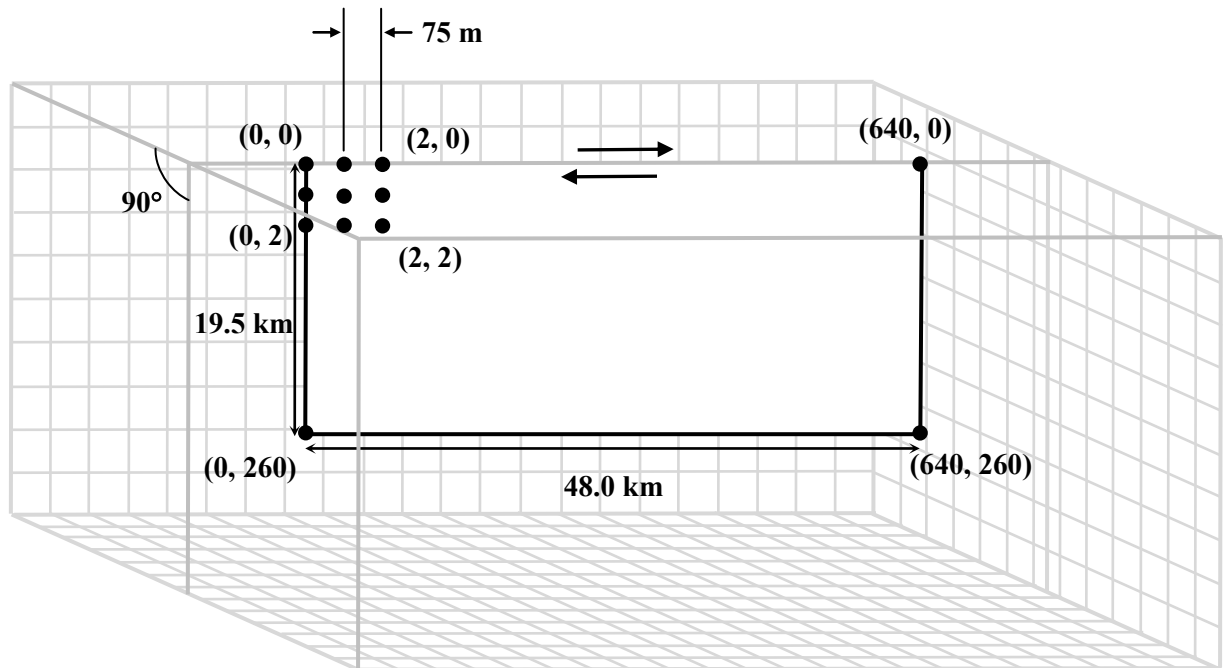We use uniform material properties as shown below.

Material Properties		
Density	V_S	V_P
2670.0 kg/m^3	3464.0 m/s	6000.0 m/s

Rock properties are taken to be linear elastic throughout the 3D model volume.

3. Node Spacing and Labeling

Node spacing is 75 meters along-strike, and 75 meters along-dip.

The fault surface has 641 nodes along-strike, and 261 nodes along-dip, making for a total of 167301 nodes.

Each node is labeled by a pair of integer coordinates (nx, nz). The coordinate nx is an integer ranging from 0 at the left edge of the fault to 640 at the right edge. The coordinate nz is an integer ranging from 0 at the top of the fault to 260 at the bottom. The node at the upper left corner of the fault has coordinates $(0, 0)$.

The input file contains the friction parameters and initial stresses for each node on the fault surface. The format of the input file is described later.

4. Linear Slip-Weakening Friction Law

We use a linear slip-weakening friction law. Each node on the fault surface is assigned the following five friction parameters:

Friction Parameters		
Symbol	*Parameter*	*Unit*
μ_s	Static coefficient of friction.	Dimensionless
μ_d	Dynamic coefficient of friction.	Dimensionless
D_c	Slip-weakening critical distance.	Meter
C	Cohesion.	Pascal
T	Time of forced rupture.	Second

In addition, each node on the fault surface is assigned initial shear and normal stresses:

Initial Stresses		
Symbol	*Parameter*	*Unit*
τ_0	Initial shear stress, at time $t = 0$.	Pascal
σ_0	Initial normal stress, at time $t = 0$.	Pascal

When the fault is sliding, the shear stress τ at a given point on the fault is related to the normal stress σ by

$$\tau = C + \mu \times \max(0, \sigma)$$

The term $\max(0, \sigma)$ implies that the fault is not permitted to open, and the friction is not allowed to drop below the cohesion, even if normal stress σ becomes negative. For TPV16-17, we do not expect the normal stress to become negative.

The time-varying coefficient of friction μ is given by:

$$\mu = \begin{cases} \mu_s + (\mu_d - \mu_s) \times D/D_c, & \text{if } D < D_c \text{ and } t < T \\ \\ \mu_d, & \text{if } D \geq D_c \text{ or } t \geq T \end{cases}$$

where D is the total distance the node has slipped and t is the time since the start of the earthquake.

The distance D that the node has slipped is path-integrated. For example, if the node slips 0.4 m in one direction and then 0.1 m in the opposite direction, the value of D is 0.5 m (and not 0.3 m).

The time of forced rupture T is used to nucleate the rupture, as described in the next section. At time $t = T$, the node is forced to rupture by setting the coefficient of friction μ equal to the dynamic coefficient of friction μ_d. If a given node does not undergo forced rupture, then the value of T is 1.0E9.

5. Nucleation

The nucleation method is built in to the input file, so you don't need to do anything special to nucleate the rupture.

For TPV16-17, we are using a new two-stage nucleation method. Nucleation is achieved by adjusting the friction parameters T and D_c in the vicinity of the hypocenter.

The first stage is a circular zone of forced rupture which surrounds the hypocenter. Its radius is approximately 1 km (the exact radius is determined as part of the stochastic method that generates the initial stresses). At the hypocenter, $T = 0$. The value of T then increases with distance from the hypocenter, which creates an expanding circular region of forced rupture. The forced rupture expands at a speed of $0.7 * V_S$ for 80% of the way, and then $0.35 * V_S$ for the remaining 20% of the way to the edge of the zone. Outside the zone of forced rupture, T is equal to 1.0E9, which means that forced rupture does not occur outside the zone.

The second stage is a circular zone of reduced D_c which surrounds the hypocenter. Its radius is approximately 4 km (the exact radius is determined as part of the stochastic method that generates the initial stresses). In the innermost 10% of the zone, D_c equals 0.04 m. The value of D_c then increases linearly with distance from the hypocenter, and reaches its final value of 0.4 m at the edge of the zone. Outside the zone, D_c equals 0.4 m. The effect is to create a circular region of reduced fracture energy surrounding the hypocenter, which helps the rupture to expand during the early part of the simulation.

6. Running Time

Run the simulation for 15 seconds.

7. Input File Format

Each input file represents one realization of heterogeneous initial stress.

The following example shows the first seven lines of an input file. (Each long line in the file is printed here on three lines, to make it fit on the page. It may help to look at an actual input file.)

```
200      3
640    260    4.800000E+04    1.950000E+04
364    117    2.730000E+04    8.775000E+03    1.127366E+03    1.127366E+03
  0      0    0.000000E+00    0.000000E+00    6.000000E+07    2.509795E+07
               0.000000E+00    4.182992E-01    0.000000E+00    6.770000E-01
               3.730000E-01    4.000000E-01    4.000000E+06    1.000000E+09
  1      0    7.500000E+01    0.000000E+00    6.000000E+07    2.523141E+07
               0.000000E+00    4.205235E-01    0.000000E+00    6.770000E-01
               3.730000E-01    4.000000E-01    4.000000E+06    1.000000E+09
  2      0    1.500000E+02    0.000000E+00    6.000000E+07    2.524198E+07
               0.000000E+00    4.206997E-01    0.000000E+00    6.770000E-01
               3.730000E-01    4.000000E-01    4.000000E+06    1.000000E+09
  3      0    2.250000E+02    0.000000E+00    6.000000E+07    2.512238E+07
               0.000000E+00    4.187063E-01    0.000000E+00    6.770000E-01
               3.730000E-01    4.000000E-01    4.000000E+06    1.000000E+09
```

The first three lines are a header, and the remaining lines contain data. The header contains information about the realization, but is not actually needed to run the simulation. In your code, you may wish to skip over the three-line header, and just read the data.

Line 1: Identifies the random number seed used to generate the initial stresses. The fields are:

- Realization number, an integer.

- Sub-realization number, an integer.

Line 2: Contains the total size of the fault surface. The fields are:

- Number of cells along-strike (this is one less than the number of nodes along-strike). For TPV16-17, it is 640.

- Number of cells down-dip (this is one less than the number of nodes down-dip). For TPV16-17, it is 260.

- Size of fault surface along-strike, in meters. For TPV16-17, it is 48000.

- Size of fault surface down-dip, in meters. For TPV16-17, it is 19500.

Line 3: Contains the hypocenter location. The fields are:

- Hypocenter location along-strike, measured in cells (counting from 0 at the left edge of the fault surface). It is an integer.

- Hypocenter location down-dip, measured in cells (counting from 0 at the earth's surface). It is an integer.

- Hypocenter location along-strike, in meters, from the left edge of the fault surface.

- Hypocenter location down-dip, in meters, from the earth's surface.

- Radius of the zone of forced rupture, along-strike, in meters.

- Radius of the zone of forced rupture, along-dip, in meters.

Remaining lines give the initial stresses and friction parameters for each node on the fault surface. For TPV16-17, there are 167301 of these lines. The fields on each line are:

- Node location along-strike, measured in cells (counting from 0 at the left edge of the fault surface). This is coordinate nx. It is an integer.

- Node location down-dip, measured in cells (counting from 0 at the earth's surface). This is coordinate nz. It is an integer.

- Node location along-strike, in meters, from the left edge of the fault surface.

- Node location down-dip, in meters, from the earth's surface.

- Initial normal stress, in Pascal. Positive values denote compression. This is σ_0. For TPV16-17, this equals 60.0 MPa.

- Initial shear stress along-strike, in Pascal. The sign convention is that positive values denote stresses that tend to cause right-lateral slip. For TPV16-17, this is τ_0.

- Initial shear stress along-dip, in Pascal. The sign convention is that positive values denote stresses that tend to cause downward slip (the far side of the fault moving downward relative to the near side). For TPV16-17, this is zero.

- Ratio of initial shear stress along-strike divided by initial normal stress. For TPV16-17, this is τ_0/σ_0.

- Ratio of initial shear stress along-dip divided by initial normal stress. For TPV16-17, this is zero.

- Static coefficient of friction. This is μ_s. For TPV16-17 this is 0.677, except that the value is increased at points where the initial shear stress is very high.

- Dynamic coefficient of friction. This is μ_d. For TPV16-17, this is 0.373.

- Slip-weakening critical distance, in meters. This is D_c. For TPV16-17, this is 0.40 m, except in the vicinity of the hypocenter where it is reduced.

- Cohesion, in Pascal. This is C. For TPV16-17, the cohesion is zero except in the upper 3 km where it tapers up to 4.0 MPa at the earth's surface.

- Time of forced rupture, in seconds. This is T. For nodes outside the zone of forced rupture, this value is 1.0E+9, indicating that the node does not undergo forced rupture. For nodes inside the zone, this is the time at which the friction is forced to drop down to the dynamic sliding friction (e.g., by reducing the static coefficient of friction to equal the dynamic coefficient of friction). At the hypocenter, the time is zero.

Nodes are listed in a specific order. The node in the upper left corner of the fault surface is listed first. Next come the remaining nodes at the earth's surface, listed left to right. Next come the nodes one cell below the earth's surface, listed left to right. And so on. At the end of the file come the nodes at the bottom of the fault surface, listed left to right, with the node in the lower right corner of the fault surface appearing last.

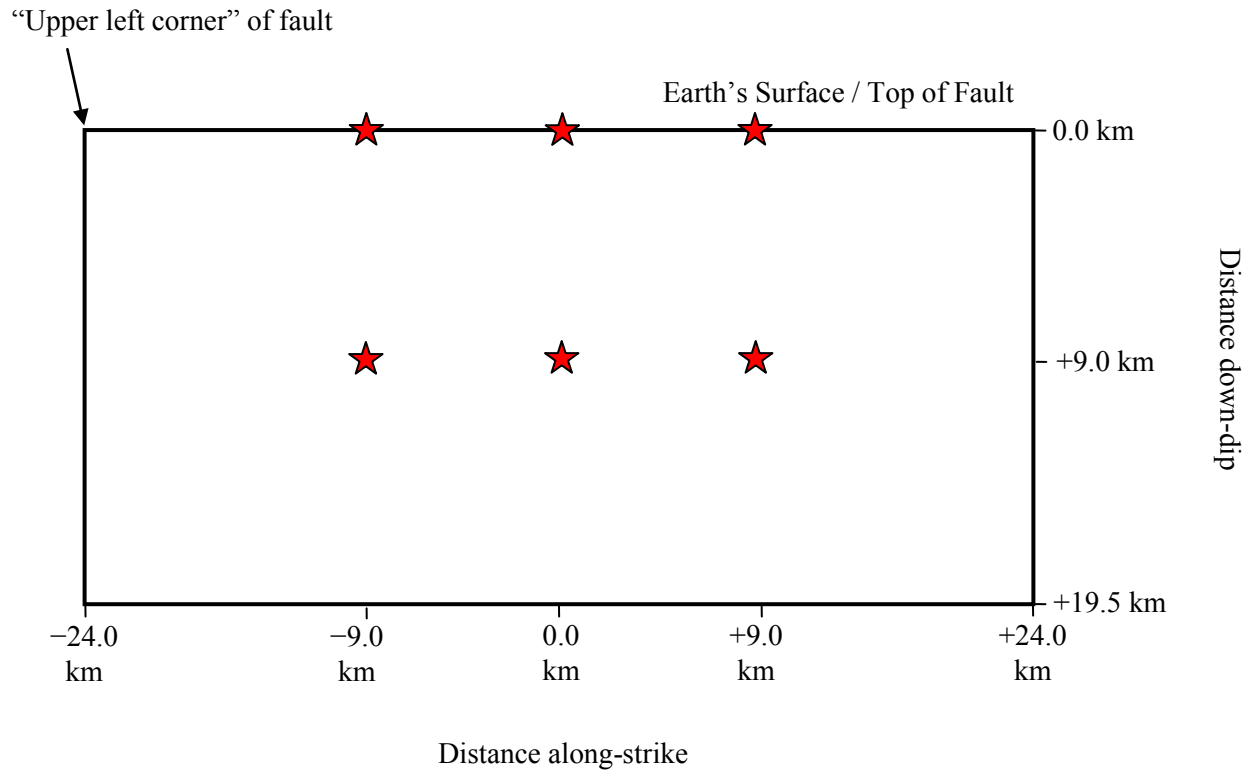## 8. On-Fault Stations, and Time-Series File Format

We use the 6 on-fault stations listed below Refer to the next page for a diagram of station locations.

You need to supply one time-series file for each station.

On-Fault Stations for TPV16-17	
Station Name	**Location**
faultst-090dp000	On fault, -9.0 km along strike, 0 km down-dip.
faultst000dp000	On fault, 0 km along strike, 0 km down-dip.
faultst090dp000	On fault, 9.0 km along strike, 0 km down-dip.
faultst-090dp090	On fault, -9.0 km along strike, 9.0 km down-dip.
faultst000dp090	On fault, 0 km along strike, 9.0 km down-dip.
faultst090dp090	On fault, 9.0 km along strike, 9.0 km down-dip.

Each on-fault station coincides with a node.

On-Fault Station Locations

"Upper left corner" of fault

Earth's Surface / Top of Fault

Distance down-dip

0.0 km

+9.0 km

+19.5 km

−24.0 km   −9.0 km   0.0 km   +9.0 km   +24.0 km

Distance along-strike

There are 3 stations at the earth's surface:
- 0 km, +9.0 km, −9.0 km along-strike, and 0 km down-dip distance.

There are 3 deeper stations:
- 0 km, +9.0 km, −9.0 km along-strike, and 9.0 km down-dip distance.

Each time series file is an ASCII file that contains 8 data fields, as follows.

On-Fault Time Series Data Fields for TPV16-17	
Field Name	**Description, Units, and Sign Convention**
t	Time (s).
h-slip	Horizontal slip along-strike (m). Sign convention: Positive means **right lateral** slip.
h-slip-rate	Horizontal slip rate along-strike (m/s). Sign convention: Positive means **right lateral** motion.
h-shear-stress	Horizontal shear stress along-strike (MPa). Sign convention: Positive means shear stress that tends to cause **right-lateral** slip.
v-slip	Vertical along-dip slip (m). Sign convention: Positive means **downward slip** (that is, the far side of the fault moving downward relative to the near side of the fault).
v-slip-rate	Vertical along-dip slip rate (m/s). Sign convention: Positive means **downward motion** (that is, the far side of the fault moving downward relative to the near side of the fault).
v-shear-stress	Vertical along-dip shear stress (MPa). Sign convention: Positive means shear stress that tends to cause **downward slip** (that is, the far side of the fault moving downward relative to the near side of the fault).
n-stress	Normal stress (MPa). Sign convention: Positive means **extension**. So, you will typically be reporting negative values.

The on-fault time series file consists of three sections, as follows.

On-Fault Time Series File Format for TPV16-17	
File Section	**Description**
File Header	A series of lines, each beginning with a # symbol, that gives the following information: • Benchmark problem (*e.g.*, TPV16) • Author • Date • Code • Code version (if desired) • Node spacing or element size • Time step • Station location • Descriptions of data columns (8 lines) • Anything else you think is relevant

Field List	A **single line**, which lists the names of the 8 data fields, in column order, separated by spaces. It should be:
	
	`t  h-slip  h-slip-rate  h-shear-stress  v-slip  v-slip-rate`
	`  v-shear-stress  n-stress`
	
	(all on one line). The code validation server examines this line to check that your file contains the correct data fields.

Time History	A series of lines. Each line contains 8 numbers, which give the data values for a single time step. The lines must appear in order of increasing time. **C/C++ users:** For all data fields except the time, we recommend using 14.6E or 14.6e floating-point format. For the time field, we recommend using 20.12E or 20.12e format (but see the note on the next page). **Fortran users:** For all data fields except the time, we recommend using E15.7 floating-point format. For the time field, we recommend using E21.13 format (but see the note on the next page). The code validation server accepts most common numeric formats. If the server cannot understand your file, you will see an error message when you attempt to upload the file.

Note: We recommend higher precision for the time field so the code validation server can tell that your time steps are all equal. (If the server thinks your time steps are not all equal, it will refuse to apply digital filters to your data.) If you use a "simple" time step value like 0.01 seconds or 0.005 seconds, then there is no need for higher precision, and you can write the time using the same precision as all the other data fields. When you upload a file, the server will warn you if it thinks your time steps are not all equal.

Here is an example of an on-fault time-series file. This is an invented file, not real modeling data.

```
# Example on-fault time-series file.
#
# This is the file header:
# problem = TPV16
# author = A.Modeler
# date = 2011/10/23
# code = MyCode
# code_version = 3.7
# element_size = 75 m
# time_step = 0.005
# location = on main fault, 9.0 km along strike, 9.0 km down-dip
# Column #1 = Time (s)
# Column #2 = horizontal slip (m)
# Column #3 = horizontal slip rate (m/s)
# Column #4 = horizontal shear stress (MPa)
# Column #5 = vertical slip (m)
# Column #6 = vertical slip rate (m/s)
# Column #7 = vertical shear stress (MPa)
# Column #8 = normal stress (MPa)
#
# The line below lists the names of the data fields:
t h-slip h-slip-rate h-shear-stress v-slip v-slip-rate v-shear-stress n-stress
#
# Here is the time-series data.
# There should be 8 numbers on each line, but this page is not wide enough
#  to show 8 numbers on a line, so we only show the first five.
0.000000E+00   0.000000E+00   0.000000E+00   7.000000E+01   0.000000E+00  ...
5.000000E-03   0.000000E+00   0.000000E+00   7.104040E+01   0.000000E+00  ...
1.000000E-02   0.000000E+00   0.000000E+00   7.239080E+01   0.000000E+00  ...
1.500000E-02   0.000000E+00   0.000000E+00   7.349000E+01   0.000000E+00  ...
2.000000E-02   0.000000E+00   0.000000E+00   7.440870E+01   0.000000E+00  ...
2.500000E-02   0.000000E+00   0.000000E+00   7.598240E+01   0.000000E+00  ...
# ... and so on.
```

9. Off-Fault Stations, and Time-Series File Format

We use the 12 off-fault stations listed below. A diagram of station locations appears on the next page.

You need to supply one time-series file for each station.

Off-Fault Stations for TPV16-17	
Station Name	**Location**
body-002st000dp000	-0.2 km off fault (near side), 0 km along strike, 0 km depth.
body002st000dp000	2.0 km off fault (far side), 0 km along strike, 0 km depth.
body-002st-090dp000	-0.2 km off fault (near side), -9.0 km along strike, 0 km depth.
body-002st090dp000	-0.2 km off fault (near side), 9.0 km along strike, 0 km depth.
body002st-090dp000	0.2 km off fault (far side), -9.0 km along strike, 0 km depth.
body002st090dp000	0.2 km off fault (far side), 9.0 km along strike, 0 km depth.
body-060st000dp000	-6.0 km off fault (near side), 0 km along strike, 0 km depth.
body060st000dp000	6.0 km off fault (far side), 0 km along strike, 0 km depth.
body-060st-090dp000	-6.0 km off fault (near side), -9.0 km along strike, 0 km depth.
body-060st090dp000	-6.0 km off fault (near side), 9.0 km along strike, 0 km depth.
body060st-090dp000	6.0 km off fault (far side), -9.0 km along strike, 0 km depth.
body060st090dp000	6.0 km off fault (far side), 9.0 km along strike, 0 km depth.

In the station names, the number after "body" is the horizontal perpendicular distance from the station to the fault surface. A positive number means that the station is located on the **far side** of the fault.

If you do not have a node at the location of a station, there are two options: (1) you can move the station to the nearest node, or (2) you can interpolate the data values from nodes near the station location.

Off-Fault Station Locations
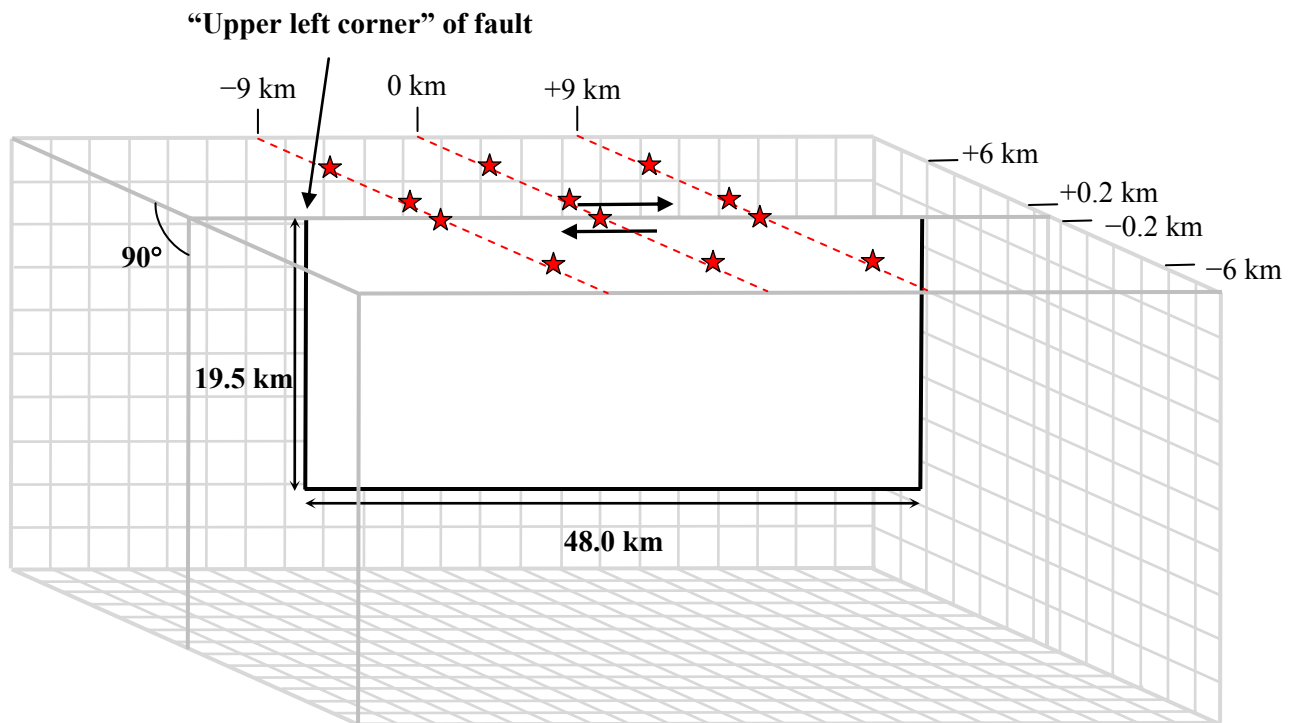
There are 12 stations at the earth's surface:
- 0 km along strike, 0 km depth, and ±0.2 km, ±6.0 km perpendicular distance **from the fault trace**.
- ±7.0 km along strike, 0 km depth, and ±0.2 km, ±6.0 km perpendicular distance **from the fault trace**.

The **near side** of the fault is in the front of the diagram.
The **far side** of the fault is in the back of the diagram.
Positive perpendicular distance from the fault means that the station is on the **far side**.

Each time series file is an ASCII file that contains 7 data fields, as follows.

Off-Fault Time Series Data Fields for TPV16-17	
Field Name	**Description, Units, and Sign Convention**
t	Time (s).
h-disp	Horizontal displacement, parallel to the fault strike (m). Sign convention: Positive means displacement **to the right** relative to the station's initial position.
h-vel	Horizontal velocity, parallel to the fault strike (m/s). Sign convention: Positive means motion **to the right**.
v-disp	Vertical displacement (m). Sign convention: Positive means displacement **downward** relative to the station's initial position.
v-vel	Vertical velocity (m/s). Sign convention: Positive means motion **downward**.
n-disp	Horizontal displacement, perpendicular to the fault strike (m). Sign convention: Positive means displacement **away from the viewer, into the paper** (that is, away from near side of the fault and toward the far side of the fault) relative to the station's initial position.
n-vel	Horizontal velocity, perpendicular to the fault strike (m/s). Sign convention: Positive means motion **away from the viewer, into the paper** (that is, away from near side of the fault and toward the far side of the fault).

The **near side** of the fault is in the front of the diagram.
The **far side** of the fault is in the back of the diagram.

The off-fault time series file consists of three sections, as follows.

Off-Fault Time Series File Format for TPV16-17	
File Section	**Description**
File Header	A series of lines, each beginning with a # symbol, that gives the following information: • Benchmark problem (*e.g.*, TPV16) • Author • Date • Code • Code version (if desired) • Node spacing or element size • Time step • Station location • Descriptions of data columns (7 lines) • Anything else you think is relevant
Field List	A **single line**, which lists the names of the 7 data fields, in column order, separated by spaces. It should be: `t  h-disp  h-vel  v-disp  v-vel  n-disp  n-vel` (all on one line). The server examines this line to check that your file contains the correct data fields.
Time History	A series of lines. Each line contains 7 numbers, which give the data values for a single time step. The lines must appear in order of increasing time. **C/C++ users:** For all data fields except the time, we recommend using 14.6E or 14.6e floating-point format. For the time field, we recommend using 20.12E or 20.12e format (but see the note on the next page). **Fortran users:** For all data fields except the time, we recommend using E15.7 floating-point format. For the time field, we recommend using E21.13 format (but see the note on the next page). The code validation server accepts most common numeric formats. If the server cannot understand your file, you will see an error message when you attempt to upload the file.

Note: We recommend higher precision for the time field so the code validation server can tell that your time steps are all equal. (If the server thinks your time steps are not all equal, it will refuse to apply digital filters to your data.) If you use a "simple" time step value like 0.01 seconds or 0.005 seconds, then there is no need for higher precision, and you can write the time using the same precision as all the other data fields. When you upload a file, the server will warn you if it thinks your time steps are not all equal.

Here is an example of an off-fault time-series file. This is an invented file, not real modeling data.

```
# Example off-fault time-series file.
#
# This is the file header:
# problem = TPV16
# author = A.Modeler
# date = 2011/10/23
# code = MyCode
# code_version = 3.7
# element_size = 75 m
# time_step = 0.005
# location = 0.2 km off fault, 9.0 km along strike, 0.0 km depth
# Column #1 = Time (s)
# Column #2 = horizontal displacement (m)
# Column #3 = horizontal velocity (m/s)
# Column #4 = vertical displacement (m)
# Column #5 = vertical velocity (m/s)
# Column #6 = normal displacement (m)
# Column #7 = normal velocity (m/s)
#
# The line below lists the names of the data fields:
t  h-disp  h-vel  v-disp  v-vel  n-disp  n-vel
#
# Here is the time-series data.
# There should be 7 numbers on each line, but this page is not wide enough
#  to show 7 numbers on a line, so we only show the first five.
0.000000E+00   0.000000E+00   0.000000E+00   0.000000E+00   0.000000E+00  ...
5.000000E-03  -2.077270E-85  -2.575055E-83  -2.922774E-86  -3.623018E-84  ...
1.000000E-02  -1.622118E-82  -2.005817E-80  -1.387778E-83  -1.713249E-81  ...
1.500000E-02  -9.020043E-80  -1.114231E-77  -4.402893E-81  -5.424313E-79  ...
2.000000E-02  -1.201684E-77  -1.467704E-75  -4.549845E-79  -5.533119E-77  ...
2.500000E-02  -1.528953E-75  -1.866265E-73  -4.126064E-77  -5.004886E-75  ...
# ... and so on.
```

10. Contour-Plot File Format

The contour plot file lists the locations of all the nodes on the fault surface, and the time at which each node ruptures.

The contour plot file is an ASCII file that contains three data fields, as follows.

Contour Plot Data Fields for TPV16-17	
Field Name	**Description, Units, and Sign Convention**
j	Distance along strike (m). Sign convention: Positive means a location **to the right** of the center line. For tpv16-17, the value of j can range from −24000 to 24000.
k	Distance down-dip (m). Sign convention: Zero is the earth's surface, and positive means **underground**. Since the fault is vertical, k is also equal to the depth below the earth's surface. For TPV16-17, the value of k can range from 0 to 19500.
t	Rupture time (s). This is the time at which fault slip-rate first changes from 0 to greater than 0.001 m/s. If this node never ruptures, use the value 1.0E+09.

A pair of numbers (j,k) denotes a point on the fault surface.

The contour plot file consists of three sections, as follows.

Contour Plot File Format for TPV16-17	
File Section	**Description**
File Header	A series of lines, each beginning with a # symbol, that gives the following information: • Benchmark problem (*e.g.*, TPV16) • Author • Date • Code • Code version (if desired) • Node spacing or element size • Descriptions of data columns (3 lines) • Anything else you think is relevant
Field List	A **single line**, which lists the names of the 3 data fields, in column order, separated by spaces. It should be: `j   k   t` (all on one line). The server examines this line to check that your file contains the correct data fields.
Rupture History	A series of lines. Each line contains three numbers, which give the `(j,k)` coordinates of a node on the fault surface, and the time `t` at which that node ruptures. **C/C++ users:** We recommend using 14.6E or 14.6e floating-point format. **Fortran users:** We recommend using E15.7 floating-point format. If a node never ruptures, the time should be given as 1.0E+09. Nodes may be listed in any order.

Note: The nodes may appear in any order. The nodes do not have to form a rectangular grid, or any other regular pattern.

Note: When you upload a file, the server constructs the Delaunay triangulation of your nodes. Then, it uses the Delaunay triangulation to interpolate the rupture times over the entire fault surface. Finally, it uses the interpolated rupture times to draw a series of contour curves at intervals of 0.5 seconds.

Here is an example of a contour-plot file. This is an invented file, not real modeling data.

```
# Example contour-plot file.
#
# This is the file header:
# problem = TPV16
# author = A.Modeler
# date = 2011/10/23
# code = MyCode
# code_version = 3.7
# element_size = 75 m
# Column #1 = horizontal coordinate, distance along strike (m)
# Column #2 = vertical coordinate, distance down-dip (m)
# Column #3 = rupture time (s)
#
# The line below lists the names of the data fields.
# It indicates that the first column contains the horizontal
#  coordinate (j), the second column contains the vertical
#  coordinate (k), and the third column contains the time (t).
j  k  t
#
# Here is the rupture history
-6.000000E+02    7.050000E+03    3.100000E-02
-6.000000E+02    7.125000E+03    4.900000E-02
-6.000000E+02    7.200000E+03    6.700000E-02
-6.750000E+02    7.050000E+03    1.230000E-01
-6.750000E+02    7.125000E+03    1.350000E-01
-6.750000E+02    7.200000E+03    1.470000E-01
# ... and so on.
```