# File Formats for TPV105-3D

**July 25, 2020**

## Contents



All files should be uploaded to the benchmark comparison tool on our website, which is http://scecdata.usc.edu/cvws/

**Note:** This document describes only the 3D version of benchmark TPV105.

**Note:** There is a Perl script available to upload multiple files in a single operation, See http://scecdata.usc.edu/cvws/downloads.html.

## *Part 1: On-Fault Time Series Data Files*

Time series data is supplied as a set of ASCII files. You need to supply one file for each station. The 3D benchmark has 13 stations. In these descriptions, **distance along strike** is the $x$ coordinate, and **distance down-dip** is the $y$ coordinate.

| **On-Fault Stations for TPV105-3D** | |
|---|---|
| **Station Name** | **Location** |
| `faultst-120dp030` | On fault, -12.0 km along strike, 3.0 km down-dip. |
| `faultst000dp030` | On fault, 0 km along strike, 3.0 km down-dip. |
| `faultst120dp030` | On fault, 12.0 km along strike, 3.0 km down-dip. |
| `faultst-180dp075` | On fault, -18.0 km along strike, 7.5 km down-dip. |
| `faultst-150dp075` | On fault, -15.0 km along strike, 7.5 km down-dip. |
| `faultst-090dp075` | On fault, -9.0 km along strike, 7.5 km down-dip. |
| `faultst000dp075` | On fault, 0 km along strike, 7.5 km down-dip. |
| `faultst090dp075` | On fault, 9.0 km along strike, 7.5 km down-dip. |
| `faultst150dp075` | On fault, 15.0 km along strike, 7.5 km down-dip. |
| `faultst180dp075` | On fault, 18.0 km along strike, 7.5 km down-dip. |
| `faultst-120dp120` | On fault, -12.0 km along strike, 12.0 km down-dip. |
| `faultst000dp120` | On fault, 0 km along strike, 12.0 km down-dip. |
| `faultst120dp120` | On fault, 12.0 km along strike, 12.0 km down-dip. |

Each time series file contains 11 data fields, as follows. In these descriptions, the **far side** of the fault is the $+z$ direction, and the **near side** of the fault is the $-z$ direction.

| On-Fault Time Series Data Fields for TPV105-3D | |
|---|---|
| **Field Name** | **Description, Units, and Sign Convention** |
| `t` | Time (s). |
| `h-slip` | Horizontal slip (m).<br>Sign convention: Positive means **right lateral** slip. |
| `h-slip-rate` | Horizontal velocity (m/s).<br>Sign convention: Positive means **right lateral** motion. |
| `h-shear-stress` | Horizontal shear stress (MPa).<br>Sign convention: Positive means shear stress that tends to cause **right-lateral** slip. |
| `v-slip` | Vertical displacement (m).<br>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 velocity (m/s).<br>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 shear stress (MPa).<br>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` | Effective normal stress (MPa).<br>Sign convention: Positive means **compression**.<br>This is the effective normal stress, which is defined to be the total normal stress minus the pore pressure. |
| `psi` | State variable (dimensionless). |
| `temperature` | Temperature (degrees Kelvin).<br>If you cannot supply temperature, then fill this field with the value 483.15 which is the initial temperature. |
| `pressure` | Pore pressure (MPa). |

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

<table>
<tr><th colspan="2">On-Fault Time Series File Format for TPV105-3D</th></tr>
<tr><th>File Section</th><th>Description</th></tr>
<tr><td>File Header</td><td>A series of lines, each beginning with a # symbol, that give the following information:
<ul>
<li>Benchmark problem (TPV105-3D)</li>
<li>Author</li>
<li>Date</li>
<li>Code</li>
<li>Code version (if desired)</li>
<li>Node spacing or element size</li>
<li>Time step</li>
<li>Number of time steps in file</li>
<li>Station location</li>
<li>Descriptions of data columns (11 lines)</li>
<li>Anything else you think is relevant</li>
</ul></td></tr>
<tr><td>Field List</td><td>A single line, which lists the names of the 11 data fields, in column order, separated by spaces. It should be:<br><br><code>t h-slip h-slip-rate h-shear-stress v-slip v-slip-rate v-shear-stress n-stress psi temperature pressure</code><br><br>(all on one line). The server examines this line to check that your file contains the correct data fields.</td></tr>
<tr><td>Time History</td><td>A series of lines. Each line contains 11 numbers, which give the data values for a single time step. The lines must appear in order of increasing time.<br><br>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).<br><br>Fortran users: For all data fields except the time, we recommend using E15.7 or 1PE15.6 floating-point format. For the time field, we recommend using E21.13 or 1PE21.12 format (but see the note on the next page).<br><br>The 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.</td></tr>
</table>

**Note:** We recommend higher precision for the time field so the 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 time-series file.
#
# This is the file header:
# problem=TPV105-3D
# author=A.Modeler
# date=2020/07/01
# code=MyCode
# code_version=3.7
# element_size=100 m
# time_step=0.005
# num_time_steps=3000
# location= on fault, 9 km along strike, 7.5km 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 = effective normal stress (MPa)
# Column #9 = state variable psi (dimensionless)
# Column #10 = temperature (K)
# Column #11 = pore pressure (MPa)
#
# The line below lists the names of the data fields:
# (Although rendered as two lines on this printed page, it must be one
# single line in the actual file.)
t  h-slip  h-slip-rate  h-shear-stress  v-slip  v-slip-rate  v-shear-stress
        n-stress  psi  temperature  pressure
#
# Here is the time-series data.
# There should be 11 numbers on each line, but this page is not wide enough
#  to show 11 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.
```

## *Part 2: Off-Fault Time Series Data Files*

Off-fault time series data is supplied as a set of ASCII files. You need to supply one file for each station. There are 6 stations, as follows. In these descriptions, the **far side** of the fault is the $+z$ direction, and the **near side** of the fault is the $-z$ direction. Also, in these descriptions, **distance off fault** is the $z$ coordinate, **distance along strike** is the $x$ coordinate, and **depth** is the $y$ coordinate.

| **Off-Fault Stations for TPV105-3D** | |
|---|---|
| **Station Name** | **Location** |
| `body-060st-120dp000` | -6.0 km off fault (near side), -12.0 km along strike, 0 km depth. |
| `body-090st000dp000` | -9.0 km off fault (near side), 0 km along strike, 0 km depth. |
| `body-060st120dp000` | -6.0 km off fault (near side), 12.0 km along strike, 0 km depth. |
| `body060st-120dp000` | 6.0 km off fault (far side), -12.0 km along strike, 0 km depth. |
| `body090st000dp000` | 9.0 km off fault (far side), 0 km along strike, 0 km depth. |
| `body060st120dp000` | 6.0 km off fault (far side), 12.0 km along strike, 0 km depth. |

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

Each time series file contains 7 data fields, as follows. In these descriptions, **to the right** means in the $+x$ direction, **downward** means in the $+y$ direction, and **away from the viewer, into the paper** means in the $+z$ direction.

| Off-Fault Time Series Data Fields for TPV105-3D | |
|---|---|
| **Field Name** | **Description, Units, and Sign Convention** |
| `t` | Time (s). |
| `h-disp` | Horizontal displacement, parallel to fault (m).<br>Sign convention: Positive means displacement **to the right** relative to the station's initial position. |
| `h-vel` | Horizontal velocity, parallel to fault (m/s).<br>Sign convention: Positive means motion **to the right**. |
| `v-disp` | Vertical displacement (m).<br>Sign convention: Positive means displacement **downward** relative to the station's initial position. |
| `v-vel` | Vertical velocity (m/s).<br>Sign convention: Positive means motion **downward**. |
| `n-disp` | Horizontal displacement, perpendicular to fault (m).<br>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 fault (m/s).<br>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 off-fault time series file consists of three sections, as follows:

<table>
<tr><th colspan="2">Off-Fault Time Series File Format for TPV105-3D</th></tr>
<tr><th>File Section</th><th>Description</th></tr>
<tr><td>File Header</td><td>A series of lines, each beginning with a # symbol, that give the following information:<ul><li>Benchmark problem (TPV105-3D)</li><li>Author</li><li>Date</li><li>Code</li><li>Code version (if desired)</li><li>Node spacing or element size</li><li>Time step</li><li>Number of time steps in file</li><li>Station location</li><li>Descriptions of data columns (7 lines)</li><li>Anything else you think is relevant</li></ul></td></tr>
<tr><td>Field List</td><td>A single line, which lists the names of the 7 data fields, in column order, separated by spaces. It should be:<br><br><code>t h-disp h-vel v-disp v-vel n-disp n-vel</code><br><br>(all on one line). The server examines this line to check that your file contains the correct data fields.</td></tr>
<tr><td>Time History</td><td>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.<br><br>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).<br><br>Fortran users: For all data fields except the time, we recommend using E15.7 or 1PE15.6 floating-point format. For the time field, we recommend using E21.13 or 1PE21.12 format (but see the note on the next page).<br><br>The 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.</td></tr>
</table>

**Note:** We recommend higher precision for the time field so the 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 time-series file.
#
# This is the file header:
# problem=TPV105-3D
# author=A.Modeler
# date=2020/07/01
# code=MyCode
# code_version=3.7
# element_size=100 m
# time_step=0.005
# num_time_steps=3000
# location= 6.0 km off fault, 12 km along strike, 0.0 km down-dip
# 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.
```

## *Part 3: Contour Plot Data Files*

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

For TPV105-3D, the contour plot file should include the entire fault, which measures 22 km by 44 km. This includes the central velocity-weakening region, the transition region, and the velocity-strengthening region.

Each file contains three data fields, as follows. See the benchmark problem description for a diagram illustrating coordinates and sign conventions.

| **Contour Plot Data Fields for TPV105-3D** | |
|---|---|
| **Field Name** | **Description, Units, and Sign Convention** |
| `j` | Distance along strike (m).<br><br>Sign convention: Positive means a location **to the right** of the fault center.<br><br>For TPV105-3D, the value of `j` can range from -22000 to 22000. It is equal to the $x$ coordinate.<br><br>Note: The central velocity-weakening region of the fault corresponds to values of `j` ranging from -15000 to 15000. |
| `k` | Distance down-dip (m).<br><br>Sign convention: Zero is the earth's surface, and positive means **underground**.<br><br>For TPV105-3D, the value of `k` can range from 0 to 22000. It is equal to the $y$ coordinate.<br><br>Note: The central velocity-weakening region of the fault corresponds to values of `k` ranging from 3000 to 15000. |
| `t` | Rupture time (s).<br><br>This is the time at which fault slip-rate first changes from zero to greater than 1 mm/s.<br><br>If this node never ruptures, use the value 1.0E+09. |

A pair of numbers `(j,k)` denotes a point on the fault surface. It equals the $(x,y)$ coordinates.

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

<table>
<tr><th colspan="2">Contour Plot File Format for TPV105-3D</th></tr>
<tr><th>File Section</th><th>Description</th></tr>
<tr><td>File Header</td><td>A series of lines, each beginning with a # symbol, that give::<ul><li>Benchmark problem (TPV105-3D)</li><li>Author</li><li>Date</li><li>Code</li><li>Code version (if desired)</li><li>Node spacing or element size</li><li>Descriptions of data columns (3 lines)</li><li>Anything else you think is relevant</li></ul></td></tr>
<tr><td>Field List</td><td>A single line, which lists the names of the three data fields, in column order, separated by spaces. It should be:<br><br><code>j   k   t</code><br><br>(on one line).</td></tr>
<tr><td>Rupture History</td><td>A series of lines. Each line contains three numbers, which give the <code>(j,k)</code> coordinates of a node on the fault surface, and the time <code>t</code> at which that node ruptures.<br><br>C/C++ users: We recommend using 14.6E or 14.6e floating-point format.<br><br>Fortran users: We recommend using E15.7 or 1PE15.6 floating-point format.<br><br>If a node never ruptures, the time should be given as 1.0E+09.<br><br>Nodes may be listed in any order.</td></tr>
</table>

**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 new contour-plot file.
#
# This is the file header:
# problem=TPV105-3D
# author=A.Modeler
# date=2020/07/01
# code=MyCode
# code_version=3.7
# element_size=100 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   7.000000E+03   3.100000E-02
6.000000E+02   7.100000E+03   4.900000E-02
6.000000E+02   7.200000E+03   6.700000E-02
7.000000E+02   7.000000E+03   1.230000E-01
7.000000E+02   7.100000E+03   1.350000E-01
7.000000E+02   7.200000E+03   1.470000E-01
# ... and so on.
```