**Compilation**

Compilation of FD3D\_TSN is handled by one script file compile.sh, that contains lines for three compilers - [PGI Fortran](https://www.pgroup.com/products/index.htm?tab=specs), Intel Fortran and GFortran. The code was tested using these versions - pgfortran 19.10, gfortran 9.2.1, ifort 19.0.5.

Variable D\_MACRO sets specialized hardcoded functions and choices in the code, list of available flags is in the table:

|  |  |  |  |
| --- | --- | --- | --- |
| -DSCEC | Run one of the USGS/SCEC benchmarks | -DDIPSLIP | -Dipslip earthquake is assumed when reading forwardmodel.dat, otherwise strikeslip. |
| -DTPV5 | Run TPV5 benchmark. | -DFVW | Fast velocity weakening friction is assumed |
| -DTPV8 | Run TPV8 benchmark. | -DFSPACE | Fullspace calculation (without free surface) |
| -DTPV9 | Run TPV9 benchmark. |  |  |
| -DTPV104 | Run TPV104 benchmark. |  |  |
| -DTPV103 | Run TPV103 benchmark |  |  |

Example: D\_MACRO=' -DSCEC -DTPV8' … compiles for TPV8 USGS/SCEC benchmark

D\_MACRO=' -DSCEC –DTPV104 -DFVW' … compiles for TPV104 USGS/SCEC benchmark with fast velocity weakening friction

Variables PFC\_OPTS, GFC\_OPTS, IFC\_OPTS sets the compiler specific flags. Setting PFC\_OPTS=' -acc -ta=tesla:ccall' enables the GPU acceleration for NVIDIA GPUs.

Note, that variables in FD3D\_TSN are set as real, option PFC\_OPTS='-r8, or IFC\_OPTS=' –autodouble' is needed for double precision calculations.

Note that for FD3D\_TSN runs on NVidia GPUs, GCC version 8+ should be used and the offloading support in GCC has to be enabled, e.g. in Ubuntu: apt install gfortran-9 gcc-9-offload-nvptx.

Compiler options to enable OpenACC are (PGI 19.10) *-acc* or *-ta=tesla:ccall* or (GCC 9.2) *-fopenacc.* For OpenACC runs on multicore CPU, PGI offers the option *-ta=multicore* and the environment variable *ACC\_NUM\_CORES*. PGI creates a profiling report of GPU accelerated loops by setting the environment variable *PGI\_ACC\_TIME*.

These input files need to be provided before running FD3D\_TSN:

**Input files**

|  |  |
| --- | --- |
| inputfd3d.dat | Finite difference parameters. |
| crustal.dat | Velocity model parameters. |
| scecmodel.dat | Parameters of the chosen USGS/SCEC benchmark. |
| forwardmodel.dat | Dynamic parameters. |
| inputinv.dat | Information about dynamic model in forwardmodel.dat |

*Inputfd3d.dat*

nxtT,nytT,nztT … Size of the FD grid, without free surface (2 more nodes in z direction) and PML.

dh … Spatial discretization step

ntfd … Number of time levels

dt … Time discretization step

dip … Dip for normal stresss calculation

nabc, pml\_vp,pml\_fact … number of PML layers, average p wave velocity, damping factor

damp\_s … factor of viscous attenuation near and at fault

Nstations … Number of off fault stations, for synthetic seismogram calculation

staX(i),staY(i),staZ(i) … Positions of off fault stations in FD grid, number of lines equals Nstations

waveT … Wavefield output time

*inputinv.dat* – only two variables on the second line are needed

NLI,NWI … number of nodes on coarser grid in x and z direction

*forwardmodel.dat*

format: 2 dummy variables, [T0I] prestress on coarser grid, [TSI] static friction coefficient on coarser grid, [DcI] Dc on coarser grid. All three are fields of NLI\*NWI variables, first is positioned in the left down corner.

*crustal.dat*

third line: ndepth … number of velocity layers

sixth line and following lines: depth(k),vp(k),vs(k),rho(k) … depth, p wave speed, s wave speed, density

*scecmodel.dat* – input file containing parameters for a given scec benchmark, required structure of the file changes for different benchmarks.

FD3D\_TSN generates these output files:

**Output files**

|  |  |
| --- | --- |
| sliprateX.res, sliprateZ.res | Binary file. Horizontal/vertical sliprate time series for all grid nodes at the fault. |
| shearstressX.res, shearstressZ.res | Binary file. Horizontal/vertical traction time series for all nodes at the fault. |
| psi.res | Binary file. State variable time series for all nodes at the fault. |
| slip.dat, rvel.dat, czone.dat, risetime.dat,  stressdrop.dat | Text file. Spatial distribution of final slip, rupture velocity, estimate of cohesive zone (see FD3D\_TSN Theoretical background for further information), risetime. |
| ruptime.dat, contour.dat | Text file. Rupture time and rupture time with explicitly written node positions. |
| stan%i.dat | Text file. Seimograms measured at %ith position |

**Plotting the results:**

Two matlab files are provided, to demonstrate retrieval of time series in a chosen node (PrintSeries.m) and spatial distribution in chosen time level (PrintSnapshot.m) from binary files sliprateX.res, sliprateZ.res, shearstressX.res, shearstressZ.res.