UNIVERSITÀ
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*The DMG Manuals*

# Ground Motion Scenario for an Extended Source

Computation of ground motion scenarios in a 1D layered medium for an extended source


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# Computation of ground motion scenarios for extended sources

In the following, the process of computing synthetic seismograms produced by a extended source model is described. The source model is produced by pulsyn06.out program. Green functions can be produced by modal summation method (esgrz0050.out, esgl0050.out, esne.out) or discrete wavenumber method (pavlov7.out). Convolution between sub-source time functions and Green functions is performed by efft.out.

In the example, the name of source model is assumed to be **z1d001**, so all output filenames will have the z1d001 root.

## Required input files

Required input files can be found in **/XDST/Examples/ExtSourceScenarioExamples/Single/Base/**. Copy them into a directory dedicated to the computations.

Here is the contents of **/XDST/Examples/ExtSourceScenarioExamples/Single/Base**:

```
-rw-r--r--  1 vaccari  dstguest     1783 Mar 19 13:31 GUSEV83.TB5
-rw-r--r--  1 vaccari  dstguest      181 Mar 21 14:05 fvg.obs
-rw-r--r--  1 vaccari  dstguest     1113 Mar 19 13:31 fvg.por
-rw-r--r--  1 vaccari  dstguest     2672 Mar 19 13:31 makescenario.par
-rw-r--r--  1 vaccari  dstguest      801 Mar 19 13:31 makesrc.par
-rw-r--r--  1 vaccari  dstguest  1778811 Mar 19 13:31 z1d0010012.spl
-rw-r--r--  1 vaccari  dstguest  2662559 Mar 19 13:31 z1d0010012.spr
-rw-r--r--  1 vaccari  dstguest      829 Mar 19 13:31 z1d0010012.stp
-rw-r--r--  1 vaccari  dstguest  1495956 Mar 19 13:31 z1d0010014.spl
-rw-r--r--  1 vaccari  dstguest  1891544 Mar 19 13:31 z1d0010014.spr
-rw-r--r--  1 vaccari  dstguest      760 Mar 19 13:31 z1d0010014.stp
-rw-r--r--  1 vaccari  dstguest  1288360 Mar 19 13:31 z1d0010016.spl
-rw-r--r--  1 vaccari  dstguest  1714001 Mar 19 13:31 z1d0010016.spr
-rw-r--r--  1 vaccari  dstguest      760 Mar 19 13:31 z1d0010016.stp
-rw-r--r--  1 vaccari  dstguest  1326447 Mar 19 13:31 z1d0010252.spl
-rw-r--r--  1 vaccari  dstguest  1700095 Mar 19 13:31 z1d0010252.spr
-rw-r--r--  1 vaccari  dstguest     1588 Mar 19 13:31 z1d0010252.stp
```

## Description of main input files

### Station files

Informations about position and structure of stations can be taken by makescenario.out in two ways:

1. station positions from a *.obs file and structural polygons from *.por file: the generic name pattern for this file is NNN888. The detailed description of *.por file is in “GNDT Deterministic Seismic Zoning Reference Guide” manual. Obs file can have an extra column with name of stations. Index of structures in obs file must be ‘0000’;
2. if file *.obs is ‘0’, a regular grid defined by minimum and maximum latitude and longitude with a step equal to cell size will be used. Structural polygons are defined in *.por file.

Option 1. is generally recommended and is illustrated in this example.

## fvg.obs

This file contains the coordinates of the sites for which the ground shaking scenario will be computed.

```
    lon      lat     struc  rdep
   13.7681   45.6494 0000   0.000 TS
   13.6221   45.9415 0000   0.000 GO
   13.2348   46.0626 0000   0.000 UD
   12.6600   45.9544 0000   0.000 PN
```

In this example they are rounded to 0.2° to fit the grid used for regional hazard computations. Defining 0000 the structure index means that structural properties will depend on the geometry of the polygons defined in .por file.

## fvg.por

This file contains the vertices of the polygons associated with different layered models. It must have the same filename root as the .obs file (*fvg* in the example)

```
Polygons that define different structural regions (lon,lat) North-Eastern Italy
stzone0012
             12.000  45.900
             12.900  46.250
             13.500  46.250
             13.500  45.711
             13.346  45.655
             13.238  45.692
             13.129  45.667
             13.093  45.612
             12.913  45.600
             12.408  45.409
             12.307  45.229
             12.336  45.094
             12.545  45.000
             12.000  45.000
stzone0014
             12.900  46.250
             13.500  46.250
             13.500  45.900
             13.680  45.900
             13.680  46.000
             13.541  46.015
             13.721  46.198
             13.492  46.321
             13.707  46.440
             13.728  46.643
             12.459  46.687
             12.127  47.000
             12.000  47.000
             12.000  45.900
stzone0016
             13.900  45.550
             13.680  45.550
             13.680  45.660
stzone0252
             13.850  45.900
             13.950  45.638
             13.900  45.550
             13.500  45.750
             13.500  45.900
```

## *.stp

These files contain the layering of the structural models defined in .por file. They must be present if DWN method is selected for the synthetic seismograms computation. See manual for Modal Summation technique for its description. The name of structures must have the following format: (name of src file)(index of structures).stp (e.g. `z1d0010012.stp`) where the name of the src file is defined in `makesrc.par` described below.

## *.spl *.spr

These files contain the modes for the structural models defined in .por file. They must be present if Modal Summation method is selected for the synthetic seismograms computation. See manual for Modal Summation technique for the their generation. The name of files must have the following format: (name of src file)(index of structures).spl (e.g. `z1d0010012.spl z1d0010012.spr`) where the name of the src file is defined in `makesrc.par` described below.

## GUSEV83.TB5

This file contains the target spectral curves to be used for the generation of the source time functions. See the Pulsyn manual for details.

## makesrc.par

This file contains the information required to generate the .src file, which contains the required source model characteristics: fault size, geometry, rupture properties etc.

```
parameters for generation of base source model (.src file) for pulsyn06.out (v0002)
--------------------------------------------------------------------------------
z1d001.src      name of src file
22              CP code (code of the characteristic point CP, written as ab (see pulsyn manual)
13.246          longitude
46.275          latitude
6.5             depth
6.4             Mw
282             strike
23              dip
119             rake
18              length of the fault (0 means: do calculate it)
12              width of the fault (0 means: do calculate it)
0.0             xdlstart (nucleation point position in relative coordinates) (-0.5<xdlstart<0.5)
0.0             ydlstart (nucleation point position in relative coordinates) (-0.5<ydlstart<0.5)
3.5             s-wave velocity (km/s) at source depth
GUSEV83.TB5      tabulated spectral scaling
10              max frequency of the source spectrum
4               interpolation (0=no, 1-9=yes)
4096            n. of samples of source spectrum (power of 2)
0               source model (mode_point: 0=extended, 1=point)
```

## makescenario.par

This file contains the information that will be used by *`makescenario.out`* to properly generate the parameter files for the programs that will actually perform the computations.

The configuration shown below asks to prepare the *`scenario.sh`* script so that programs are executed till the generation of paths. This preliminary run is recommended so that the user can check that no mistakes have been made in the preparation of the required input files.

```
parameter file for definition of a extended fault scenario    (v0007)
-------------------------------------------------------------------
RUN DEFINITION
-------------------------------------------------------------------
z1d                                     Name of the run (max 3 char.)
12 15                                   Min and max longitude       (degrees)
45 47                                   Min and max latitude        (degrees)
2                                       Execution   (0=full ,1=till sources,2=till paths)
7                                       Clean level (0=no, 3=save all seis, 7=clean immediately and save
[un]scaled, 31 clean all; see manual)
0                                       Big run  (ibig)  (1=yes, 0=no) (not active yet!)
-------------------------------------------------------------------
SOURCE DEFINITION
-------------------------------------------------------------------
z1d001.src                              name of src file (3 chars+3 digits).src
-------------------------------------------------------------------
PATH DEFINITION
-------------------------------------------------------------------
-1  500                                 Min. and max path length in km   (0=auto, if 0 look for
hazdistance.min|.max)
1                                       Short paths (ishortpaths)        (0=elim,1=use rmin,2=adjust)
fvg.por                                 name of por file
fvg.obs                                 name of obs file     (0=grid)      (max 12 char.)
.2                                      Cell size
-------------------------------------------------------------------
TIME SERIES
-------------------------------------------------------------------
```

```
0               Program for Green function computation (igreen) (0 - only MS; 1 - MS and DWN for short distance;
2 - only DWN)
0               Seismogram format      (iform)      (0=ASCII, 1=bin) (set 0 if plotting is required)
-------------------------------------------------------------
OUTPUTS
-------------------------------------------------------------
0                Output formats (iouform) (0=ASCII, 1=bin)
0                File with code resp. spectra for computing DGA (max 12 char.)
1                Plot seismograms       (isis)       (1=yes,0=no)
1                Compute response spectra (irs)      (0=no, 1 = only 5% damping,2 = all damping)
```

The choice of program for Green function computation in the TIME SERIES section of `makescenario.par` is critical. Modal summation (MS) allows for much faster computations but cannot be used in the near-field conditions. It is a good practice to make a test run using MS (igreen=0) to check if all the input files have been properly prepared and the job can get to completion. Then, in case epicentral distances from fault subsources to sites defined in .obs file are shorter than the hypocentral depth, repeat the computations using igreen=1 (automatic choice of MS or DWN, based on epicentral distance) or igreen=2 (DWN only), taking into account that DWN can imply great CPU time (hours, if not days, depending on the source-sites configuration).

Clean level *iclean*, converted in binary format, can be interpreted as follows:

| | **no clean** | **clean as soon as possible** | **clean at the end of the run** | **save merged seismograms** | **save scaled seismograms** | **save all seismograms** |
|---|---|---|---|---|---|---|
| as soon as possible ($2^0$=1) | 0 | 1 | 0 | 1 | 1 | 1 |
| others ($2^1$=2) | 0 | 1 | 1 | 1 | 1 | 1 |
| unmerged seismograms ($2^2$=4) | 0 | 1 | 1 | 1 | 1 | 0 |
| unscaled seismograms ($2^3$=8) | 0 | 1 | 1 | 0 | 1 | 0 |
| scaled seismograms ($2^4$=16) | 0 | 1 | 1 | 0 | 0 | 0 |
| **iclean (sum)** | **0** | **31** | **30** | **7** | **15** | **3** |

## Additional input files for source model

Additional information can be needed by PULSYN06, and it is read from other files. Names o these files are given in the special block FIL of *.src file. Instead of the GUSEV83.TB5 file, provided with this example, other spectral models can be specified in file `makesrc.par`. Also, external 2D final slip distribution over a fault can be loaded from file. These files must be present in the current directory but this requires a manual editing of .src file and this is beyond the purpose of this manual. See more detailed information in PULSYN06 manual.

# Steps to compute the ground motion scenario

## Generation of src file

The first step is the generation of the .src file, running command:

```
makesrc.out
```

## Generation of parameter files and script

Preliminary to the computation of the synthetic seismograms is the preparation of the shell script (named `scenario.sh`) that will call the sequence of programs performing the actual computations.

To create the shell script simply run the command:

```
makescenario.out
```

The program check the existence of input files and write parameters files for the programs called by shell script.

## Computation of source model and verification of input data

The script to execute is:

```
scenario.sh
```

If no typing/editing errors are present in the input files, it will generate some graphic files that should be checked to see if the source model and the stations location have been properly defined:

| | |
|---|---|
| `fvg.obs.ps` | Plot with fault and sites |
| `z1d001.slip.ps` | Detailed view of slip distribution and rupturing of the fault |

Check the plots with commands:

```
gs fvg.obs.ps
gs z1d001.slip.ps
```

and correct the input files if needed.

The script is configured so to generate the synthetic seismograms for the three components of motion (north-south, east-west and vertical) and to produce (rough) plots of the waveforms and maps of the peak values.Waveform plot works only for ASCII format.

## Full run till the computation of the ground shaking scenario

Once the input files have been properly checked, a full run can be requested. In order to do so, edit file `makescenario.par`, editing just the record describing Execution, evidenced in **bold**, specifying 0 (full) instead of 2 (till paths):

```
parameter file for definition of a extended fault scenario    (v0007)
-----------------------------------------------------------------
RUN DEFINITION
-----------------------------------------------------------------
z1d                                         Name of the run (max 3 char.)
12 15                                       Min and max longitude       (degrees)
45 47                                       Min and max latitude        (degrees)
0                                           Execution   (0=full ,1=till sources,2=till paths)
7                                           Clean level (0=no, 3=save all seis, 7=clean immediately and save
[un]scaled, 31 clean all; see manual)
0                                           Big run  (ibig)  (1=yes, 0=no) (not active yet!)
-----------------------------------------------------------------
SOURCE DEFINITION
-----------------------------------------------------------------
z1d001.src                                  name of src file (3 chars+3 digits).src
-----------------------------------------------------------------
PATH DEFINITION
-----------------------------------------------------------------
-1  500                                     Min. and max path length in km   (0=auto, if 0 look for
hazdistance.min|.max)
1                                           Short paths (ishortpaths)        (0=elim,1=use rmin,2=adjust)
fvg.por                                     name of por file
fvg.obs                                     name of obs file     (0=grid)      (max 12 char.)
.2                                          Cell size
-----------------------------------------------------------------
TIME SERIES
-----------------------------------------------------------------
0               Program for Green function computation (igreen) (0 - only MS; 1 - MS and DWN for short distance;
2 - only DWN)
0               Seismogram format      (iform)      (0=ASCII, 1=bin) (set 0 if plotting is required)
-----------------------------------------------------------------
OUTPUTS
-----------------------------------------------------------------
0                Output formats (iouform) (0=ASCII, 1=bin)
0                File with code resp. spectra for computing DGA (max 12 char.)
1                Plot seismograms       (isis)       (1=yes,0=no)
1                Compute response spectra (irs)      (0=no, 1 = only 5% damping,2 = all damping)
```

Repeat the sequence of commands:

```
makescenario.out
scenario.sh
```

This time, the execution of *scenario.sh* will generate also the seismograms and will save the unscaled seismograms for further use in MCSI computations. With the cleaning options defined in the example makescenario.par file the original input data will be saved in the Input directory. And the Results, Scaled and Unscaled directories have been created and populated accordingly. A brief description of the most important files follows.

## Results

The synthetic seismograms at the four considered sites are shown in:

| | |
|---|---|
| z1d001.acc.1.ps | acceleration |
| z1d001.dis.1.ps | displacement |
| z1d001.vel.1.ps | velocity |

Maps with peak values at the sites are shown in:

```
z1d001f0max.cou.ps
z1d001f0res.cou.ps
z1d001f0rzz.cou.ps
z1d001f0sew.cou.ps
z1d001f0sns.cou.ps
z1d001f1max.cou.ps
z1d001f1res.cou.ps
z1d001f1rzz.cou.ps
z1d001f1sew.cou.ps
z1d001f1sns.cou.ps
z1d001f2max.cou.ps
z1d001f2res.cou.ps
z1d001f2rzz.cou.ps
z1d001f2sew.cou.ps
z1d001f2sns.cou.ps
```

where kind of motion can be

| | |
|---|---|
| f0 | displacement |
| f1 | velocity |
| f2 | acceleration |

and component can be:

| | |
|---|---|
| max | maximum horizontal |
| res | resultant horizontal |
| rzz | vertical |
| sew | EW |
| sns | NS |

## Scaled

Scaled synthetic seismograms in displacement (f0), velocity (f1) and acceleration (f2) for NS (.sns) EW (.sew) and vertical (.rzz) components are saved in the Scaled directory:

```
z1d0010012mf0.rzz
z1d0010012mf0.sew
z1d0010012mf0.sns
z1d0010012mf1.rzz
z1d0010012mf1.sew
z1d0010012mf1.sns
z1d0010012mf2.rzz
z1d0010012mf2.sew
z1d0010012mf2.sns
z1d0010014mf0.rzz
z1d0010014mf0.sew
z1d0010014mf0.sns
z1d0010014mf1.rzz
z1d0010014mf1.sew
z1d0010014mf1.sns
z1d0010014mf2.rzz
z1d0010014mf2.sew
z1d0010014mf2.sns
z1d0010252mf0.rzz
z1d0010252mf0.sew
z1d0010252mf0.sns
z1d0010252mf1.rzz
z1d0010252mf1.sew
z1d0010252mf1.sns
z1d0010252mf2.rzz
z1d0010252mf2.sew
z1d0010252mf2.sns
```

## UnScaled

Scaled synthetic seismograms in displacement (f0), velocity (f1) and acceleration (f2) for NS (.sns) EW (.sew) and vertical (.rzz) components are saved in the Scaled directory. The index 0012, 0014 and 0252 point to the structural polygon defined in .por file.

```
z1d0010012m.rzz
z1d0010012m.sew
z1d0010012m.sns
z1d0010014m.rzz
z1d0010014m.sew
z1d0010014m.sns
```

```
z1d0010252m.rzz
z1d0010252m.sew
z1d0010252m.sns
```

These unscaled seismogram files are conveniently used for MCSI computations where randomly generates slip distributions can be adopted to quickly scale the seismograms according to different rupturing models.

## MCSI

See the MCSI manual for a description of how to compute multiple realisations of the source rupturing process, and of the computation of MCSI for the generated scenarios.