UNIVERSITÀ
DEGLI STUDI DI TRIESTE

dipartimento di matematica e geoscienze

The DMG Manuals

1D Discrete Wavenumber Technique

Computation of synthetic seismograms with the discrete wavenumber technique

Document Name: DSTXDWN.pdf
Document Version: 1.0
Date Issued: 25 September 2017 17:33

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Foreword

The present manual describes the use of pavlov7.f90 program (V.M.Pavlov) for the computation of green functions in a 1D layered structural model. The compiled executable module is pavlov7.out.

In the example, the root name is assumed to be **fol001**, so generated filenames refer to that. Change the model name in each input parameter file to whatever fit your needs, if you run your own tests. All the filenames will change accordingly.

Example input files

Required input files can be found in **/XDST/Examples/Pavlov/PavlovExample**. One example input dataset (**/XDST/Examples/Pavlov/PavlovExample/Base** directory) is given. You should copy the required files into a new directory dedicated to your own computations.

Here is what you find in the **Base** directory:

```
-rw-r--r-- 1 magrin 5.2K Sep 26 12:27 fft.par
-rw-r--r-- 1 magrin  682 Sep 26 12:27 fol001.isg
-rw-r--r-- 1 magrin  630 Sep 26 12:27 fol002.stp
-rw-r--r-- 1 magrin  321 Sep 26 12:27 pvl.par
-rw-r--r-- 1 magrin 3.2K Sep 26 12:27 pvl.tun
```

Required input files

pvl.par	parameters file for pavlov7.out
fol001.isg	file with path and source parameters
fol002.stp	1D layered structural model

pvl.par

Input parameter file names are passed to pavlov7 code through the initial “parameter” file that essentially performs the function of the set of command line arguments. It consists of four lines; it has a standard name pvl.par and looks like

```
0                       ! output format (0 - ASCII, 1 - binary)
2                       ! coordinate system [1 - (N,W,U);  2 - (rad,tra_left,U)] or
                          name of tun file
fol001.isg              ! first pair of file names of the structure: isg file
fol002.stp              ! first pair of file names of the structure: stp file
```

xxxxxx.isg

Path and source parameters are taken from isg file. For more details see “GNDT Deterministic Seismic Zoning Reference Guide”.

```
 I N P U T   P A R A M E T .   F O R       1 S E I S M O G R A M (S)
        1 2  1  0   0.000   0   0 0 0 0.1000E+02 0.5000E-01  201 4096  19.699  30.000  28.544  29.000
270.000 GEN.
 1 1 0.0000E+00 0 0 0.0000E+00 0.0000E+00 0.0000E+00 FORCE SYSTEM AND DURATION
 0 0 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0.0000E+00 INSTRUMENT
 0 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00  24.366 FILTER AND EXTRA
 0201sz00410052   15.6429  38.0840  30.000  24.366  29.000 270.000  7.00    1  0.1000E+01  0.0000E+00 S
             1  7.00    2   15.6265  38.2610    2  19.699 355.822  19.699  0.1000E+01    1   0.000   R
```

Explanation of data

record 0 (title)
number of seismogram to be created by program

record 1 (“gen”)

sisnam	name (or num) of seismogram
itype	type (1-displ., 2-vel., 3-accel) - from box
npint	interpolation (0, 1-9) - from box
iflg	ground motion component =0 (see box) - computed
thkr	receiver depth - from box
modest,modetr	first,last used modes (0-all) - from box
igrdmo	input ground motion (0-calc, 1-read in) - from box
marflg	input(1)/calculate(0) eigenfunctions - computed
fifr	final frequency - from box
delfrq	spectrum frequency “interval” (step) - from box
nfqm	number of frequency points (==201) - from box
npts	number of time series points (2**n)=1024,..8192 - from box
dist	distance source-receiver (km) - computed
thk	source depth (km)
phideg	angke (strike-receiver) with strike
deldeg	dip - (see idip in box) = idip in rec.5
xlmdeg	rake - (see irake in box) = irake in rec.5

record 2 (“force system and duration”)

iptf	force type (1 = double couple)
itystf	time function (1=step)
durat	source duration (=0)
istd	shape of time function
ifinit	source fitiness (0-point)
frbsou	rupture velocity (see box)
falen1	fault length along strike (km)
falen2	fault length anti-strike (km)

record 3 (“instrument”) - see identificators in box

record 4 (“filter and extra”)

igauss	flag for computation of low-pass gaussian filter
cmaxf	cutoff frequency (Hz)
pfocf	percentage of cutoff with unit response
cutamp	amplitude at cutoff
extra1,extra2,extra3,extra4,extra5	not used (extra5=iangl - see record5)

record 5(“source”)

iev	index of source in *.fps
lev	aa-run name, ix,iy - coordinates on grid
elon,elat	coordinates of source (longitude,latitude)
xdepth	depth of source in used fps (info only)
xangl	fps: strike
xdip,xrake	fps: dip and rake (= deldeg and xlmdeg in rec.1)
xma	magnitude (== xma1 in rec.6)
nsub	number of subsources (not implemented yet)
sweight	for subsources (not implemented yet)
tshift	shift time for subsources (not implemented yet)

record 6(“receiver”)

ne	index of seismogenic zone(by order in file pos)
lev1	2 symbols- name of run, xxxyyy - two int value (see file *.sut)
xma	magnitude (==xma in rec.5)
ipsou	index poligon source(num of struct.zone -# by order in file por)
slon,slat	coordinates of site (longitude,latitude)
istr	index of structure for receiver (# by order in file por)
dist	== dist (rec.1)
azim	azimut of receiver
distr	dist in use (in the case *.obs may differ from dist in record1)
weicor	correction factor for distance when dist.ne.distl
nsubp	for subsources (not implemented yet)
thkr	receiver depth

xxxxx.stp

Here is the content of the example file `fol002.stp`. with the definition of the layer properties:

```
  thk(km) rho   Vp(km/s)  Vs(km/s)    Qp       Qs     depth(km) layer
   1.0000 2.300  2.650000  1.400000   1000.00  100.00     1.00000   1
   1.6000 2.350  3.600000  2.500000   1000.00  100.00     2.60000   2
   1.5000 2.550  5.500000  3.200000   1000.00  100.00     4.10000   3
   2.0000 2.800  6.100000  3.500000   1000.00  100.00     6.10000   4
   9.0000 2.750  5.000000  2.750000   1000.00  100.00    15.10000   5
  17.0000 2.900  6.322000  3.650000   1000.00  300.00    32.10000   6
  20.0000 3.250  7.015000  4.050000   1000.00  300.00    52.10000   7
  47.9000 3.250  8.227000  4.750000   1000.00  300.00   100.00000   8
```

Optional input file

pvl.tun

This file can be used for a better definition of some parameters that the program can define automatically.

```
!   THIS *.tun file is FOR PVL of v.6 10.12.2004 (5 rows for comments)
! All data are real except nparin (number of data); format is free;
!
! begin
!
&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&
&&&!
14          nparin (integer) is number of data rows after this; others lines are
ignored
 1.          c_in1 (key): 0 for test; 1 for ICTP input format;
 0.         c_in2 (key) - not active
 0.         c_in3 (key) - not active
 1.         c_out1 (key): 1 for ICTP output format
 2.         c_out2 (key) - coordinate system: 1 - (N,W,U);  2 - (rad,tra_left,U)
 0.         c_out3 (key) - not active
 1000.0      rabound (in km) : L > r/2 + T*al_max;
 1.0        aw (dimensionless): omi=-pi/T*aw
 1.0E000    f0 (Hz) - reference frequency
 1.0E-7     accur=ep (dimensionless) - relative accuracy for spectra
 0.2        c1 (dimensionless, c1 <= c0), it must be c1 <= 1.0
 0.2        c0 (dimensionless, c0 >= c1), it must be c0 <= 1.0
 0.0        c_shift (key), when c_shift>0.5 the beginning time in seismogram is
shifting to tp
 0.0        tshift (seconds), (it works when c_shift < 0.5 !!)
```

The file contains following parameters:

rabound=L (in km): epicentral distance to artificial remote boundary (along radial coordinate)

The recommended condition to select L:

L > r/2 + T*al_max

where r is epicentral distance of receiver (maximum if many receivers), T is required seismogram duration and al_max is maximum P-wave velocity above the source

aw: dimensionless parameter that defines the value of the imaginary part

omi of angular frequencies (of "omega", not f) through:

omi=-pi/T*aw;

the default/recommended value aw=1

f0 - reference frequency (Hz) for the formula that defines absorption; f0 is the frequency which ordinary velocity profile refers to. It is assumed that the specified velocity profile of the layered medium corresponds to propagation of waves of frequency f0; body waves of other frequencies propagate at different velocities because of absorption-related dispersion. Typical/default value: 1 Hz

accur=ep - relative contribution of the last used term of the series. Not recommended to use more than 10^-4 without experiments. Default value: 10^(-4).

c1, c0: define low pass filter LP(f/fn) with cosine taper; where fn is Nyquist frequency tapering band (from 1 to 0) is over the frequency interval:

[c1*fn, c1*fn]

typically, c1=0.25, c0=0.5, and the tapering band is [0.25*fNyq 0.5*fNyq]. Default: [0.5, 1] for practical simulation, [0.25 0.5] for nice pictures.

tshift (seconds) is the beginning time in seismogram with respect to origin time at the source; default value 0.

Output files

Names of output files will be

fol001u.rad : radial component

fol001u.rzz : vertical component

fol001u.tra : transversal component

If coordinate system is N,E,U, the output files will be:

fol001u.sew : radial component

fol001u.rzz : vertical component

fol001u.sns : transversal component

Format of output files can be ASCII or binary. An example of an ASCII file is:

```
 synthetic seismograms -   DWN              1 by V.Pavlov"s code PVL v.6, 12.12.
       1 2  1  0  0  30.000   0.000   0   0 10.0  4096     0  4096 1 1  0.0000E+00 0 0   0.000   0.000   0.000
0 0  28.544 0.976562500E-02
 0201sz00410052   15.6429  38.0840  30.000  24.366  29.000 270.000  7.00    1  0.1000E+01  0.0000E+00 S
            1  7.00    2  15.6265  38.2610    2  19.699 355.822  19.699  0.1000E+01    1   0.000    R
  0.343449E-06-0.291874E-06-0.824597E-06-0.105948E-05-0.910059E-06-0.430457E-06 0.204147E-06 0.761480E-06
0.103713E-05 0.929478E-06
  0.477091E-06-0.155103E-06-0.735977E-06-0.105271E-05-0.988731E-06-0.566590E-06 0.600718E-07 0.662540E-06
0.102065E-05 0.100343E-05
  0.617193E-06 0.347433E-08-0.612608E-06-0.100468E-05-0.102805E-05-0.672914E-06-0.682075E-07 0.565316E-06
0.995756E-06 0.106497E-05

....

 -0.136964E-04-0.402931E-07 0.135953E-04 0.222124E-04 0.226438E-04 0.147158E-04
0.131843E-05-0.126475E-04-0.220622E-04-0.234621E-04
 -0.163128E-04-0.321202E-05 0.110552E-04 0.212638E-04 0.236612E-04 0.173455E-04
0.460227E-05-0.992492E-05-0.209289E-04-0.243801E-04
 -0.190038E-04-0.675246E-05 0.790286E-05 0.196042E-04 0.240658E-04 0.196450E-04
          amax  = 0.273000160E-02          amin  = 0.155305797E-02 amaxa  = 0.273000160E-02 0.000000000E+00
0.000000000E+00
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nsubp	for subsources (not implemented yet)
thkr	receiver depth