

The DMG Manuals

FTAN Computer Exercises

Frequency-time analysis of synthetic and recorded seismograms

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FTAN Computer Exercises

Foreword

To better understand how the FTAN analysis works, it is very useful to practice on synthetic seismograms, where in each experiment the structural model and its dispersion properties are known. Synthetic seismograms will be generated along a path, for a given source and structural model. For seismograms generated in a laterally homogeneous layered model, the dispersion features retrieved from the FTAN map will be compared with the theoretical group velocity dispersion curves of the structure. The influence of lateral heterogeneities in the structural model will also be investigated, before tackling the case of an observed time series.

Logging in and getting to the working directory

Six accounts have been made available for the students:

Username:	sg01	sg02	sg03	sg04	sg05	sg06
Password:

From the computer used to login into the system, connect to is01 server, using the Terminal application:

```
[it01:/XDST/sg01] sg01% ssh is01
[is01:/XDST/sg01] sg01%
```

To get to the working directory, give the following commands:

```
[is01:/XDST/sg01] sg01% cdt
[is01:/tmpXDST/sg01] sg01% cd Ftan
[is01:/tmpXDST/sg01/Ftan] sg01%
```

Example input files

Required input files can be found in `/XDST/Examples/Ftan`. Four example input datasets (available in **10Hz**, **1Hz**, **2D**, **Obs** directories) are given. Each one has a **Base** directory where the input files can be found. You should copy the required files into a new directory dedicated to your own computations.

Here is what you find in the `/XDST/Examples/Ftan` directory:

```
[is01:/XDST/Examples/Ftan] vaccari% ls -lR
.:
total 0
drwxr-xr-x 3 vaccari dstquest 102 Mar  5 13:02 10Hz
drwxr-xr-x 3 vaccari dstquest 102 Mar  5 12:50 1Hz
drwxr-xr-x 3 vaccari dstquest 102 Mar  5 13:08 2D
drwxr-xr-x 3 vaccari dstquest 102 Mar  5 13:05 Obs

./10Hz:
total 0
drwxr-xr-x 2 vaccari dstquest 170 Mar  5 13:04 Base

./10Hz/Base:
total 12
-rw-r--r-- 1 vaccari dstquest  829 Mar 30 2011 a.stp
-rw-r--r-- 1 vaccari dstquest 1300 Mar 13 2013 ftanparatest.par
-rw-r--r-- 1 vaccari dstquest  844 Mar 30 2011 p5r.par
```

```

./1Hz:
total 0
drwxr-xr-x 2 vaccari dstquest 238 Mar  5 12:51 Base

./1Hz/Base:
total 20
-rw-r--r-- 1 vaccari dstquest  217 Mar  5 2013 eigr.par
-rw-r--r-- 1 vaccari dstquest 1292 Mar  4 2013 ftanparatest.par
-rwxr-xr-x 1 vaccari dstquest 1381 Mar  4 2013 levc_n.stp
-rwxr-xr-x 1 vaccari dstquest 1243 Mar  4 2013 levp_n.stp
-rw-r--r-- 1 vaccari dstquest  857 Mar  4 2013 p5r.par

./2D:
total 0
drwxr-xr-x 2 vaccari dstquest 816 Mar  5 13:27 Base

./2D/Base:
total 92
-rw-r--r-- 1 vaccari dstquest 1296 Mar 25 2013 ftanparatest.par
-rw-r--r-- 1 vaccari dstquest  511 Mar 21 2013 gusev01.xy
-rw-r--r-- 1 vaccari dstquest  642 Mar 21 2013 gusev02.xy
-rw-r--r-- 1 vaccari dstquest  581 Mar 21 2013 gusev03.xy
-rw-r--r-- 1 vaccari dstquest  726 Mar 21 2013 gusev04.xy
-rw-r--r-- 1 vaccari dstquest  707 Mar 21 2013 gusev05.xy
-rw-r--r-- 1 vaccari dstquest  817 Mar 21 2013 gusev06.xy
-rw-r--r-- 1 vaccari dstquest  890 Mar 21 2013 gusev07.xy
-rw-r--r-- 1 vaccari dstquest 1094 Mar 21 2013 gusev08.xy
-rw-r--r-- 1 vaccari dstquest 1109 Mar 21 2013 gusev09.xy
-rw-r--r-- 1 vaccari dstquest  974 Mar 21 2013 gusev10.xy
-rw-r--r-- 1 vaccari dstquest  719 Mar 21 2013 m0.pof
-rw-r--r-- 1 vaccari dstquest 1266 Mar 21 2013 m1.pof
-rw-r--r-- 1 vaccari dstquest 1266 Mar 21 2013 m2.pof
-rw-r--r-- 1 vaccari dstquest 1266 Mar 21 2013 m3.pof
-rw-r--r-- 1 vaccari dstquest 1265 Mar 21 2013 m4.pof
-rw-r--r-- 1 vaccari dstquest 1755 Mar 21 2013 m5.pof
-rw-r--r-- 1 vaccari dstquest  877 Mar 20 2013 p5r.par
-rw-r--r-- 1 vaccari dstquest 4707 Mar 21 2013 pfdg13.par
-rw-r--r-- 1 vaccari dstquest 1105 Apr 10 2013 s1.stp
-rw-r--r-- 1 vaccari dstquest 1105 Apr 10 2013 s2.stp
-rw-r--r-- 1 vaccari dstquest  116 Mar 21 2013 syn2ftan.par

./Obs:
total 0
drwxr-xr-x 2 vaccari dstquest 102 Mar  5 13:07 Base

./Obs/Base:
total 8
-rw-r--r-- 1 vaccari dstquest 6636 Mar 30 2011 obs.sac
[is01:/XDST/Examples/Ftan] vaccari%

```

For each exercise, create a dedicated directory, and copy into it the files you find in the pertinent Base directory:

```

[is01:/tmpXDST/sg01/Ftan] sg01% mkdir Sg01Test01
[is01:/tmpXDST/sg01/Ftan] sg01% cp /XDST/Examples/Ftan/1Hz/Base/* Sg01Test01/
[is01:/tmpXDST/sg01/Ftan] sg01% cd Sg01Test01/
[is01:sg01/Ftan/Sg01Test01] sg01% ls
ftanparatest.par levc_n.stp levp_n.stp p5r.par
[is01:sg01/Ftan/Sg01Test01] sg01%

```

Synthetic seismograms in 1D models (1 Hz)

Create a new directory for this exercise and copy the required files:

```
[is01:/tmpXDST/sg01/Ftan] sg01% mkdir Sg01Test01
[is01:/tmpXDST/sg01/Ftan] sg01% cd Sg01Test01/
[is01:sg01/Ftan/Sg01Test01] sg01% cp /XDST/Examples/Ftan/1Hz/Base/* .
[is01:sg01/Ftan/Sg01Test01] sg01% ls
eigr.par ftanparatest.par levc_n.stp      levp_n.stp p5r.par
```

Computation of the modes

1) See the structures:

```
[is01:sg01/Ftan/Sg01Test01] sg01% cat levp_n.stp
thk(km) rho    Vp(km/s) Vs(km/s) Qp    Qs    depth(km) layer
 4.0000 2.410  4.410000 2.550000 750.00 300.00  4.00000  1
26.0000 2.660  5.580000 3.180000 750.00 300.00 30.00000  2
30.0000 2.900  6.500000 3.760000 750.00 300.00 60.00000  3
20.0000 3.360  8.100000 4.510000 750.00 300.00 80.00000  4
10.0000 3.370  8.070000 4.460000 750.00 300.00 90.00000  5
10.0000 3.380  8.020000 4.410000 750.00 300.00 100.00000 6
25.0000 3.390  7.930000 4.370000 750.00 300.00 125.00000 7
25.0000 3.410  7.850000 4.350000 750.00 300.00 150.00000 8
25.0000 3.430  7.890000 4.360000 750.00 300.00 175.00000 9
25.0000 3.460  7.980000 4.380000 750.00 300.00 200.00000 10
25.0000 3.480  8.100000 4.420000 750.00 300.00 225.00000 11
25.0000 3.500  8.210000 4.460000 750.00 300.00 250.00000 12
50.0000 3.530  8.380000 4.540000 750.00 300.00 300.00000 13
50.0000 3.580  8.620000 4.680000 750.00 300.00 350.00000 14
50.0000 3.620  8.870000 4.850000 750.00 300.00 400.00000 15
50.0000 3.690  9.150000 5.040000 750.00 300.00 450.00000 16
50.0000 3.800 10.000000 5.500000 750.00 300.00 500.00000 17
[is01:sg01/Ftan/Sg01Test01] sg01%
```

```
[is01:sg01/Ftan/Sg01Test01] sg01% cat levc_n.stp
thk(km) rho    Vp(km/s) Vs(km/s) Qp    Qs    depth(km) layer
20.0000 2.740  6.140000 3.550000 750.00 300.00 20.00000  1
19.0000 3.000  6.580000 3.800000 750.00 300.00 39.00000  2
12.0000 3.320  8.200000 4.650000 750.00 300.00 51.00000  3
10.0000 3.340  8.170000 4.620000 750.00 300.00 61.00000  4
10.0000 3.350  8.140000 4.570000 750.00 300.00 71.00000  5
10.0000 3.360  8.100000 4.510000 750.00 300.00 81.00000  6
10.0000 3.370  8.070000 4.460000 750.00 300.00 91.00000  7
10.0000 3.380  8.020000 4.410000 750.00 300.00 101.00000 8
25.0000 3.390  7.930000 4.370000 750.00 300.00 126.00000 9
25.0000 3.410  7.850000 4.350000 750.00 300.00 151.00000 10
25.0000 3.430  7.890000 4.360000 750.00 300.00 176.00000 11
25.0000 3.460  7.980000 4.380000 750.00 300.00 201.00000 12
25.0000 3.480  8.100000 4.420000 750.00 300.00 226.00000 13
25.0000 3.500  8.210000 4.460000 750.00 300.00 251.00000 14
50.0000 3.530  8.380000 4.540000 750.00 300.00 301.00000 15
50.0000 3.580  8.620000 4.680000 750.00 300.00 351.00000 16
50.0000 3.620  8.870000 4.850000 750.00 300.00 401.00000 17
50.0000 3.690  9.150000 5.040000 750.00 300.00 451.00000 18
50.0000 3.800 10.000000 5.500000 750.00 300.00 501.00000 19
[is01:sg01/Ftan/Sg01Test01] sg01%
```

2) Prepare for the conversion to modal summation format

```
[is01:sg01/Ftan/Sg01Test01] sg01% cat p5r.par
Parameters file for program p5r
0          reference structure (0 = none)
1          max frequency (10 Hz or 1 Hz or 0.1 Hz)
6.42      min velocity for halfspace (1Hz=6.42,10Hz=4.50)
0          max depth (0=use vel; x=km,if in channel stay above)
0          split more at physical interfaces (0=no, 1=YES)
1          add num gradient to num layers (0=no, 1=YES)
1          take care of low-velocity channels (0=no, 1=YES)
2.0       largest Vs to split using wavelength (sugg. 2.0)
```

```

1.          wavelength correction factor (suggested 1.0)
0          max depth for plotting (0=all)
levc_n.stp      physical layers first structure
levp_n.stp
[is01:sg01/Ftan/Sg01Test01] sg01%

```

3) Generate the structure files for modal summation and plot the structures

```

[is01:sg01/Ftan/Sg01Test01] sg01% p5r.out
-----
reference structure file.....: not used
-----
physical structure file.....: levc_n.stp
structure file for program ray and lov...: levc_n.str
not enough depth or velocity reached, and reference structure missing
maximum frequency (hz).....: 1.00
number of water layers.....: 0
number of solid layers.....: 78
number of low velocity channels.....: 1
maximum depth (km).....: 0.00
halfspace s-wave velocity (km/s).....: 5.50
-----
physical structure file.....: levp_n.stp
structure file for program ray and lov...: levp_n.str
not enough depth or velocity reached, and reference structure missing
maximum frequency (hz).....: 1.00
number of water layers.....: 0
number of solid layers.....: 83
number of low velocity channels.....: 1
maximum depth (km).....: 0.00
halfspace s-wave velocity (km/s).....: 5.50
-----

```

p5r, - execution terminated, check file p5r.pri

You can plot the structure (density and velocities vs depth and quality factors for P and S wave vs depth) issuing the command

```

plotstructure levc_n.str
plotstructure levp_n.str

```

Files `levc_n.str.ps`, `levc_n.q.ps`, `levp_n.str.ps` and `levp_n.q.ps` are created that can be printed or viewed. You can redefine the depth range and/or the density and velocity ranges, or use colors in the plots using options of `plotstructure`. The correct syntax is:

```

plotstructure [-options] [<minimum depth (km) to plot>-<maximum depth
(km) to plot>] <input files>

```

Input files can be in str, stp, spl or spr format. The options are:

- cf convert from ps format to format *f*, where *f* means:
 - b bmp
 - e eps
 - f pdf
 - j jpg
 - g png
 - G png (transparent)
 - m ppm
 - t tif
- C plot with color
- dNNN define density (dpi) of raster format, NNN is the value to use
- h print help
- n no title

4) Generate the modes for Love (SH) and Rayleigh (P-SV) waves


```
[is01:sg01/Ftan/Sg01Test01] sg01% lov
[is01:sg01/Ftan/Sg01Test01] sg01% ray
```

The modes must be plotted to check that all modes have been properly computed:

```
plotmodes levp_n.spl      (plot Love modes)
plotmodes levp_n.spr      (plot Rayleigh modes)
```

The first command generates the PostScript file `levp_n.spl.ps` with the plot of the Love modes, the second command generates the file `levp_n.spr.ps` with the Rayleigh modes.

```
gs levp_n.spl.ps          (visualize on screen Love modes)
gs levp_n.spr.ps          (visualize on screen Rayleigh modes)
```

You can redefine the frequency range and/or the phase velocity and/or number of modes ranges using options of `plotmodes` script. The correct syntax is:

```
plotmodes [-options] [name_of_var=value_of_var] [<first modes to plot>-
<last modes to plot>] <input files>
```

List of options:

- a alternate colors for consecutive modes
- cf convert from ps format to format f, where f means:
 - b bmp
 - e eps
 - f pdf
 - j jpg
 - g png
 - G png (transparent)
 - m ppm
 - t tif
- dNNN define density (dpi) of raster format, NNN is the value to use
- e plot ellipticity in additional file
- h print help
- i plot iend in additional file
- l use logscale for x axis
- q plot qx instead of c2
- t use period instead of frequency
- N define line color, default is red, 0 means black

Max and min values of y and x axis can be set by this variables:

- Fmin Fmax: frequency
- Tmin Tmax: period
- Cmin Cmax: phase velocity
- Umin Umax: group velocity
- Imin Imax: energy Integral
- C2min C2max: phase attenuation
- Qmin Qmax: Q
- Zmin Zmax: depth of structure (for iend)
- Vmin Vmax: velocity of P and S waves (for iend)

Generation of the synthetic seismograms

5) Edit the parameters for synthetic seismogram computations

```
[is01:sg01/Ftan/Sg01Test01] sg01% vi ftanparatest.par
Parameter file for program paratest
-----
p          Test label (root for output filenames - 13 chars max)
0          Ref. box file for values not listed below (0=no, 13 chars max)
levp_n.spl Love spectrum file
levp_n.spr Rayleigh spectrum file
1          Motion (1=displ, 2=vel, 3=acc)
200       Time length for plot seismograms (s)
1 0.0 0.0 0.0 Source (1=point, 2=extended), lon, lat, strike (Nord)
1         Force system (1=dc, 2=single, 3=dip, 4=sc, 5=pex, 6=cex)
SRE 0    60  60 15  Strike (loop 0=no,1=yes, start, stop, step) (Degrees)
DIP 0    90  90 10  Dip (loop 0=no,1=yes, start, stop, step) (Degrees)
RAK 0   180  40 10  Rake (loop 0=no,1=yes, start, stop, step) (Degrees)
SDE 1    10  30  2  Source Depth (loop 0=no/1=yes, start, stop, step) (km)
EDI 0   100 200 10  Epicentral Distance (loop 0=no/1=yes, start, stop, step) (km)
RDE 0  0  3  1  Receiver Depth (loop 0=no/1=yes, start, stop, step) (km)
MOD 0  0  0  1  Modes (loop 0=no/1=yes, start, stop (step must be 1) )
INT 0  0  30  1  Interpolation (0-9) (flag 0=no,1=yes, start, stop, step)
MAG 0  0.0 6.5 0.1 Magnitude (flag 0=no,1=yes, start, stop, step)
```

6) Generate the script for the computation of the synthetic seismograms

```
[is01:sg01/Ftan/Sg01Test01] sg01% ftanparatest.out
1 loop to evaluate

Total number of seismograms :    11

Generating the input for syl and syr...

OK - Execution terminated

*** Now you can execute the shell script named: ftanparajob ***
```

7) Generate the synthetic seismograms

```
[is01:sg01/Ftan/Sg01Test01] sg01% ftanparajob
Computing Radial Component...
Computing Vertical Component...
Computing Transverse Component...
2014/03/05 19:04:26      efft treating seismograms...
2014/03/05 19:04:26      efft OK - Execution terminated
Converting to FTAN format

pf0.syr... 11
pf0.syz... 22
pf0.syl... 33

*** To plot the seismograms: gs p.sde.sis.*.ps
*** To plot the peak values: gs p.sde.ps
```

8) Example of list of generated seismograms, to be read with FTAN (ASCII format):

```
[is01:sg01/Ftan/Sg01Test01] sg01% ll *.ft
-rw-r--r-- 1 sg01 dstguest 70097 Mar  5 02:55 p.syz.00001.ft
-rw-r--r-- 1 sg01 dstguest 70097 Mar  5 02:55 p.syz.00002.ft
-rw-r--r-- 1 sg01 dstguest 70097 Mar  5 02:55 p.syz.00003.ft
-rw-r--r-- 1 sg01 dstguest 70097 Mar  5 02:55 p.syz.00004.ft
-rw-r--r-- 1 sg01 dstguest 70097 Mar  5 02:55 p.syz.00005.ft
-rw-r--r-- 1 sg01 dstguest 70097 Mar  5 02:55 p.syz.00006.ft
```

```
-rw-r--r-- 1 sg01 dstguest 70097 Mar  5 02:55 p.syz.00007.ft
-rw-r--r-- 1 sg01 dstguest 70097 Mar  5 02:55 p.syz.00008.ft
-rw-r--r-- 1 sg01 dstguest 70097 Mar  5 02:55 p.syz.00009.ft
-rw-r--r-- 1 sg01 dstguest 70097 Mar  5 02:55 p.syz.00010.ft
-rw-r--r-- 1 sg01 dstguest 70097 Mar  5 02:55 p.syz.00011.ft
```

FTAN analysis

Launch XFTAN. You can have more than one window open, and in each window you can perform the following steps:

- 9) Read one of the generated seismogram, in ASCII format.
- 10) Adjust the FTAN parameter and generate the FTAN map by pushing the "Map" button.
- 11) Draw a dispersion curve by clicking on the FTAN map, following the curve you think is the fundamental mode. When done, push the "Filter" button, being sure to use manual mode ("Manual" checkbox must be checked).
- 12) Check that the automatically selected region (four red marks) contains the green mark plotted along the curve. If the green mark is not visible in the plotted region, zoom out by alt-shift-click on the plot. If the green mark is outside of the four red marks, define manually the proper red marks by clicking four times on the plot around the peak closest to the green mark. Click OK to do the filtering.
- 13) As a cross-check, read the modes (file *.spr) used to generate the seismograms, to see how they fit with the pattern of the FTAN map. To do this, push the "Map" button again, ctrl-click on the ftan map and select the "Read Modes..." contextual menu to select the proper *.spr file. The first three modes of the structure will be plotted (the darkest being the fundamental mode).
- 14) When a satisfactory FTAN processing has been achieved, it is suggested to save the analysis from the File-->Save menu. Remember to add a .ftan extension to the file saved.

Variations

In the original example, source depth was varied, and all modes were generated. The fundamental mode was then obtained by filtering the FTAN map. Modify file ftanparatest.par in step 5) to generate only the fundamental mode changing the MOD record to look like this:

```
MOD 0 1 1 1          Modes (loop 0=no/1=yes, start, stop (step must be 1) )
```

(and set change "p" to "fp" in test label, to obtain different filenames and avoid overwriting the results). Compare theoretical and filtered fundamental mode seismograms.

Repeat the computations using a different epicentral distance. Any difference in the FTAN map you obtain?

Repeat the computations generating the seismograms in velocity or displacement, rather than in acceleration. Any difference in the FTAN map you obtain?

Eigenfunction computations

You may want to visualize the eigenfunctions running script `checkEig`, for selected modes and frequencies. Script `checkEig` computes and plots the eigenfunctions starting from spectrum (`spl` or `spr`) file. The correct syntax is:

```
checkEig [-options] [name_of_var=value_of_var] m=<first modes to plot>-  
<last modes to plot> f=<first frequency to plot>-<last frequency to plot>  
<input files>
```

Input files must be a Love or Rayleigh spectrum. Name of the output file has this format:

```
<root name of input file>.<first mode to plot>-<last mode to plot>.eig[rl].ps
```

List of options:

- B grey-scale plot
- b plot Ray and Love eigenfunctions
- cf convert from ps format to format f, where f means:
 - b bmp
 - e eps
 - f pdf
 - j jpg
 - g png
 - G png (transparent)
 - m ppm
 - t tif
- dNNN define density (dpi) of raster format, NNN is the value to use
- i plot iend
- l use logscale for x axis in iend plot
- t use period instead of frequency in iend plot
- h print help
- n no title

Useful variables that can be set:

- | | |
|------------|---|
| iend | defines iend for eigenfunction computation |
| depth | defines maximum depth for eigenfunction computation |
| Zmax, Zmin | maximum and minimum depths to plot |
| Fmax, Fmin | maximum and minimum frequency to plot (for iend) |

Synthetic seismograms in 1D models (10 Hz)

Create a new directory for this exercise and copy the required files:

```
[is01:/tmpXDST/sg01/Ftan] sg01% mkdir Sg01Test10
[is01:/tmpXDST/sg01/Ftan] sg01% cd Sg01Test10/
[is01:sg01/Ftan/Sg01Test10] sg01% cp /XDST/Examples/Ftan/10Hz/Base/* .
[is01:sg01/Ftan/Sg01Test10] sg01% ls
a.stp ftanparatest.par p5r.par
```

The steps to be performed are the same as those executed in the previous exercise. The FTAN map parameters will have to be adapted to the new period and velocity ranges.

Computation of the modes

1) See the structure:

```
[is01:sg01/Ftan/Sg01Test10] sg01% cat a.stp
thk(km) rho Vp(km/s) Vs(km/s) Qp Qs depth(km) layer
0.0430 2.000 0.550000 0.300000 10000.00 10000.00 0.04300 1
0.0760 2.100 1.500000 0.900000 10000.00 10000.00 0.11900 2
0.3810 2.120 2.250000 1.300000 10000.10 10000.00 0.50000 3
0.5000 2.150 2.600000 1.500000 10000.00 10000.00 1.00000 4
0.5000 2.300 3.200000 1.800000 10000.00 10000.00 1.50000 5
0.5000 2.300 3.600000 2.100000 10000.00 10000.00 2.00000 6
0.5000 2.300 4.000000 2.300000 10000.00 10000.00 2.50000 7
0.5000 2.300 4.400000 2.500000 10000.00 10000.00 3.00000 8
0.5000 2.450 4.800000 2.700000 10000.00 10000.00 3.50000 9
0.5000 2.500 5.400000 3.100000 10000.00 10000.00 4.00000 10
6.0000 2.600 5.600000 3.200000 10000.00 10000.00 10.00000 11
[is01:sg01/Ftan/Sg01Test10] sg01%
```

2) Prepare for the conversion to modal summation format

```
[is01:sg01/Ftan/Sg01Test10] sg01% cat p5r.par
Parameters file for program p5r
0 reference structure (0 = none)
10. max frequency (10 Hz or 1 Hz or 0.1 Hz)
4.5 min velocity for halfspace (1Hz=6.42,10Hz=4.50)
0. max depth (0=use vel; x=km,if in channel stay above)
0 split more at physical interfaces (0=no, 1=YES)
1 add num gradient to num layers (0=no, 1=YES)
1 take care of low-velocity channels (0=no, 1=YES)
2.0 largest Vs to split using wavelength (sugg. 2.0)
1. wavelength correction factor (suggested 1.0)
0.3 max depth for plotting (0=all)
a.stp physical layers first structure
```

3) Generate the structure files for modal summation and plot the structures

```
[is01:sg01/Ftan/Sg01Test10] sg01% p5r.out
-----
reference structure file.....: not used
-----
physical structure file.....: a.stp
structure file for program ray and lov...: a.str
not enough depth or velocity reached, and reference structure missing
maximum frequency (hz).....: 10.00
number of water layers.....: 0
number of solid layers.....: 47
number of low velocity channels.....: 0
maximum depth (km).....: 0.00
halfspace s-wave velocity (km/s).....: 3.20
-----

p5r, - execution terminated, check file p5r.pri
```

You can plot the structure (density and velocities vs depth and quality factors for P and S wave vs depth) issuing the command

```
plotstructure levc_n.str
plotstructure levp_n.str
```

Files `levc_n.str.ps`, `levc_n.q.ps`, `levp_n.str.ps` and `levp_n.q.ps` are created that can be printed or viewed. You can redefine the depth range and/or the density and velocity ranges, or use colors in the plots using options of `plotstructure`. The correct syntax is:

```
plotstructure [-options] [<minimum depth (km) to plot>-<maximum depth (km) to plot>] <input files>
```

Input files can be in str, stp, spl or spr format. The options are:

```
-cf convert from ps format to format f, where f means:
    b  bmp
    e  eps
    f  pdf
    j  jpg
    g  png
    G  png (transparent)
    m  ppm
    t  tif
-C   plot with color
-dNNN define density (dpi) of raster format, NNN is the value to use
-h   print help
-n   no title
```

4) Generate the modes for Love (SH) and Rayleigh (P-SV) waves

```
[is01:sg01/Ftan/Sg01Test01] sg01% lov
[is01:sg01/Ftan/Sg01Test01] sg01% ray
```

The modes must be plotted to check that all modes have been properly computed:

```
plotmodes levp_n.spl      (plot Love modes)
plotmodes levp_n.spr      (plot Rayleigh modes)
```

The first command generates the PostScript file `levp_n.spl.ps` with the plot of the Love modes, the second command generates the file `levp_n.spr.ps` with the Rayleigh modes.

```
gs levp_n.spl.ps          (visualize on screen Love modes)
gs levp_n.spr.ps          (visualize on screen Rayleigh modes)
```

You can redefine the frequency range and/or the phase velocity and/or number of modes ranges using options of `plotmodes` script. The correct syntax is:

```
plotmodes [-options] [name_of_var=value_of_var] [<first modes to plot>-<last modes to plot>] <input files>
```

List of options:

```
-a alternate colors for consecutive modes
-cf convert from ps format to format f, where f means:
    b  bmp
    e  eps
    f  pdf
    j  jpg
    g  png
```

G png (transparent)
m ppm
t tif

- dNNN define density (dpi) of raster format, NNN is the value to use
- e plot ellipticity in additional file
- h print help
- i plot iend in additional file
- l use logscale for x axis
- q plot qx instead of c2
- t use period instead of frequency
- N define line color, default is red, 0 means black

Max and min values of y and x axis can be set by this variables:

- Fmin Fmax: frequency
- Tmin Tmax: period
- Cmin Cmax: phase velocity
- Umin Umax: group velocity
- Imin Imax: energy Integral
- C2min C2max: phase attenuation
- Qmin Qmax: Q
- Zmin Zmax: depth of structure (for iend)
- Vmin Vmax: velocity of P and S waves (for iend)

Generation of the synthetic seismograms

5) Edit the parameters for synthetic seismogram computations

```
[is01:sg01/Ftan/Sg01Test01] sg01% vi ftanparatest.par  
Parameter file for program ftanparatest
```

```
-----  
s01a          Test label (root for output filenames - 13 chars max)  
0            Ref. box file for values not listed below (0=no, 13 chars max)  
a.spl        Love spectrum file  
a.spr        Rayleigh spectrum file  
3           Motion (1=displ, 2=vel, 3=acc)  
40          Time length for plot seismograms (s)  
1 0.0 0.0 0.0 Source (1=point, 2=extended), lon, lat, strike (Nord)  
2          Force system (1=dc, 2=single, 3=dip, 4=sc, 5=pex, 6=cex)  
SRE 0 0 60 15 Strike (loop 0=no,1=yes, start, stop, step) (Degrees)  
DIP 0 90 90 10 Dip (loop 0=no,1=yes, start, stop, step) (Degrees)  
RAK 0 270 40 10 Rake (loop 0=no,1=yes, start, stop, step) (Degrees)  
SDE 1 0.001 0.031 0.002 Source Depth (loop 0=no/1=yes, start, stop, step) (km)  
EDI 0 5.00 15. 1.0 Epicentral Distance (loop 0=no/1=yes, start, stop, step) (km)  
RDE 0 0 3 1 Receiver Depth (loop 0=no/1=yes, start, stop, step) (km)  
MOD 0 0 0 1 Modes (loop 0=no/1=yes, start, stop (step must be 1) )  
INT 0 2 30 1 Interpolation (0-9) (flag 0=no,1=yes, start, stop, step)  
MAG 0 1. 6.0 .1 Magnitude (flag 0=no,1=yes, start, stop, step)
```

6) Generate the script for the computation of the synthetic seismograms

```
[is01:sg01/Ftan/Sg01Test10] sg01% ftanparatest.out  
1 loop to evaluate
```

Total number of seismograms : 16

Generating the input for syl and syr...

OK - Execution terminated

*** Now you can execute the shell script named: ftanparajob ***

7) Generate the synthetic seismograms

```
[is01:sg01/Ftan/Sg01Test10] sg01% ftanparajob
Computing Radial Component...
Computing Vertical Component...
Computing Transverse Component...
2014/03/05 18:59:48      efft treating seismograms...
2014/03/05 18:59:49      efft OK - Execution terminated
Converting to FTAN format
```

```
s0laf2.syr... 16
s0laf2.syz... 32
s0laf2.syl... 48
```

```
*** To plot the seismograms: gs s0la.sde.sis.*.ps
*** To plot the peak values: gs s0la.sde.ps
```

8) Example of list of generated seismograms, to be read with FTAN (ASCII format):

```
[is01:sg01/Ftan/Sg01Test10] sg01% ll *.ft
-rw-r--r-- 1 sg01 dstguest 70134 Mar  5 18:59 s0la.syz.00001.ft
-rw-r--r-- 1 sg01 dstguest 70134 Mar  5 18:59 s0la.syz.00002.ft
-rw-r--r-- 1 sg01 dstguest 70134 Mar  5 18:59 s0la.syz.00003.ft
-rw-r--r-- 1 sg01 dstguest 70134 Mar  5 18:59 s0la.syz.00004.ft
-rw-r--r-- 1 sg01 dstguest 70134 Mar  5 18:59 s0la.syz.00005.ft
-rw-r--r-- 1 sg01 dstguest 70134 Mar  5 18:59 s0la.syz.00006.ft
-rw-r--r-- 1 sg01 dstguest 70134 Mar  5 18:59 s0la.syz.00007.ft
-rw-r--r-- 1 sg01 dstguest 70134 Mar  5 18:59 s0la.syz.00008.ft
-rw-r--r-- 1 sg01 dstguest 70134 Mar  5 18:59 s0la.syz.00009.ft
-rw-r--r-- 1 sg01 dstguest 70134 Mar  5 18:59 s0la.syz.00010.ft
-rw-r--r-- 1 sg01 dstguest 70134 Mar  5 18:59 s0la.syz.00011.ft
-rw-r--r-- 1 sg01 dstguest 70134 Mar  5 18:59 s0la.syz.00012.ft
-rw-r--r-- 1 sg01 dstguest 70134 Mar  5 18:59 s0la.syz.00013.ft
-rw-r--r-- 1 sg01 dstguest 70134 Mar  5 18:59 s0la.syz.00014.ft
-rw-r--r-- 1 sg01 dstguest 70134 Mar  5 18:59 s0la.syz.00015.ft
-rw-r--r-- 1 sg01 dstguest 70134 Mar  5 18:59 s0la.syz.00016.ft
```

FTAN analysis

Launch XFTAN. You can have more than one window open, and in each window you can perform the following steps:

- 9) Read one of the generated seismogram, in ASCII format.
- 10) Adjust the FTAN parameter and generate the FTAN map by pushing the "Map" button.
- 11) Draw a dispersion curve by clicking on the FTAN map, following the curve you think is the fundamental mode. When done, push the "Filter" button, being sure to use manual mode ("Manual" checkbox must be checked).
- 12) Check that the automatically selected region (four red marks) contains the green mark plotted along the curve. If the green mark is not visible in the plotted region, zoom out by alt-shift-click on the plot. If the green mark is outside of the four red marks, define manually the proper red marks by clicking four times on the plot around the peak closest to the green mark. Click OK to do the filtering.
- 13) As a cross-check, read the modes (file *.spr) used to generate the seismograms, to see how they fit with the pattern of the FTAN map. To do this, push the "Map" button again, ctrl-click on the ftan

map and select the "Read Modes..." contextual menu to select the proper *.spr file. The first three modes of the structure will be plotted (the darkest being the fundamental mode).

- 14) When a satisfactory FTAN processing has been achieved, it is suggested to save the analysis from the File->Save menu. Remember to add a .ftan extension to the file saved.

Variations

Modify the properties of the uppermost layers, generate again the modes and the seismograms and see how much the dispersion properties of the fundamental mode can change.

Synthetic seismograms in 2D models (coupling, 10 Hz)

In this exercise, the 2D coupling modal summation technique is used to generate synthetic seismograms for the transverse component of motion. Two structural models are defined in `s1.stp` and `s2.stp`, and the modes are already available in the corresponding `.spl` files.

To get to the working directory, give the following commands:

```
[is01:Ftan/2D/Coupling] sg01% cdt
[is01:/tmpXDST/sg01] sg01% cd Ftan
[is01:/tmpXDST/sg01/Ftan] sg01% mkdir -p 2D/Coupling
[is01:/tmpXDST/sg01/Ftan] sg01% cd 2D/Coupling
[is01:Ftan/2D/Coupling] sg01%
```

Copy the files you find in the example directory:

```
[is01:Ftan/2D/Coupling] sg01% ls -l /XDST/Examples/Ftan/2D/Coupling/Base
total 3084
-rw-r--r-- 1 vaccari dstguest      975 Apr  7 15:22 couplov.par
-rw-r--r-- 1 vaccari dstguest      104 Apr  7 15:23 coupsplit.par
-rw-r--r-- 1 vaccari dstguest     5268 Apr  7 15:25 fft.par
-rw-r--r-- 1 vaccari dstguest 1544897 Apr  7 09:14 s1.spl
-rw-r--r-- 1 vaccari dstguest     1105 Apr 10 2013 s1.stp
-rw-r--r-- 1 vaccari dstguest 1571386 Apr  7 09:14 s2.spl
-rw-r--r-- 1 vaccari dstguest     1105 Apr 10 2013 s2.stp
-rw-r--r-- 1 vaccari dstguest     2371 Apr  7 14:58 syl2d.box
-rw-r--r-- 1 vaccari dstguest      891 Apr  7 15:35 sylcoup.par
-rw-r--r-- 1 vaccari dstguest       86 Apr  7 15:25 syn2ftan.par

[is01:Ftan/2D/Coupling] sg01% cp /XDST/Examples/Ftan/2D/Coupling/Base/* .
[is01:Ftan/2D/Coupling] sg01%
```

Exercise

1) See the structures:

thk(km)	rho	Vp(km/s)	Vs(km/s)	Qp	Qs	depth(km)	layer
0.0300	2.000	2.600000	1.500000	220.00	100.00	0.03000	1
0.1700	2.000	2.940000	1.700000	220.00	100.00	0.20000	2
0.8000	2.100	3.500000	1.900000	220.00	100.00	1.00000	3
1.0000	2.210	4.800000	2.400000	220.00	100.00	2.00000	4
3.0000	2.550	5.570000	3.220000	220.00	100.00	5.00000	5
3.0000	2.660	5.899000	3.410000	220.00	100.00	8.00000	6
7.0000	2.680	5.985000	3.460000	220.00	100.00	15.00000	7
4.0000	2.740	6.150000	3.560000	220.00	100.00	19.00000	8
9.0000	2.780	6.290000	3.640000	220.00	100.00	28.00000	9
12.0000	2.980	6.920000	4.000000	220.00	100.00	40.00000	10
5.0000	3.100	7.280000	4.210000	220.00	100.00	45.00000	11
11.0000	3.240	7.730000	4.470000	220.00	100.00	56.00000	12
9.0000	3.250	7.750000	4.480000	220.00	100.00	65.00000	13
9.0000	3.260	7.767000	4.494000	220.00	100.00	74.00000	14
18.0000	3.290	7.785000	4.500000	220.00	100.00	92.00000	15

```
[is01:Ftan/2D/Coupling] sg01% cat s2.stp
thk(km) rho Vp(km/s) Vs(km/s) Qp Qs depth(km) layer
```

0.0300	1.900	0.780000	0.450000	220.00	100.00	0.03000	1
0.1700	2.000	1.730000	1.000000	220.00	100.00	0.20000	2
0.8000	2.100	3.500000	1.900000	220.00	100.00	1.00000	3
1.0000	2.210	4.800000	2.400000	220.00	100.00	2.00000	4
3.0000	2.550	5.570000	3.220000	220.00	100.00	5.00000	5
3.0000	2.660	5.899000	3.410000	220.00	100.00	8.00000	6
7.0000	2.680	5.985000	3.460000	220.00	100.00	15.00000	7
4.0000	2.740	6.150000	3.560000	220.00	100.00	19.00000	8
9.0000	2.780	6.290000	3.640000	220.00	100.00	28.00000	9
12.0000	2.980	6.920000	4.000000	220.00	100.00	40.00000	10
5.0000	3.100	7.280000	4.210000	220.00	100.00	45.00000	11
11.0000	3.240	7.730000	4.470000	220.00	100.00	56.00000	12
9.0000	3.250	7.750000	4.480000	220.00	100.00	65.00000	13
9.0000	3.260	7.767000	4.494000	220.00	100.00	74.00000	14
18.0000	3.290	7.785000	4.500000	220.00	100.00	92.00000	15

[is01:Ftan/2D/Coupling] sg01%

- 2) Convert the Love modes files (.spl) into direct access format using program *modes2daf01.out*:

```
[is01:Ftan/2D/Coupling] sg01% ls *.spl
s1.spl      s2.spl
[is01:Ftan/2D/Coupling] sg01% modes2daf01.out
NUMBER OF SPECTRA (MAX 29)
2
          2
SPECTRUM TYPE (1=LOVE 2=RAYLEIGH):
1
          1

SEQUENTIAL INPUT SPECTRUM          1 (MAX 20 CHARACTERS)
s1.spl

INPUT SPECTRUM (FORMATTED SEQUENTIAL).....: s1.spl
OUTPUT SPECTRUM (FORMATTED DIRECT ACCESS)...: s1.sdl
SPECTRAL INFORMATION FILE.....: s1.sil

SEQUENTIAL INPUT SPECTRUM          2 (MAX 20 CHARACTERS)
s2.spl

INPUT SPECTRUM (FORMATTED SEQUENTIAL).....: s2.spl
OUTPUT SPECTRUM (FORMATTED DIRECT ACCESS)...: s2.sdl
SPECTRAL INFORMATION FILE.....: s2.sil

[is01:Ftan/2D/Coupling] sg01%
```

- 3) Compute the coupling coefficients using program *couplov01.out*:

```
[is01:Ftan/2D/Coupling] sg01% couplov01.out
EXECUTION HAS STARTED FOR          1 . INTERFACE

Input parameters..... (IN) ..: coplov.inp
Output writings..... (OUT)...: coplov.pri

Output files created.....:

Coupling file transmission... (OUT)...: tran01.cdl

COMPUTATIONS OK - EXECUTION ENDED
[is01:Ftan/2D/Coupling] sg01%
```

if you happen to run more than once *couplov01.out*, please remember to remove file *tran01.cdl* before re-running the program, or you will obtain an error message like this:

```
At line 218 of file couplov01.f (unit = 9, file = '')
Fortran runtime error: File 'tran01.cdl' already exists
```

So, in case:

```
[is01:Ftan/2D/Coupling] sg01% rm tran01.cdl
```

4) Generate the direct access coupling file for the mode paths:

```
[is01:Ftan/2D/Coupling] sg01% coupsplit01.out
NUMBER OF COUPLINGFILES ? (MAX 15)
    1
SPECTRUM TYPE (1=LOVE, 2=RAYLEIGH)
    1
INPUT COUPLING FILE(S) (extension .cdl)
INPUT COUPLING FILE (FORMATTED DIRECT ACCESS):: tran01.cdl

OUTPUT SPLIT FILE (UNFORMATTED DIRECT ACCESS):: coupmode.mdl
OUTPUT INFO FILE (FORMATTED SEQUENTIAL).....: coupmode.mil

THE OUTPUT FILES ARE USED BY sylcoup
```

```
[is01:Ftan/2D/Coupling] sg01%
```

5) Generate the synthetic seismogram. Seismogram parameters are defined in file *sylcoup.par* and *sy12d.box*:

```
[is01:Ftan/2D/Coupling] sg01% sylcoup01.out
Parameters are read from file sylcoup.par

THE SPECTRUM FOR STRUCTURE 1 CONTAINS LESS MODES THAN THE FLAG LASTMODE IN
SYL2D.BOX ALLOWS IN THE SUM.
LASTMODE IS RESET TO MAXIMALLY 138. HIGHER MODE IN THE SUM.

THE SUM OF MODES IN THE SEISMOGRAM CONSISTS OF 843533 MODE PATHS.
THE SUM CONSIST OF ALL MODE PATHS (ALSO CROSS COUPLED PATHS) THAT
INVOLVES MODES IN THE RANGE FROM FUNDAMENTAL TO 138. HIGHER MODE.

[is01:Ftan/2D/Coupling] sg01%
```

6) Convert seismogram into FTAN format:

```
[is01:Ftan/2D/Coupling] sg01% syn2ftan.out
[is01:Ftan/2D/Coupling] sg01%
```

Variations

Changing the parameter *icrossflag* in file *sylcoup.par* and *firstmode* and *lastmode* in file *sy12d.box*:

- 1) Compute new seismograms ignoring the cross-couplings between modes of different orders
- 2) Focus on the incoming fundamental mode, with or without cross-couplings

Synthetic seismograms in 2D models (hybrid, 10 Hz)

To get to the working directory, give the following commands:

```
[is01:/XDST/sg01] sg01% cdt
[is01:/tmpXDST/sg01] sg01% cd Ftan
[is01:/tmpXDST/sg01/Ftan] sg01% cd 2D
[is01:sg01/Ftan/2D] sg01%
```

Copy the files you find in the example directory:

```
[is01:sg01/Ftan/2D] sg01% ls -l /XDST/Examples/Ftan/2D/Base/
total 140
-rw-r--r-- 1 vaccari dstguest 1296 Apr  7 10:53 ftanparatest.par
-rw-r--r-- 1 vaccari dstguest  511 Apr  7 10:53 gusev01.xy
-rw-r--r-- 1 vaccari dstguest  642 Apr  7 10:53 gusev02.xy
-rw-r--r-- 1 vaccari dstguest  581 Apr  7 10:53 gusev03.xy
-rw-r--r-- 1 vaccari dstguest  726 Apr  7 10:53 gusev04.xy
-rw-r--r-- 1 vaccari dstguest  707 Apr  7 10:53 gusev05.xy
-rw-r--r-- 1 vaccari dstguest  817 Apr  7 10:53 gusev06.xy
-rw-r--r-- 1 vaccari dstguest  890 Apr  7 10:53 gusev07.xy
-rw-r--r-- 1 vaccari dstguest 1094 Apr  7 10:53 gusev08.xy
-rw-r--r-- 1 vaccari dstguest 1109 Apr  7 10:53 gusev09.xy
-rw-r--r-- 1 vaccari dstguest  974 Apr  7 10:53 gusev10.xy
-rw-r--r-- 1 vaccari dstguest  719 Apr  7 10:53 m0.pof
-rw-r--r-- 1 vaccari dstguest 1266 Apr  7 10:53 m1.pof
-rw-r--r-- 1 vaccari dstguest 1266 Apr  7 10:53 m2.pof
-rw-r--r-- 1 vaccari dstguest 1266 Apr  7 10:53 m3.pof
-rw-r--r-- 1 vaccari dstguest 1265 Apr  7 10:53 m4.pof
-rw-r--r-- 1 vaccari dstguest 1755 Apr  7 10:53 m5.pof
-rw-r--r-- 1 vaccari dstguest  877 Apr  7 10:53 p5r.par
-rw-r--r-- 1 vaccari dstguest 4707 Apr  7 10:53 pfdg13.par
-rw-r--r-- 1 vaccari dstguest 4707 Apr  7 10:53 pfdg13.par.m0
-rw-r--r-- 1 vaccari dstguest 4707 Apr  7 10:53 pfdg13.par.m1
-rw-r--r-- 1 vaccari dstguest 4707 Apr  7 10:53 pfdg13.par.m2
-rw-r--r-- 1 vaccari dstguest 4707 Apr  7 10:53 pfdg13.par.m3
-rw-r--r-- 1 vaccari dstguest 4707 Apr  7 10:53 pfdg13.par.m4
-rw-r--r-- 1 vaccari dstguest 4707 Apr  7 10:53 pfdg13.par.m5
-rw-r--r-- 1 vaccari dstguest 1105 Apr  7 10:53 s1.stp
-rw-r--r-- 1 vaccari dstguest 1105 Apr  7 10:53 s2.stp
-rw-r--r-- 1 vaccari dstguest  116 Apr  7 10:53 syn2ftan.par

[is01:sg01/Ftan/2D] sg01% cp /XDST/Examples/Ftan/2D/Base/* .
[is01:sg01/Ftan/2D] sg01%
```

Exercise

1) See the structures:

```
[is01:sg01/Ftan/2D] sg01% cat s1.stp
```

thk(km)	rho	Vp(km/s)	Vs(km/s)	Qp	Qs	depth(km)	layer
0.0300	2.000	2.600000	1.500000	220.00	100.00	0.03000	1
0.1700	2.000	2.940000	1.700000	220.00	100.00	0.20000	2
0.8000	2.100	3.500000	1.900000	220.00	100.00	1.00000	3
1.0000	2.210	4.800000	2.400000	220.00	100.00	2.00000	4
3.0000	2.550	5.570000	3.220000	220.00	100.00	5.00000	5

3.0000	2.660	5.899000	3.410000	220.00	100.00	8.00000	6
7.0000	2.680	5.985000	3.460000	220.00	100.00	15.00000	7
4.0000	2.740	6.150000	3.560000	220.00	100.00	19.00000	8
9.0000	2.780	6.290000	3.640000	220.00	100.00	28.00000	9
12.0000	2.980	6.920000	4.000000	220.00	100.00	40.00000	10
5.0000	3.100	7.280000	4.210000	220.00	100.00	45.00000	11
11.0000	3.240	7.730000	4.470000	220.00	100.00	56.00000	12
9.0000	3.250	7.750000	4.480000	220.00	100.00	65.00000	13
9.0000	3.260	7.767000	4.494000	220.00	100.00	74.00000	14
18.0000	3.290	7.785000	4.500000	220.00	100.00	92.00000	15

[is01:sg01/Ftan/2D] sg01% cat s2.stp

thk(km)	rho	Vp(km/s)	Vs(km/s)	Qp	Qs	depth(km)	layer
0.0300	1.900	0.780000	0.450000	220.00	100.00	0.03000	1
0.1700	2.000	1.730000	1.000000	220.00	100.00	0.20000	2
0.8000	2.100	3.500000	1.900000	220.00	100.00	1.00000	3
1.0000	2.210	4.800000	2.400000	220.00	100.00	2.00000	4
3.0000	2.550	5.570000	3.220000	220.00	100.00	5.00000	5
3.0000	2.660	5.899000	3.410000	220.00	100.00	8.00000	6
7.0000	2.680	5.985000	3.460000	220.00	100.00	15.00000	7
4.0000	2.740	6.150000	3.560000	220.00	100.00	19.00000	8
9.0000	2.780	6.290000	3.640000	220.00	100.00	28.00000	9
12.0000	2.980	6.920000	4.000000	220.00	100.00	40.00000	10
5.0000	3.100	7.280000	4.210000	220.00	100.00	45.00000	11
11.0000	3.240	7.730000	4.470000	220.00	100.00	56.00000	12
9.0000	3.250	7.750000	4.480000	220.00	100.00	65.00000	13
9.0000	3.260	7.767000	4.494000	220.00	100.00	74.00000	14
18.0000	3.290	7.785000	4.500000	220.00	100.00	92.00000	15

[is01:sg01/Ftan/2D] sg01%

2) Prepare for the conversion to modal summation format

[is01:sg01/Ftan/2D] sg01% cat p5r.par

Parameters file for program p5r

```

0          reference structure (0 = none)
10.        max frequency (10 Hz or 1 Hz or 0.1 Hz)
4.50      min velocity for halfspace (1Hz=6.42,10Hz=4.50)
0.        max depth (0=use vel; x=km,if in channel stay above)
1         split more at physical interfaces (0=no, 1=YES)
1         add num gradient to num layers (0=no, 1=YES)
1         take care of low-velocity channels (0=no, 1=YES)
2.0      largest Vs to split using wavelength (sugg. 2.0)
1.        wavelength correction factor (suggested 1.0)
2         max depth for plotting (0=all)
s1.stp    physical layers
s2.stp    physical layers

```

3) Generate the structure files for modal summation and plot the structures

[is01:sg01/Ftan/2D] sg01% p5r.out

```

-----
reference structure file.....: not used
-----
physical structure file.....: s1.stp
structure file for program ray and lov...: s1.str
maximum frequency (hz).....: 10.00
number of water layers.....: 0
number of solid layers.....: 107
number of low velocity channels.....: 0
maximum depth (km).....: 0.00
halfspace s-wave velocity (km/s).....: 4.50
-----
physical structure file.....: s2.stp
structure file for program ray and lov...: s2.str

```

```

maximum frequency (hz).....: 10.00
number of water layers.....: 0
number of solid layers.....: 110
number of low velocity channels.....: 0
maximum depth (km).....: 0.00
halfspace s-wave velocity (km/s).....: 4.50

```

```

p5r, - execution terminated, check file p5r.pri
[is01:sg01/Ftan/2D] sg01%

```

```

[is01:sg01/Ftan/2D] sg01% plotstructure *.str

```

```

[is01:sg01/Ftan/2D] sg01% ll *.ps

```

```

-rw-r--r-- 1 sg01 dstguest 18542 Apr 11 00:26 s1.str.ps
-rw-r--r-- 1 sg01 dstguest 18622 Apr 11 00:26 s2.str.ps

```

```

[is01:sg01/Ftan/2D] sg01% gs s?.str.ps

```

4) Generate the modes for Love (SH) and Rayleigh (P-SV) waves and plot them

```

[is01:sg01/Ftan/2D] sg01% lov
[is01:sg01/Ftan/2D] sg01% ray
[is01:sg01/Ftan/2D] sg01% plotmodes *.sp?
[is01:sg01/Ftan/2D] sg01% ll *.sp?.ps
-rw-r--r-- 1 sg01 dstguest 491567 Apr 11 00:28 s1.spl.ps
-rw-r--r-- 1 sg01 dstguest 503822 Apr 11 00:28 s1.spr.ps
-rw-r--r-- 1 sg01 dstguest 490647 Apr 11 00:28 s2.spl.ps
-rw-r--r-- 1 sg01 dstguest 511410 Apr 11 00:28 s2.spr.ps
[is01:sg01/Ftan/2D] sg01% gs *.sp?.ps

```

5) See the parameters for synthetic seismogram computations

```

[is01:sg01/Ftan/2D] sg01% cat ftanparatest.par
Parameter file for program paratest

```

```

slm          Test label (root for output filenames - 13 chars max)
0            Ref. box file for values not listed below (0=no, 13 chars max)
s1.spl      Love spectrum file
s1.spr      Rayleigh spectrum file
2           Motion (1=displ, 2=vel, 3=acc)
10          Time length for plot seismograms (s)
1 0.0 0.0 0.0 Source (1=point, 2=extended), lon, lat, strike (Nord)
1           Force system (1=dc, 2=single, 3=dip, 4=sc, 5=pex, 6=cex)
SRE 0 50 360 15 Strike (loop 0=no,1=yes, start, stop, step) (Degrees)
DIP 0 80 90 10 Dip (loop 0=no,1=yes, start, stop, step) (Degrees)
RAK 0 10 40 10 Rake (loop 0=no,1=yes, start, stop, step) (Degrees)
SDE 0 0.050 0.050 0.005 Source Depth (loop 0=no/1=yes, start, stop, step) (km)
EDI 0 3.00 1.5 0.1 Epicentral Distance (loop 0=no/1=yes, start, stop, step) (km)
RDE 0 0 3 1 Receiver Depth (loop 0=no/1=yes, start, stop, step) (km)
MOD 1 0 50 1 Modes (loop 0=no/1=yes, start, stop (step must be 1) )
INT 0 0 30 1 Interpolation (0-9) (flag 0=no,1=yes, start, stop, step)
MAG 0 0. 6.0 .1 Magnitude (flag 0=no,1=yes, start, stop, step)
[is01:sg01/Ftan/2D] sg01%

```

6) Generate the script to compute the 1D synthetic seismograms for S1 model

```

[is01:sg01/Ftan/2D] sg01% ftanparatest.out
1 loop to evaluate

```

```

Total number of seismograms : 51

```

Generating the input for syl and syr...

OK - Execution terminated

*** Now you can execute the shell script named: ftanparajob ***

```
[is01:sg01/Ftan/2D] sg01%
```

7) Generate the 1D synthetic seismograms for S1 model

```
[is01:sg01/Ftan/2D] sg01% sh ftanparajob
Computing Radial Component...
Computing Vertical Component...
Computing Transverse Component...
2013/04/11 00:32:19      efft OK - Execution terminated
Converting to FTAN format
```

```
slmf1.syr... 51
slmf1.syz... 102
slmf1.syl... 153
```

```
*** To plot the seismograms: gs slm.mod.sis.*.ps
*** To plot the peak values: gs slm.mod.ps
```

8) Example of list of generated seismograms, to be read with FTAN (ASCII format):

```
[is01:sg01/Ftan/2D] sg01% ll *.ft
-rw-r--r-- 1 sg01 dstguest 70099 Apr 11 00:32 slm.syz.00001.ft
-rw-r--r-- 1 sg01 dstguest 70099 Apr 11 00:32 slm.syz.00002.ft
-rw-r--r-- 1 sg01 dstguest 70099 Apr 11 00:32 slm.syz.00003.ft
-rw-r--r-- 1 sg01 dstguest 70099 Apr 11 00:32 slm.syz.00004.ft
-rw-r--r-- 1 sg01 dstguest 70099 Apr 11 00:32 slm.syz.00005.ft
-rw-r--r-- 1 sg01 dstguest 70099 Apr 11 00:32 slm.syz.00006.ft
-rw-r--r-- 1 sg01 dstguest 70099 Apr 11 00:32 slm.syz.00007.ft
-rw-r--r-- 1 sg01 dstguest 70099 Apr 11 00:32 slm.syz.00008.ft
-rw-r--r-- 1 sg01 dstguest 70099 Apr 11 00:32 slm.syz.00009.ft
-rw-r--r-- 1 sg01 dstguest 70099 Apr 11 00:32 slm.syz.00010.ft
...
...
...
[is01:sg01/Ftan/2D] sg01%
```

9) Repeat steps 5) to 8) for structure S2. There are 3 occurrences of "s1" to be substituted with "s2" in file ftanparatest.par

10) Generate the synthetic seismograms for the 2D laterally heterogeneous model, selecting the proper model (file .pof and adjusting the run label accordingly)

```
[is01:sg01/Ftan/2D] sg01% pfdg13.out
m0.
```

```
N. of polygons for heterogeneities... 2
No special treatment of topography...
Sampling along x..... 0.00500 km
Sampling along z..... 0.00500 km
  depnfb,nfb  0.00000000000000000000 40
Dz change at (km from free surface).. 0.22000 km (nfb(2D)= 45, nfb(1D)= 45)
Number of layers in reference model.. 107
Multiplying factor for dz (nf)..... 1
Sampling along z below heterogeneity: 0.00500 km
Dimension along x..... 2.51500 km ( 504 grid points)
Dimension along z..... 1.00500 km ( 202 grid points)
```



```

Source to first site distance.....: 0.99500 km
Distance between two sites.....: 0.02000 km
Time of the first snapshot (1D,2D)...: 6.00000 6.00000 s (SH)
Total of the first snapshot (1D,2D)...: 6.00000 6.00000 s (P-SV)
Total duration of signal (1D,2D)....: 15.00000 15.00000 s (SH)
Total duration of signal (1D,2D)....: 15.00000 15.00000 s (P-SV)
Time skipped at the beginning.....: 0.00000 s (SH)
Time skipped at the beginning.....: 0.00000 s (P-SV)

```

```

Generating the FD models...
Generating the input for sylvdv and syndv...
Generating the input for syl and syr...

```

```
nsisfd,mrecn      101      100
```

```
Checking the .l1d model...
```

```
m0.f1l.VEL.xyz
```

```
m0.f1l.VEL.xyz
```

```
m0.f2l.VEL.xyz
```

```
m0.f1l.VEL.xyz
```

```
Checking the .r1d model...
```

```
m0.f1r.VEL.xyz
```

```
m0.f1r.VEL.xyz
```

```
m0.f2r.VEL.xyz
```

```
m0.f1r.VEL.xyz
```

```
Checking the .l2d model...
```

```
m0.f2l.VEL.xyz
```

```
m0.f1l.VEL.xyz
```

```
m0.f2l.VEL.xyz
```

```
m0.f1l.VEL.xyz
```

```
Checking the .r2d model...
```

```
m0.f2r.VEL.xyz
```

```
m0.f1r.VEL.xyz
```

```
m0.f2r.VEL.xyz
```

```
m0.f1r.VEL.xyz
```

```

If you are going to work with 2D regional structure
you have to create the input files for 2D from those
created here for 1D: m0.bol      m0.bor
using program changebox1D2Da, and remember that
2D programs do not include the gaussian filtering
used in the FD programs. You need to filter the
obtained seismograms with fft program

```

```
OK - Execution terminated
```

```
[is01:sg01/Ftan/2D] sg01%
```

11) Edit file jobfd and comment the call to the plotting script by adding a # in front of "plotall"

```
[is01:sg01/Ftan/2D] sg01% vi jobfd
```

```
...
```

```
...
```

```
rcheck4.out
```

```
echo Plotting...
```

```
#sh plotall
```

```
...
```

```
...
```

12) Generate the 2D synthetic seismograms for the laterally heterogeneous model

```
[is01:sg01/Ftan/2D] sg01% echo "jobfd > m0.log" | at now
job 1912 at Thu Apr 11 00:49:20 2013
```

```
[is01:sg01/Ftan/2D] sg01% atq
```

```
1912 Thu Apr 11 00:49:00 2013
```

```
[is01:sg01/Ftan/2D] sg01%
```

13) Check the running jobs with alias "mj"

```
[is01:sg01/Ftan/2D] sg01% mj
96.3 12:49AM sg01      42947 finray80.out
0.0 12:53AM sg01      43054 sort -r
0.0 12:53AM sg01      43053 grep sg01
0.0 12:49AM sg01      42923 /bin/bash ./jobldr
0.0 12:49AM sg01      42920 /bin/bash ./jobld 0
0.0 12:49AM sg01      42916 /bin/bash ./jobfd
0.0 12:49AM sg01      42915 sh
0.0 12:20AM sg01      24829 -tcsh
0.0 12:20AM sg01      24810 /usr/sbin/sshd -i
0.0 12:16AM sg01      13289 -tcsh
0.0 12:16AM sg01      13274 /usr/sbin/sshd -i
[is01:sg01/Ftan/2D] sg01%
```

until all *finit80.out*, *finray80.out*, *rcheck4.out* and *jobfd* processes disappear (should take about 15' to complete)

14) Convert 2D synthetic seismograms to FTAN format, after checking the parameter file *syn2ftan.par*

```
[is01:sg01/Ftan/2D] sg01% syn2ftan.out
[is01:sg01/Ftan/2D] sg01% ls -l m*.ft
...
-rw-r--r-- 1 sg01 dstguest 45097 Apr 11 01:00 m0f0.r2d.zve.00098.ft
-rw-r--r-- 1 sg01 dstguest 45097 Apr 11 01:00 m0f0.r2d.zve.00099.ft
-rw-r--r-- 1 sg01 dstguest 45097 Apr 11 01:00 m0f0.r2d.zve.00100.ft
[is01:sg01/Ftan/2D] sg01%
```

15) Now use XFTAN to process file *m0f0.r2d.zve.00100.ft*

Read structures *s1.stp* and *s2.stp* (both as structure and reference structure) to overlap their group velocity dispersion curves on the ftan map. Use the following FTAN parameters:

FTAN

Map	
Tmin (s):	0.1
Tmax (s):	0.8
Vmin (km/s):	0.18
Vmax (km/s):	3
N. of filters:	32
Alpha:	50

16) Try to fit the yellow area on the FTAN map that you might interpret as the fundamental mode of a 1D structure, by modifying the two or three uppermost layers (*Vs* and thickness), using the mouse on the structure plot. Once you get an acceptable fit, see how the structure compares with models S1 and S2.

Observed data

Create a new directory for this exercise and copy the required files:

```
[is01:/XDST/sg01] sg01% cdt
[is01:/tmpXDST/sg01] sg01% cd Ftan
[is01:/tmpXDST/sg01/Ftan] sg01% mkdir Obs
[is01:/tmpXDST/sg01/Ftan] sg01% cd Obs
[is01:sg01/Ftan/Obs] sg01% cp /XDST/Examples/Ftan/Obs/Base/* .
[is01:sg01/Ftan/Obs] sg01% ls
obs.sac
[is01:sg01/Ftan/Obs] sg01%
```

The file obs.sac contains one recording in SAC format, that can be read in from XFTAN.

FTAN analysis

Launch XFTAN. You can have more than one window open, and in each window you can perform the following steps:

- 1) Read the seismogram from obs.sac, in SAC format.
- 2) Adjust the FTAN parameter and generate the FTAN map by pushing the "Map" button.
- 3) Draw a dispersion curve by clicking on the FTAN map, following the curve you think is the fundamental mode. When done, push the "Filter" button, being sure to use manual mode ("Manual" checkbox must be checked).
- 4) With the help of partial derivatives dU/dVs , try to modify the default structure so to obtain a theoretical group velocity dispersion curve compatible with the observed one.