The DMG Quick Reference Manuals

2D Modal Summation Technique Love Couplings

Coupling coefficients (Gregersen) and synthetic seismograms

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Love waves computation in 2D structure

Introduction

You wish to generate synthetic seismograms for Love waves, using a 2D structural model consisting of a set of substructures, where discontinuities are approximated by vertical boundaries, and where the wavefield is assumed to be modeled by normal incidence modes. The manual explains how to arrange input for the various programs, the meaning of variables you have to set, and what output the current program gives.

In the program suite, it is STRONGLY recommended to maintain a certain logic in the naming conventions of the generated output files. In general, the naming convention IN the program suite takes the part of a structure name before a possible extension (strucname.extension), and adds an extension specific for the current program. This extension gives information about the contents of a given file. Do NOT change extensions! General information from a given program is given in output files named programname.pri. Error messages are given in these files. If You get strange results, check these files. For further explanations, contact Fabio or Davide. For suggestions to improve the manual, contact Fabio or Davide.

The suite consists of 5 programs :

lov	generates sequentially format spectra for the substructures.
modes2daf01.out	converts sequentially formatted spectra to direct access format.
couplov01.out	computes coupling coefficients at vertical boundaries.
coupsplit01.out	locates modepaths from source to receiver.
sylcoup01.out	computes seismograms for 2D structural models.

Note, processing of the computed seismograms (instrument response and Gaussian filtering, scaling for magnitude) has to be done separately with program efft (ask Franco for details).

Throughout the manual, explanations are given using an example where the structural model consists of 3 structures, struc1, struc2, struc3 appearing in this order in the structural model. In the suite of programs, the input ordering of the structures are actually independent until the program which locates the modepaths runs (*coupsplit01.out*). This ensures a great degree of freedom when modelling the path from source to receiver, and the number of necessary recomputations is thereby minimized if a structure is changed, moved or deleted. Since computation of the coupling coefficients are the most time consuming part of the program suite, changes in the model are less time consuming this way. In the manual though, the order of struc1, struc2 and struc3 are kept fixed for clarity.

How to proceed

Structures

Prepare the appropriate structures using for instance available literature, trial and error and/or the I-data set. Name the structures with extension .str.

Example

3 structures in the model, named struc1, struc2, struc3.

`struc1.str`	first structure
`struc2.str`	second structure
struc3.str	third structure

Spectra

Use program *`lov`* to generate a spectrum file for each structure. Input data for *`lov`* are set in the file `lov.par`. The output is a number of sequential spectra with extension .spl.

Example

An example of input file `lov.par` for structure file struc*.str is given:

```
List of structures for lov program:
struc1.str
struc2.str
struc3.str
```

Command in terminal:

```
lov
```

Output files wiith Love modes:

`struc1.spl`	first output spectrum
`struc2.spl`	second output spectrum
`struc3.spl`	third output spectrum

Spectra conversion to Direct Access Format

Use program *`modes2daf.out`* to convert the nn (here nn=3) spectrum files to Direct Access Format files (daf files) and nn spectral information files. A spectral information file contains information needed for the various programs to locate the correct data from the daf spectral files (mode number, starting index in units of Δf for this mode and first record number for data for this mode). The input is the total number of spectrum files, spectra type and the name of each spectrum. For this program no .par file is needed, all information are requested by terminal

Example

3 sequential spectra, named `struc1.spl`, `struc2.spl`, `struc3.spl`.

Input

3	number of spectra
1	spectra type (1=Love waves, 2=Rayleigh waves)
struc1.spl	first input spectrum
struc2.spl	second input spectrum
struc3.spl	third input spectrum

Command in terminal:

```
modes2daf.out
```

Output files generated:

`struc1.sdl`	first Direct Access spectrum
`struc1.sil`	first spectral information file
`struc2.sdl`	second Direct Access spectrum
`struc2.sil`	second spectral information file
`struc3.sdl`	third Direct Access spectrum
`struc3.sil`	third spectral information file
`modes2daf.pri`	list of spectra type and output files

Note, the output names are NOT optional. The extensions stands for Spectrum Direct access Love and Spectrum Information Love.

Coupling coefficients computation

Use program *couplov01.out* to generate nn-1 (here nn-1=2) Direct access Coupling files, one for each vertical boundary in the structural model. Input to program *couplov01.out* is set in the file couplov.par. General input is the total number of coupling files, and first and last frequency for the couplings. Individual input is in (nn-1) repetitions of a block giving the names of the two daf-spectra (files with extension .sdl) which, according to the structural model, are spectra for the two structures at the current boundary and their corresponding spectral information files (files with extension .sil), a list of mode settings (explained later), percentage of energy to be transmitted (if it is greater than 1., all energy is transmitted), and minimum amount carried by an excited mode in order for it to be considered.

Example

2 boundaries, input spectra: struc1.sdl, struc2.sdl, struc3.sdl; input information: struc1.sil, struc2.sil, struc3.sil.

Input file couplov.par

```
2               number of boundaries
0.005           first frequency
1.000           last frequency
struc1.sdl      first input spectrum
struc1.sil      first spectral information file
struc2.sdl      second input spectrum
struc2.sil      second spectral information file
1               modil  -  first incoming mode index
3               modih  -  last incoming mode index
2               mless  -  number of lower outgoing modes
1               mmore  - number of higher outgoing modes
1               modol  -  first outgoing mode index
4               modoh  -  last outgoing mode index
0.950           energy to be transmitted
0.005           minimum energy limit in transmitted mode
struc2.sdl      second input spectrum
struc2.sil      second spectral information file
struc3.sdl      third input spectrum
struc3.sil      third spectral information file
1               modil  -  first incoming mode index
4               modih  -  last incoming mode index
2               mless  -  number of lower outgoing modes
1               mmore  - number of higher outgoing modes
1               modol  -  first outgoing mode index
3               modoh  -  last outgoing mode index
0.950           energy to be transmitted
0.005           minimum energy limit in transmitted mode
```

Output files produced:

tran01.cdl	coupling file for first boundary
tran02.cdl	coupling file for second boundary
couplov.pri	input listing and messages

Note, the output names are NOT optional. The extension stands for Couplings Direct access Love.

Note, at this step in the program suite, as a security measure, you have to rename these output files if you change something in a model. In that case you don't have to recompute parts of your first model if it was better than the changed model.

Note, if you want to check the couplings file in ascii format you have to run the program

```
daf2asc.out
```

every needed information about input file is requested in terminal while running it.

For the mode settings (modil, modih, mless, mmore, modol, modoh) some conventions has to be respected. Modil and modih are respectively first and last incoming mode at a given boundary. At the boundary, you can choose to include intercouplings by setting mless and mmore to values≠0. Thereby energy is transmitted to modes with index different from the index of the incoming mode. Modol and modoh are respectively first an last outgoing mode at a given boundary. If mless=mmore=0, then modol=modil and modoh=modih. If mless≠0 and/or mmore≠0, then modol and modoh are not necessarily equal to modil and modih. In the example above, mless=2 and mmore=1, while modil=1 and modih=3. This means that some energy is transmitted to the third higher mode, so that modoh has to be equal to 4. At the next boundary, modih=1 and modih=4 because of the inclusion of splitmodes. At this boundary you can chose a different setting of mless and mmore if you want, but remember to change modol and modoh if some modes are generated and/or others are killed. If your structural model has more than 3 structures, add the necessary number of blocks to `couplov.par`, and set the mode settings according to the conventions given above.

Note, for all the boundaries, the ultimate restriction on modoh is the number of modes calculated in the spectrum. You can NOT set the mode settings to values outside this limit !!!!!.

Right disposition of coupling coefficients file for chosen path

Use program *`coupsplit01.out`* to generate one coupling file (direct access format) containing coupling coefficients and mode paths listed after frequency, and one information file containing information about the possible mode paths. The information gives frequency and first and last record number for mode paths for this frequency.

Input file `coupsplit.par`

```
2               number of coupling files
1               spectra type (1=Love waves, 2=Rayleigh waves)
tran01.cdl      coupling file for first boundary
tran02.cdl      coupling file for second boundary
```

Command in terminal:

```
coupsplit01.out
```

Output files

```
coupmode.mdl        Direct Access modepath file
coupmode.mil        Modepath information file
```

Note, the output names are NOT optional. The extension stands for Modepath Direct access Love and Modepath Information Love. They can be renamed by you since you give the name as input to the last program. But remember, be logical in your choice of name.

Note, if you change the structural model thereby creating new coupling files, you HAVE to run *`coupsplit01.out`* again, since the allowed modepaths and/or coupling coefficients might have changed because the structural model has been changed.

Seismograms computation

Use program *sylcoup01.out* to compute synthetic seismograms. Input files are set in sylcoup.par and settings for the program are set in syl2d.box. This version of the program allows the user to compute in a single run different seismograms for different receivers placed in the last structure

Input file sylcoup.par

```
syl2d.box       filename of input parameters
seis.syl             name of output seismogram file
3               number of structures in structural model
struc1.sdl      first input spectrum
struc1.sil      name of first spectrum information file
d1              distance from source to 1. boundary (km)
struc2.sdl      second input spectrum
struc2.sil      name of second spectrum information file
d2              distance from 1. to 2. boundary (km)
struc3.sdl      third input spectrum
struc3.sil      name of third spectrum information file
n               number of receivers in which compute seismograms
d31 d32 d33...d3n   different distances from 2. to receivers (km)
coupmode.mdl    name of modepath file
coupmode.mil    name of modepath information file
icrossflag      include (=1) or exclude (=0) cross couplings
```

Command in terminal:

```
sylcoup01.out
```

Output file with synthetic seismograms

seis.syl   computed synthetic seismogram

The box syl2d.box is the same as the standard box used with program *syl0048.out* (the so called “IGG format”) for the 1D modal summation, except for significance of first and last mode, distance and a warning message. This means that you have to use syl2d.box when using *sylcoup01.out*, but the output seismogram will have the standard IGG format, so that other standard IGG programs already developed for 1D (plotting programs, filtering programs or what ever) can be utilized.

The distance is not written in syl2d.box but is computed by the program *sylcoup01.out* summing distances given in sylcou.par.

The warning message tells that instrument response and Gaussian filtering has to be done by a separate program. The flags for these two options are automatically set to zero in the program.

The important difference between standard IGG box and syl2d.box is in the significance of the values of first and last mode. The settings for icrossflag and the values for first and last mode gives four different combinations for which modepaths that is contributing to the seismogram. This combination option saves timeconsumming recomputations. **Be aware of the settings**.

The combination options are :

1: icrossflag=0, firstmode=lastmode (also for firstmode=lastmode=0)

If firstmode=lastmode≠0, modepaths which involves ONLY firstmode from source to receiver is used when computing the seismogram. If firstmode=lastmode=0, all modepaths which involves cross couplings are excluded, while the modepaths which involves the same mode from source to receiver are used when computing the seismogram. This setting will show effects of e.g. higher modes. Output seismogram can thus be compared with 1D computation to see effects of 2D structure.

2: icrossflag=1, firstmode=lastmode (also for firstmode=lastmode=0)

If firstmode=lastmode≠0, modepaths which involves firstmode is used when computing the seismogram, thereby also including modepaths whith cross couplings if the modepath involves firstmode. This setting will show effects of cross couplings which involves a given mode. If firstmode=lastmode=0, all modepaths are used when computing the seismogram.

3: icrossflag=0, firstmode<lastmode

Modepaths which involves the same mode from source to receiver in a range given by firstmode and lastmode is used when computing the seismogram. All modepaths within the range which involves cross couplings are excluded. This setting will show effects from a range of modes without cross couplings. Output seismogram can thus be compared with 1D computation to see effects of 2D structure.

4: icrossflag=1, firstmode<lastmode

Modepaths which involves modes within the range given by firstmode and lastmode, thereby also including modepaths which involves cross couplings within the range of firstmode and lastmode, are used when computing the seismogram. This setting will show effects of cross couplings within the range of modes.

Input and example of run

You can find input data for using this suite at

/XDST/Examples/2Dcoup/Greg/Lov/Input

and an example of run at

/XDST/Examples/2Dcoup/Greg/Lov