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The DMG Quick Reference Manuals

Rayleigh waves propagation in 2D media with solid-liquid interface

Yanovskaya coupling

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Introduction

You wish to generate synthetic seismograms for Rayleigh waves, using a 2D structural model consisting of 2 substructures, one solid and the other with liquid layers at his top, where discontinuities are approximated by vertical boundaries, and where the wavefield is assumed to be modeled by normal incidence modes. This is a step by step manual to tell you how to use a suite of programs written for this purpose. 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 :

ray: generates sequentially format spectra for the substructures.
modes2daf01: converts sequentially formatted spectra to direct access format.
coupyanray01: computes coupling coefficients at vertical boundary.
coupsplit01 : put coupling file in the right form.
syrcoupyan01: 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 2 structures, struc1mod, struc2wat.

The important thing to know about this routine is that it works ONLY for liquid-solid or solid-solid couplings. Other setting will give you an error message. The part in the name of structures indicating whether they are solid, “mod”, or liquid “wat” are not strictly necessary but they could be very useful.

In this computation, differently from these of Gregersen’s couplings, IT IS IMPORTANT also the order in which the coupling are computed by copyanray01.

It means that the order in which you put structures in copyanray.par must be the same of the one in syrcouyan.par. In this example we put the structures in the order solid-liquid, obviously also the opposite case can ben treated.

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 struc1mod, struc2wat.

struc1mod.str	first structure
struc2wat.str	second structure

Spectra

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

Input file ray.par for structure file strucX.str

```
List of structures for ray program:
struc1mod.str
struc2wat.str
```

Output

struc1mod.spr	first output spectrum
struc2wat.spr	second output spectrum

Spectra conversion to Direct Access Format

Use program modes2daf.f to convert the 2 spectrum files to Direct Access Format files (daf files) and 2 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 file.par file is needed, all information are requested by terminal

Example : 3 sequential spectra, named struc1mod.spr, struc2wat.spr.

Command in terminal:

```
modes2daf.out
```

Input

2	number of spectra
2	spectra type (1=Love waves, 2=Rayleigh waves)
struc1mod.spr	first input spectrum
struc2wat.spr	second input spectrum

Output

struc1mod.sdr	first Direct Access spectrum
struc1mod.sir	first spectral information file
struc2wat.sdr	second Direct Access spectrum

struc2wat.sir	second 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 Rayleigh and Spectrum Information Rayleigh.

Coupling coefficients computation

Use program **coupyanray01.f** to generate 2 Direct access Coupling files, one for the solid-liquid (or liquid-solid) interface. Input to program coupyanray01 is set in the file couyanpray.par. General input is the total number of coupling files, and first and last frequency for the couplings. Individual input is in a r block giving the names of the two daf-spectra (files with extension .sdr) 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 .sir), 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: struc1mod.sdr, struc2wat.sdr; input information: struc1mod.sir, struc2wat.sir.

Input file coupyanray.par

```
1               number of boundaries
0.005           first frequency
1.000           last frequency
struc1mod.sdr        first input spectrum
struc1mod.sir        first spectral information file
struc2wat.sdr        second input spectrum
struc2wat.sir        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
```

Output

gamt01.cdr	coupling file for first boundary
coupyanray.pri	input listing and messages

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

Note: the output gamt01.cdr includes normalized couplung coefficients (differently for Gregersen coupling programs), you have to compute seismograms with proper program **syrcouyan01.f!**

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.

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

Right form of coupling coefficients

Use program coupsplit01.f 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 couplsplit.par

```
1               number of coupling files
2               spectra type (1=Love waves, 2=Rayleigh waves)
gamt01.cdr      coupling file for first boundary
```

Output

coupmode.mdr	Direct Access modepath file
coupmode.mir	Modepath information file

Note, the output names are NOT optional. The extension stands for Modepath Direct access Rayleigh and Modepath Information Rayleigh. 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.

Seismograms computation

Use program **syrcoupyan01.f** to compute synthetic seismograms. Input files are set in syrcoupyan.par and settings for the program are set in syr2d.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 syrcoupyan.par

```
syr2d.box       filename of input parameters
seis.syr              name of output seismogram file
2                number of structures in structural model
struc1mod.sdr         first input spectrum
struc1mod.sir         name of first spectrum information file
d1               distance from source to 1. boundary (km)
struc2wat.sdr         second input spectrum
struc2wat.sir         name of second spectrum information file
n               number of receivers in which compute seismograms
d31 d32 d33...d3n   different distances from 2. to receivers (km)
couplmode.mdr    name of modepath file
couplmode.mir    name of modepath information file
icrossflag       include (=1) or exclude (=0) cross couplings
```

Output

seis.syr	computed synthetic seismogram

The box syr2d.box is the same as the standard IGG box, except for significance of first and last mode, distance and a warning message. This means that you have to use syr2d.box when using syrcoupyan01.f , but the output seismogram has 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 syr2d.box but is computed by the program syrcoupyan01.f summing distances given in syrcou.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 syr2d.box are 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

/Volumes/xr01/NetDST/Examples/2Dcoup/Yano/Input

and an example of run at

/Volumes/xr01/NetDST/Examples/2Dcoup/Yano