README for the surface wave multiple scattering program 'couplage.f'

Valérie Maupin, University of Oslo

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The background for this program is described in Maupin (2001). It calculates the wavefield produced by a monochromatic surface wave mode incoming on a 3D cartesian structure. It is based on mode coupling and multiple scattering.

By November 25, 2005, only the isotropic version is available on the SPICE website. Contact V. Maupin if you need the anisotropic one.

1 Programs

The program is located in the directory **src**. It is written in Fortran and can be compiled using the following files:

couplage.f
coupliso.f
bessel.f
couplage.inc
coupliso.inc

To compile the program, use your favorite Fortran compiler, with the '-r8' option to work in double precision. On the platforms I am using for the moment (Linux), this is:

f77 -O4 src/couplage.f src/coupliso.f src/bessel.f
-xtypemap=real:64,double:64,integer:mixed -o src/bin/coupliso

where '-xtypemap=real:64,double:64,integer:mixed' stands for the double precision option.

To run the program:

src/bin/coupliso examples/rayl0.in examples/rayl0.out examples/rayl0.outplot

rayl0.in: example of input file (for an incoming fundamental Love mode)

rayl0.out: output file with information on the run. Some variables are written out at some intermediate stages in the program. Most of this file is useful mainly for debugging purposes.
rayl0.outplot: results, that is amplitude and phases of the different modes and of the total field at the successive orders of scattering. See inside the program for a detailed description of this file.

2 Example of input files:

Examples of input files are in the directory **examples**.

To run this program, you need a basic input file, as indicated above, plus four files: a file for the reference model, a file for the Rayleigh wave eigenfunctions, a file for the Love wave eigenfunctions, and a file for the heterogeneous model. I am using the programs written by Saito (1988) to calculate the eigenfunctions in the reference model. If you want to use other routines than those of Saito to calculate the eigenfunctions, you replace the files ref.mod, modesray and modeslov by your own type of file. You will need to modify the subroutines readmd and readyp in couplage.f. Be careful then to get a depth sampling of your reference model and eigenfunctions which is compatible with couplage.f.

rayl0.in: input file which contains a number of parameters necessary for the multiple-scattering programs. See inside the file itself and in couplage.f for the details.

ref.mod: reference model.
Model used in this program and in the program by Saito (1988) to calculate the Love and Rayleigh wave eigenfunctions.

The file contains:
title
number of depth points
0 for no attenuation
thickness below that point, density, S-wave velocity, P-wave velocity, depth

modesray: fundamental and 5 first Rayleigh overtones at 25s period in the reference model.
Output from the Saito's program.

modeslov: fundamental and 5 first Love overtones at 25s period in the reference model.
Output from the Saito's program.

hexamod.out: the 3D heterogeneous model. A very simple case here, which corresponds to the hexagonal heterogeneity used in Maupin (2001). The heterogeneity is given in absolute perturbations of the S-wave velocity in the present case. Some rules are used (see coupliso.f) to calculate the associated P-wave velocity and density anomalies.
The file contains:
title
number of points in x, y and z
sampling intervals in x, y and z
values of the heterogeneity (external loop in x, loop in y, internal loop in z)

3 Example of output file:

Examples of output files are in the directory **output**.

The total wavefield in written in files of the type **rayl0.outplot** which contains:

number of points in x, sampling interval in x
number of points in y, sampling interval in y
reference surface amplitudes in x, y and z (that is surface horizontal or vertical displacement of the incoming mode to be used as reference amplitude in the three directions)
number of iterations
loop in number of iterations with:
number of modes (number of modes actually used in the coupling + 1 for the total field, except if we use one mode only).
loops in number of modes (+1), in x, in y with:
3 amplitudes and 4 phases.

The amplitudes and phases are the amplitudes and phases of the different components of the wavefield at location (x, y), for a given mode and after a given number of scattering orders.

The amplitudes are the amplitudes along the x, y and z axes (0. for Love wave modes in z).

The phases are for Rayleigh modes:
phase anomaly of the vertical component, phase difference between the x and z components, phase difference between the y and x components, total phase of the vertical component.
and for Love waves:

phase anomaly of the y-component, phase difference between the z and y components (0 for single modes), phase difference between the y and x components, total phase of the y component.

For the total field, one uses the same variables as Rayleigh if the incoming wave is a Rayleigh mode, and the same variables as the Love modes if the incoming mode is a Love mode.

4 Tools to plot

A program *couplageplot.m* in matlab in the directory **tools** can be used to read the output files of the type **rayl0.outplot** and to plot different attributes of the wavefield. Since what you want to plot may be different from what I am interested in, you have to be prepared to modify this program to suit your needs.

References

Maupin, V., 2001. A multiple-scattering scheme for modelling surface wave propagation in isotropic and anisotropic three-dimensional structures, *Geophys. J. Int.* **146**, 332-348.

Saito, M., 1988. Disper80: a subroutine package for the calculation of seismic normal mode solutions, in *Seismological Algorithms*, pp. 293-319, ed. Doornbos, D.J., Academic Press, London.