"8th Workshop on Three-Dimensional Modelling of Seismic Waves Generation, Propagation and their Inversion"

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Laboratory Exercises

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The programs in this lab will allow you to construct 3D finite-frequency kernels in complicated crustal models. Since the computations are time-consuming, and all plotting is 2D in any case, we limit the size of the model by restricting its width in the y-direction to only 3 pixels (against 50 for x and 30 for z). However, once it is clear to you how the software works, it will be easy to modify program example.f and mkslw3d.f to create and analyse real 3D models with a larger width in the y-direction.

If you have succesfully installed the directory named 'Distribution' on your machine, first edit `compile` and replace the GNU Fortran compile `g77` with your own Fortran compiler if you do not have `g77`. The run:

`compile`.

Also, make sure you have the GMT plotting programs installed on your machine. GMT can be downloaded for a number of platforms from `gmt.soest.hawaii.edu/gmt/gmt_download.html`. Mac users can also use Fink to install GMT and any dependent software automatically (`http://sourceforge.net/index` Windows users may have some trouble if they do not first download a free Unix emulation package Cygwin from `http://sourceware.org/cygwin/` so they can install GMT just as if they run Linux or Unix.

To test if all works, I recommend you run the cook-book script:

`runexample`.

This:

- Creates and plots a model (Fig 1).

- Creates and plots travel times (in sec) from a source (s1) and receiver (s2) node, as well as geometrical spreading (in km). (Figs 2-5).

- Computes a 2D slice through the banana-dougnut kernel and plots the travel time and amplitude kernels (Fig 6-7).

Excercise 1

Once you have determined that the software works correctly, we may experiment a bit. The first thing is to study how the BD kernel depends on the dominant period. If you look at the last few lines of script `runexample` you see the input for program `bdexample` – really a front end for the subroutine `bdsub` which at some later stage you may wish to incorporate into your own tomography software:

```
bdexample << eof
ictp3d
0.5                       ! dominant P wave period in sec
t.s1
t.s2
eof
gmtkt kts.cpt
gmtka kas.cpt
```

You can simply type in the input when requested by the program, so omit the piping with 'eof'. The travel time files `ts1` and `t.s2` have already been computed for these sources in this model, so we do not need to recompute them. Simply run bdexample again but now with, e.g. 1.0 as dominent period input. The colour scale may not be very appropriate for some periods, but you can use the GMT scripts without an argument and they will create a new colour scale (the best colour scales require you run GMT's `makecpt` yourself since the kernels become almost singular near the sources and this biases the colour scaling). Try out different periods and see how the kernel changes width. Compare to the Fresnel zone width.

Excercise 2

Run `grafbdyn` for another source and receiver (name these s3 and s4 so you do not overwrite earlier files), and see how the width of the kernel depends on the distance to the source. Can you spot the influence of the depression in the Moho at the center of the model?

Excercise 3

Finally, edit the crustal model. The 3D model is constructed from a 2D model by simply repeating it in the y-direction for three pixels. The 2D model is written very compactly using hexadecimal numbers in file `ictp2d`, where 0 stand for 6.2 km/s, 1 for 6.4 km/s, 2 for 6.6 etc, until F for 9.2 km/s. You can create larger heterogeneities and see the effects on travel time, geometrical spreading, and finite-frequency kernel.
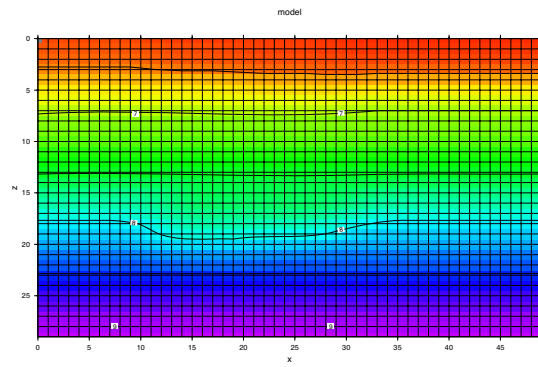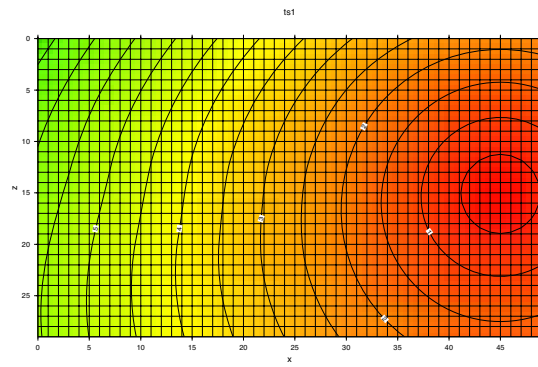
Figure 1: The example model, plotted by script gmtm

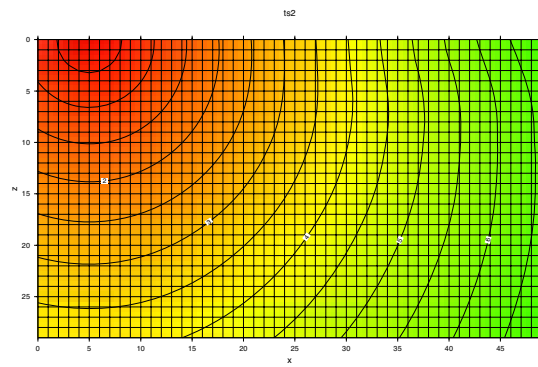Figure 2: The travel time field from source s1, plotted with gmtt.

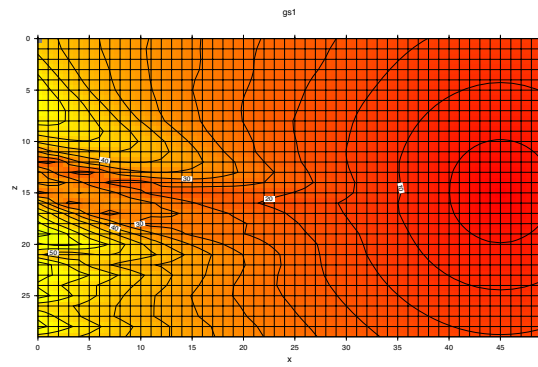Figure 3: The travel time field from source s2, plotted with gmtt.

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Figure 4: The geometrical spreading from source s1, plotted with gmtg.
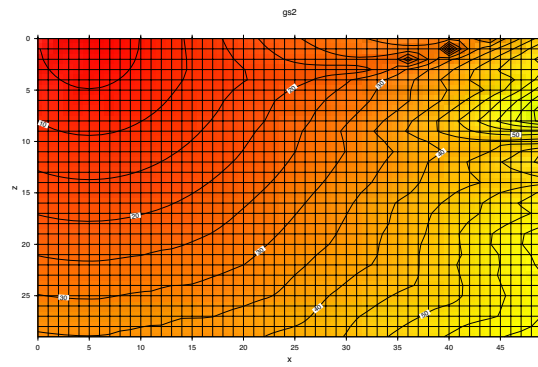

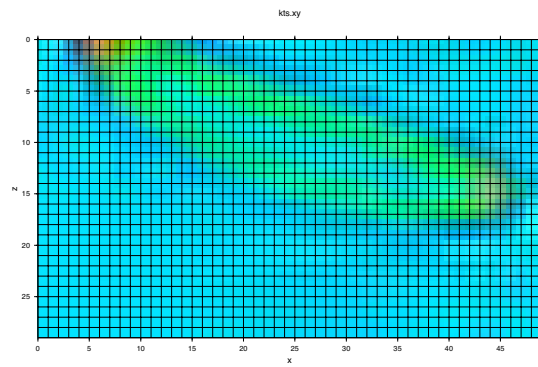Figure 5: The geometrical spreading from source s2, plotted with gmtg.
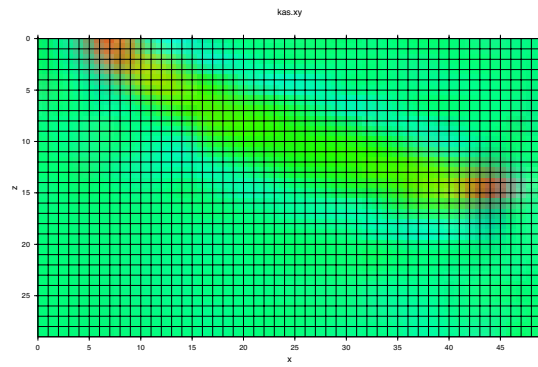

Figure 6: The travel time kernel, plotted with gmtkt.

Figure 7: The amplitude kernel, plotted with gmtka.