Pyrocko
A Versatile Software Framework for Seismology

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Introduction

Pyrocko is an open source seismology toolbox and library, written in the Python programming language. It can be utilized flexibly for a variety of geophysical tasks, like seismological data processing and analysis, modelling of waveforms, InSAR or GPS displacement data, or for seismic source characterization.

At its core, Pyrocko is a library and framework providing building blocks for researchers and students wishing to develop their own applications.

This poster gives a glimpse of Pyrocko's features, for more examples and tutorials visit **http//pyrocko.org**.

Waveform Processing

With Pyrocko you can read, handle and write many different file formats such as MiniSEED, SAC, SEISAN, GSE1/2, SEG-Y and many more. Your local waveform archives can be organized, accessed and batch-processed through pyrocko.pile in a memory-efficient way.

```
from pyrocko import pile

p = pile.make_pile(['project_folder/'])  # or thousands of filenames here

for traces in p.chopper(tmin=tmin, tinc=tinc, tpad=tpad):
    for tr in traces:
        tr.downsample_to(target_deltat, snap=True, demean=False)
```

Listing 1: Example how a pile of waveform data is build, and chops of traces are downsampled efficiently.

With **Snuffler** you interactively browse through your seismograms, may they be big archives or small datasets. Snuffler features plug-ins (*snufflings*) that provide you with a broad variety of seismological applications. A selection of features include:
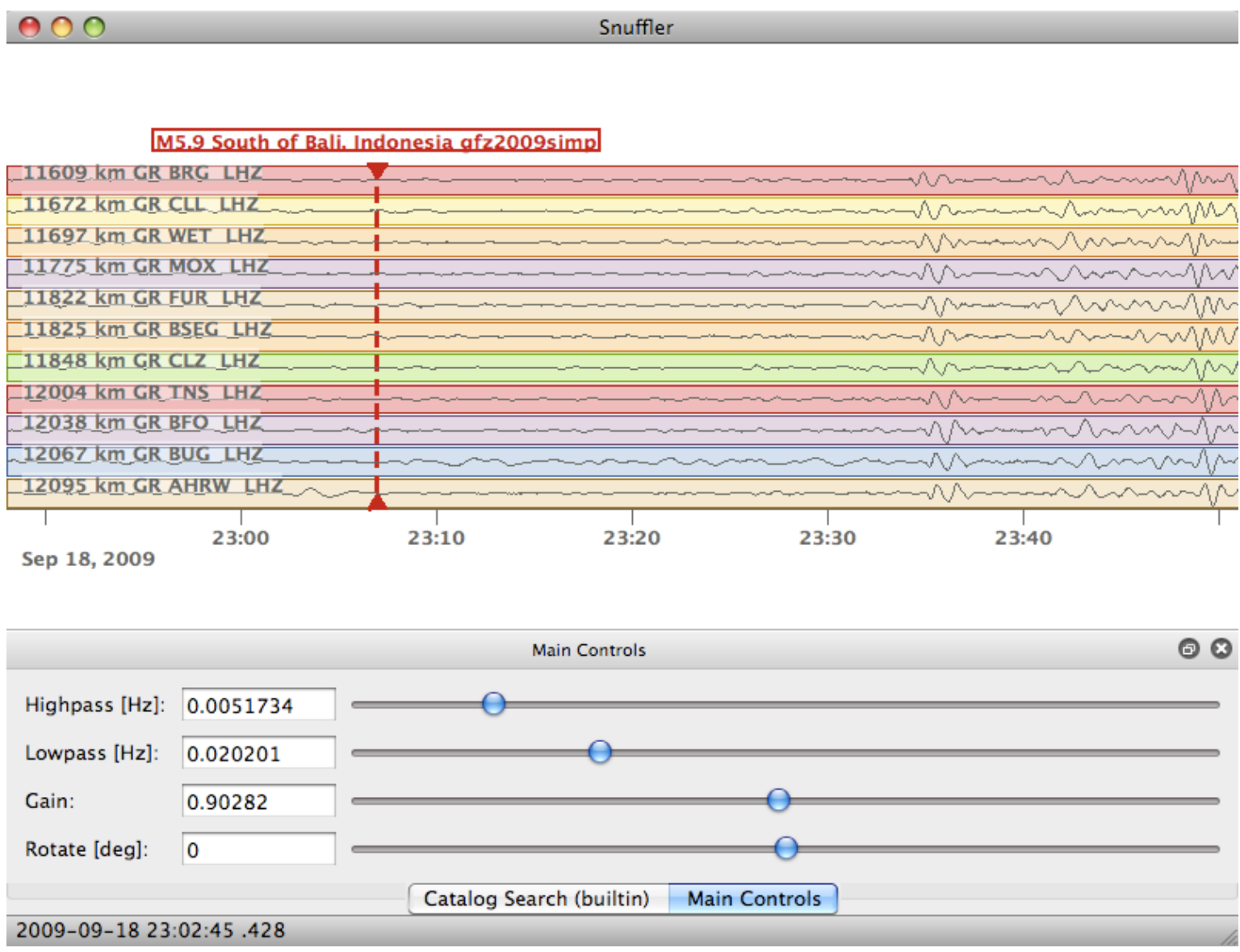
- Event and phase picking and management
- Easthquake cluster analysis
- Beamforming
- Cross-correlation of traces
- Station network mapping
- Synthetic travel-time markers
- Interactive synthetic waveform modelling

Clients and Data Access

Online waveform data archives from different institutions can be accessed throught the FDSN protocol - popular providers are pre-configured in Pyrocko (e.g. *IRIS, Geofon*).

Earthquake catalog data from *Geofon, GlobalCMT, USGS* and more.

GPS position data served by the *National Geodetic Lab of the University of Nevada, Rheno* can be accessed.

Datasets

The pyrocko.dataset submodule gives convinient access to useful online and offline geo datasets:

Seismic velocity models through *CRUST2.0* and the *Global Crustal Database* (USGS).

DEM data from *ETOPO1* and *SRTML3*.

Tectonic datasets include a plate boundary model *PeterBird2003* and global strain rate model *GSRM1*.

Geographical data from the *GSHHG* coast-line database and *Geonames.org*, (city names and population)
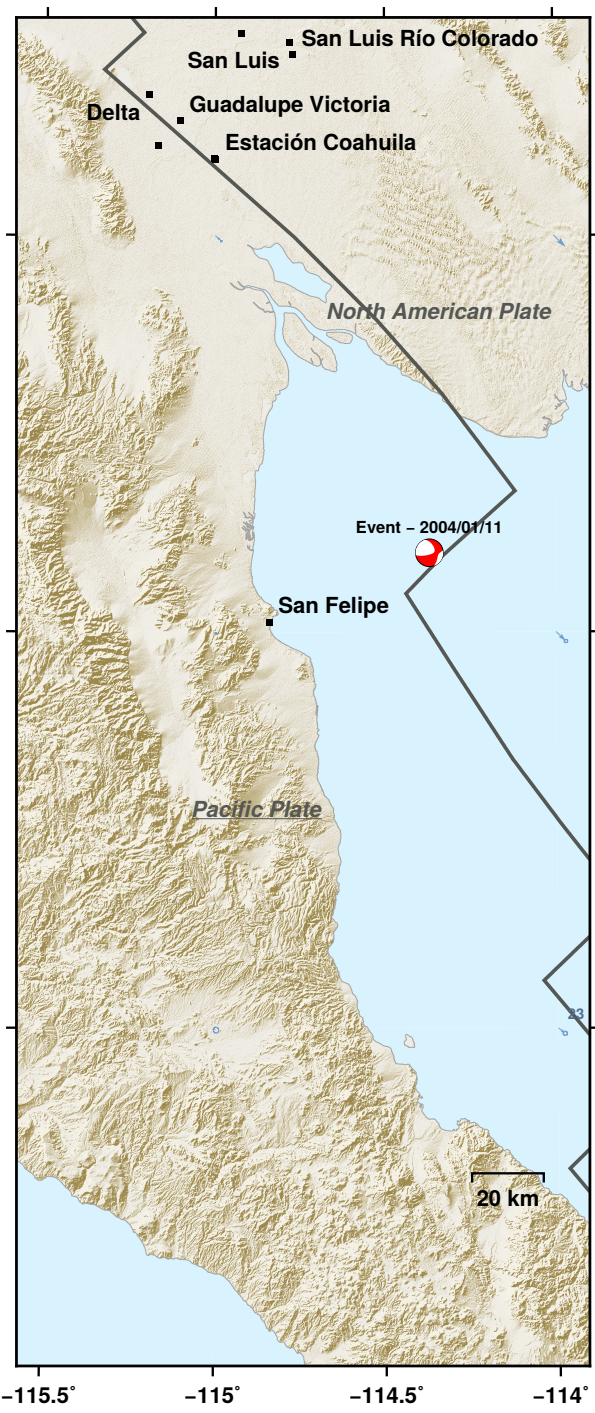
Travel-Time Calculations

Cake is a very tasty tool for 1D travel-time and ray-path computations. You can use to solve classical seismic ray theory problems for layered-earth models (layer cake models) on a spherical Earth.
E.g. for various seismic phases Cake calculates:

- Phase arrival times
- Ray paths
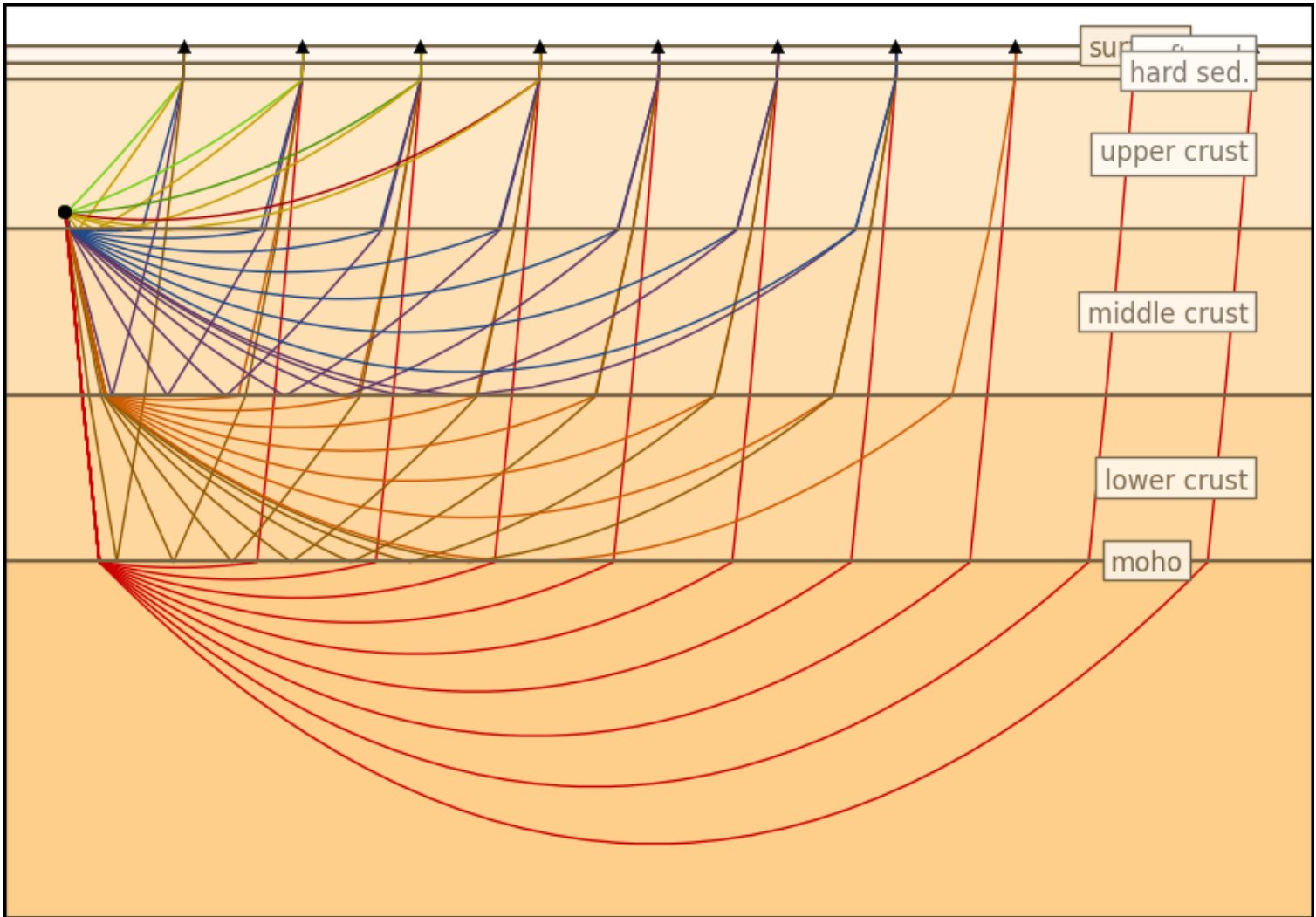- Reflection and transmission coefficients
- Take-off and incidence angles

Figure 1: Seismic rays in layered media - calculated and plotted with Cake.

Forward Modelling

Use **Fomosto** and pyrocko.gf to calculate Green's functions (GF) taylored to your earth model and problem. The GFs are stored and managed in ready-to-use databases. In this way you can seperate the computationally expensive operation from any sorce modelling. Pyrocko wraps different numerical forward-modelling codes, such as *QSEIS*, *QSSP* and *PSGRN/PSCMP* to calculate Green's function databases.
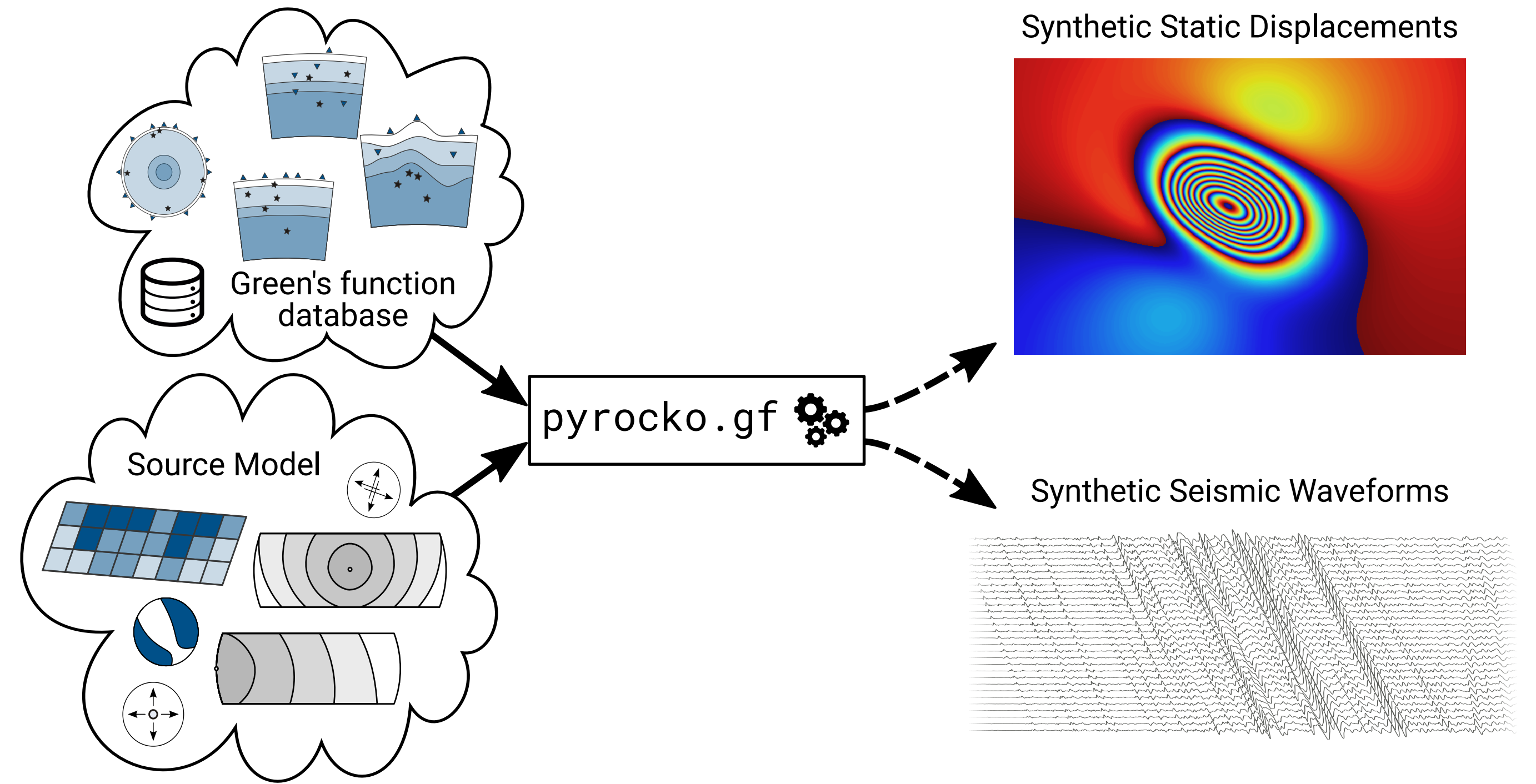

Figure 2: Synthetic waveforms (left) and static LOS displacement (right) calculated through Pyrocko's Green's function database submodule.

The calculation of gridded Green's function databases enables forward-modelling of **arbitrary source geometries**. Currently implemented are (1) explosion source, (2) double couple, (3) moment tensor, (4) rectangular fault plane and (5) ringfault system.

Ecosystem

In Pyrocko's wake the development of seismological software thrives:

- Grond – The Earthquake Buster.
  Propabalistic source optimisation from waveform and geodetic data.
- Lassie – A friendly Earthquake Detector.
  Even sniffs the finest tremor.
- BEAT – Bayesian Earthquake Analysis Tool.
  Source optimisation from geodetic and seismic data.
- Talpa – Interactive Static Source Modelling.
  Analytical and numerical displacement source modeling.
- Automap – Beautiful Maps from GMT.
  Swiftly create informational maps through Pyrocko
- Jackseis – Waveform archive data manipulation.
  The Seismologist' Swiss Army Knive

Selected References

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