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 **https://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 more. Your local waveform archives can be organized, accessed and batch-processed through `pyrocko.pile` in a memory-efficient way.

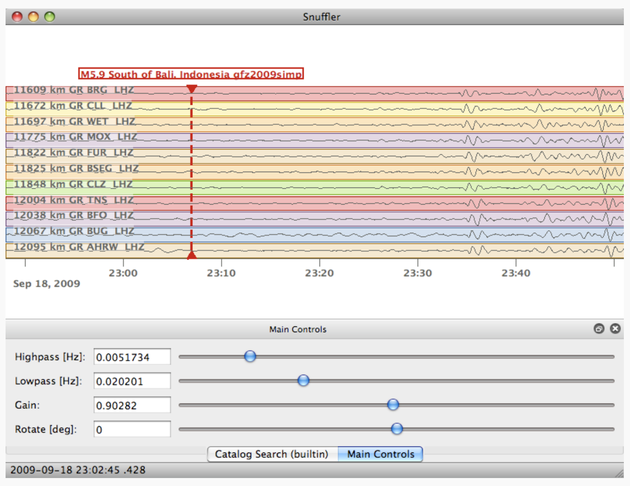
```
from pyrocko import pile

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
- Earthquake cluster analysis
- Beamforming
- Cross-correlation of traces
- Station network mapping
- Synthetic travel-time markers
- Interactive synthetic waveform modelling

Clients and Data Access

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

Earthquake catalog data from *Geofon, GlobalCMT, USGS* and more can be accessed and implemented.

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

Datasets

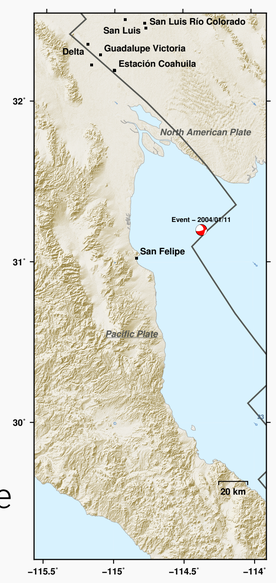
The `pyrocko.dataset` submodule provides you with a convenient access to prominent online and offline geodatasets:

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

Digital Elevation Models from *ETOPO1* and *SRTML3*.

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

Geographical data provided through the *GSHHG* coast-line database and *Geonames.org*, (city names and population)



Travel-Time Calculations

Cake is your tasty tool for 1D travel-time and ray-path computations. You can use it to solve classical seismic ray theory problems for layered (1D) models in a spherical Earth.
E. g. for various seismic phases you may calculate:

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

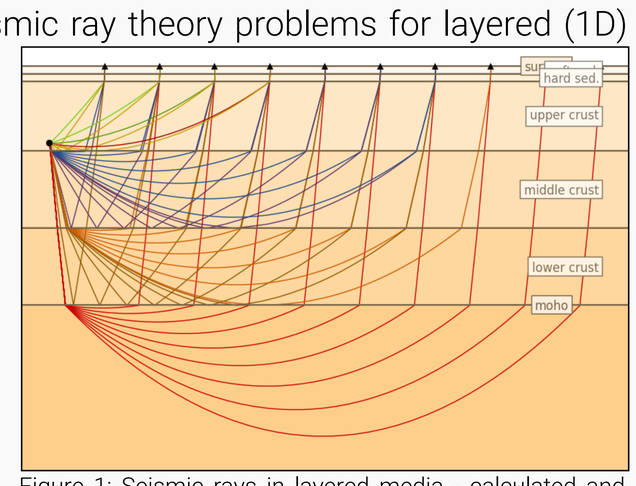
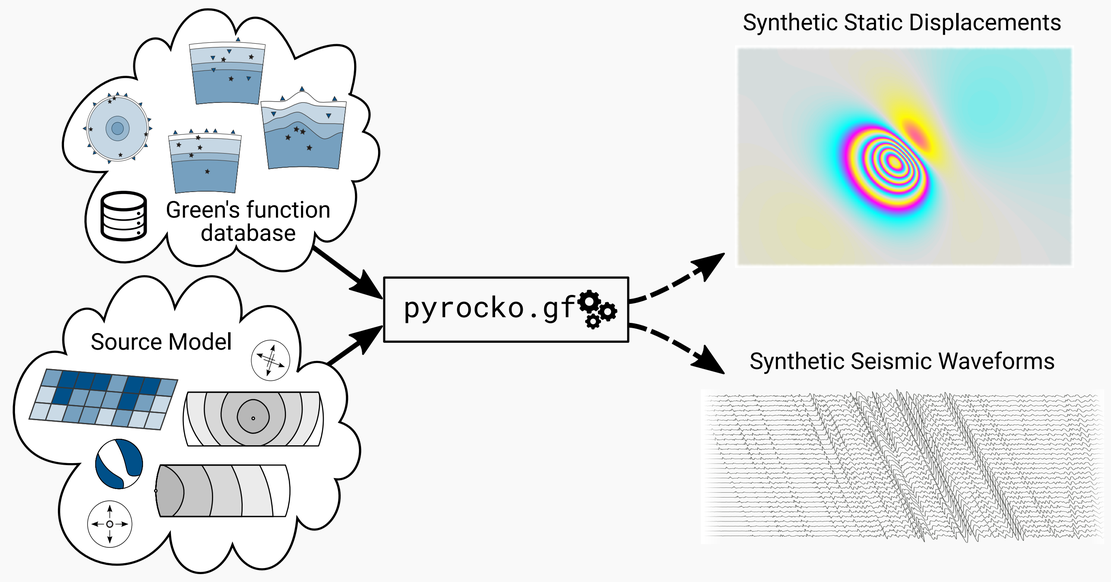


Figure 1: Seismic rays in layered media - calculated and plotted with Cake.

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 separate the computationally expensive operation from any source modelling. Pyrocko wraps different numerical forward-modelling codes, such as *QSEIS*, *QSSP* and *PSGRN/PSCMP* to calculate Green's function databases.



Choose a **source type.** Currently implemented for your modelling are:
(1) explosion source, (2) double-couple source, (3) moment tensor, (4) rectangular fault plane and (5) a ringfault system.
Or an **arbitrary source geometry** created by yourself. It is possible with our gridded Green's function databases.
Finally, get what you want: **dynamic** and **static**, **near-field** and **far-field** surface displacements.

Ecosystem

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

- **Grond** – The Earthquake Buster
  Probabilistic source optimisation from waveforms and geodetic data
- **Lassie** – A friendly Earthquake Detector
  Even sniffs the faintest tremor.
- **BEAT** – Bayesian Earthquake Analysis Tool
  Source optimisation from geodetic and seismic data
- **KITE** - Interactive InSAR data Postprocessor
  InSAR displacement analysis, subsampling and error estimation
- **Talpa** – Interactive Static Source Modelling
  Analytical and numerical displacement source modelling
- **Automap** – Beautiful Maps from GMT
  Swiftly create informational maps through Pyrocko
- **Jackseis** – Waveform archive data manipulation
  The Seismologist's Swiss Army Knife

GitHub

Selected References

Heimann, S., Kriegerowski, M., Isken, M., Cesca, S., Daout, S., Grigoli, F., … Dahm, T. (2017). Pyrocko - An open-source seismology toolbox and library (Version 0.3). GFZ Data Services. https://doi.org/10.5880/gfz.2.1.2017.001

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