

Bridging Geodesy and Seismology

Pyrocko - new open-source software tools
for source modelling of earthquakes combining
InSAR data and **seismic waveforms**

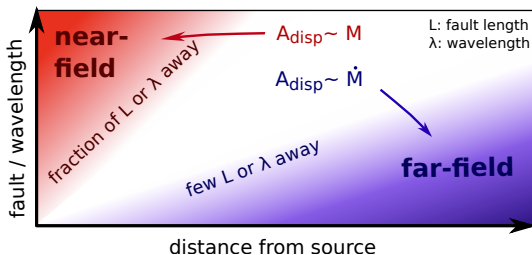
Henriette Sudhaus, Sebastian Heimann,
Andreas Steinberg, Marius Isken
& Hannes Vasyura-Bathke



hsudhaus@ifg.uni-kiel.de
www.pyrocko.org
www.bridges.uni-kiel.de

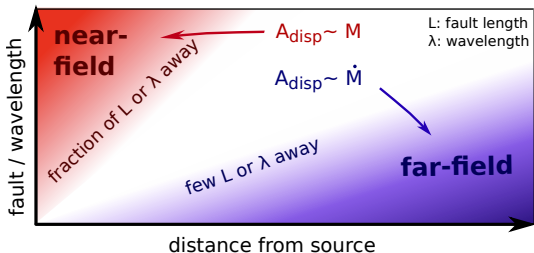
Bridging Geodesy and Seismology

Pyrocko - new open-source software tools
for source modelling of earthquakes combining
InSAR data and **seismic waveforms**



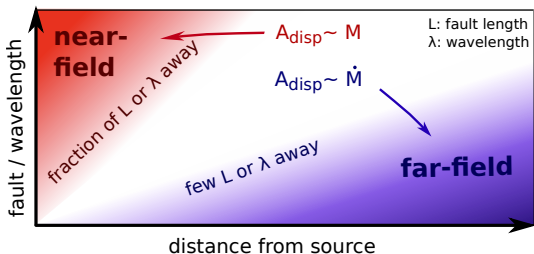
Bridging Geodesy and Seismology

Pyrocko - new open-source software tools
for source modelling of earthquakes combining
InSAR data and **seismic waveforms**



Bridging Geodesy and Seismology

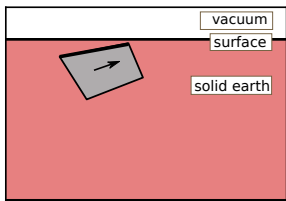
Pyrocko - new open-source software tools
for source modelling of earthquakes combining
InSAR data and **seismic waveforms**



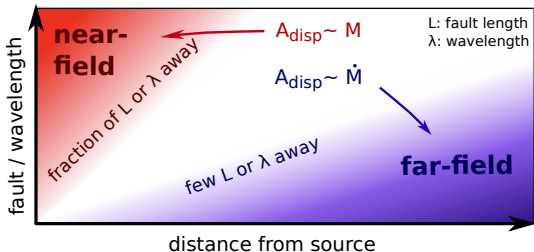
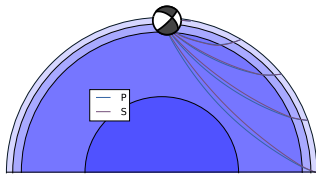
Sensitivity	near-field (static)	far-field (waves)
source location	✓	(✓)
moment	✓	✓
directivity	-	(✓)
centroid time	-	✓
rupture duration	-	✓
rupture mechanism	✓	✓
fault slip	✓	(-)
rupture extension	✓	-

Medium & source models harmonized using pyrocko

rectangular dislocation model
elastic half space



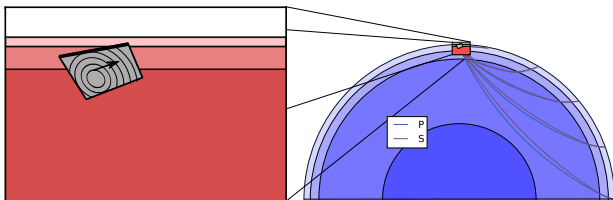
point-source moment tensor
layered 1d- velocity model



Sensitivity	near-field (static)	far-field (waves)
source location	✓	(✓)
moment	✓	✓
directivity	-	(✓)
centroid time	-	✓
rupture duration	-	✓
rupture mechanism	✓	✓
fault slip	✓	(-)
rupture extension	✓	-

Medium & source models harmonized using pyrocko

rectangular rupture model
layered 1d velocity model

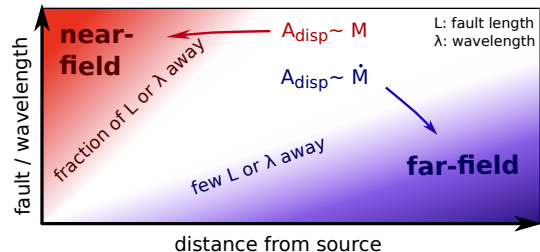


Green's function methods used:

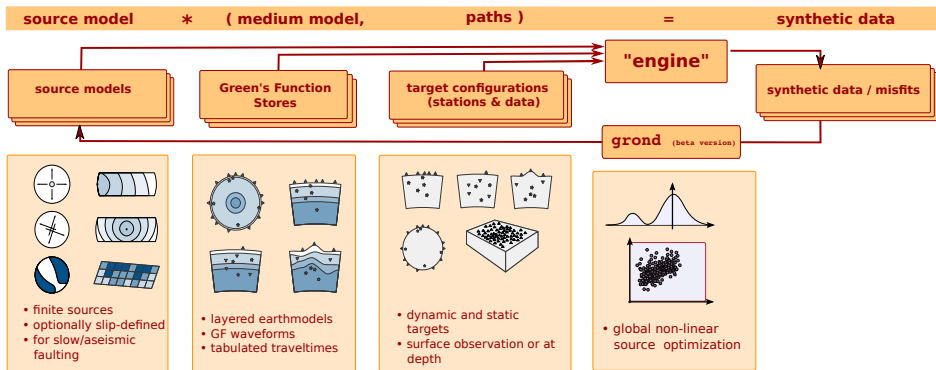
- Qseis/QSSP for waveforms
- PSGRN for static displacements

by Wang et al.,

<http://www.gfz-potsdam.de/en/section/physics-of-earthquakes-and-volcanoes/data-products-services/downloads-software/>

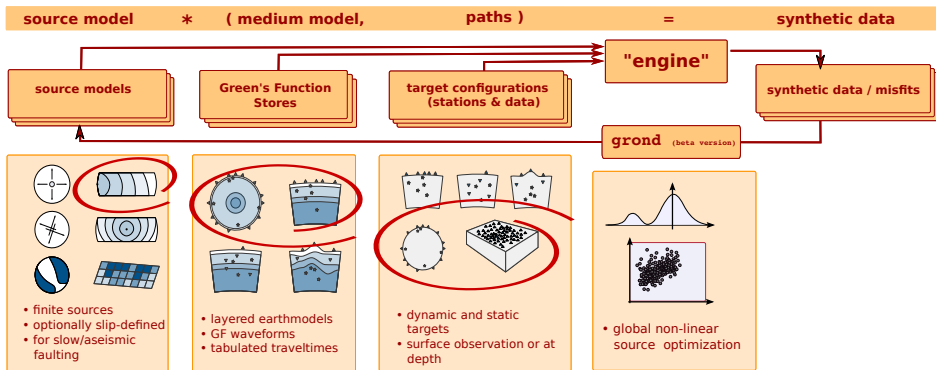


The Toolbox (see pyrocko.org, available on [github](https://github.com))



pyrocko software doi: [10.5880/GFZ.2.1.2017.001](https://doi.org/10.5880/GFZ.2.1.2017.001)

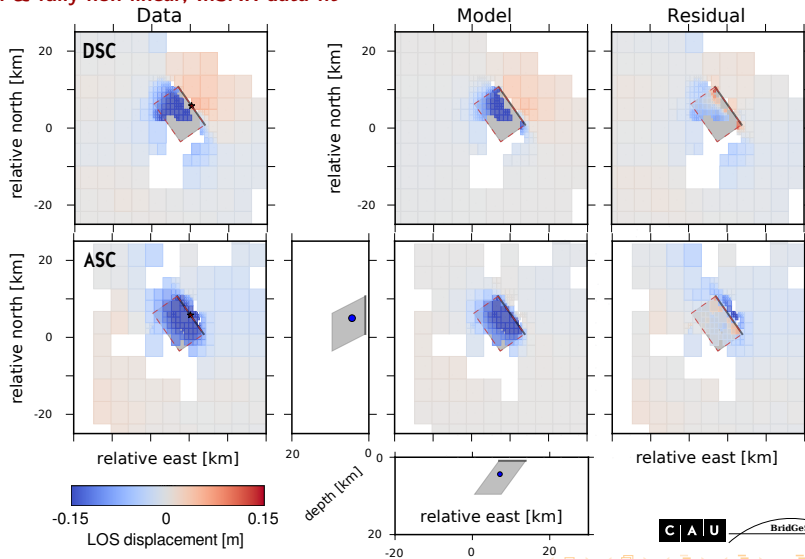
The Toolbox (see pyrocko.org, available on [github](https://github.com))



pyrocko software doi: [10.5880/GFZ.2.1.2017.001](https://doi.org/10.5880/GFZ.2.1.2017.001)

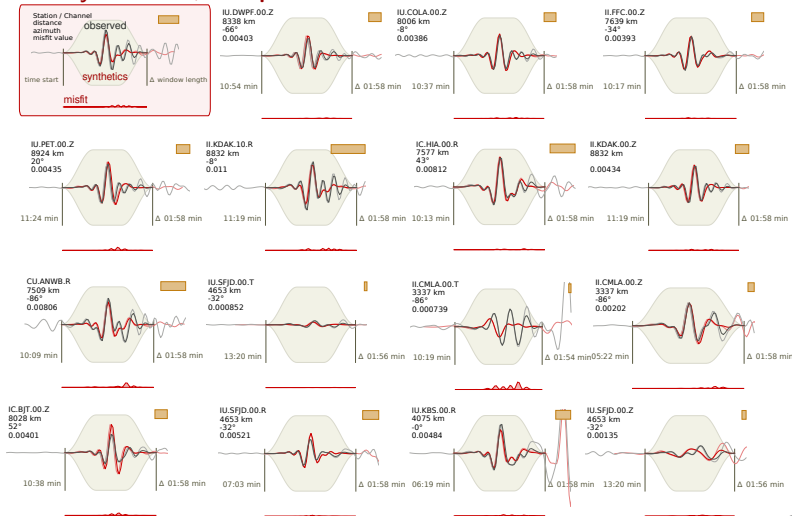
Example joint optimization: 2009 L'Aquila eq.

global & fully non-linear, InSAR data fit



Example joint optimization: 2009 L'Aquila eq.

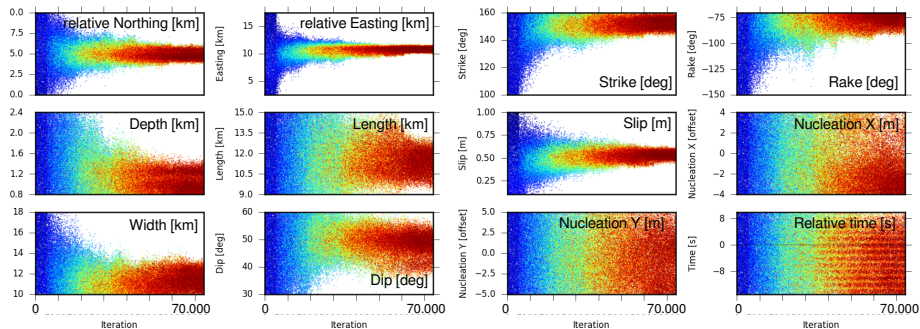
global & fully non-linear, example waveform fits



in total full-waveform fits of 48 P phases and 15 S phases

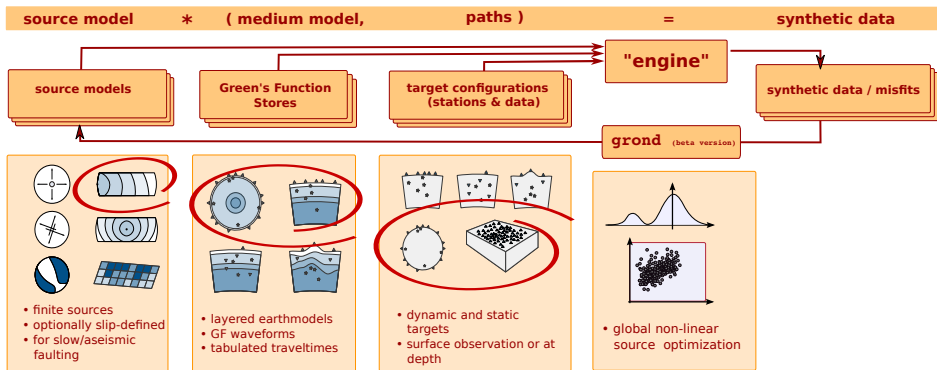
Example joint optimization: 2009 L'Aquila eq.

global & fully non-linear, source parameter convergence

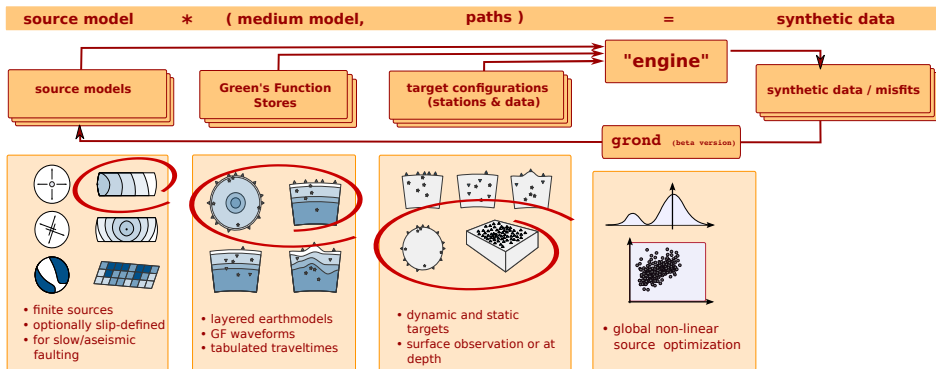


12 source parameters optimized with
560 InSAR samples, 126 seismic phases
70.000 forward models with 4 cores in 3.8 h (0.2 s per model)

The Toolbox (see pyrocko.org, available on [github](https://github.com))

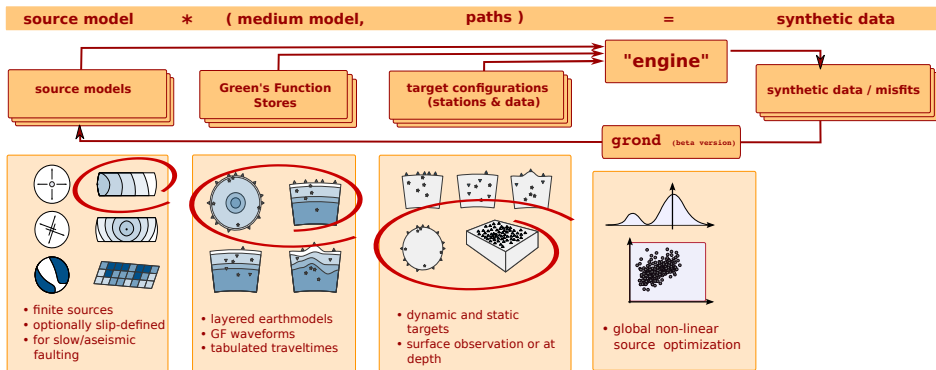


The Toolbox (see pyrocko.org, available on [github](https://github.com))



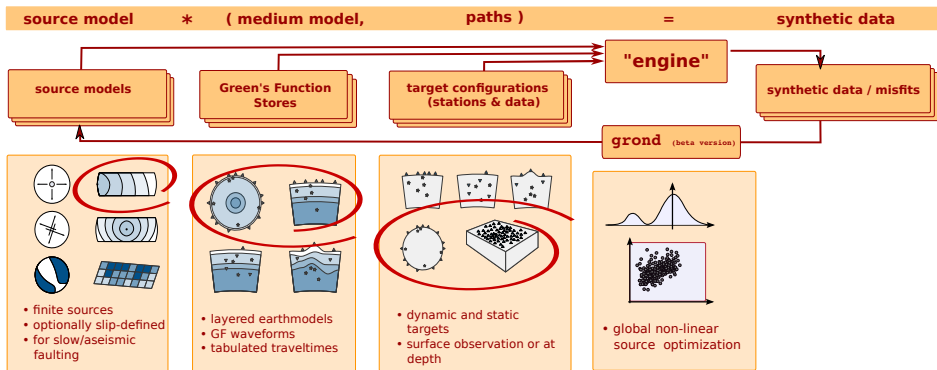
- pyrocko facilitates waveform data download, processing, GF calculation
 - ▶ snuffler interactive waveform browser (+ forward modelling)

The Toolbox (see pyrocko.org, available on [github](https://github.com))



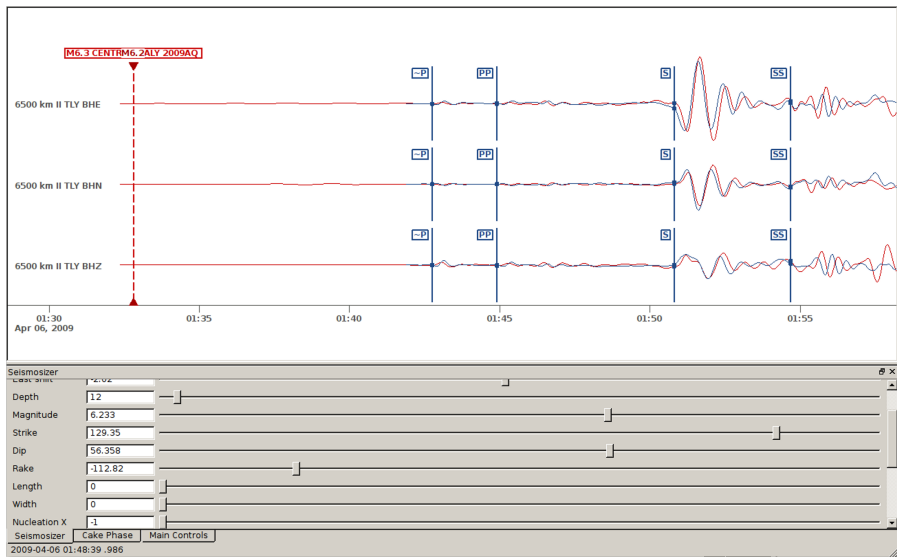
- pyrocko facilitates waveform data download, processing, GF calculation
 - ▶▶ snuffler interactive waveform browser (+ forward modelling)
 - ▶▶ module kite post-processes InSAR displacement to become static targets
 - ▶▶ talpa is an interactive sandbox for displacement forward modelling

The Toolbox (see pyrocko.org, available on [github](https://github.com))

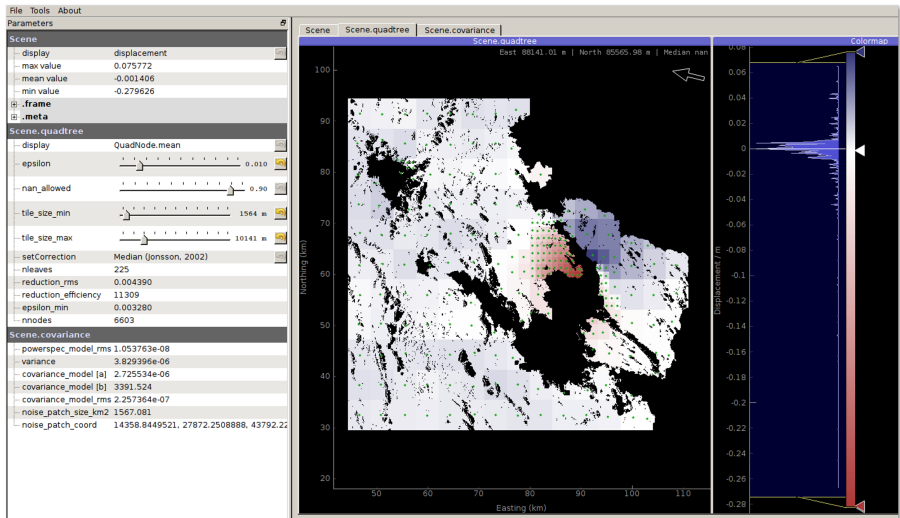


- pyrocko facilitates waveform data download, processing, GF calculation
 - ▶▶ snuffler interactive waveform browser (+ forward modelling)
 - ▶▶ module kite post-processes InSAR displacement to become static targets
 - ▶▶ talpa is an interactive sandbox for displacement forward modelling
- module grond is an optimizer for pyrocko

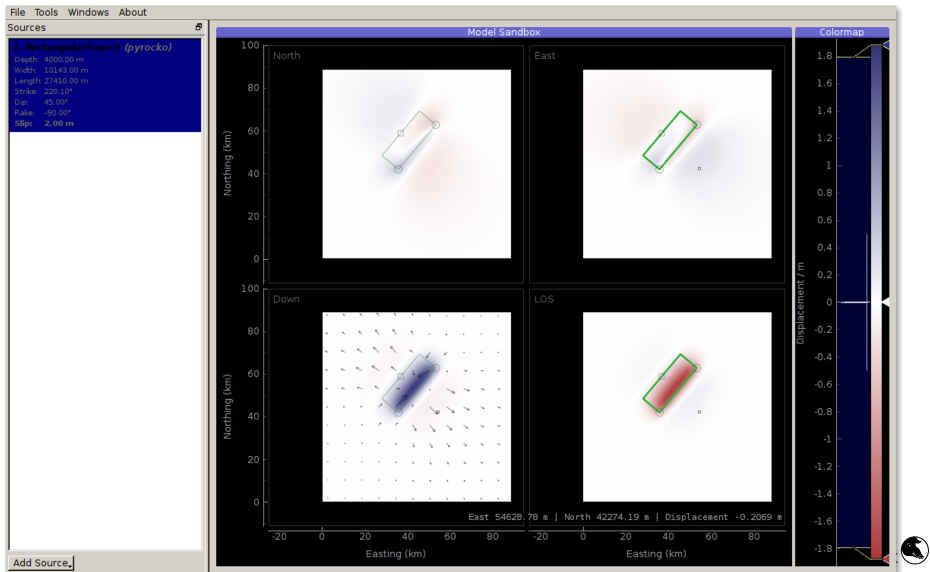
Use snuffler to playfully model the far field



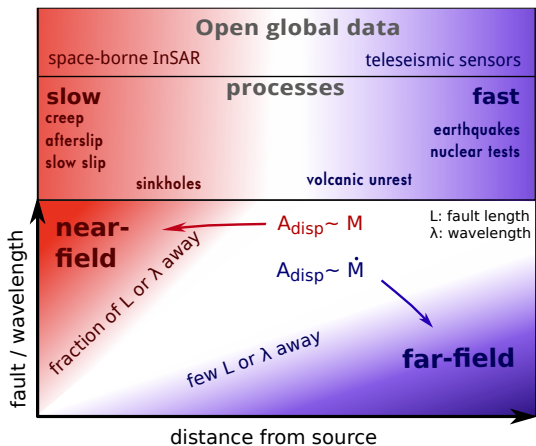
Use kite to post-process your InSAR data



Use kite's talpa to playfully model the near-field



Summary



Check us out at

pyrocko.org »



pyrocko.org - Software for Seismology

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 InSAR, GPS data and dynamic waveforms, or for seismic source characterization.

Development and support is coordinated at <https://github.com/pyrocko>.



Pyrocko framework

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



Pyrocko manual



Download and installation



Project page on GitHub



Support



Code examples