Short Oral

SSA2py: A seismic source imaging tool in Python based on the Source-Scanning Algorithm

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Intro

SSA Principles

Process Flowchart

Applications

Wrap-up

EGU General Assembly 2022

OSPP contest!

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SSA2py: A seismic source imaging tool in Python based on the Source-Scanning Algorithm

Abstract

SSA Principles

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We introduce SSA2py, an open-source tool for the implementation of the Source-Scanning Algorithm (SSA) (Honn Kao and Shao-Ju Shan, 2007) in near-real time conditions. In general, Back-Projection methods due to their simplistic but at the same time effective approach provide the circumstances for fast analysis of the seismic rupture with relatively low computational cost and minimum initial assumptions. In accordance with that and by exploiting local strong motion data, SSA can be used for the detailed imaging of the high frequency seismic radiation after the occurrence of a major earthquake by stacking records based on the predicted arrival times for a specific seismic phase. Areas in a spatiotemporal grid system that produce high brightness values due to constructive stacking, usually point out the radiation of meaningful seismic energy at the examined frequency band.

SSA2py is a command line tool, developed in Python high-level programming language and mainly designed to closely work with 'FDSN Compliant Web Services' for a real-time seismic event triggering and seismic waveform data provision. After the report of a significant seismic event SSA2py initially calculates the necessary travel timetables, using the optimal velocity model for the study area. The software is intended to offer several travel time calculation alternatives such as the fast marching or the finite difference method together with the possibility to use 1D or 3D velocity models (if it's applicable). In a subsequent step, it automatically obtains seismic waveform data and metadata from the user defined data sources (e.g., an FDSN web service) and applies a variety of signal assessment algorithms that examine data-clipping, signal-to-noise ratio, long period disturbances, station's performance based on power spectral density (PSD) of seismic noise etc. Selected data are carefully pre-processed, based on the user given configuration file and back-projected using SSA in a highly efficient way parallelized and adapted to run in GPU and CPU multiprocessing architectures.

An extended configuration file is provided, allowing the user to manipulate in detail SSA settings, ranging from the style and the size of the grid system to the frequencies and the type of the used signals. Finally, the software elucidates the method results by producing a series of plots and other important output info. The robustness of this new software will be presented in case studies from major earthquakes around the world (e.g., Japan, Greece). The program will be open source and freely available to the scientific community, oriented for computers with Linux OS and access to FDSN Web Services.

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SSA2py

is an open-source Python-based software for the automatic implementation of Source Scanning Algorithm of seismic events provided by the FDSN Web Services in real-time, oriented for High-Performance Computing

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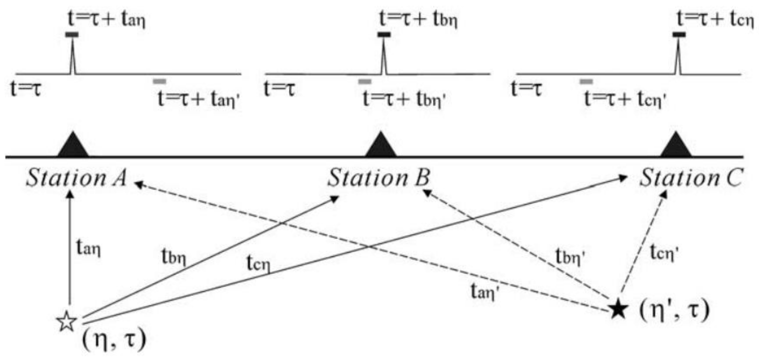
SSA Principles

Introduced by Kao and Shan, 2004

- Use of SM/BB records at **local or regional** distances.
- Define **3-D grid** in an area of interest.
- **Scan** the area in space and time.
- **'Brightness'** of each grid point is calculated by **summing** the observed waveforms at the specific arrival times at all defined stations.



→ Delay-and-sum method ~ **Backprojection**

Key Points

- Limited ***a priori*** knowledge of the rupture details.
- **High frequency** (HF) parts of the rupture can be resolved.
- Suitable for studying earthquakes when limited sources/data are available.

Rapid imaging of earthquake rupture characteristics

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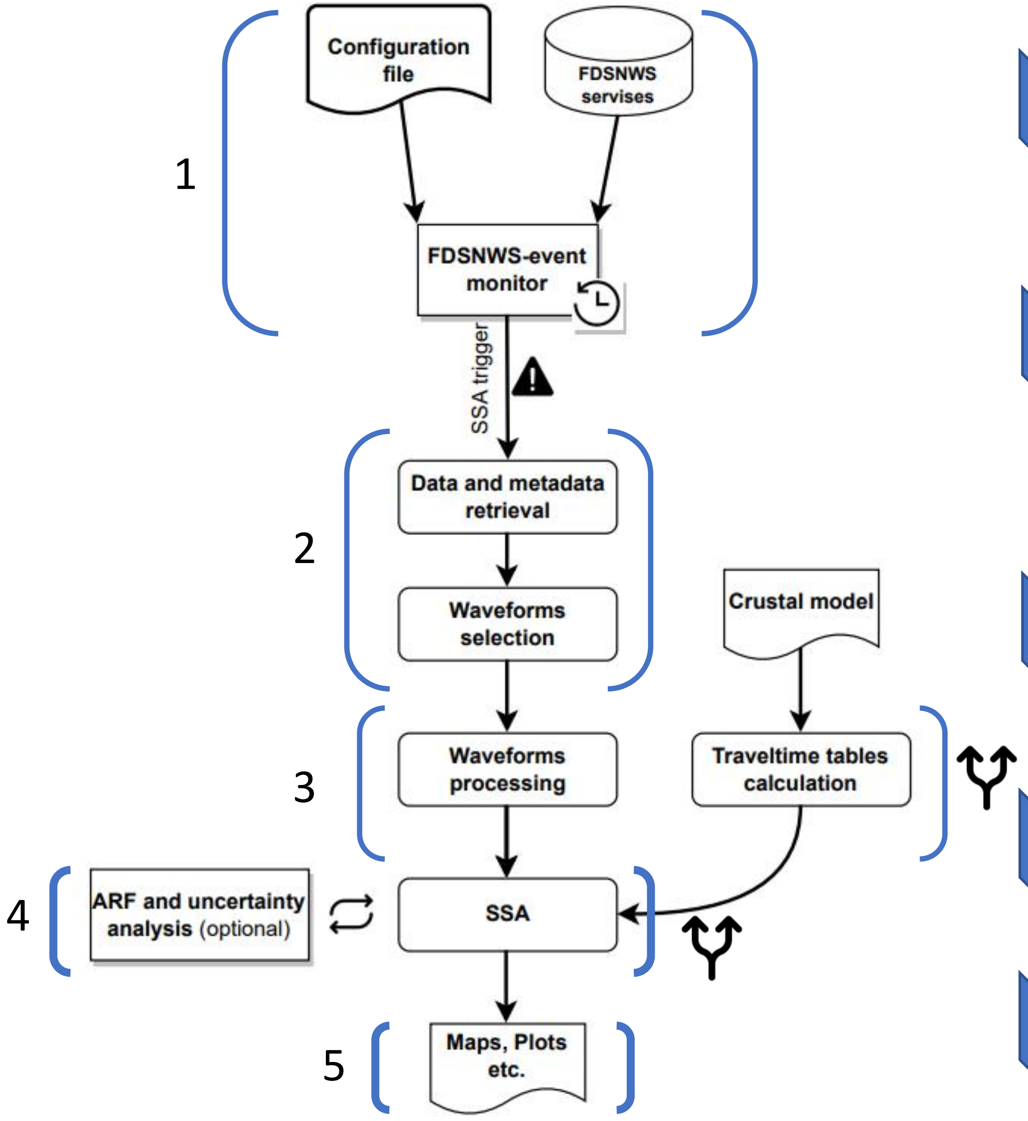
Automatic Process Flowchart



1.

Check for new events

- Monitor **FDSNWS-event** for new seismic events.
- Filter events based on **restrictions.**

2.

Select Inventory/Waveforms

- Retrieve Inventory from **FDSNWS-station**, **Station XML** , **Station YAML** .
- Retrieve Waveforms from **SeedLink**, **SDS**, **mseed**, **FDSNWS-dataselect**.
- Filter waveforms by **quality** based on plug-in modules e.g., **SNR**, **Clipping** etc.

3.

Waveforms Processing/Travel-time Tables

- Rotate, filter, change waveforms type, normalize etc.
- Calculate travel-time tables.

4.

SSA Calculations

- Source Scanning Algorithm calculations in time for an adjustable 4-D grid.
- Array Response Function (ARF), Bootstrap and Jackknife tests.

5.

Results Analysis

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Methodological Applications

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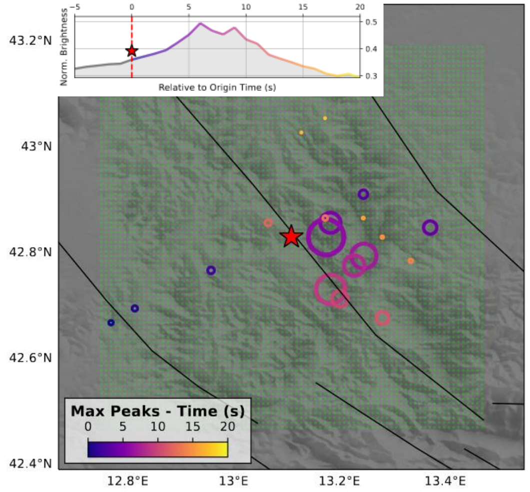
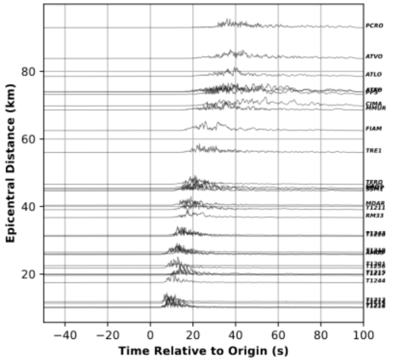
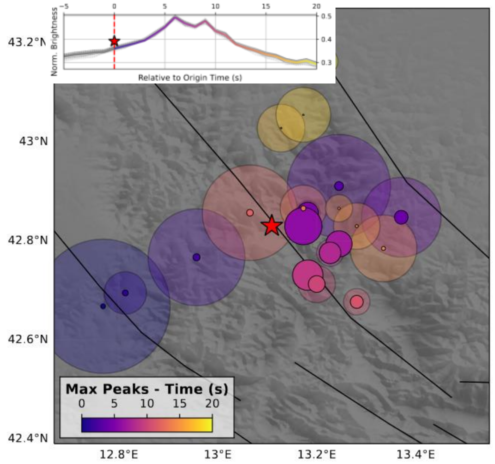
- **Quick** Energy Estimation: Relatively sparse 4D grid spatio-temporal search.



* Mw 6.5 Norcia earthquake (30/10/2016). SSA calculations using envelopes, data filtered between 0.1-5 Hz and S phase.

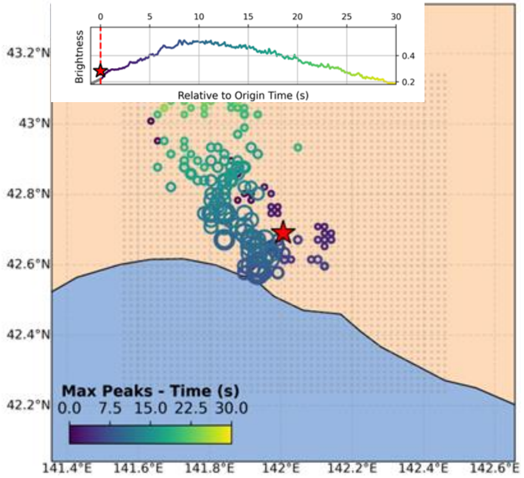


Uncertainty estimations



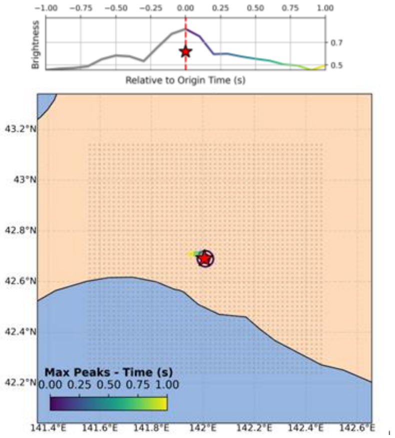
Images from SSA2PY

- **Best SSA Estimation**: Dense 4D grid spatio-temporal search.



* Mw 6.6 Hokkaido earthquake (06/09/2018). SSA calculations using envelopes data, filtered between 2-8 Hz and S phase.

Array response function



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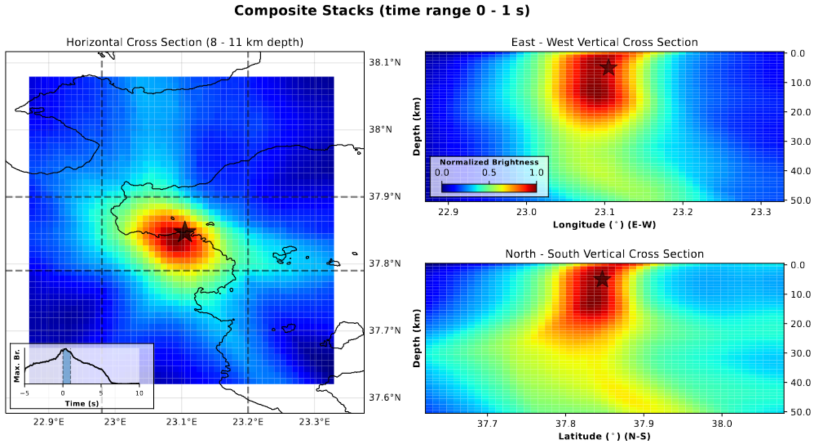
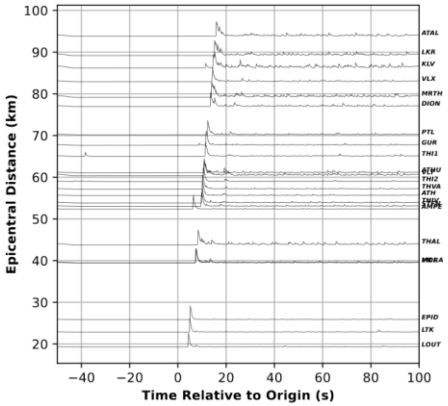
- **Hypocenter evaluation** using the SSA method.



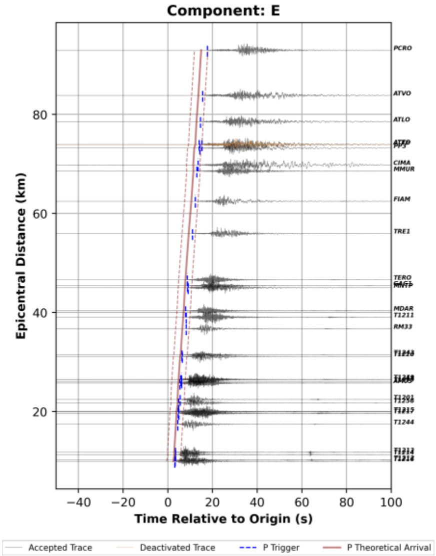


* SSA calculations using Kurtosis data, filtered between 1-10 Hz and P phase. Example of 4.1 ML seismic event in Greece.

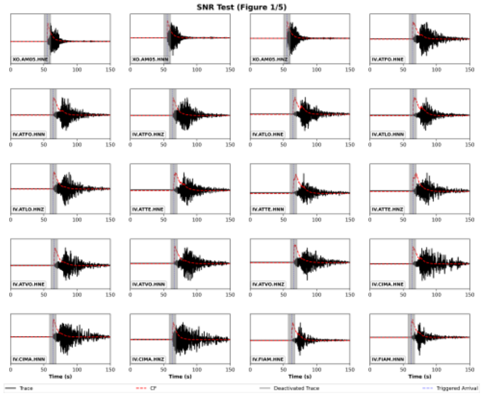
Images from SSA2PY

Simple but efficient tests have been designed to ensure high quality input data!

Timing test



SNR test



* Example of automatic tests incorporated in SSA2PY.

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Geo-specific Applications

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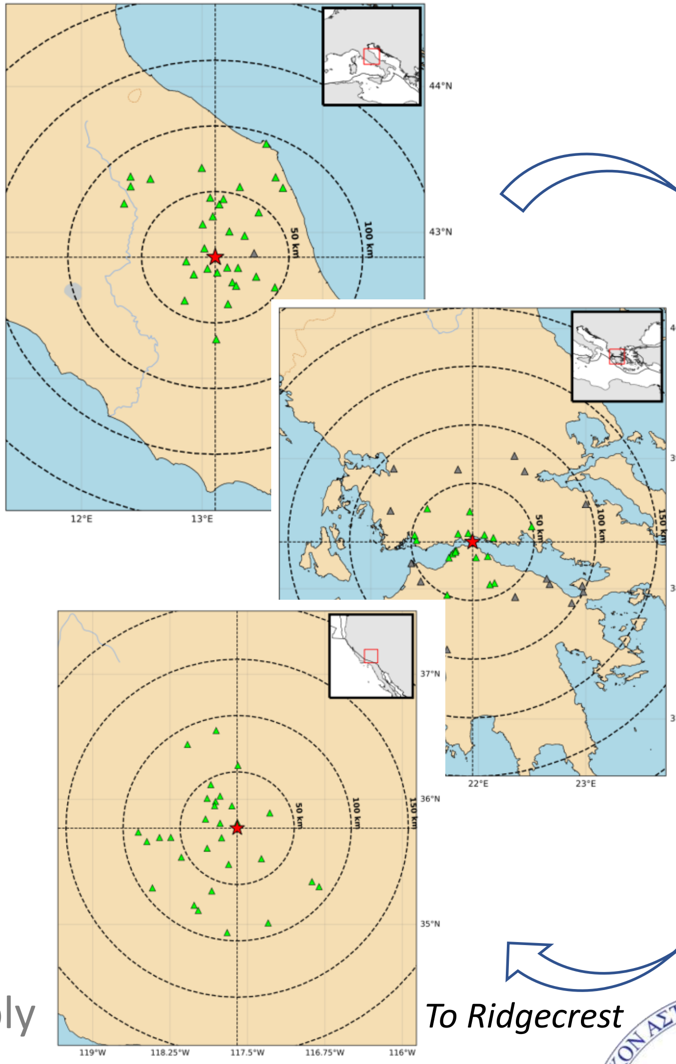
➡ Areas covered from an **FDSN node**

➡ European area **(EIDA Federator)**

➡ World-Wide **(EIDA + IRIS Federator)**

SSA from Norcia…



To G.O.C.

To Ridgecrest

Providing local Data and Inventory you can apply SSA in **any part of the world!**

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Thanks!

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Any questions ?

(source code available in a few weeks!)

SSA 2py

Coming Soon in GitHub

You can find us

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SCAN ME

or

https://github.com/ifountoul/SSA2PY