New directions in earthquake seismology

Introduction to Back-projection

Exercise 1

Bo Li

E-mail: bli@geophysik.uni-muenchen.de

November 19, 2020

Install conda:

https://docs.conda.io/projects/conda/en/latest/commands/install.html

Set up python environment

https://docs.conda.io/projects/conda/en/latest/user-guide/getting-started.html

Next, use pip to install some necessary libraries

Open terminal window:
pip install pydsm
Pip install obspy
pip install imagesc
Pip install geopy

Exercise 1:

- Data request and processing
- ARF test
- Locate a point source using array data (beamforming)

Exercise 2:

- Pick up one earthquake and do BP

Example_1

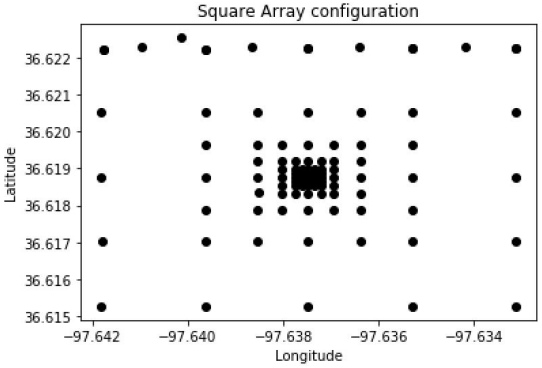
Array response function (ARF)

The ratio of the amplitude of the output of the array to that of the same number of elements concentrated at one location (Sherrif & Geldart, 1995)

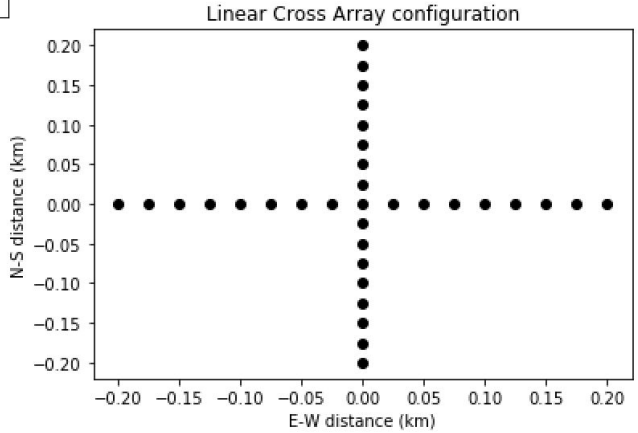
Files
There are two txt files containing the array locations

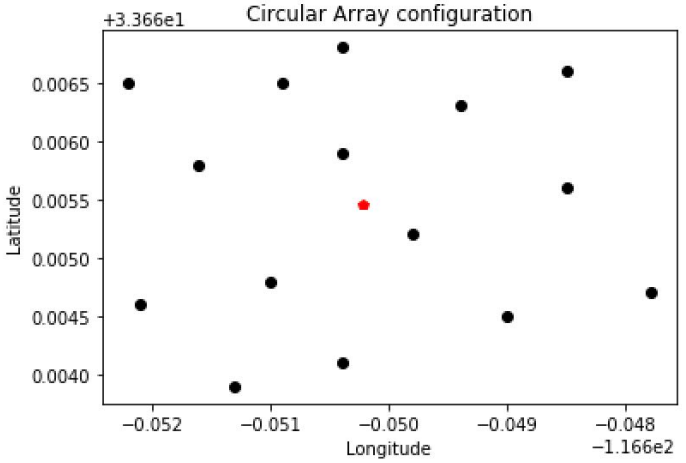
ARF_test.py is the python script to calculate the ARF for different arrays

ARF

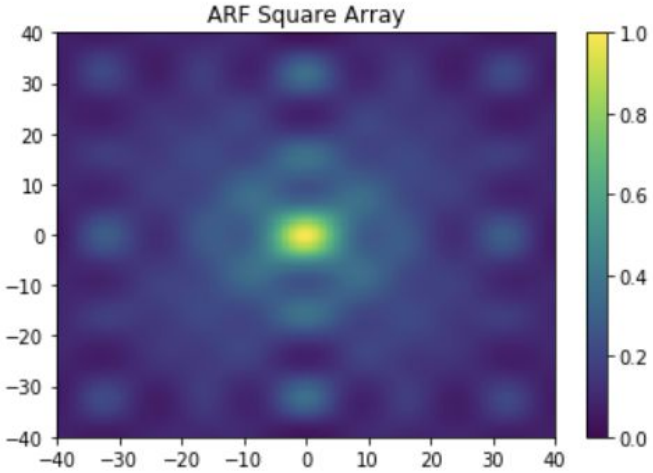


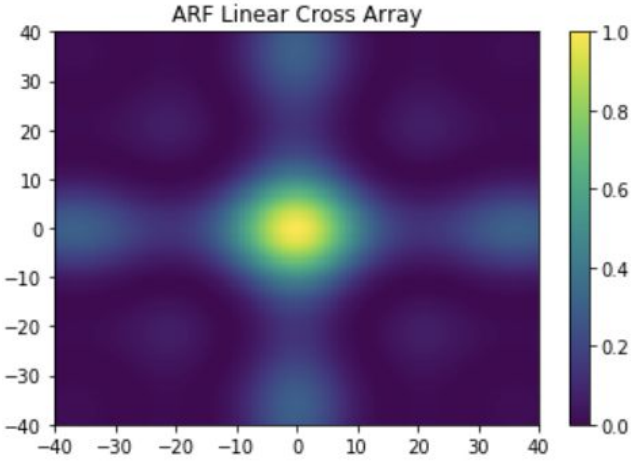
ARF for different array configuration

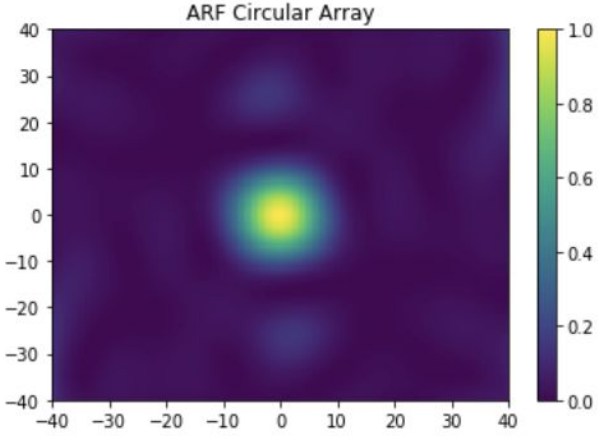




ARF for various frequency/wavenumber


ARF Square Array
40
30
20
10
0
−10
−20
−30
−40
−40 −30 −20 −10 0 10 20 30 40
1.0
0.8
0.6
0.4
0.2
0.0


ARF Linear Cross Array
40
30
20
10
0
−10
−20
−30
−40
−40 −30 −20 −10 0 10 20 30 40
1.0
0.8
0.6
0.4
0.2
0.0

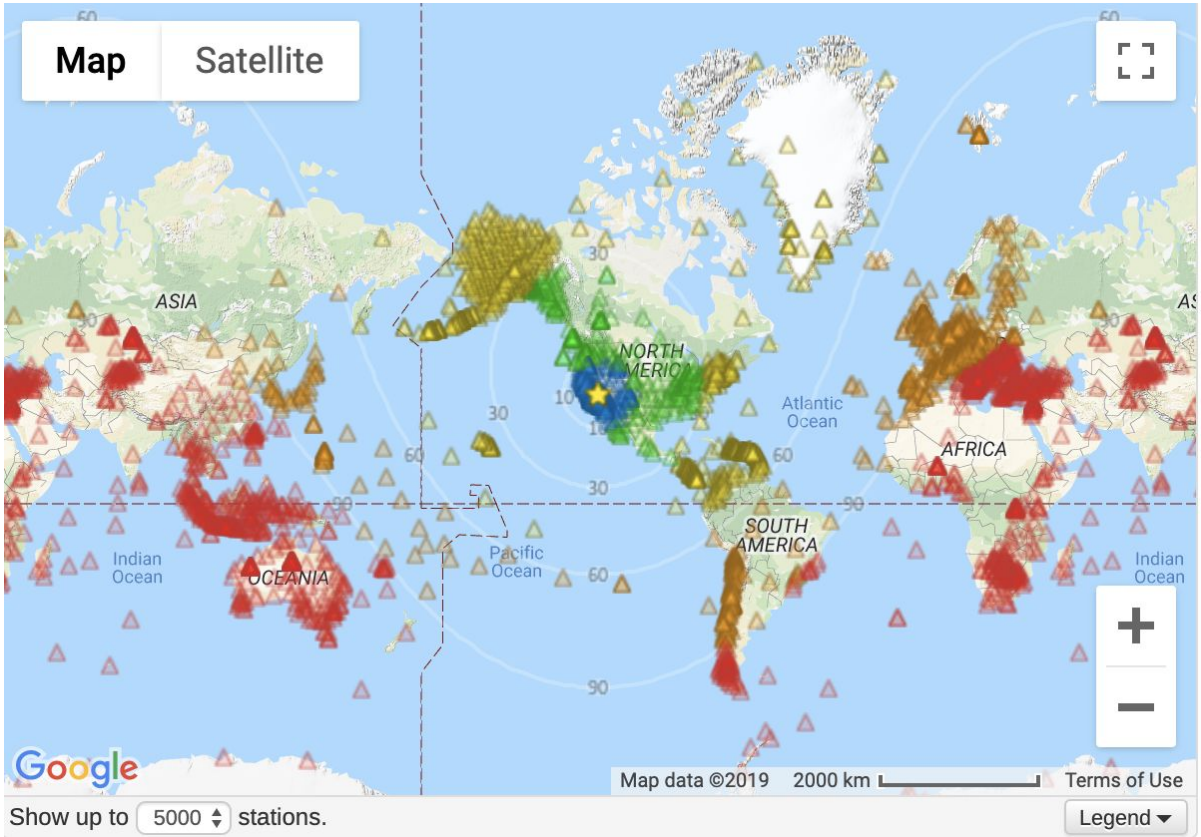

ARF Circular Array
40
30
20
10
0
−10
−20
−30
−40
−40 −30 −20 −10 0 10 20 30 40
1.0
0.8
0.6
0.4
0.2
0.0

Example_2

Data process and beamforming

- **Download data**
- **Remove instrument response**
- **Beamforming for each array**
- **Find earthquake location**

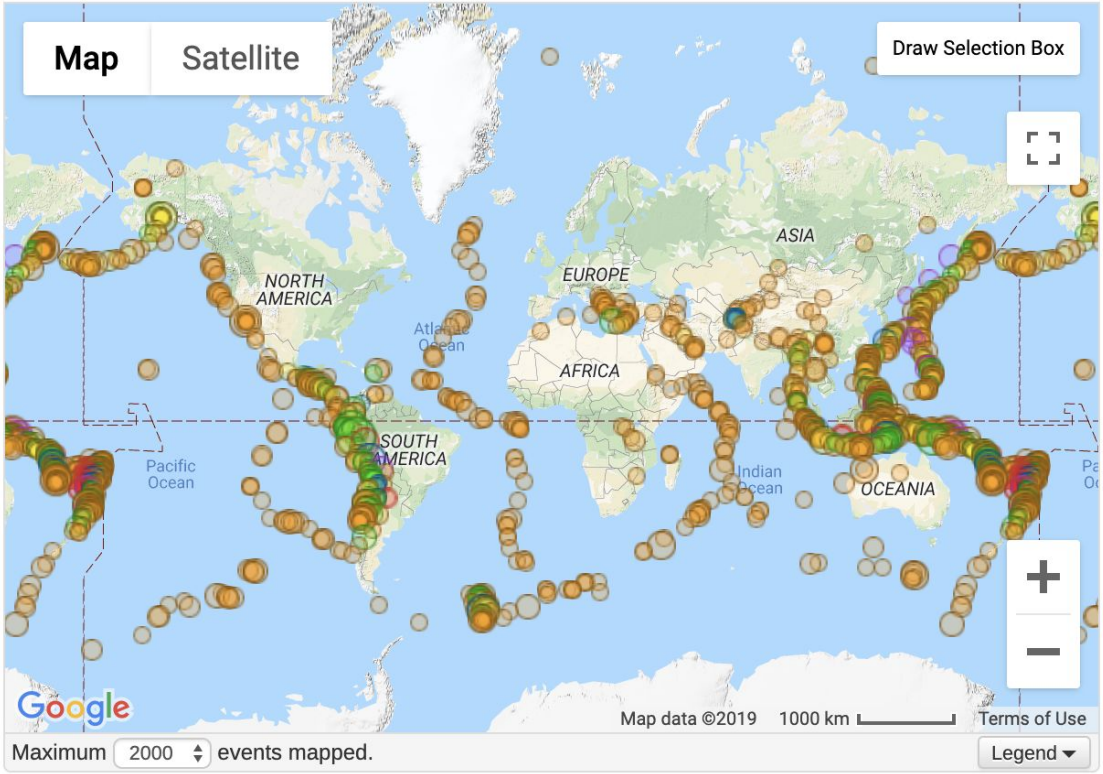
Global arrays & stations recorded the 2019 Ridgecrest earthquake

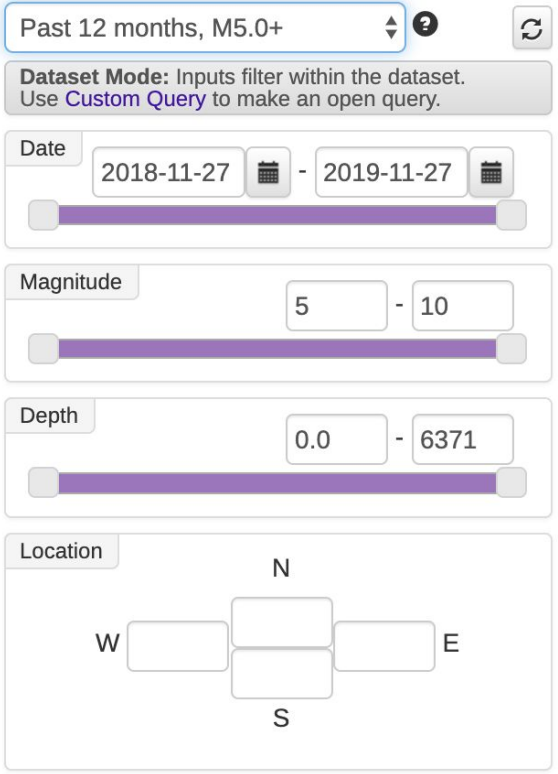


https://www.iris.edu

Data Request and Process

Request data from web: http://ds.iris.edu/wilber3/find_event



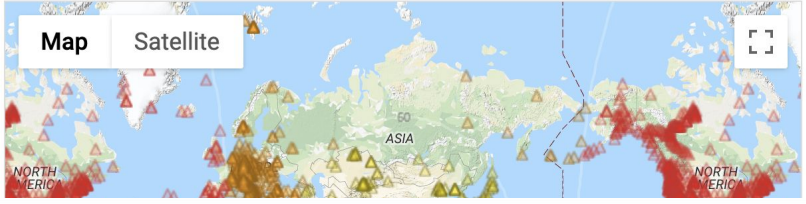


Data Request and Process

2004-12-26 MW9.0 Off W Coast Of Northern Sumatra

Latitude	Longitude	Date	Depth	Magnitude	Description	Related Pages
3.4125° N	95.9012° E	2004-12-26 00:58:52 UTC	26.1 km	MW9.0	Off W Coast Of Northern Sumatra	IRIS Event Page

The map below shows stations operational during this event, filtered by the criteria in the form to the right.



Request Only

Networks

Channels

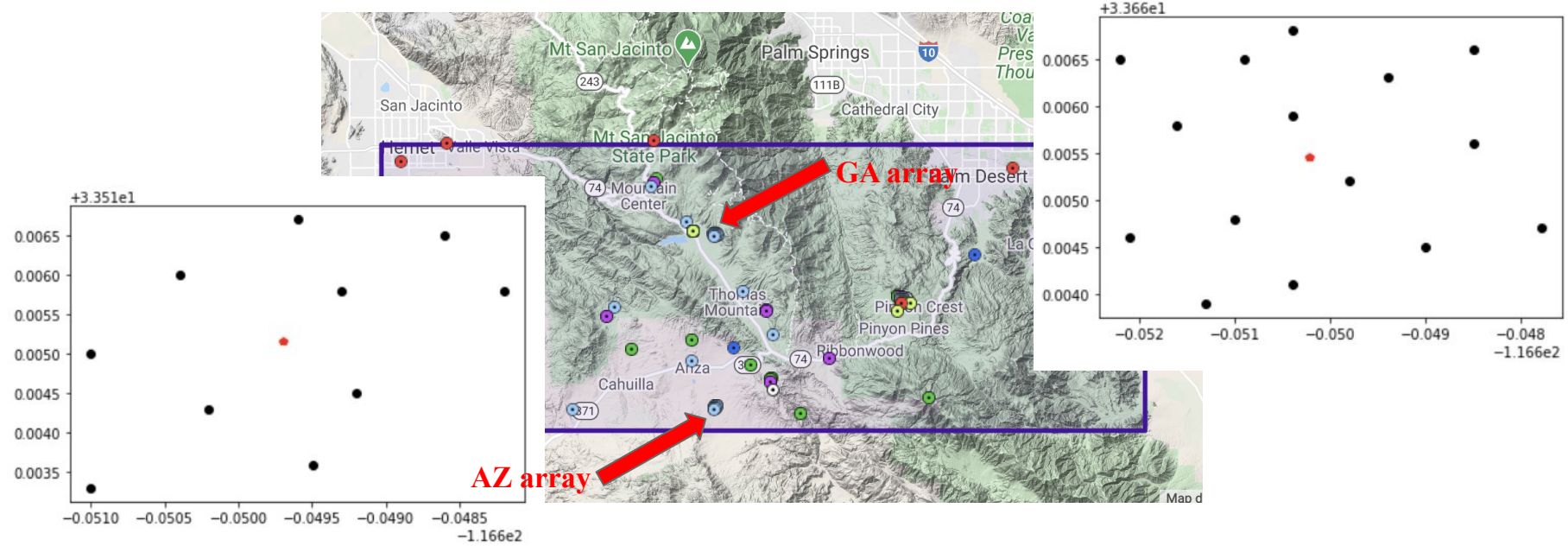
× BH?

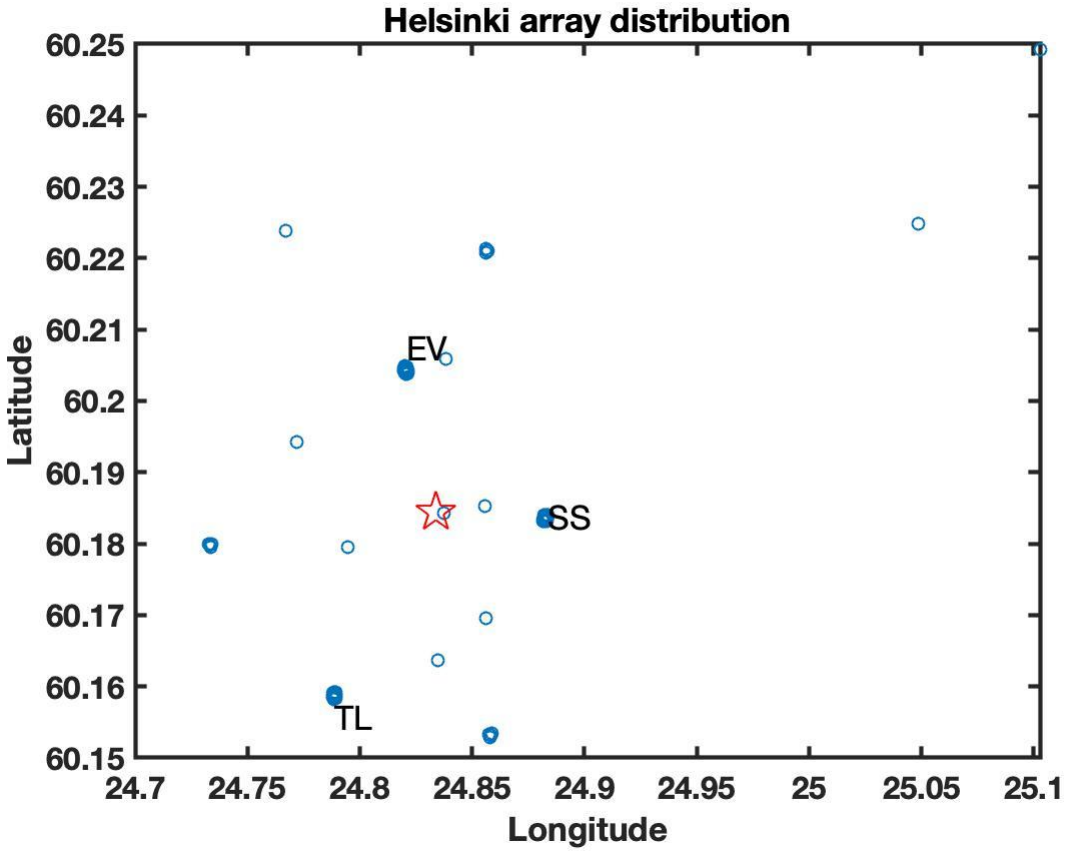
Channel Code	Band / Sample Rate	Instrument Type	Orientation
HHZ	H: 80Hz - 250Hz	H: High Gain Seismometer	Z: Vertical
BHZ	B: 10Hz - 80Hz	H: High Gain Seismometer	Z: Vertical
HNZ	H: 80Hz - 250Hz	N: Accelerometer	Z: Vertical
EHZ	E: 80Hz - 250Hz	H: High Gain Seismometer	Z: Vertical

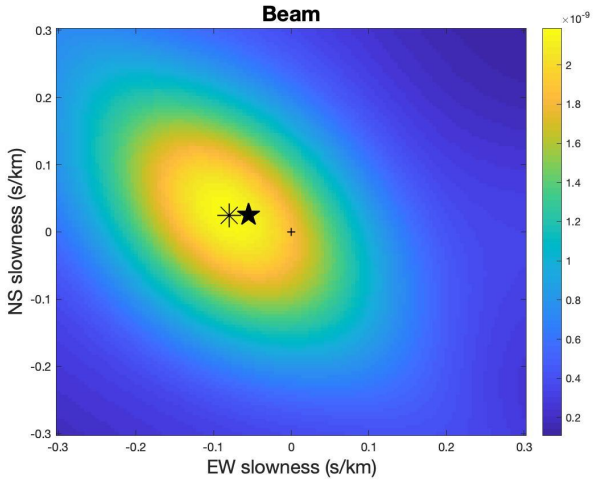
Data Request and Process

https://ds.iris.edu/mda/?

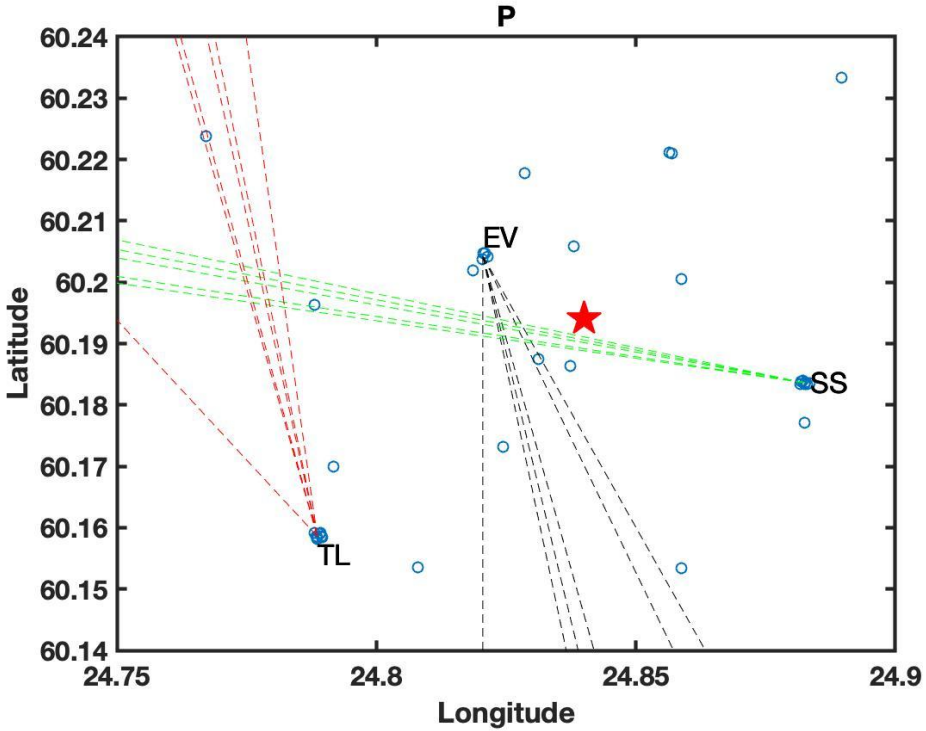
https://ds.iris.edu/gmap/#network=*&starttime=2011-06-06T00:00:00&endtime=2011-06-06T23:59:59&maxlat=33.75&maxlon=-116.2&minlat=33.5&minlon=-117&drawingmode=box&planet=earth





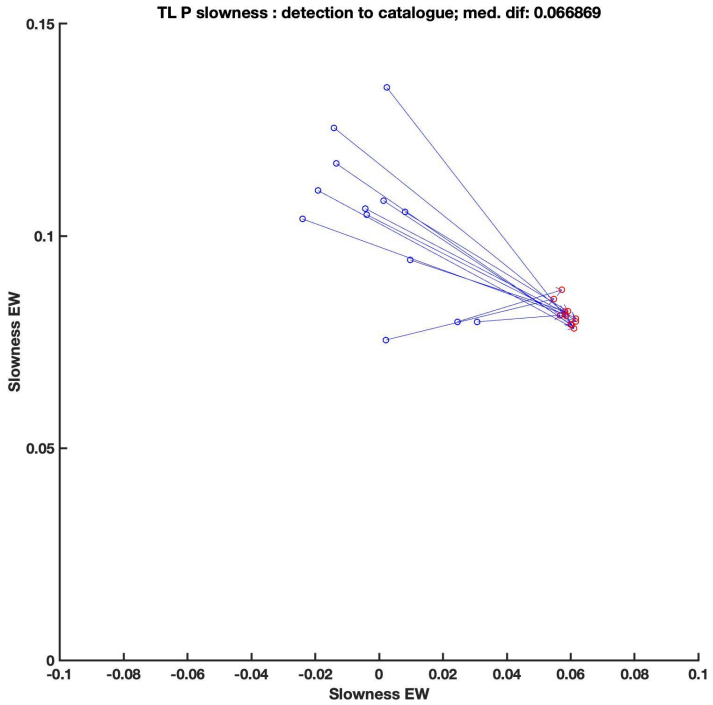


Beamforming using P phase (SS array)

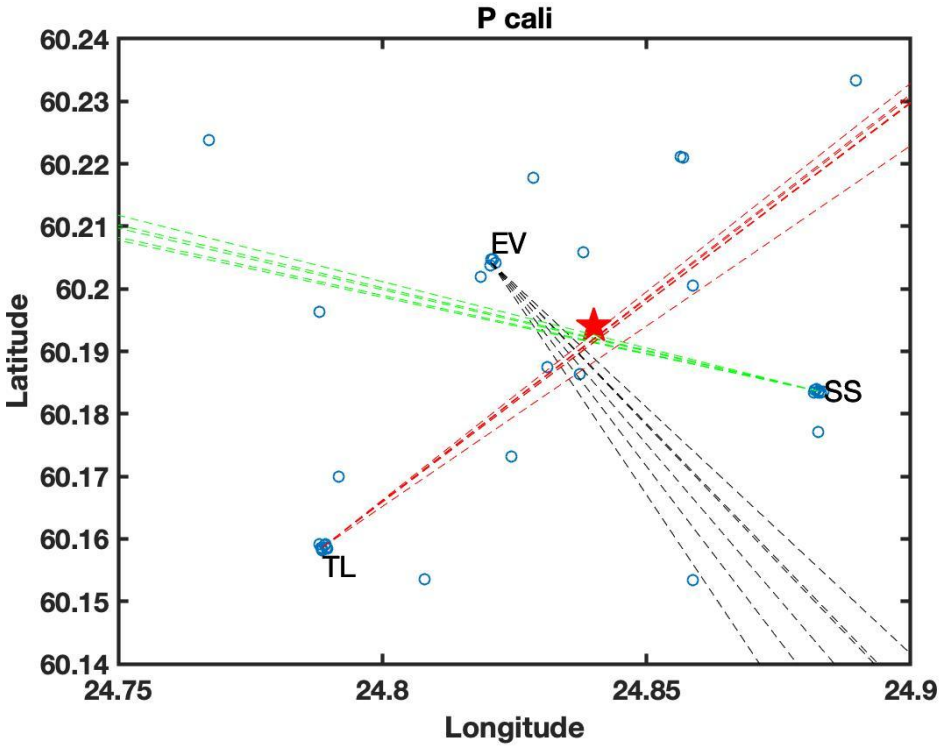


P phase beamforming for a Mg 1.4 events in Helsinki. Each dashed line shows the slowness vector direction in each bootstrap beamforming result. The red star represents catalog location.

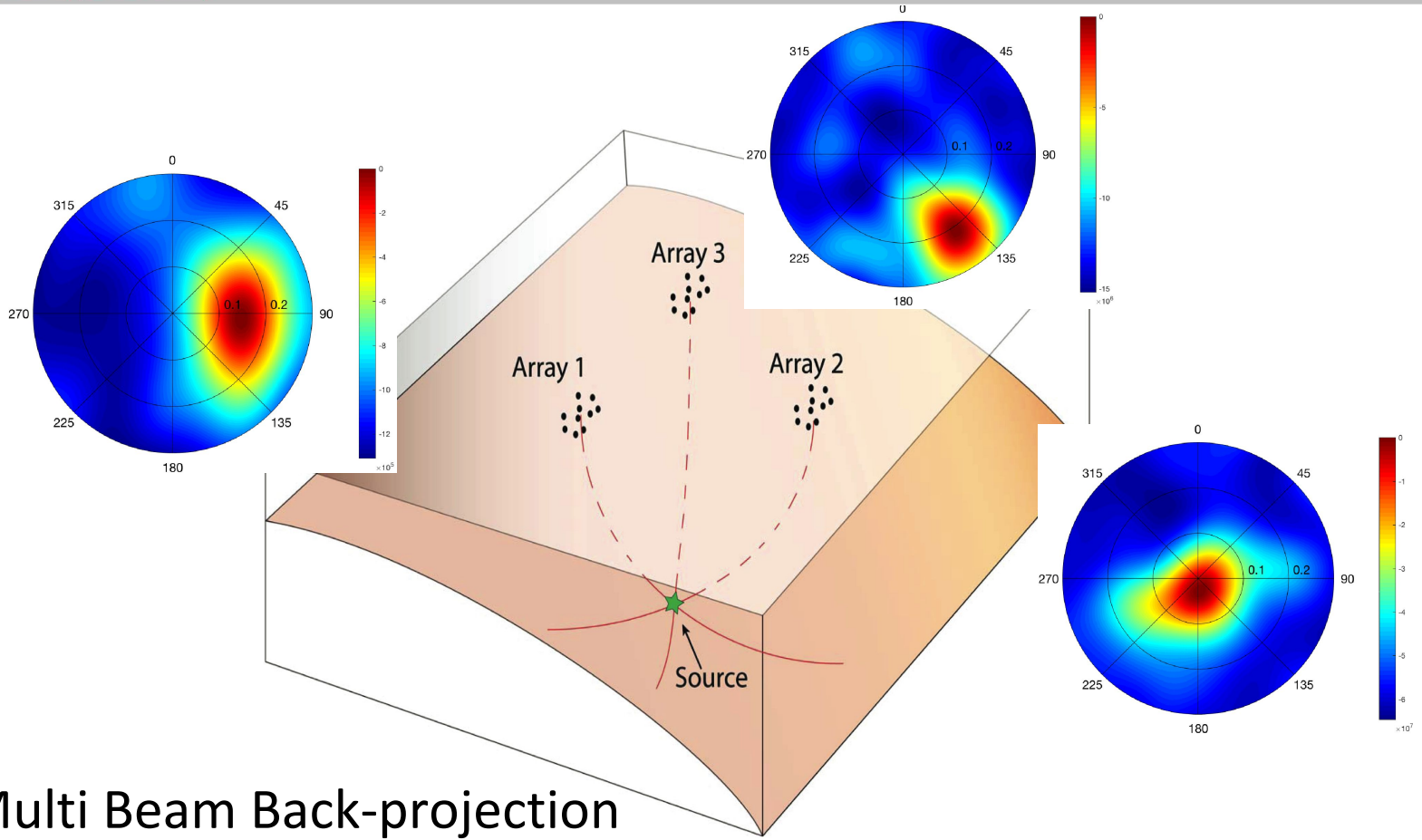
Systematic slowness bias



After calibration



Beam Back-projection



Multi Beam Back-projection