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dbMISS project progress report:

Attenuation tomography in NRW

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Die Landesregierung Nordrhein-Westfalen

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Objectives of the study:

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Seismic Attenuation:

- loss of energy in seismic waves due to intrinsic absorption (conversion to heat) and scattering (redistribution due to heterogeneities).

- insights into geological structures, material properties, and dynamic processes. Frequency dependent attenuati improves accuracy in **modeling** and **interpreting** seismic waveforms and

ground vibrations

Q quality factor (non-dimensional): the ratio of the wave energy to the energy dissipated per cycle of oscillation

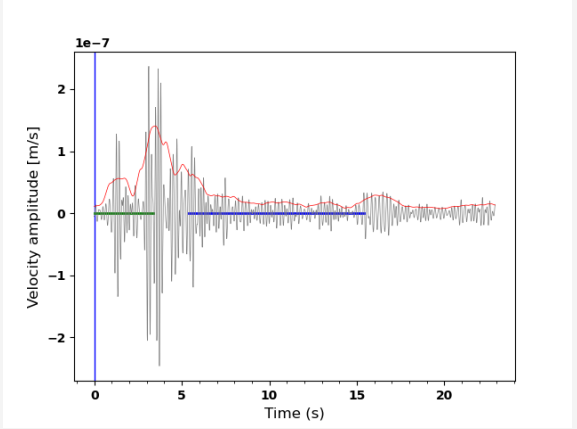
Study Method

MuRAT (De Siena, et al., 2014)

Peakdelay

Q

Qc

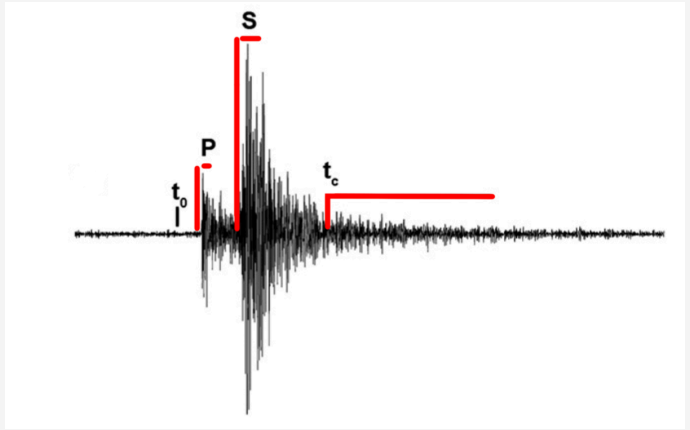


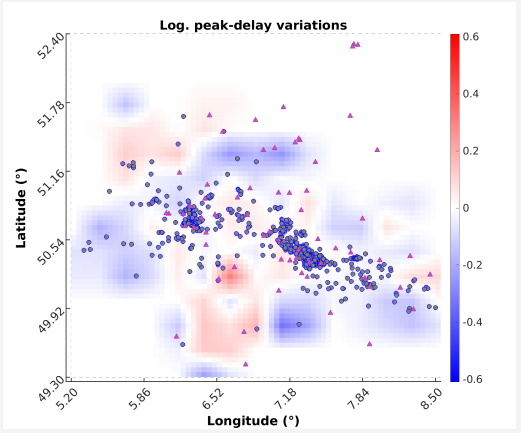
$$\ln\left[\frac{A_P(f,\ r)\,r^{\alpha}}{A_c(f,\ t_c)}\right]_{r\pm\Delta r} = -\frac{\pi f}{Q_P(f)\,V_P}r + const(f)$$

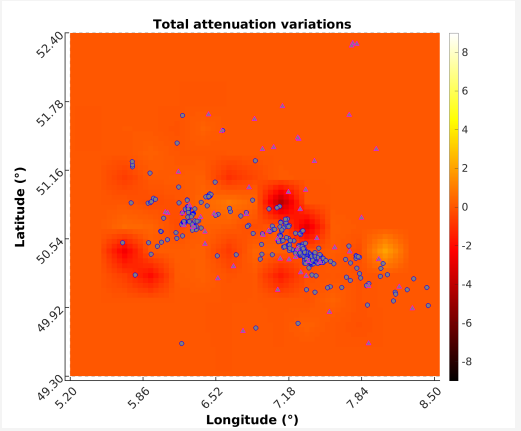
$$\ln\left[\frac{A_S(f,\ r)\,r^{\alpha}}{A_c(f,\ t_c)}\right]_{r\pm\Delta r} = -\frac{\pi f}{Q_S(f)\,V_S}r + const(f),$$

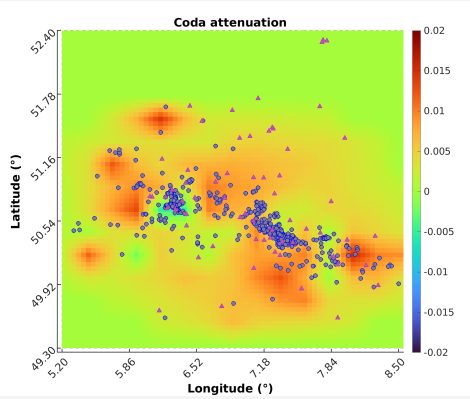
High Q: low attenuation, dense elastic rocks
geological stable regions with low hetr.

Low Q: High attenuation, fractured rocks and fault zone
Fluid-filled or porous media,
Elevated temperature (geothermal)









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Status of Data collection

Collected Data:

RuhrNet-Seismic Network of the Ruhr-university Bochum (RN)

Geological survey of NRW (GD)

FDSN servers

Temporary broadband network by university of Münster

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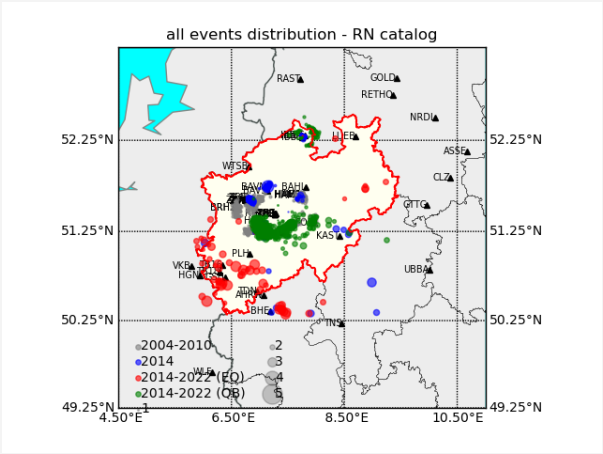
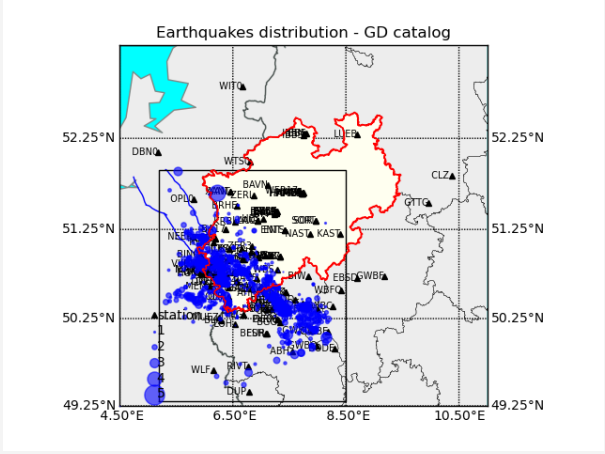
Processed Data

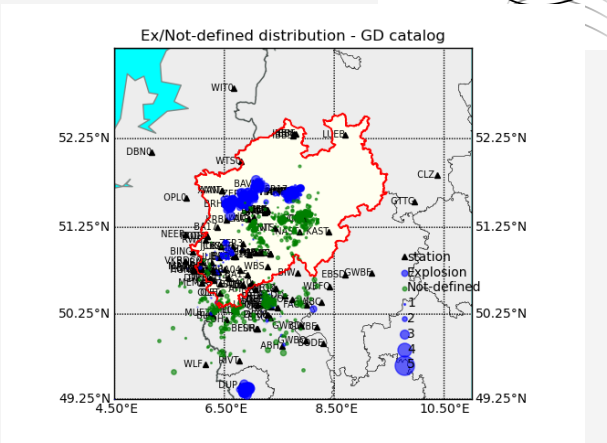
From total number of 2674 Earthquakes and 2867 Quarry Blast

and 1682 non-defined events:

Initial data





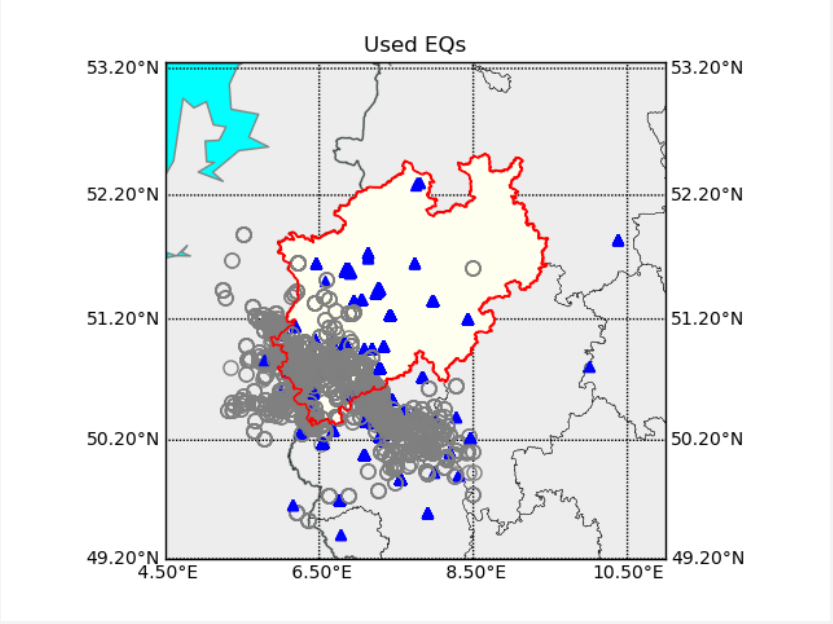


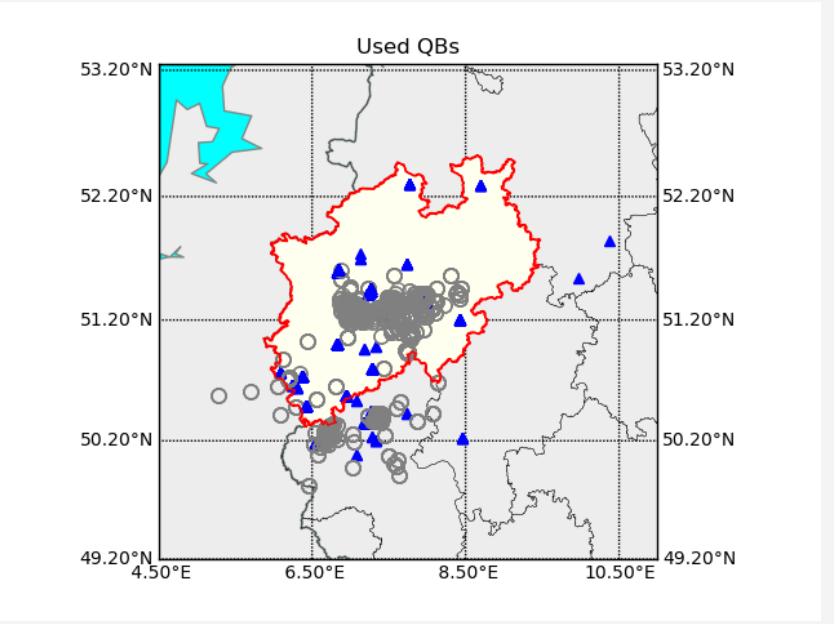
I could preprocess 1665 earthquake at 101 stations,

588 Quarry blasts at 36 stations and include in the process.

events in plotted region, depth < 20 km, magnitude, availability of station XML file

Included in the processing





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Data to be added to the processing:

Not defined events to the explosion and earthquake data sets.

adding waveforms of GD network to the events of RN catalog.

(for RN catalog, waveforms are downloaded from FDSN servers which does not include NH network stations)!

Rays of recent events that are recorded by our temporary network.

Permission request to use stations of LE network is also submitted.

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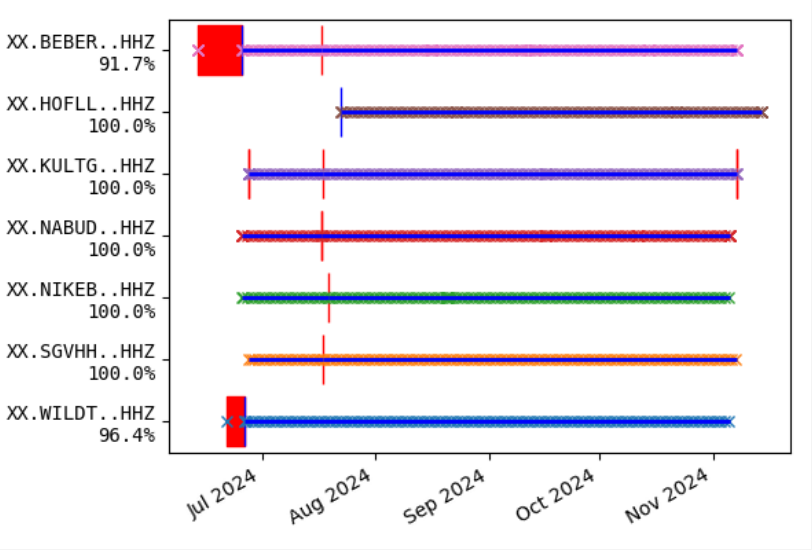
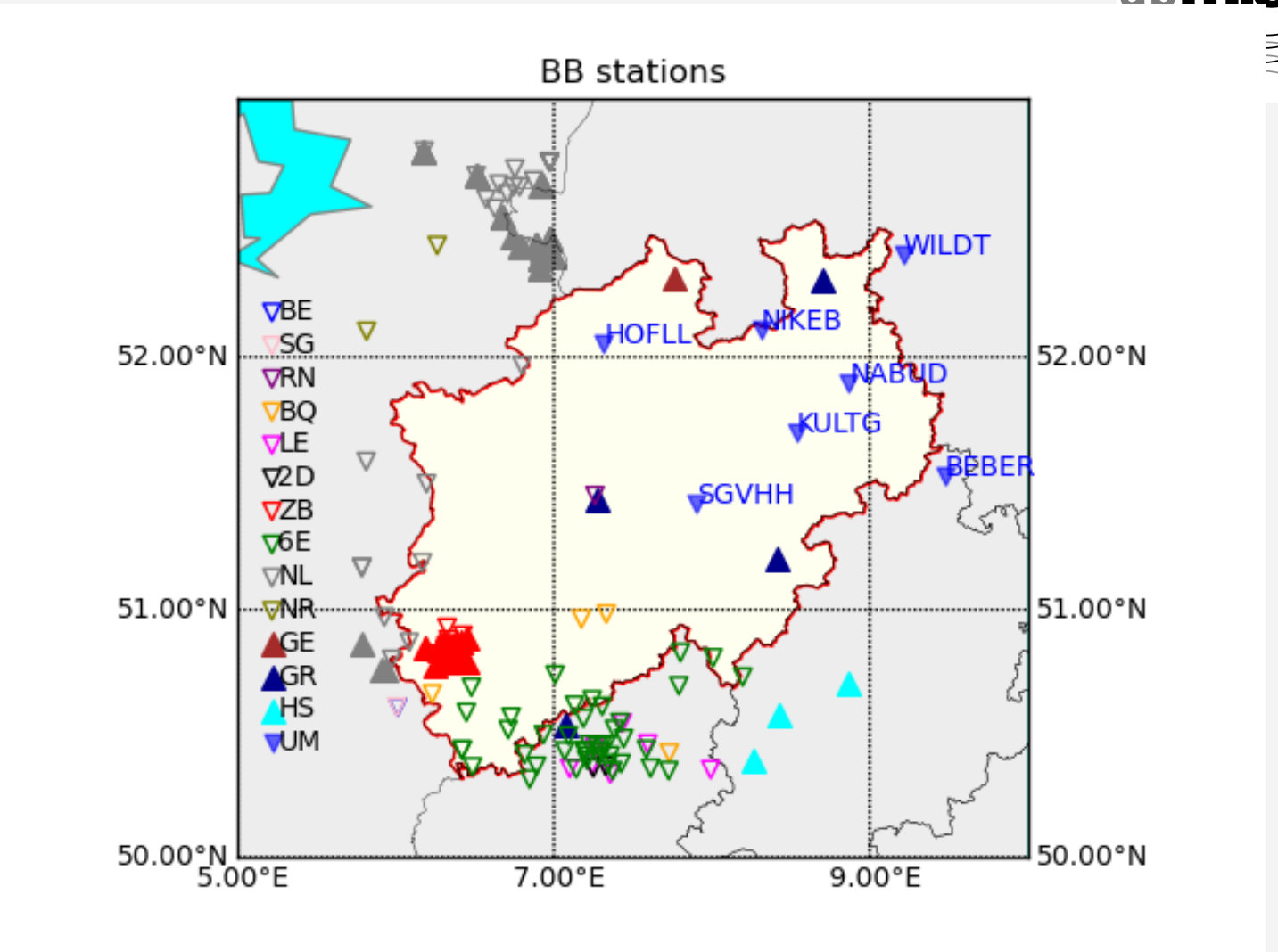
Broadband stations available in study region

Total number of BB stations: 182
Open access from FDSN servers: 72
Temporary stations: 7
Can be used for ambient noise CC

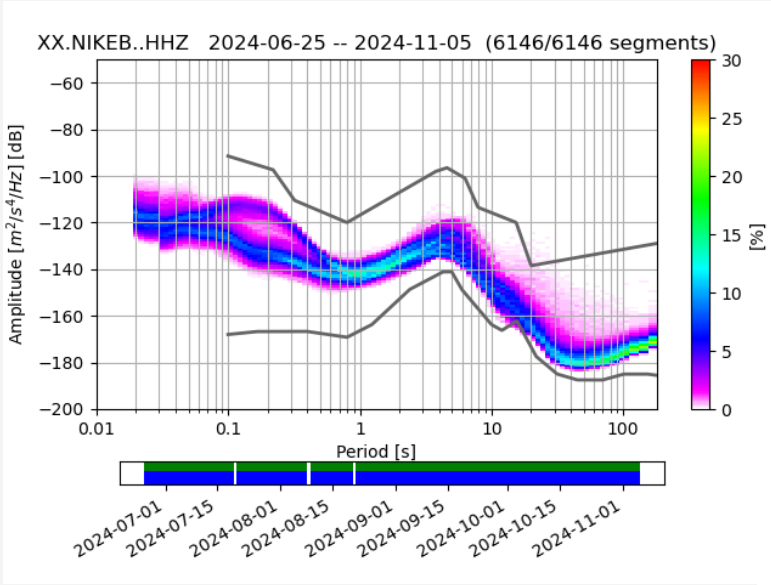


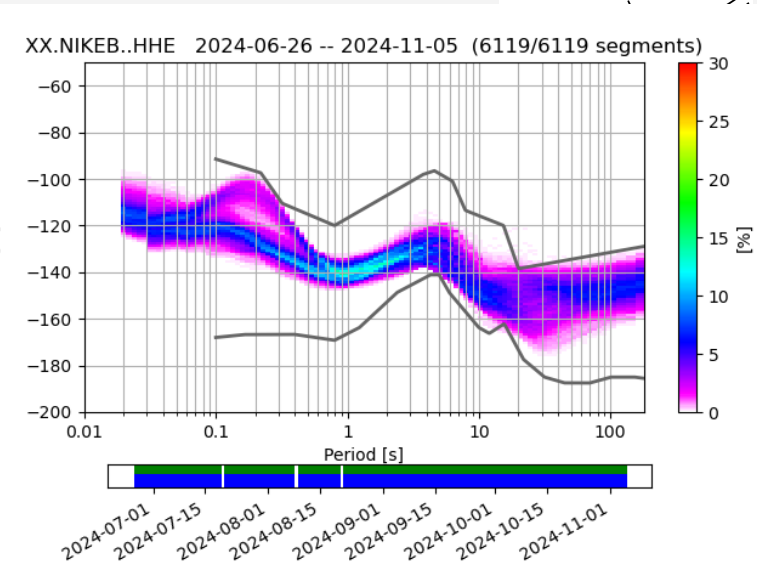


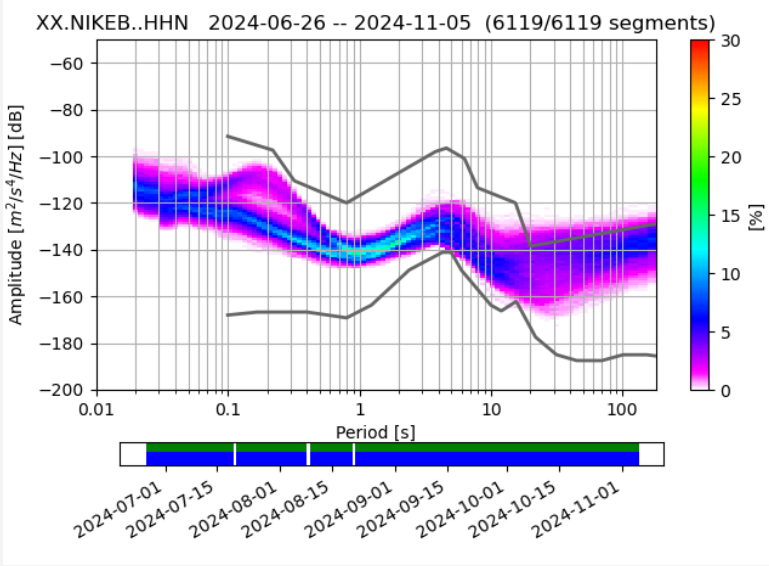
Filled triangles represent stations with available data in FDSN

Temporary Broad Band network

Broad band seismometer/Trillium 120 PA
Nanometrics Taurus datalogger
Buffered battery + Direct power







Overview of Earthquakes data processing Results

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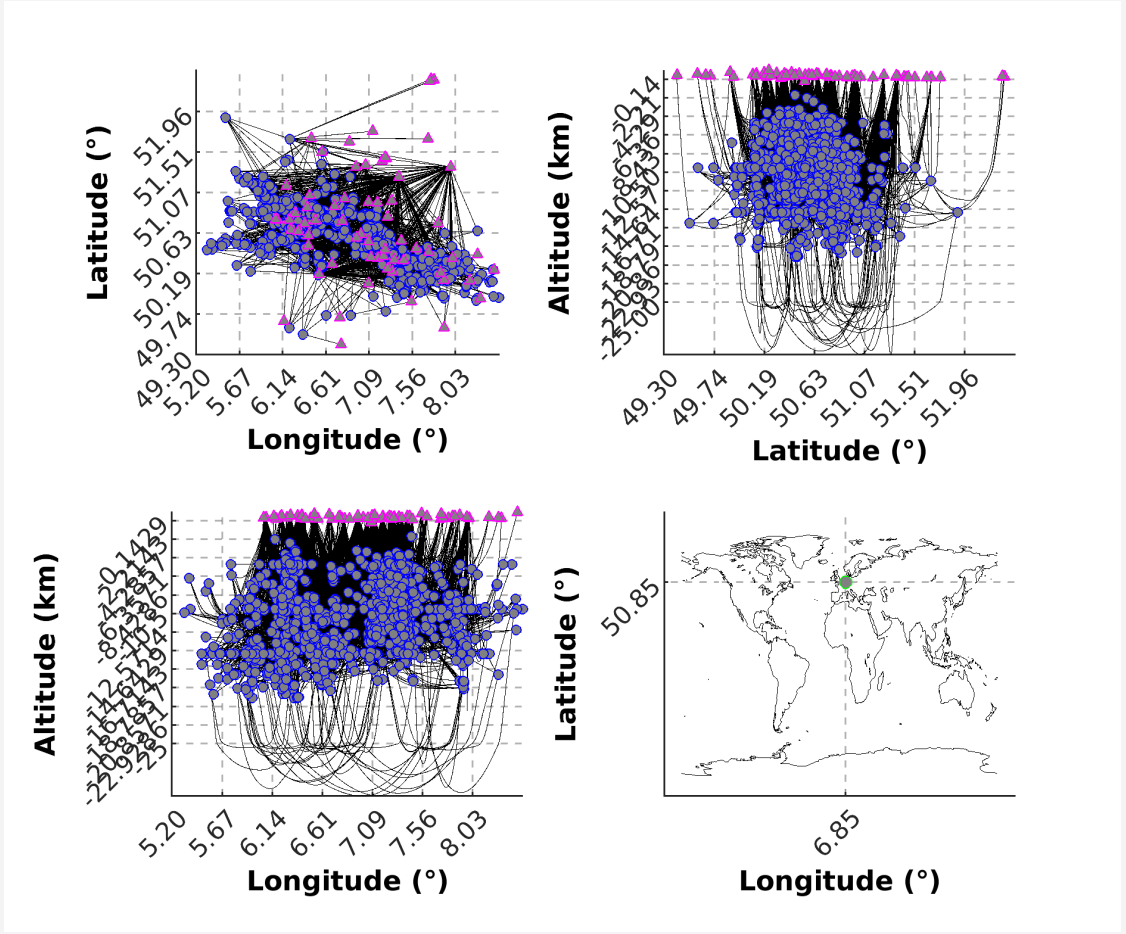
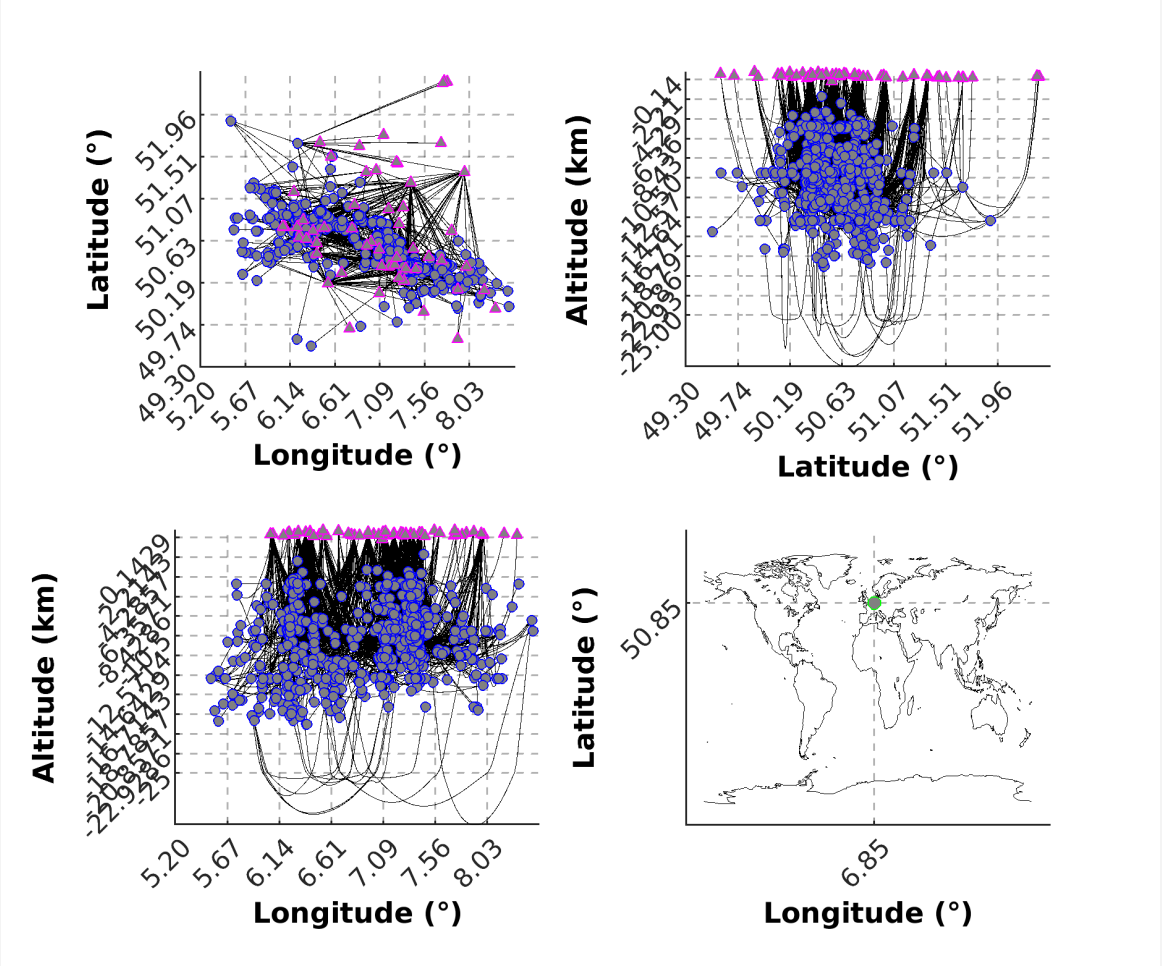
Ray coverage used for:
Peak delay method (1-5 Hz)



Ray coverage used for:
Q method (1-5 Hz)



Different Frequency dependent Ray coverage for different methods (according to the processing parameters, SNR, Body waves and coda waves time window, …)

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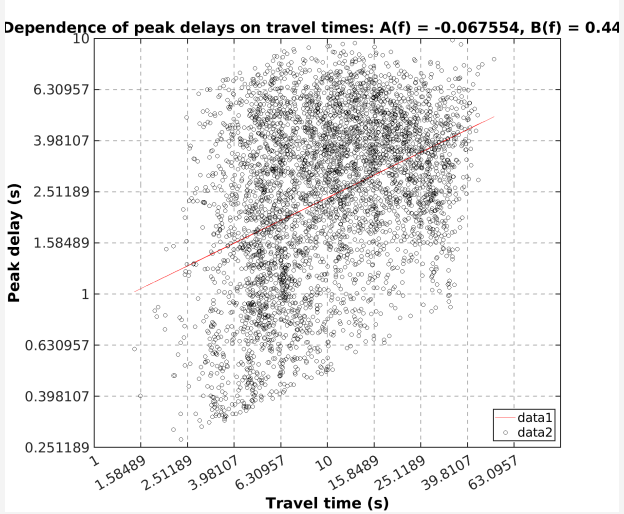
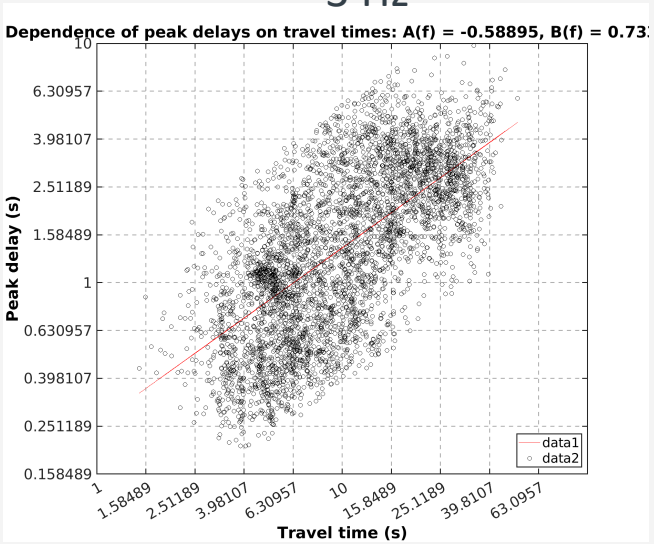
Reliability Test on measured parameters before looking at results on map

Peak delay (test of results):

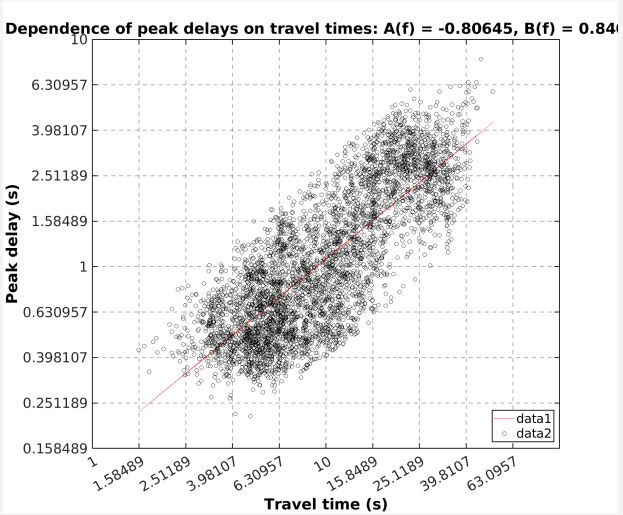
1-5 Hz



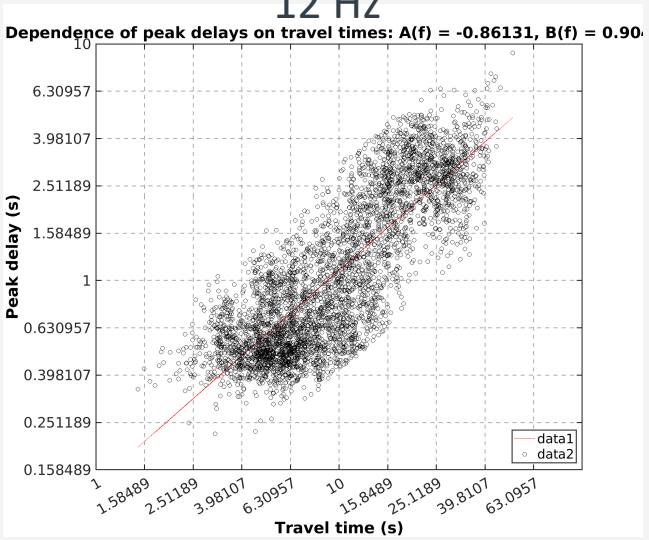
3 Hz



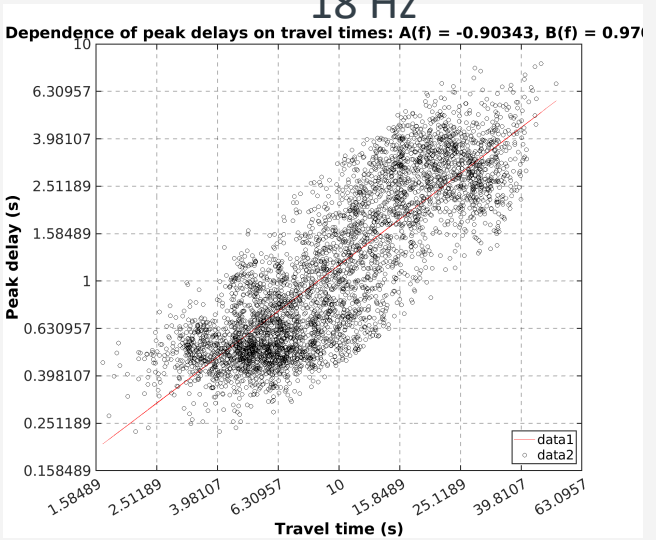
6 Hz



12 Hz



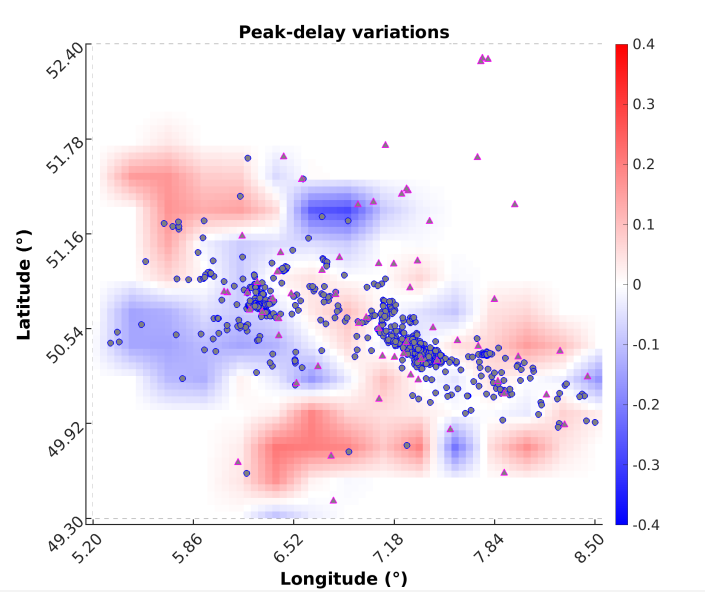
18 Hz

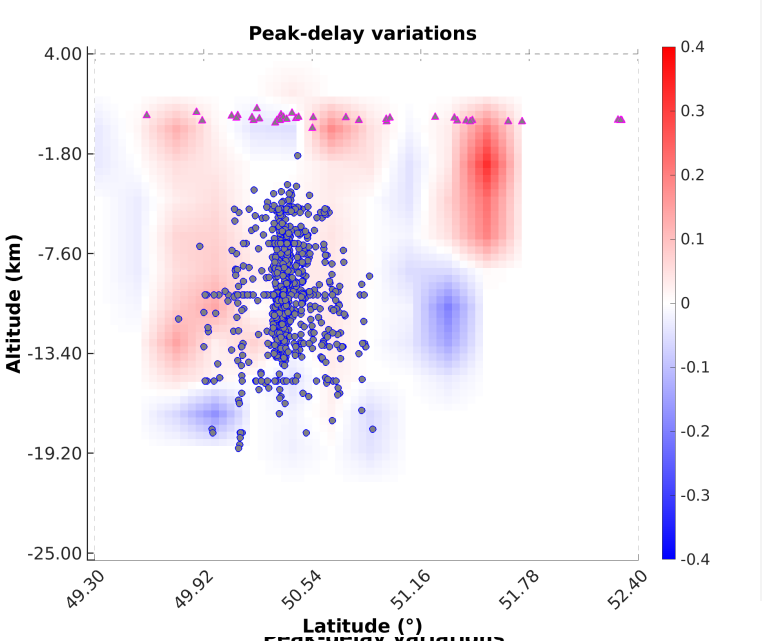


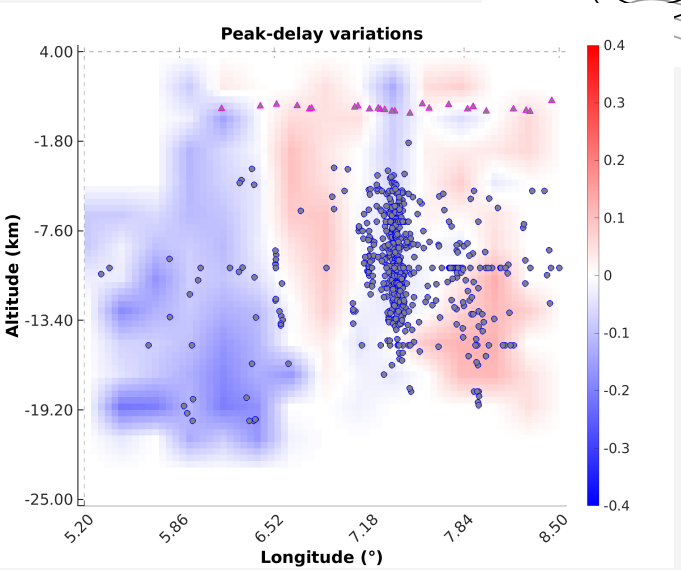
hypothesis:
peaks increase vs travel times.

Results: Peak delay regionalization

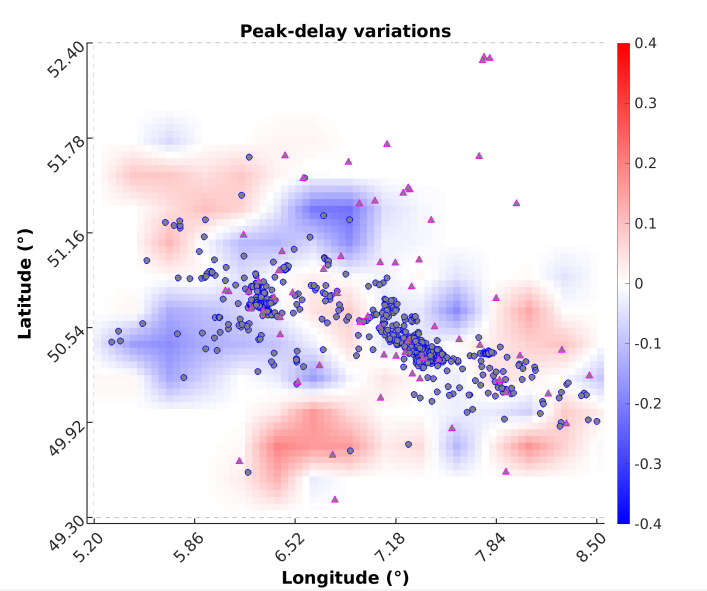
12 Hz

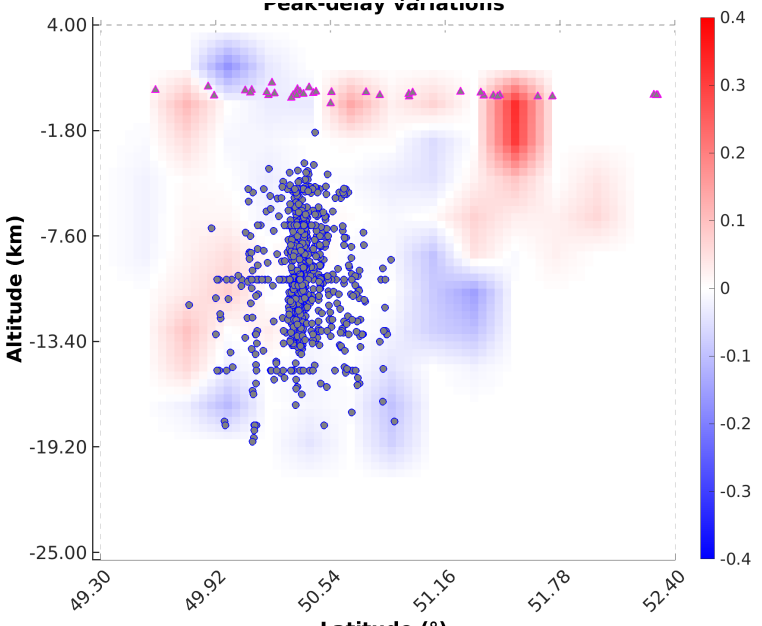


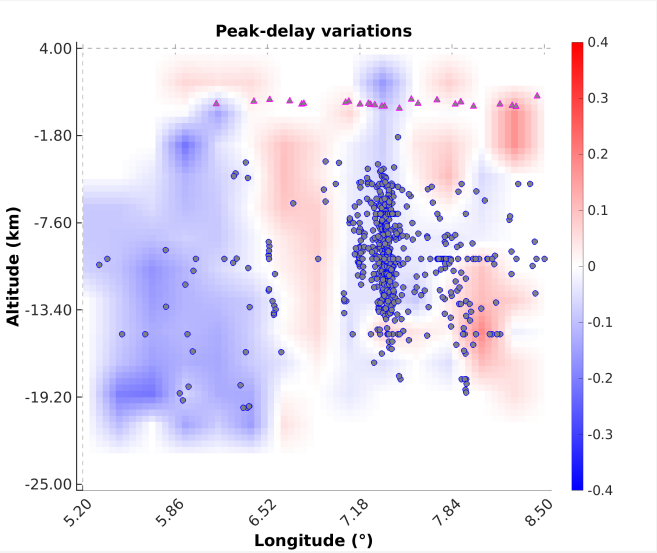




18 Hz

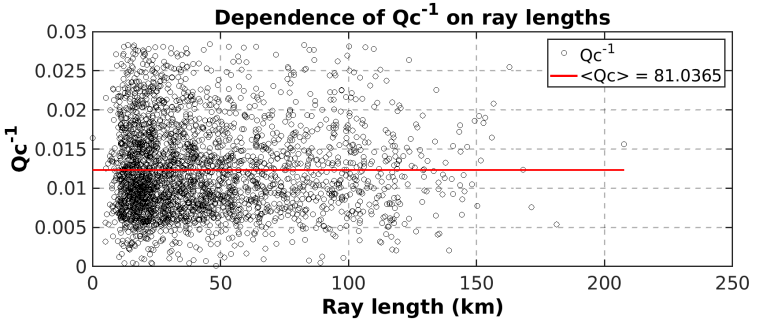




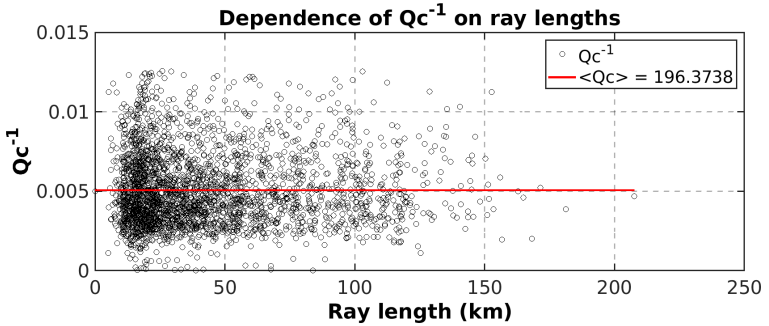


Qc (test of results):

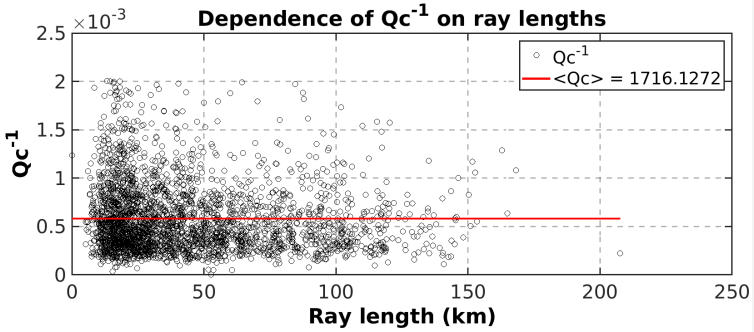
1-5 Hz



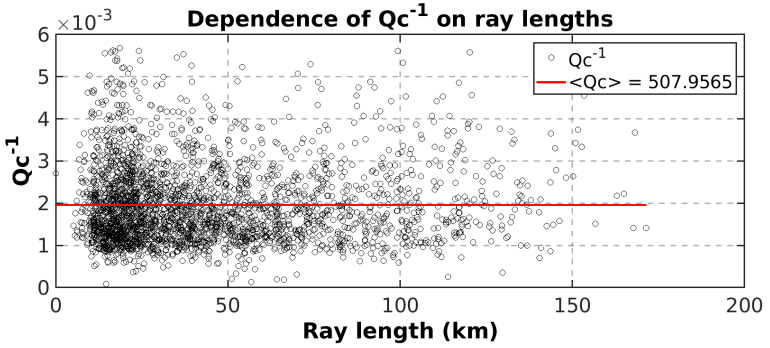
3 Hz



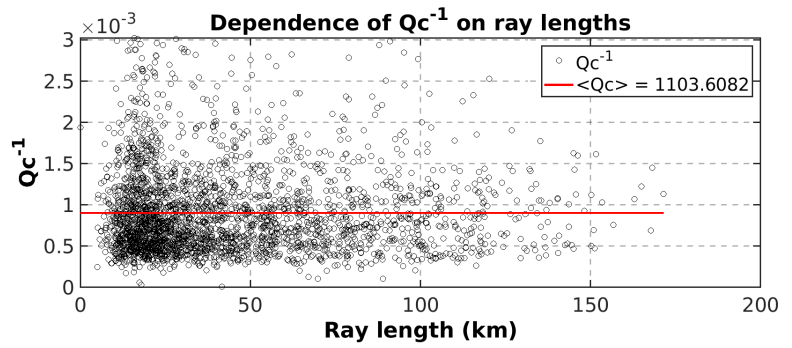
18 Hz



6 Hz

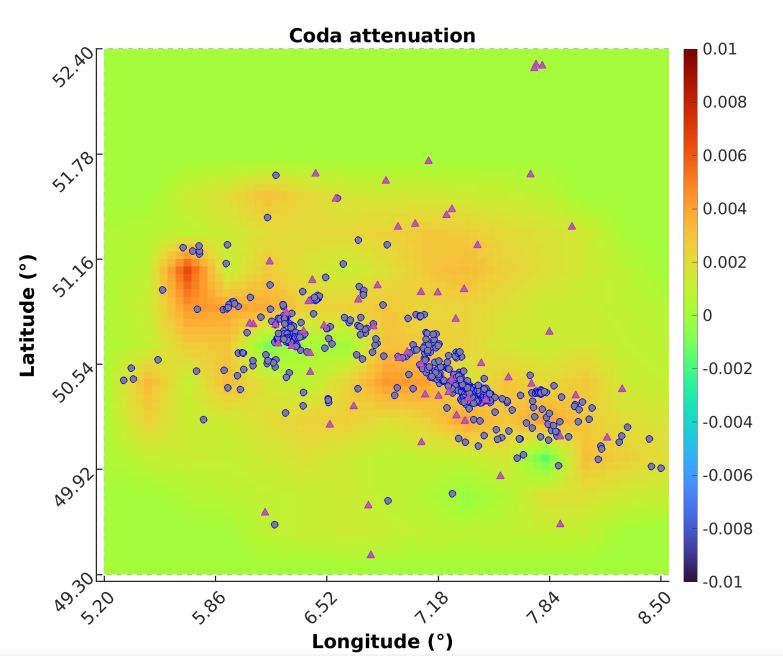


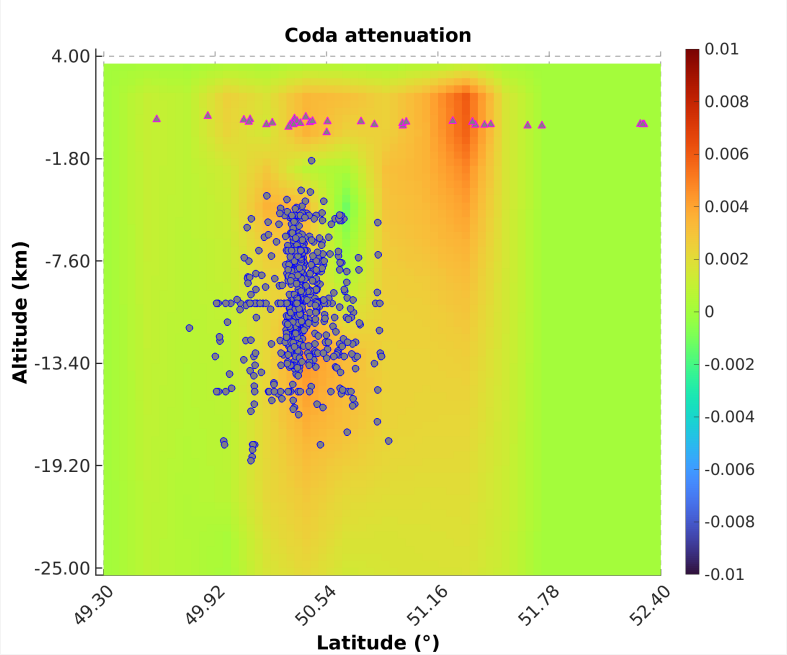
12 Hz

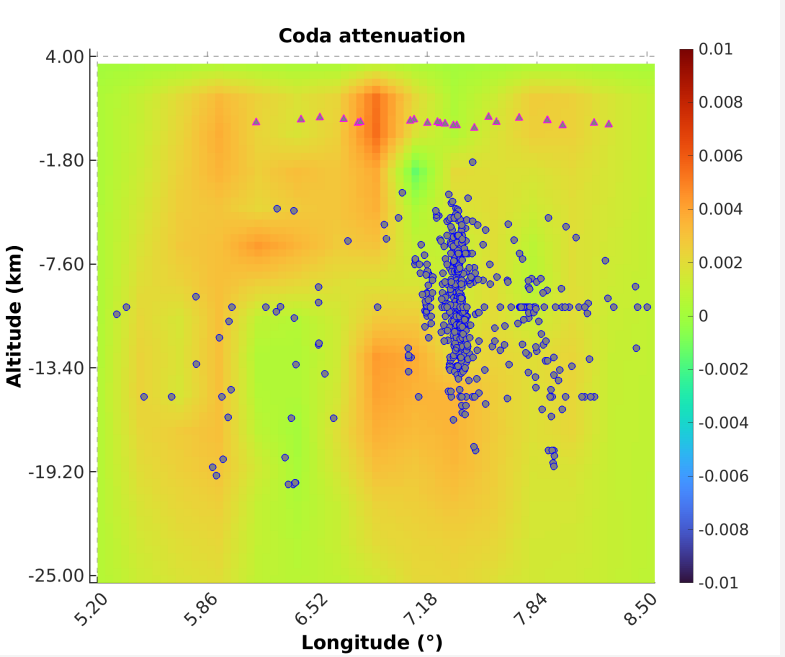


coda attenuation must be constant with increasing ray length to interpret values of Qc as absorption

Spatial variation of 1/Qc at 6 Hz







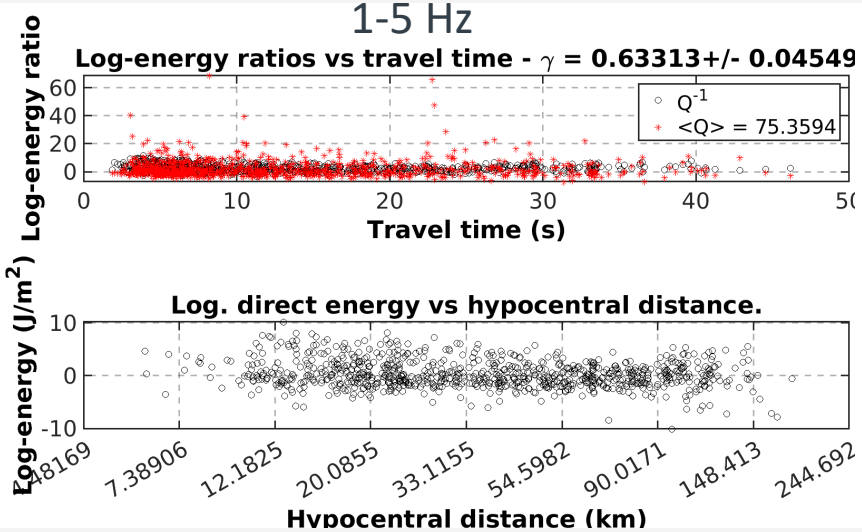
Checkerboard test

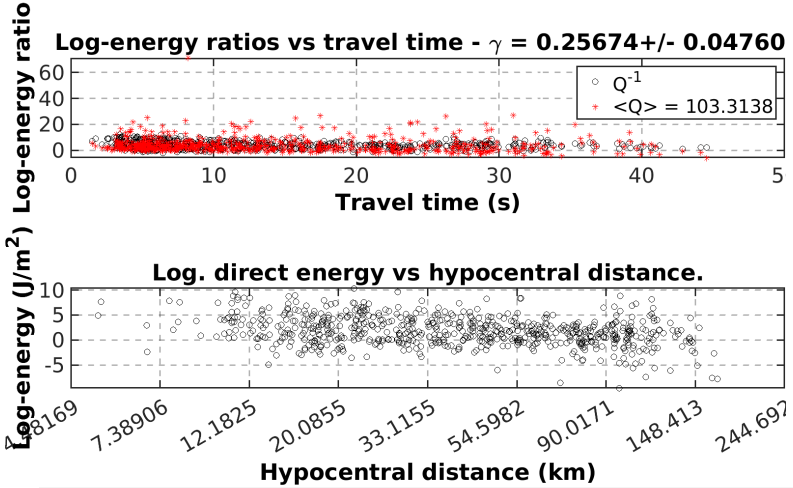
Spike test to test the modeling performance

Q(test of results)

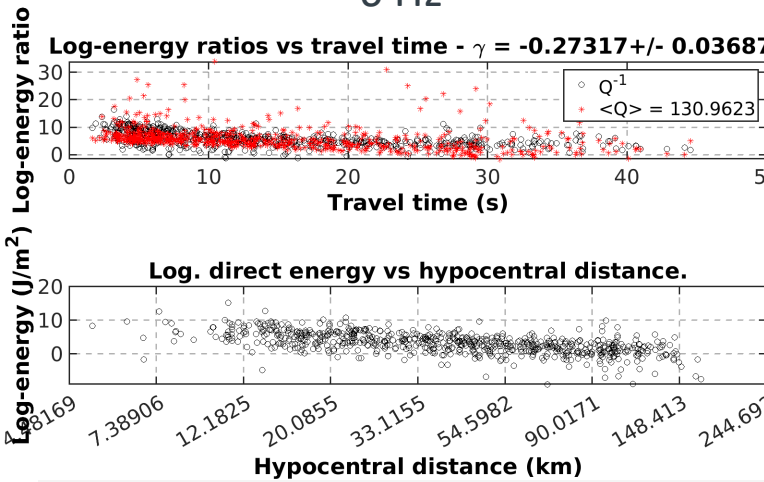
3 Hz

1-5 Hz





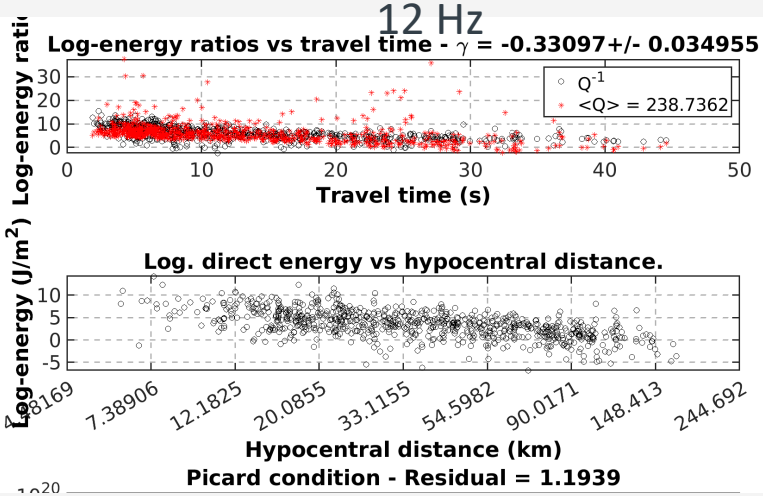
6 Hz



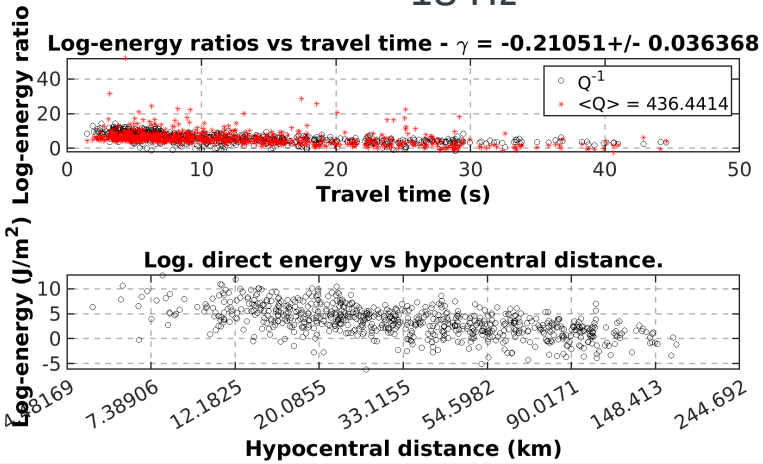
significant scatter:

inhomogeneities or Error in travel time

12 Hz



18 Hz



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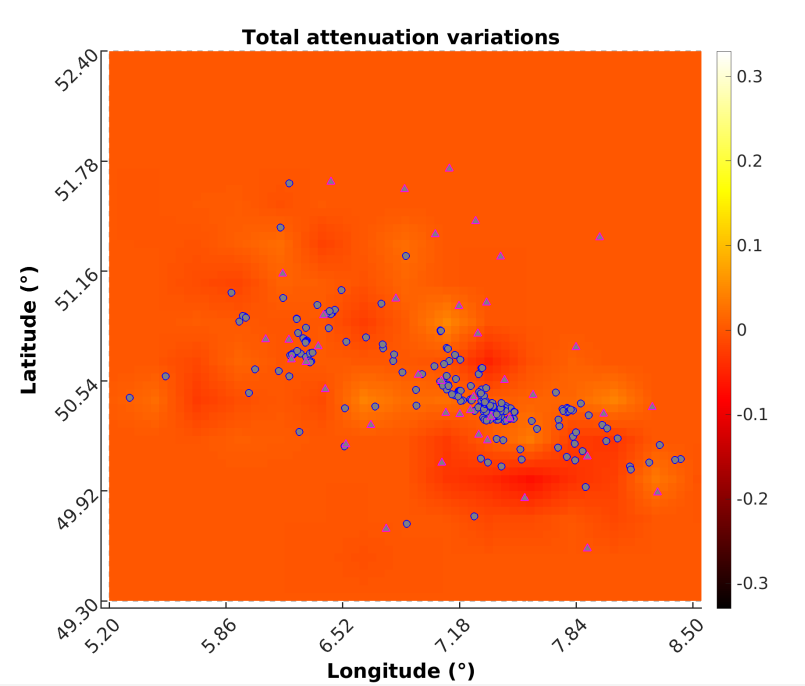
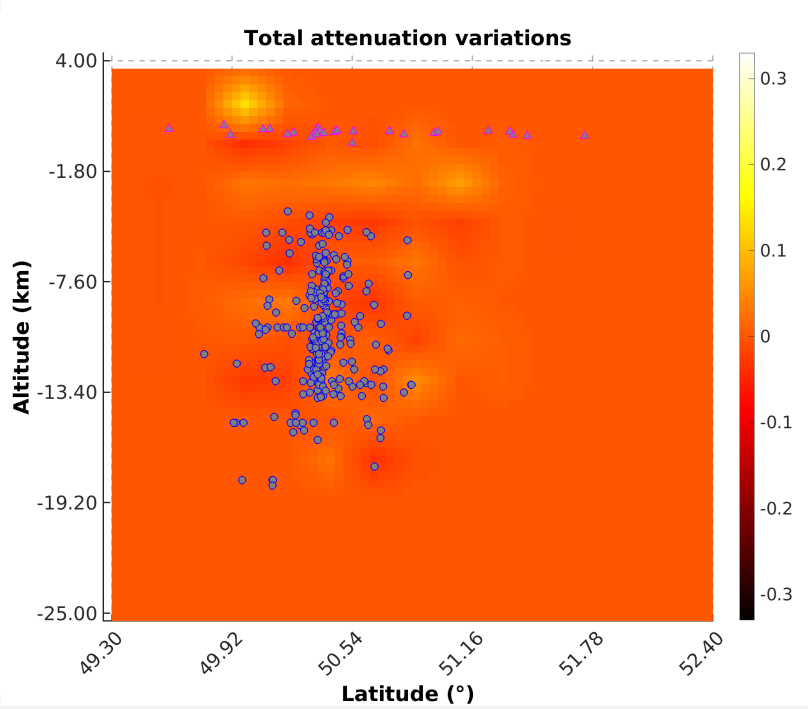
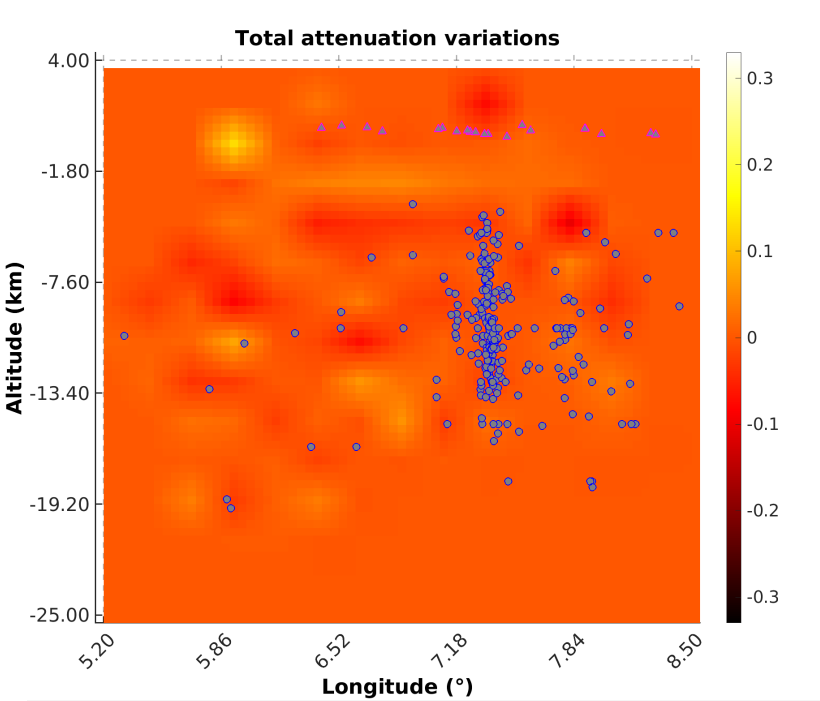
Variation of 1/Q at 18 Hz







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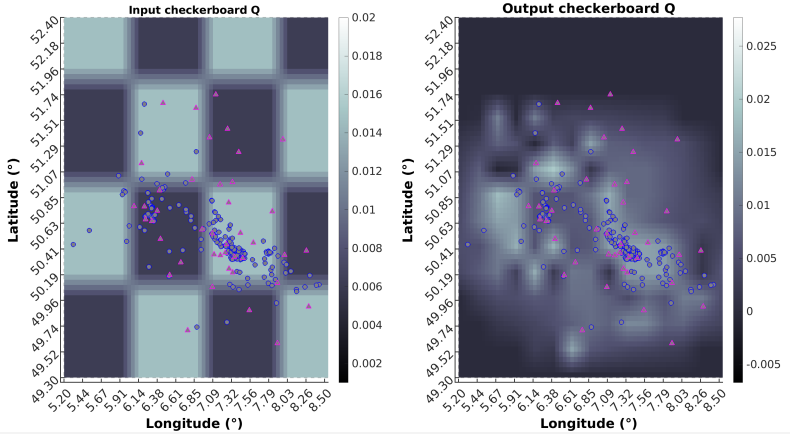
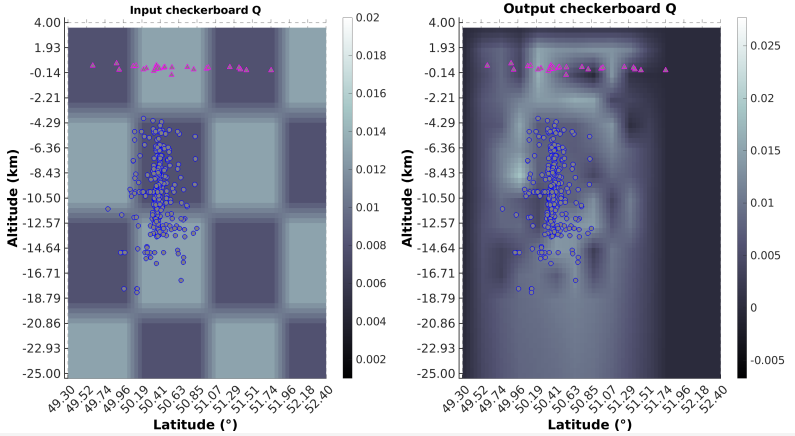
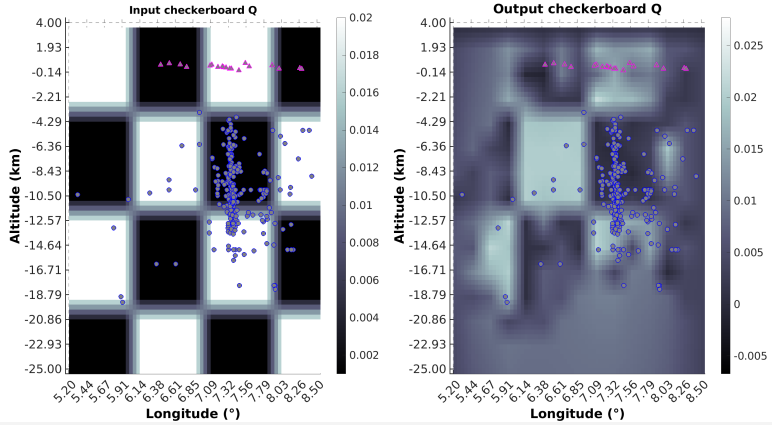
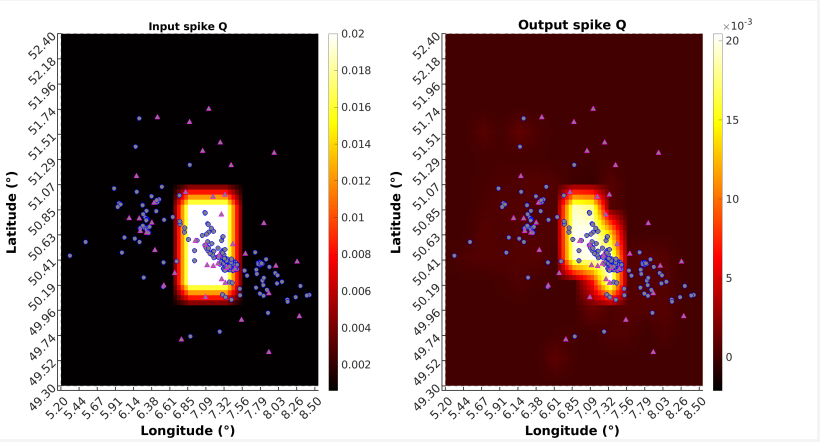
Checkerboard Test for results of Q:

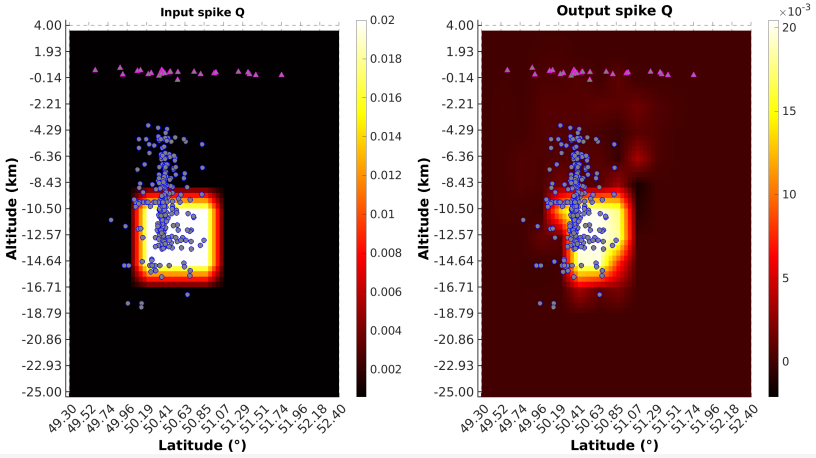


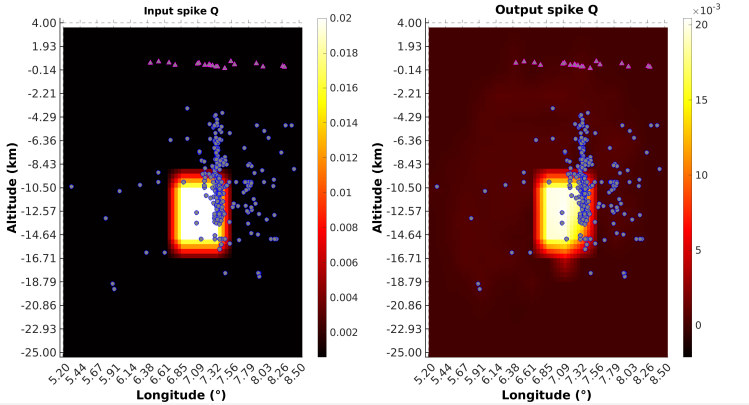




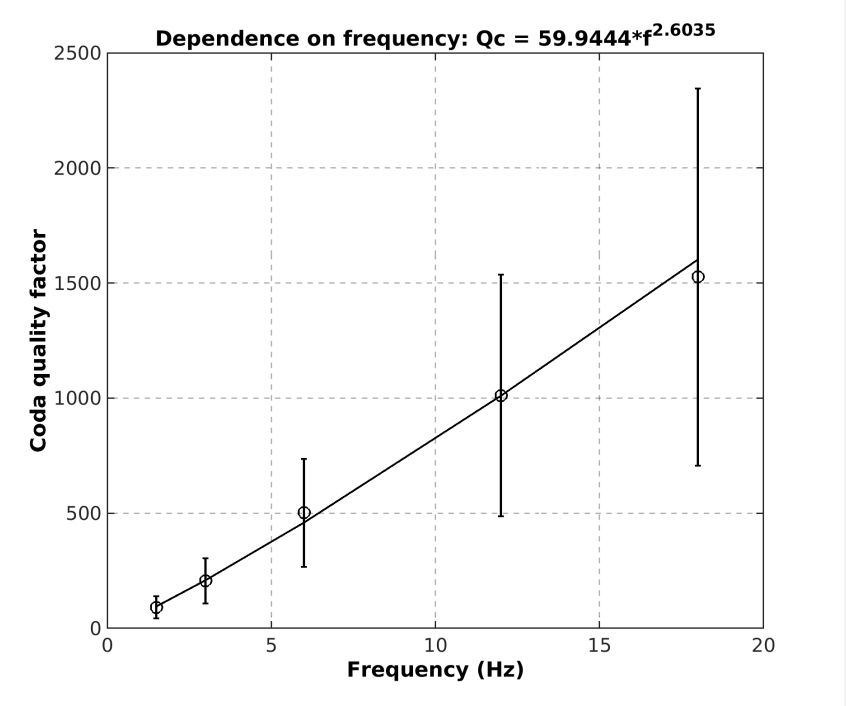
Spike Test for results of Q:







Dependence of average Qc to frequency



Qc shows strong frequency dependent

Coda waves are more affected by scattering and small scale heterogeneities

Concluding remarks

- Given the non uniform distribution of earthquakes in the study area, our preliminary results suggests that we can get reliable results for 3D attenuation parameters such as Qc and peakdelay in case of good ray coverage for frequencies between 6-18 Hz. To interpret the results we need other geophysical 3D models.
- Peakdelay variation gives rather consistent results, which are not very frequency dependent
- the dominant attenuation mechanism remains constant in the region showing absence of strong frequency-dependent processes
- Other geological data such as 3D faults and Geological map, temperature data are collected, and needed to be unified and plotted …
- Preparing publication