

Waveform based seismic catalog generation practical

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International Training Course on Seismology,
Seismic Data Analysis, Hazard Assessment and
Risk Mitigation

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Potsdam, Germany

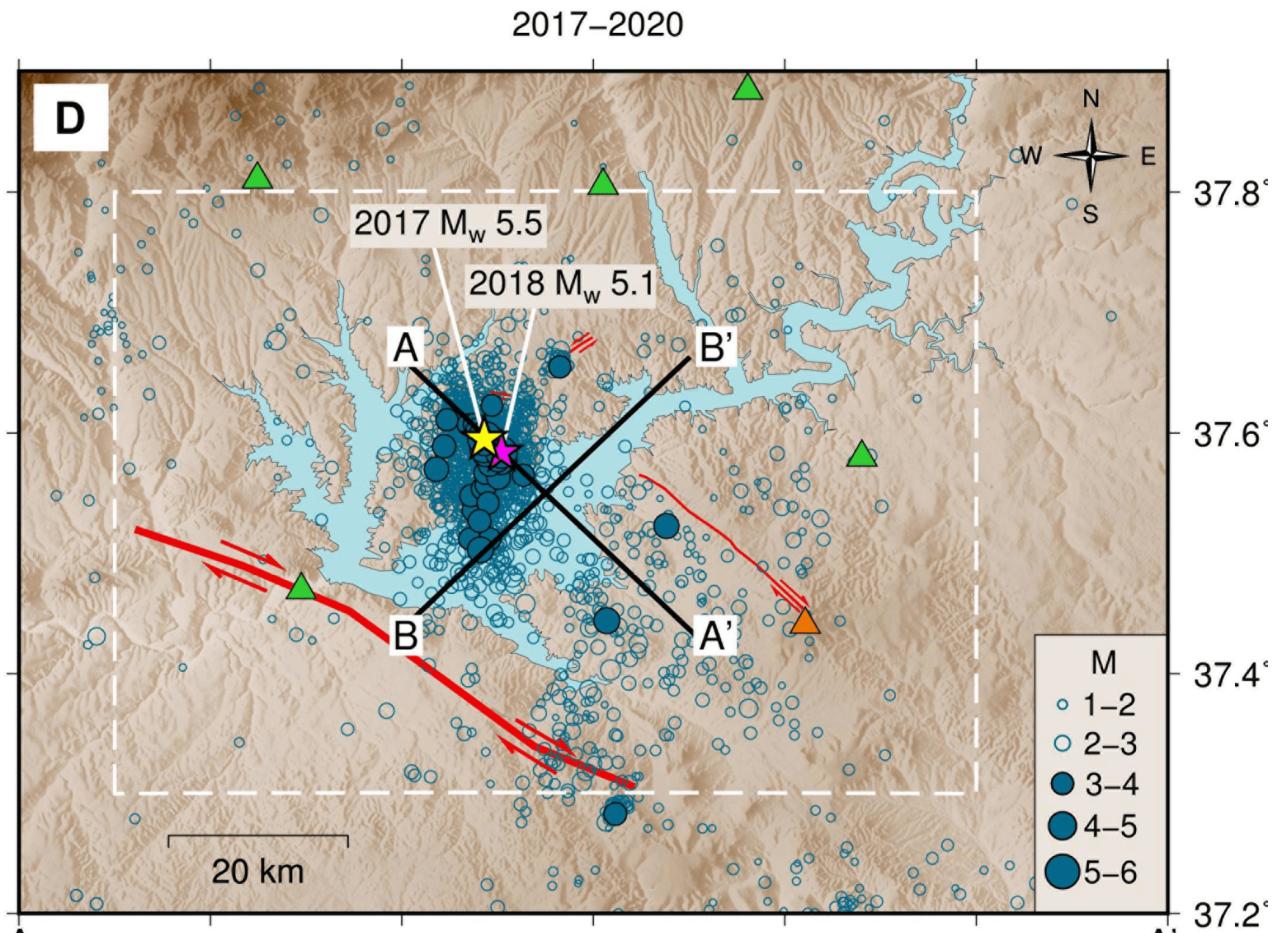
Before starting:



GFZ - Training course 2017 Potsdam

Our practical today:

We will use "Qseek" to detect and locate the earthquakes around Ataturk Dam



itc-ataturk-qseek folder:
1) data
2) metadata
3) velocity structure
4) qseek-configuration

What we need?

Softwares

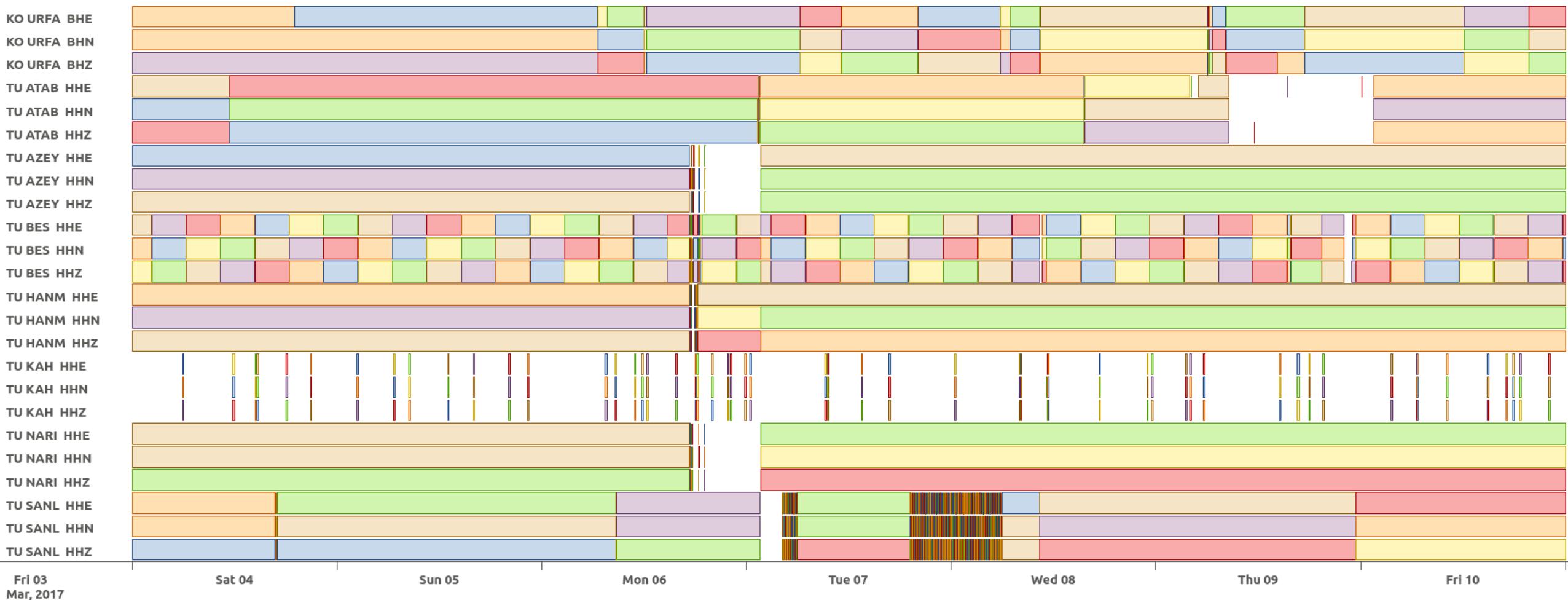
- Pyrocko → Open source seismology toolbox and library
Snuffler, Squirrel, Sparrow
- Qseek → A data-driven Framework for Machine-Learning
Earthquake Detection, Localization and Characterization

Data and explanations on task

<https://github.com/pinarbap/itc-qseek-2024>

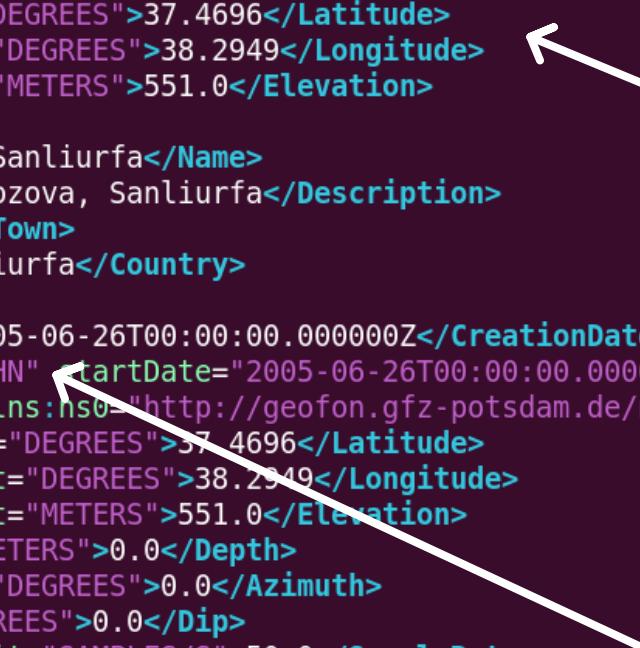
Data

Weekly data is available for March 4, 2017 and March 10, 2020



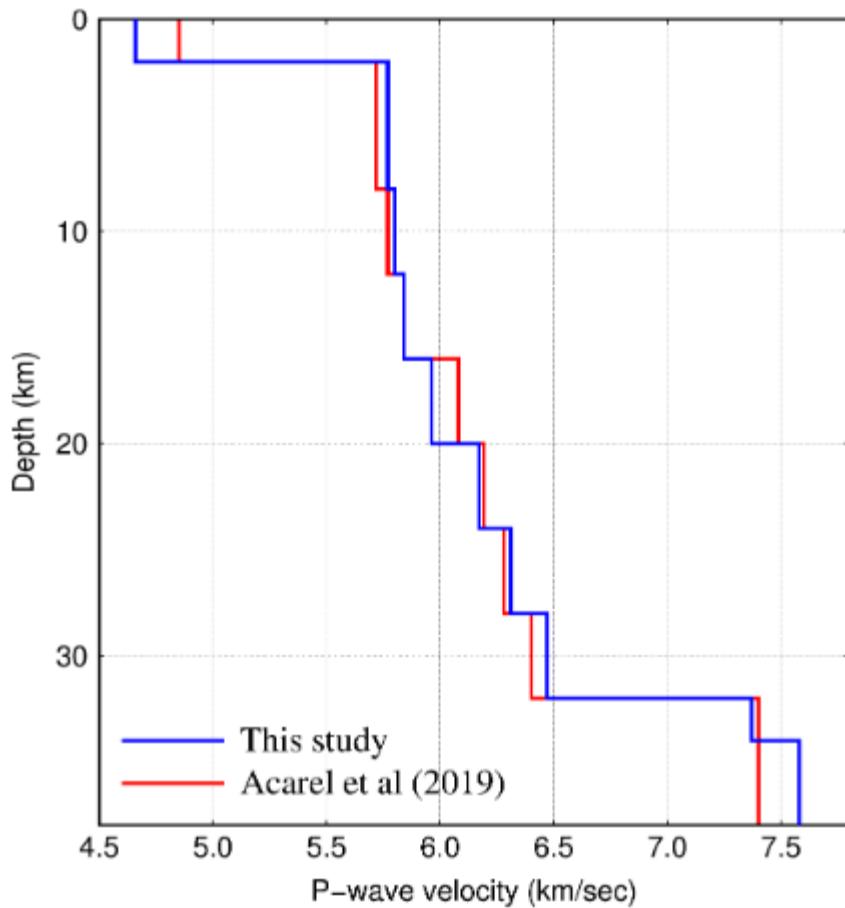
Metadata (StationXML)

```
<?xml version='1.0' encoding='UTF-8'?>
<FDSNStationXML xmlns="http://www.fdsn.org/xml/station/1" schemaVersion="1.1">
  <Source>Arclink Inventory Import</Source>
  <Sender>ObsPy Inventory</Sender>
  <Module/>
  <ModuleURI/>
  <Created>2022-02-01T13:00:05.926766Z</Created>
  <Network code="TU" startDate="1980-01-01T00:00:00.000000Z" restrictedStatus="open">
    <Description>National Seismic Network of Turkiye</Description>
    <Station code="ATAB" startDate="2005-06-26T00:00:00.000000Z" restrictedStatus="open">
      <Latitude unit="DEGREES">37.4696</Latitude>
      <Longitude unit="DEGREES">38.2949</Longitude>
      <Elevation unit="METERS">551.0</Elevation>
      <Site>
        <Name>Bozova, Sanliurfa</Name>
        <Description>Bozova, Sanliurfa</Description>
        <Town>Bozova</Town>
        <Country> Sanliurfa</Country>
      </Site>
      <CreationDate>2005-06-26T00:00:00.000000Z</CreationDate>
      <Channel code="BHN" startDate="2005-06-26T00:00:00.000000Z" endDate="2012-03-01T00:00:00.000000Z" restrictedStatus="open" locationCode="">
        <ns0:format xmlns:ns0="http://geofon.gfz-potsdam.de/ns/Inventory/1.0/">None</ns0:format>
        <Latitude unit="DEGREES">37.4696</Latitude>
        <Longitude unit="DEGREES">38.2949</Longitude>
        <Elevation unit="METERS">551.0</Elevation>
        <Depth unit="METERS">0.0</Depth>
        <Azimuth unit="DEGREES">0.0</Azimuth>
        <Dip unit="DEGREES">0.0</Dip>
        <SampleRate unit="SAMPLES/S">50.0</SampleRate>
        <SampleRateRatio>
          <NumberSamples>50</NumberSamples>
          <NumberSeconds>1</NumberSeconds>
```



/meta folder includes metadata for the stations

Velocity Structure



-3.00	2.50	1.20	2.1
0.00	4.66	2.70	2.2
2.00	4.66	2.70	2.2
2.00	5.77	3.33	2.3
8.00	5.77	3.33	2.3
8.00	5.82	3.37	2.5
12.00	5.82	3.37	2.5
12.00	5.85	3.39	2.7
16.00	5.85	3.39	2.7
16.00	5.96	3.45	2.8
20.00	5.96	3.45	2.8
20.00	6.17	3.57	2.9
24.00	6.17	3.57	2.9
24.00	6.31	3.65	3.1
28.00	6.31	3.65	3.1
28.00	6.47	3.74	3.2
32.00	6.47	3.74	3.2
32.00	7.37	4.26	3.4

itc-ataturk-qseek/velocity_pinar.nd

Qseek Configuration (test.json)

```
{  
    "project_dir": "",  
    "stations": {  
        "pyrocko_station_yamls": [  
        ],  
        "station_xmlets": [  
            "meta/koeri.xml",  
            "meta/geofon.xml",  
            "meta/ATAB_H.xml",  
            "meta/AZEY_H.xml",  
            "meta/BES_H.xml",  
            "meta/HANM_H.xml",  
            "meta/KAH_H.xml",  
            "meta/NARI_H.xml",  
            "meta/SANL_H.xml"  
        ],  
        "blacklist": [],  
        "stations": []  
    },  
    "data_provider": {  
        "provider": "PyrockoSquirrel",  
        "environment": ".",  
        "waveform_dirs": ["/home/pinar/ataturk/data"],  
        "start_time": null,  
        "end_time": null,  
        "channel_selector": null  
    },  
}
```

Metadata

Data_selection

Qseek Configuration (test.json)

```
"pre_processing": [{"process": "downsample", "sampling_rate":100.0}, {"process": "bandpass", "bandpass": [2.0, 20.0]}],  
  "octree": {  
    "location": {  
      "lat": 37.60,  
      "lon": 38.47,  
      "east_shift": 0.0,  
      "north_shift": 0.0,  
      "elevation": 1000.0,  
      "depth": 0.0  
    },  
    "root_node_size": 2000.0,  
    "n_levels": 6,  
    "east_bounds": [  
      -15000.0,  
      15000.0  
    ],  
    "north_bounds": [  
      -15000.0,  
      15000.0  
    ],  
    "depth_bounds": [  
      0.0,  
      30000.0  
    ]  
  },  
  "post_processing": {  
    "process": "stack",  
    "stack_size": 1000.0  
  }  
}
```

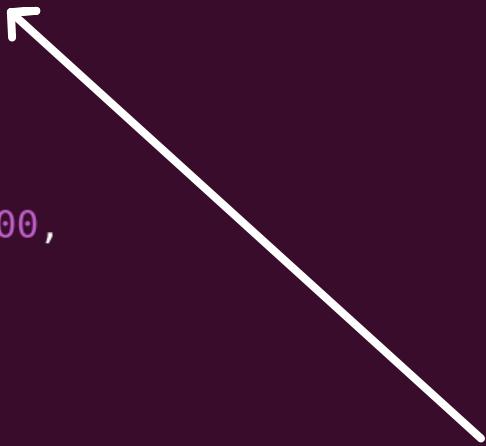
Preprocessing

Specifying the octree

Qseek Configuration (test.json)

```
  "image_functions": [  
    {  
      "image": "SeisBench",  
      "model": "PhaseNet",  
      "pre_trained": "original",  
      "window_overlap_samples": 2000,  
      "torch_use_cuda": true,  
      "torch_cpu_threads": 4,  
      "batch_size": 64,  
      "stack_method": "avg",  
      "phase_map": {  
        "P": "cake:P",  
        "S": "cake:S"  
      },  
      "weights": {  
        "P": 1.0,  
        "S": 1.0  
      }  
    }  
  ],
```

Image functions



Qseek Configuration (test.json)

```
"distance_weights": {  
    "exponent": 1.0,  
    "radius_meters": 0.0015,  
    "lut_cache_size": 209715200  
},  
"features": [],  
"semblance_sampling_rate": 100,  
"detection_threshold": 0.4,  
"absorbing_boundary": "without_surface",  
"absorbing_boundary_width": "root_node_size",  
"node_peak_interpolation": true,  
"detection_blinding": "PT2S",  
"power_mean": 1.0,  
"window_length": "PT400S",  
"n_threads_parstack": "auto",  
"n_threads_argmax": "auto",  
"plot_octree_surface": false  
}
```

Distance weighting

Detection_threshold

Detection_blinding

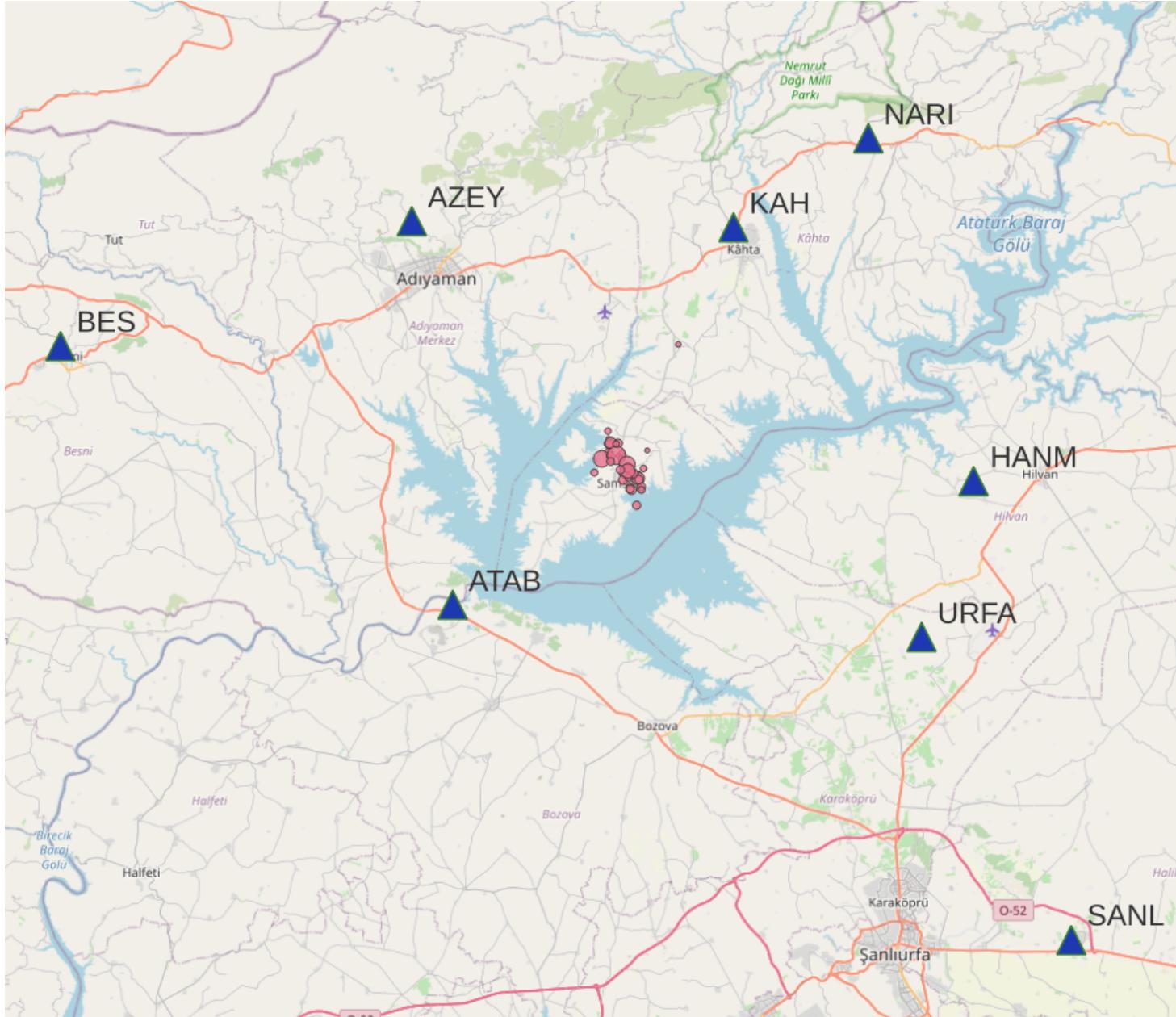
Qseek Configuration (test.json)

```
    "distance_weights": {  
        "exponent": 1.0,  
        "radius_meters": 100.0,  
        "lut_cache_size": 209715200  
    },  
    "features": [],  
    "semblance_sampling_rate": 100,  
    "detection_threshold": 0.4,  
    "absorbing_boundary": "without_surface",  
    "absorbing_boundary_width": "root_node_size",  
    "node_peak_interpolation": true,  
    "detection_blinding": "PT2S",  
    "power_mean": 1.0,  
    "window_length": "PT400S",  
    "n_threads_parstack": "auto",  
    "n_threads_argmax": "auto",  
    "plot_octree_surface": false  
}
```

Please select two parameters:
exponent and **radius_meters**



Regional seismic catalog (AFAD)



37 earthquakes
reported in the first half
of March 4, 2017

Station distances to
Ataturk Reservoir:

TU.ATAB: 22 km

TU.KAH: 25 km

TU.AZEY: 32 km

KO.URFA: 34 km

TU.HANM: 35 km

TU.NARI: 40 km

TU.BES: 55 km

TU.SANL: 65 km

Our task: Distance weights

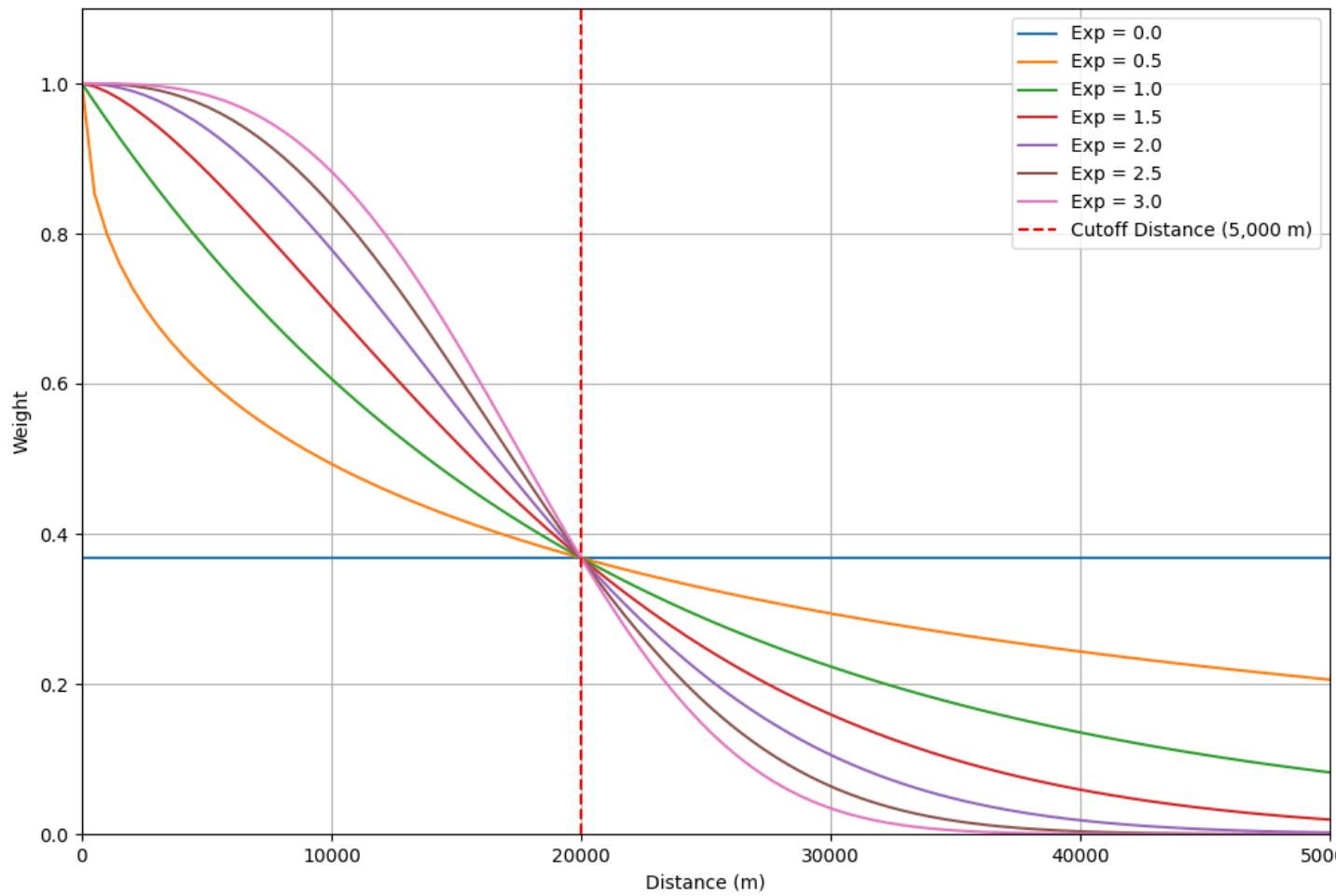
Exponential Decay Function: The weights are calculated using the following formula:

$$w = e^{-\left(\frac{d^p}{r^p}\right)}$$

where:

- (w) is the weight.
- (d) is the distance from the station to the node.
- (r) is the cutoff distance (in meters).
- (p) is the exponent of the spatial decay function (default is 3.0).

This method provides a weight that decreases exponentially with distance.



Outputs: Seismic Catalog

Please copy your test/csv/detections_jittered.csv file into

cp test/csv/detections_jittered.csv /mnt/pool/itc-ataturk-qseek/results

detections_jittered_name.csv

We will compare our results...

**If you have any further
questions**

pinar@gfz-potsdam.de
isken@gfz-potsdam.de

**We will dive into Snuffler more to visualize
the seismic data next week**

Wednesday, Nov. 13 Data Processing with Pyrocko

See you next week!

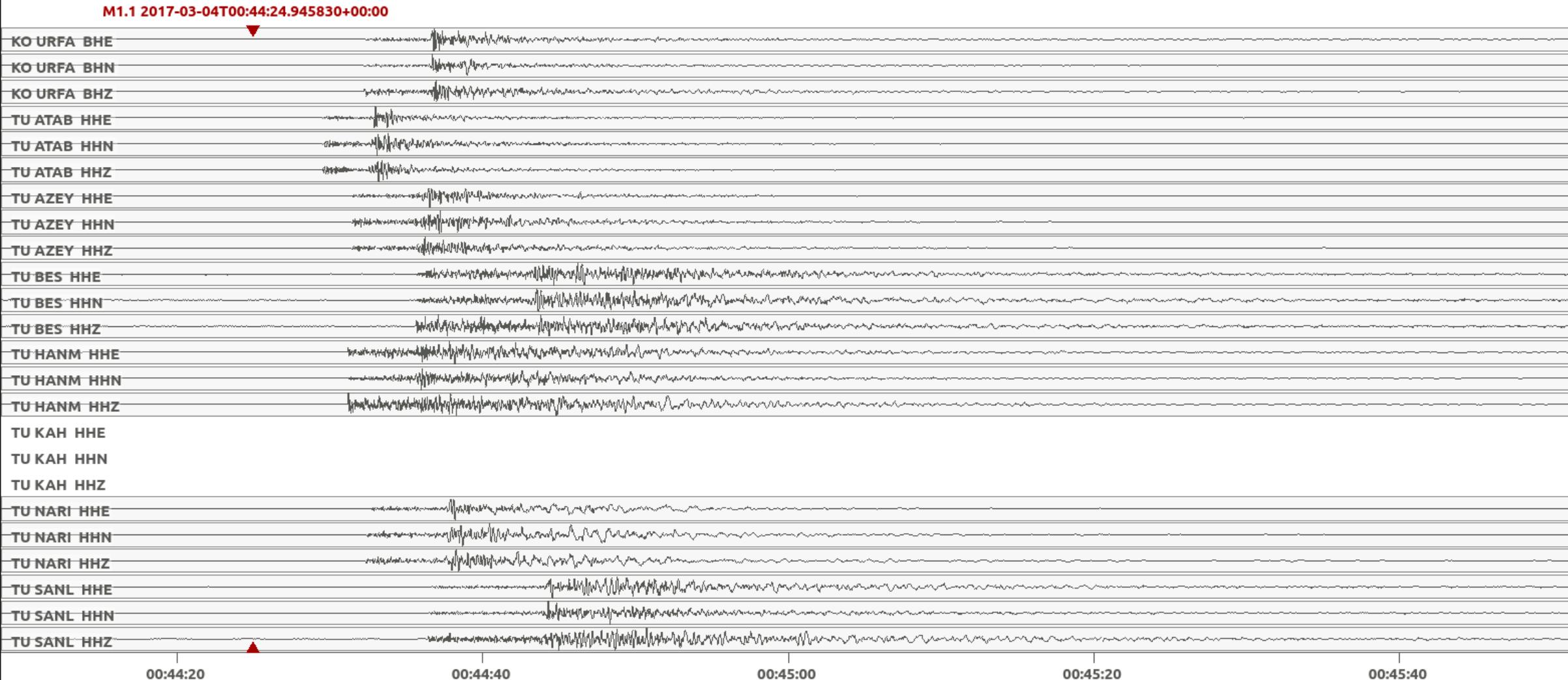


Do not forget joining our mattermost channel:

<https://hive.pyrocko.org/pyrocko-support/channels/itc-qseek>

Some more commands:

qseek snuffler test

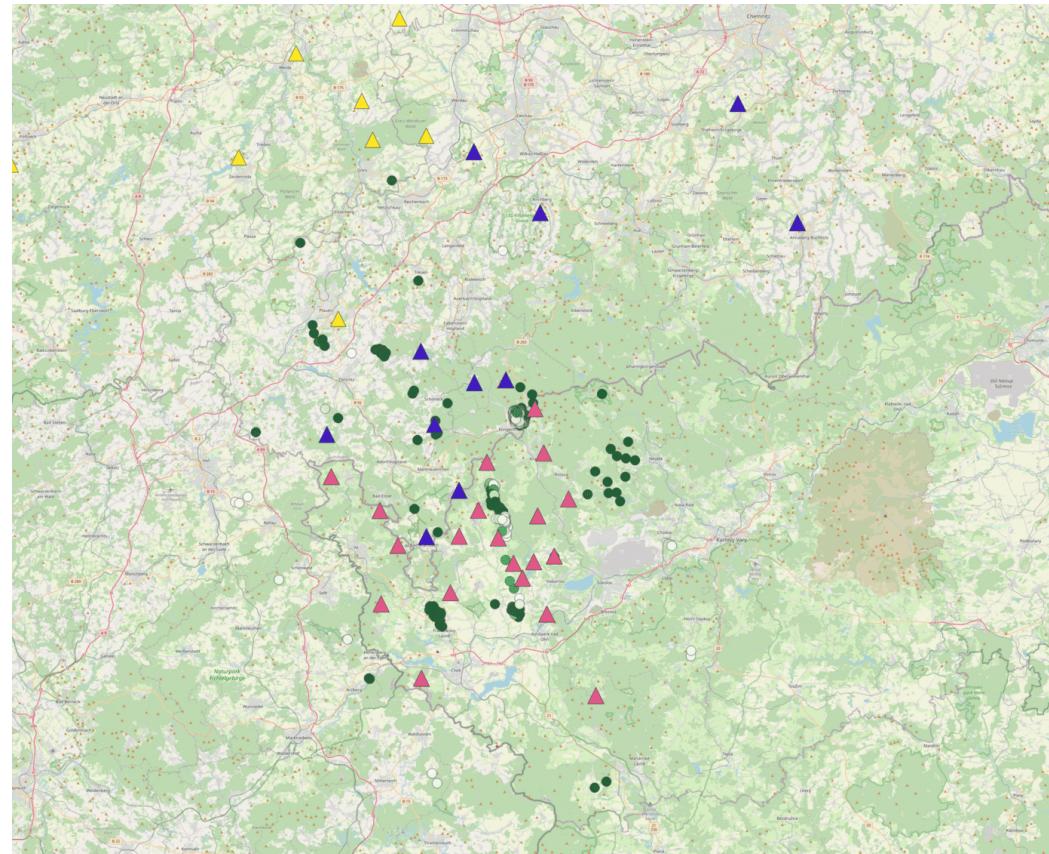


Visualization in QGIS

A Free and Open Source Geographic Information System

It is very effective for quick plots
CSV files can be added as layers
easily

<https://qgis.org/de/site/>



References

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- Heimann, S., Kriegerowski, M., Isken, M., Cesca, S., Daout, S., Grigoli, F., Juretzek, C., Megies, T., Nooshiri, N., Steinberg, A., Sudhaus, H., Vasyura-Bathke, H., Willey, T., & Dahm, T. (2017). Pyrocko - An open-source seismology toolbox and library. GFZ Data Services. <https://doi.org/10.5880/GFZ.2.1.2017.001>
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- Kandilli Observatory And Earthquake Research Institute, Boğaziçi University. (1971). Kandilli Observatory And Earthquake Research Institute (KOERI) [Data set]. International Federation of Digital Seismograph Networks. <https://doi.org/10.7914/SN/KO>
- Marius Paul Isken, Peter Niemz, Jannes Münchmeyer, Sebastian Heimann, Simone Cesca, Torsten Dahm, Qseek: A data-driven Framework for Machine-Learning Earthquake Detection, Localization and Characterization, Seismica, 2024, in revision.
- Weiqiang Zhu, Gregory C Beroza, PhaseNet: a deep-neural-network-based seismic arrival-time picking method, *Geophysical Journal International*, Volume 216, Issue 1, January 2019, Pages 261–273, <https://doi.org/10.1093/gji/ggy423>