AutoStatsQ: A toolbox for automated quality control of large seismic networks and its application to AlpArray & Swath-D

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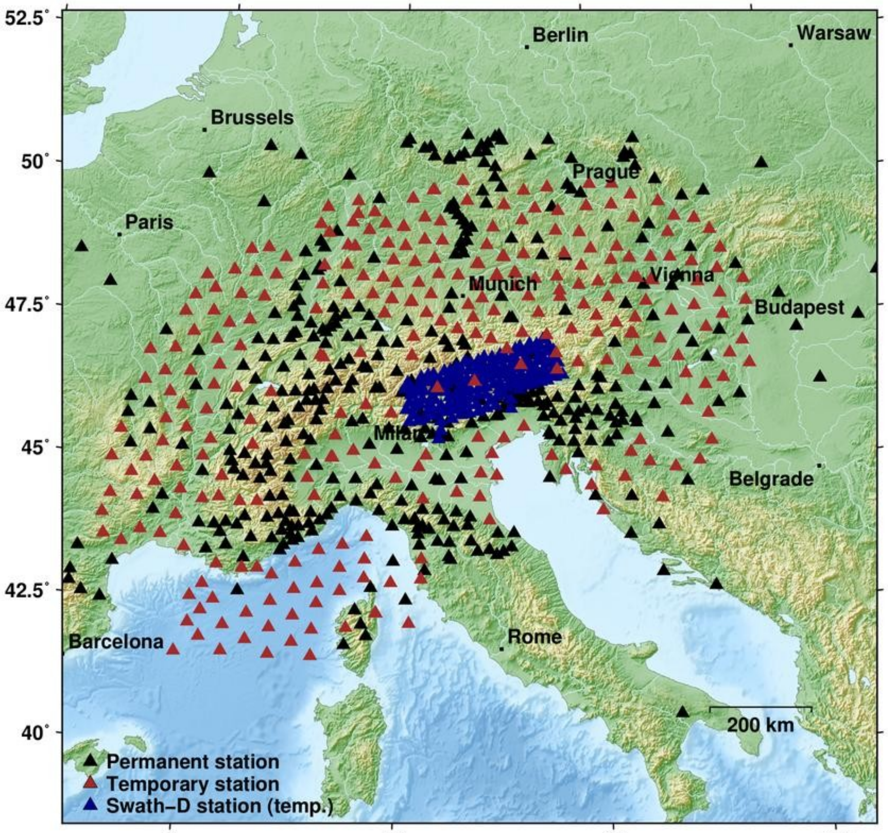
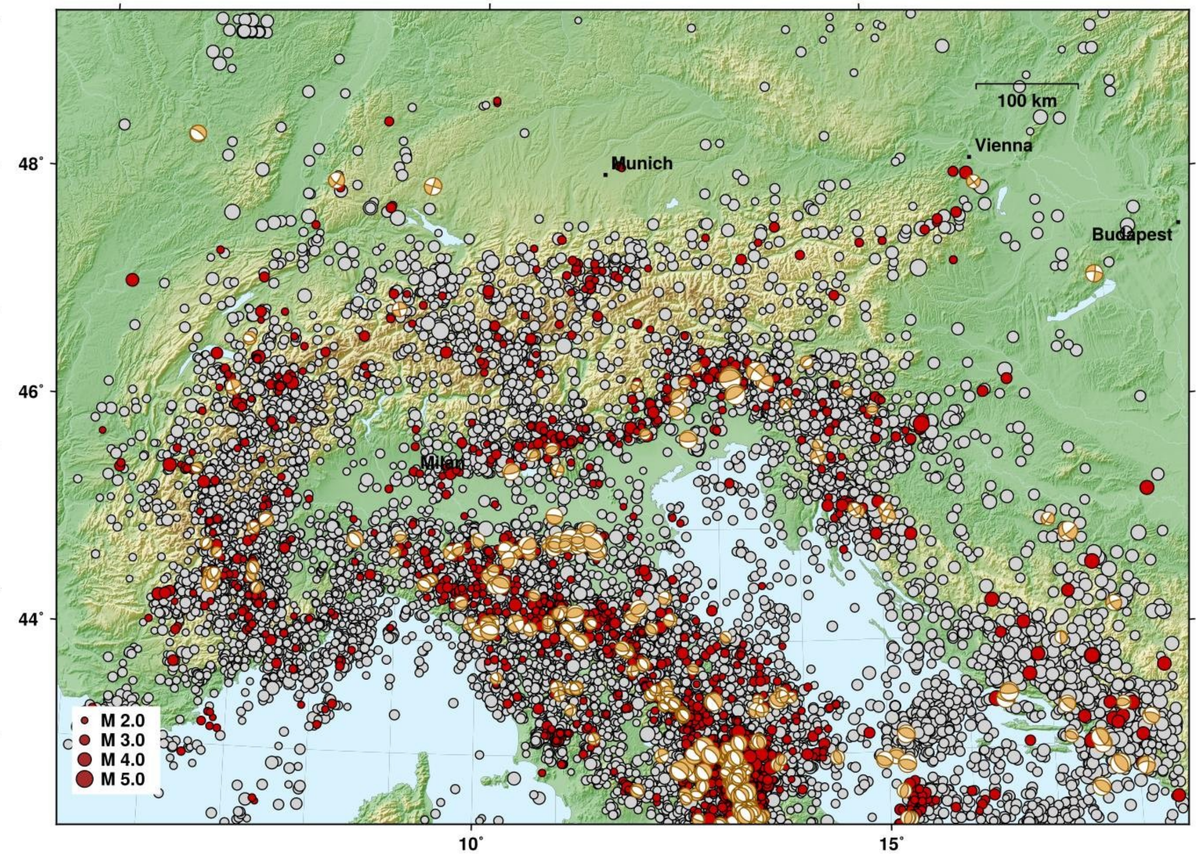
Motivation: MT inversion for M < 4



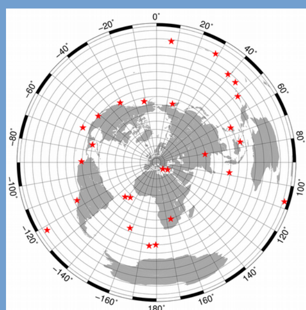
AlpArray seismic network



Seismicity 1970-2017 (gCMT, geofon, INGV)

AutoStatsQ

Input: Station file
& Time range

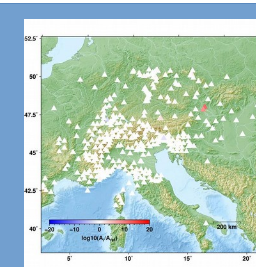


- Teleseismic catalog search & event selection
- Data and metadata download
- Preprocessing: restitution, filtering, downsampling
- Computation of synthetic data

Tests

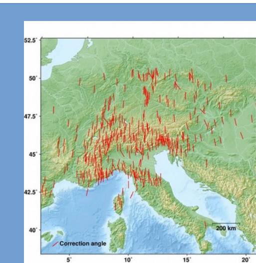
Amplitude gains

Inter-station comparison

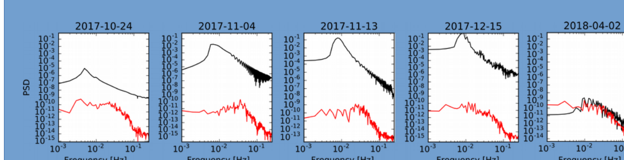


Sensor Orientation

Single stations R&Z comp



PSDs Synth. & real



https://pyrocko.org/

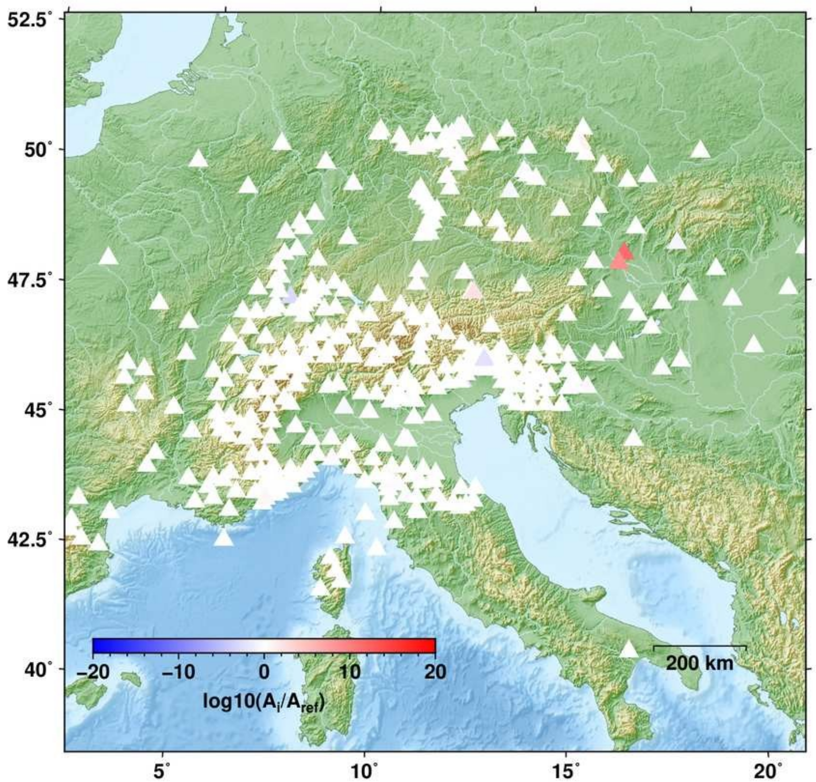
AutoStatsQ: Gain error test

Computation of median ratios of maximum P phase amplitudes with respect to one reference station:

$$median\left(\frac{A_{i,j}}{A_{ref,j}}\right)$$

i: Station
ref: reference station
j: Event

```
- !autostatsq.config.GainfactorsConfig
  gain_factor_method:
  - reference_nsl
  - [ZS, D017]
  fband:
    corner_hp: 0.01
    corner_lp: 0.2
    order: 4
  wdw_st_arr: 5
  wdw_sp_arr: 60
```



Perm. AlpArray stations, Z component
reference Station: GE.MATE

AutoStatsQ: Gain error test - Results

Permanent AlpArray stations

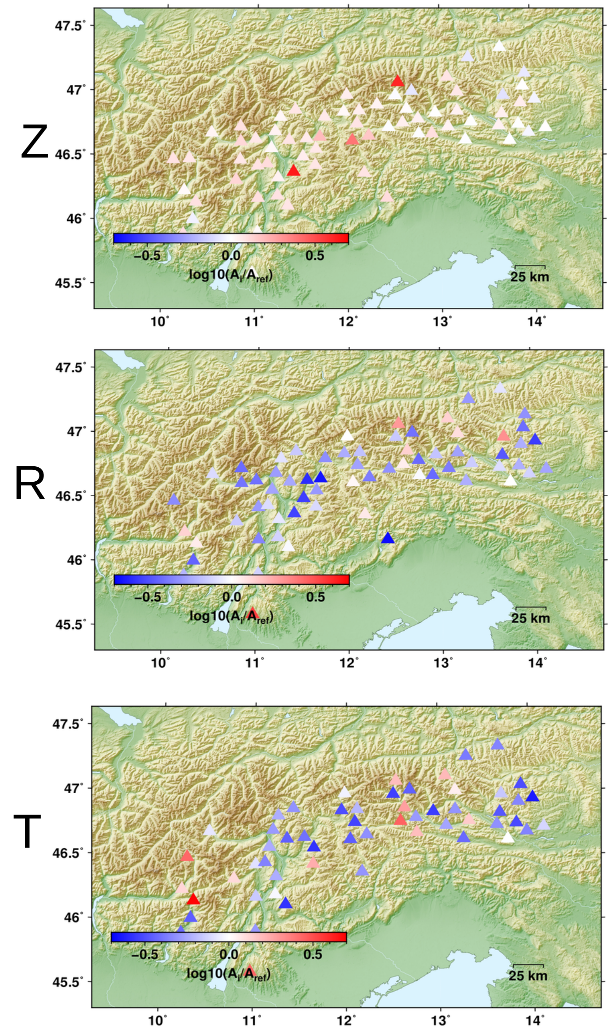
- 3 Stations with errors of several magnitudes: SK.MODS, SK.ZST, RD.MFF
- 3 % amplitude ratio > 10 or < 0.1

Temporary AlpArray stations

- No station with significantly wrong amplification factors
- 2/211 station with amplitude ratio > 10 or < 0.1: CR.SMRN, Z3.A112A

Swath-D

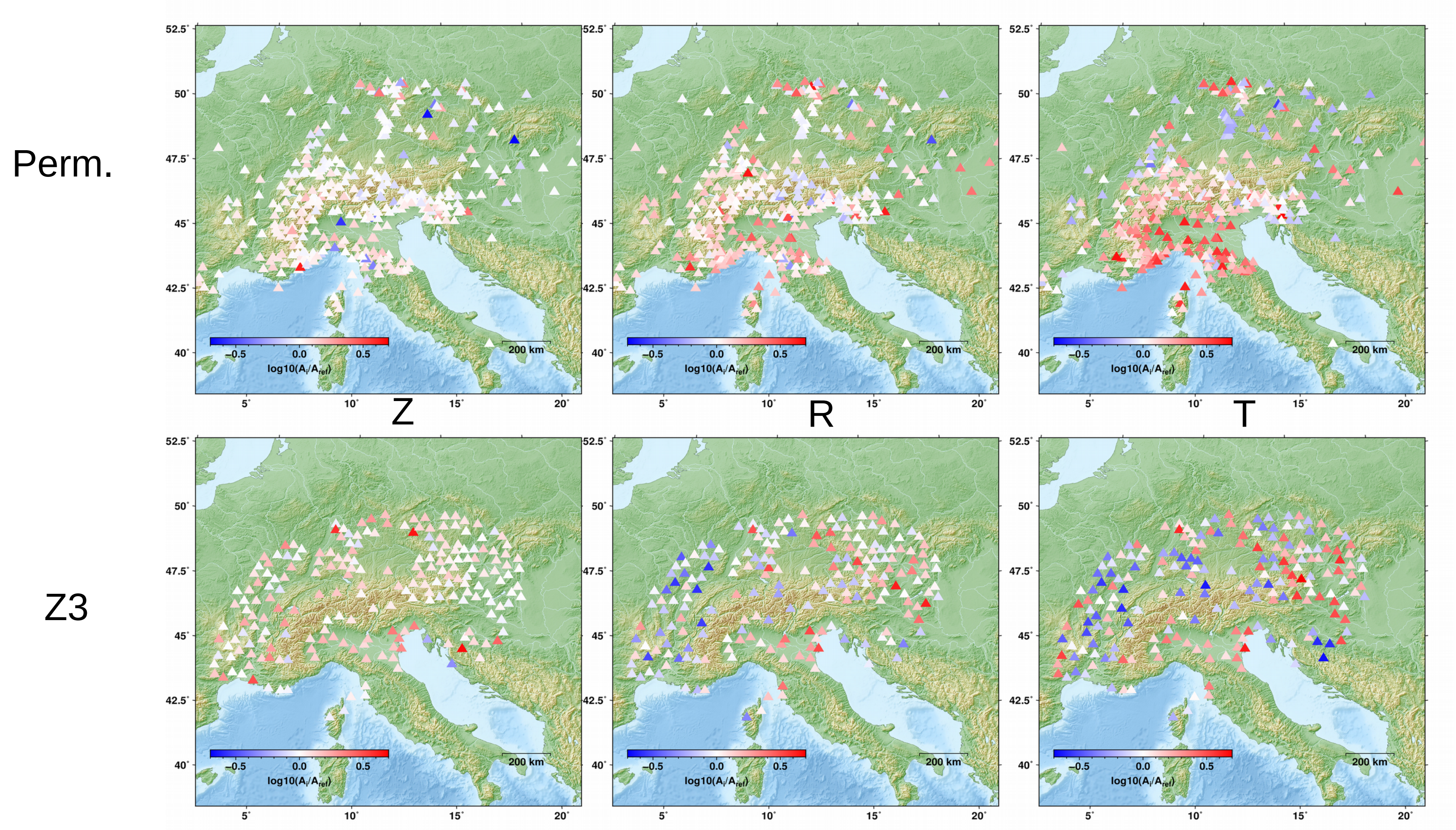
- 1/69 malfunctioning station detected: D046



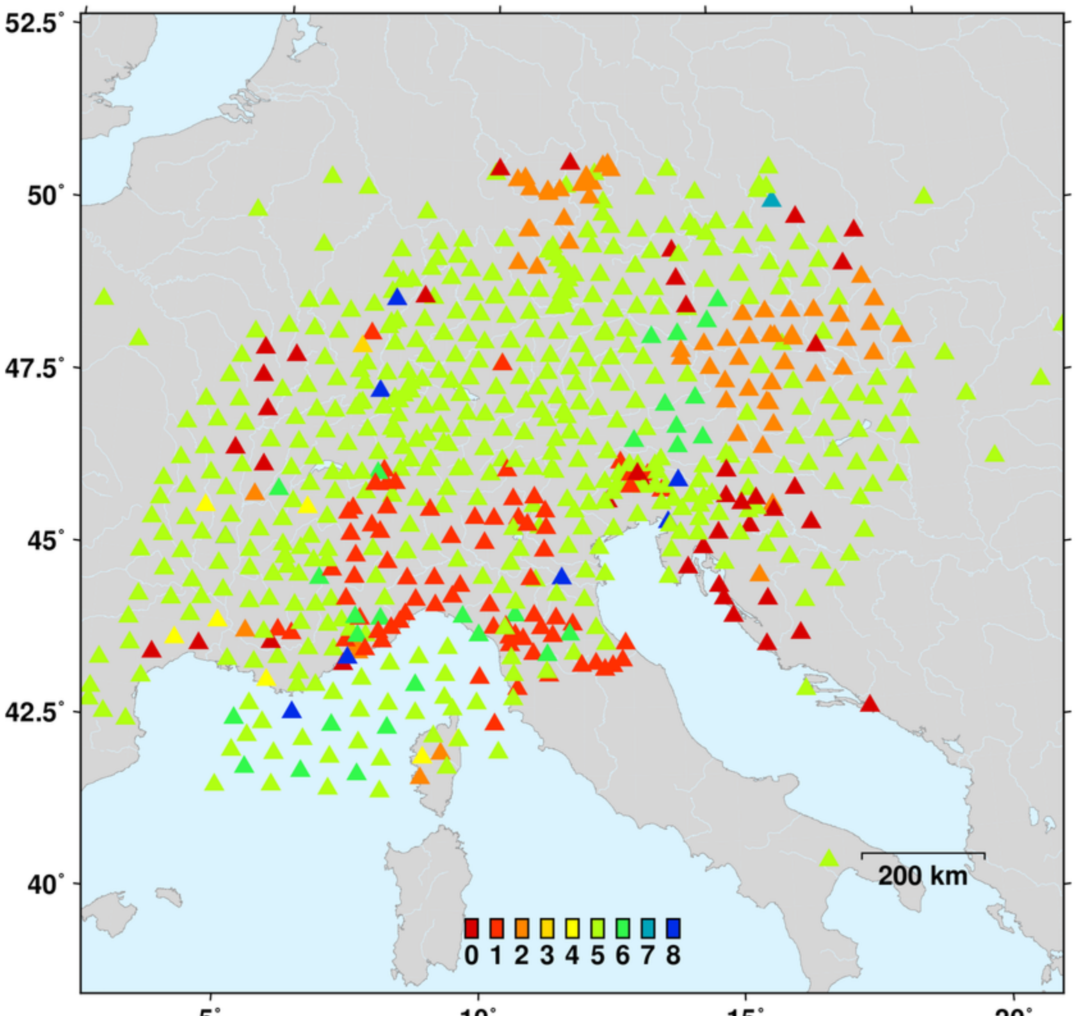
Median amplitude ratios of ZS stations

AutoStatsQ: Gain error test - Results

Median P amplitude ratios after removal of outliers – site-effect study (?):



AutoStatsQ: Gain error test - Results



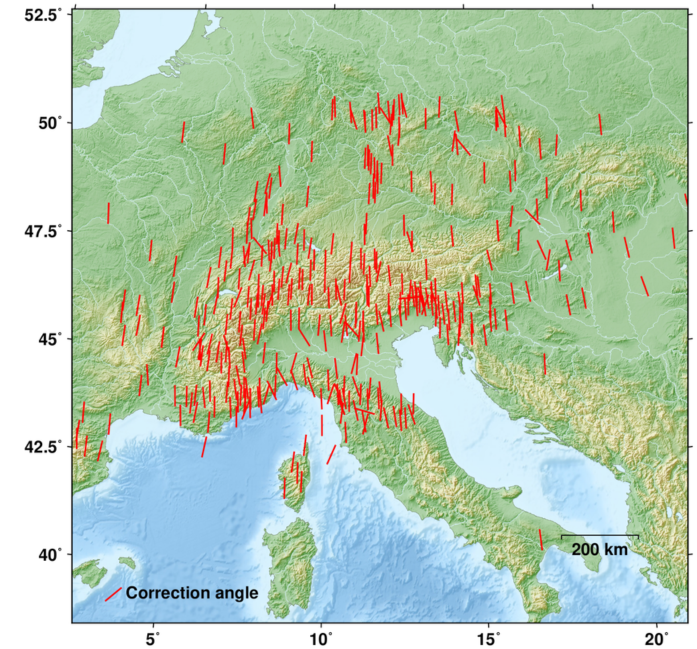
Instrument corner frequencies from metadata of permanent and temporary AlpArray stations

- 0: 30 s
- 1: 40 s
- 2: 60 s
- 3: 78 s
- 4: 90 s
- 5: 120 s
- 6: 240 s
- 7: 360 s
- (8: 999 s)

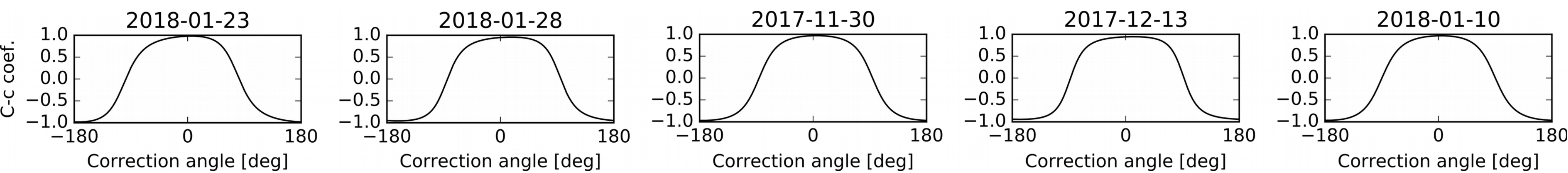
AutoStatsQ: Orientation error test

- Rayleigh wave polarization: 90° phase shift between radial and vertical component

  → Rotate Hilbert-transformed, theo. R comp. in 1° steps, search for max. cross-correlation
- Stable detection of misorientations > 15°
- Detection of wrong polarities of horizontal (or vertical) components

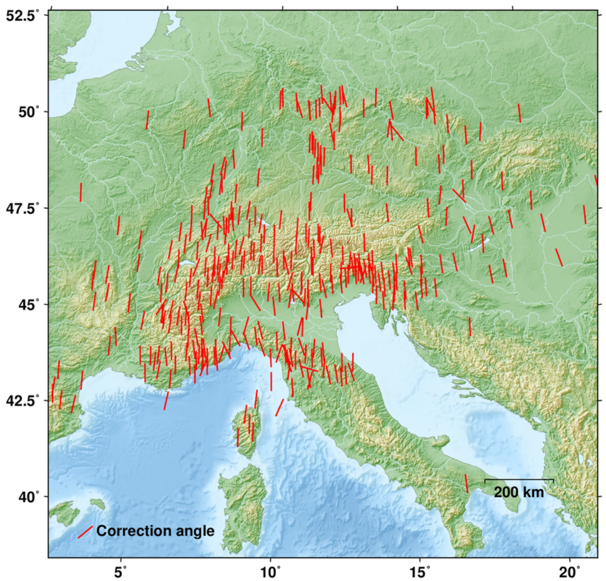


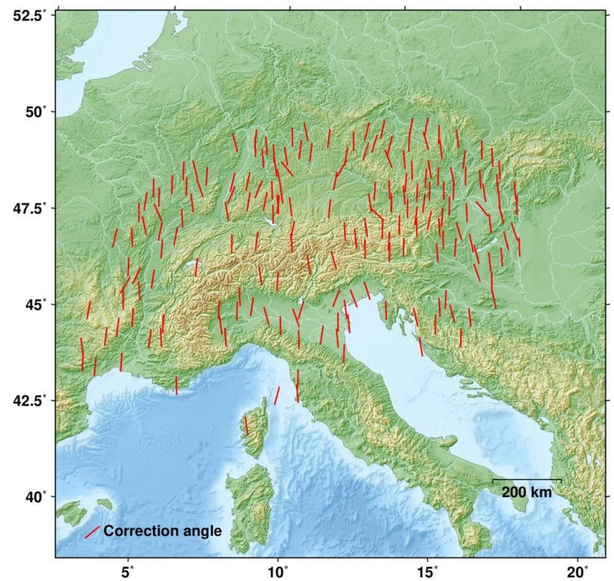
Misorientation of perm. AlpArray stations

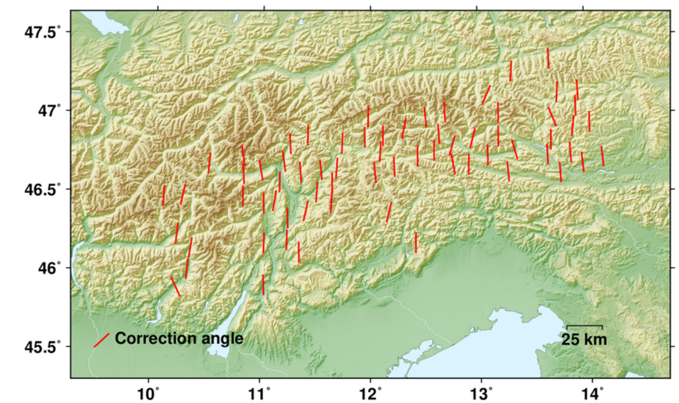


Correction angle vs. cross-correlation coefficient, station GR.BFO, 5 example events.

AutoStatsQ: Orientation error test – Results







Permanent AlpArray stations:

- 90 % orientation within 15°
- 4 Stations with wrong polarities: GU.RORO, IV.SARZ, IV.ZCCA, NI.VINO

Temporary AlpArray stations:

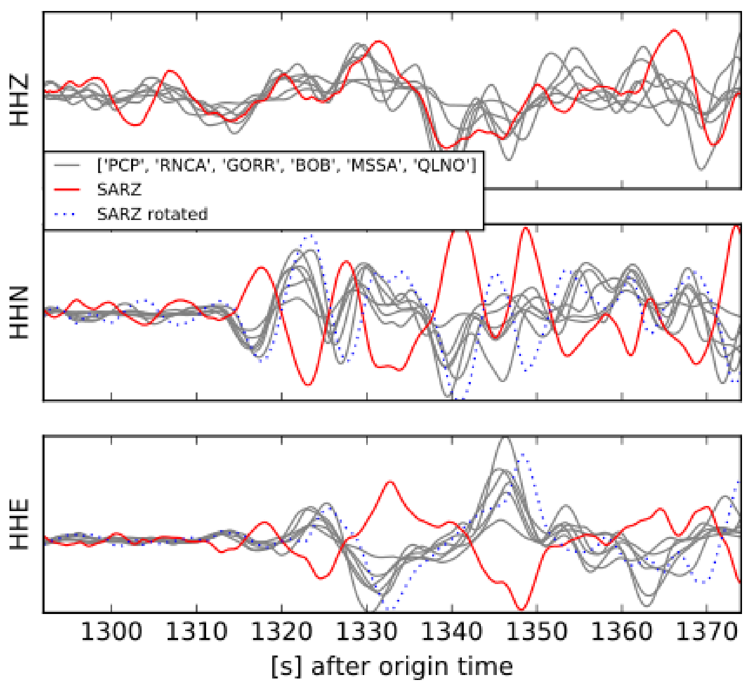
- 95 % orientation within 20°
- 2 Stations with wrong polarities: Z3.A263A, Z3.A300A

Sensor orientations:

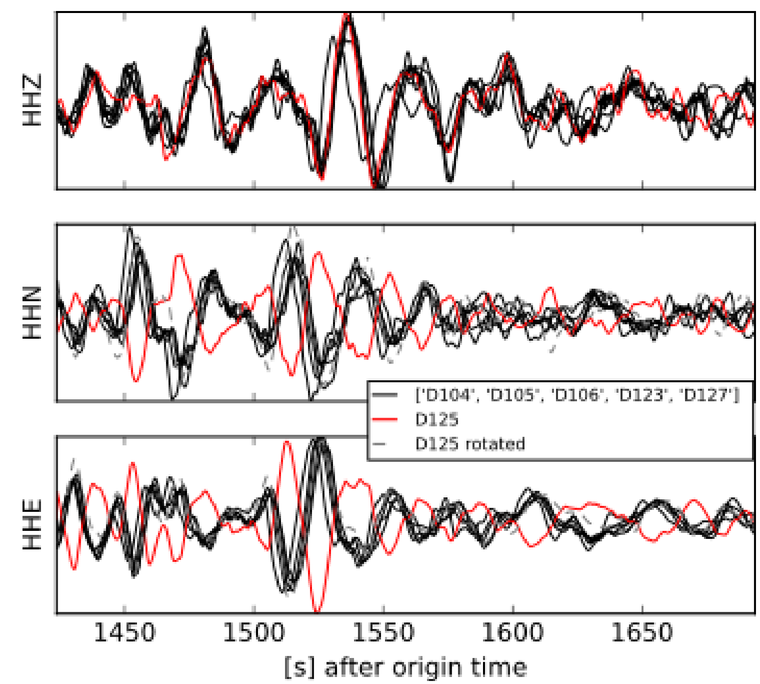
- 3 Stations ~ 25°: D001, D078, D116
- D125 – polarity error

AutoStatsQ: Orientation error test – Results

Examples of wrong polarities (horizontal components)



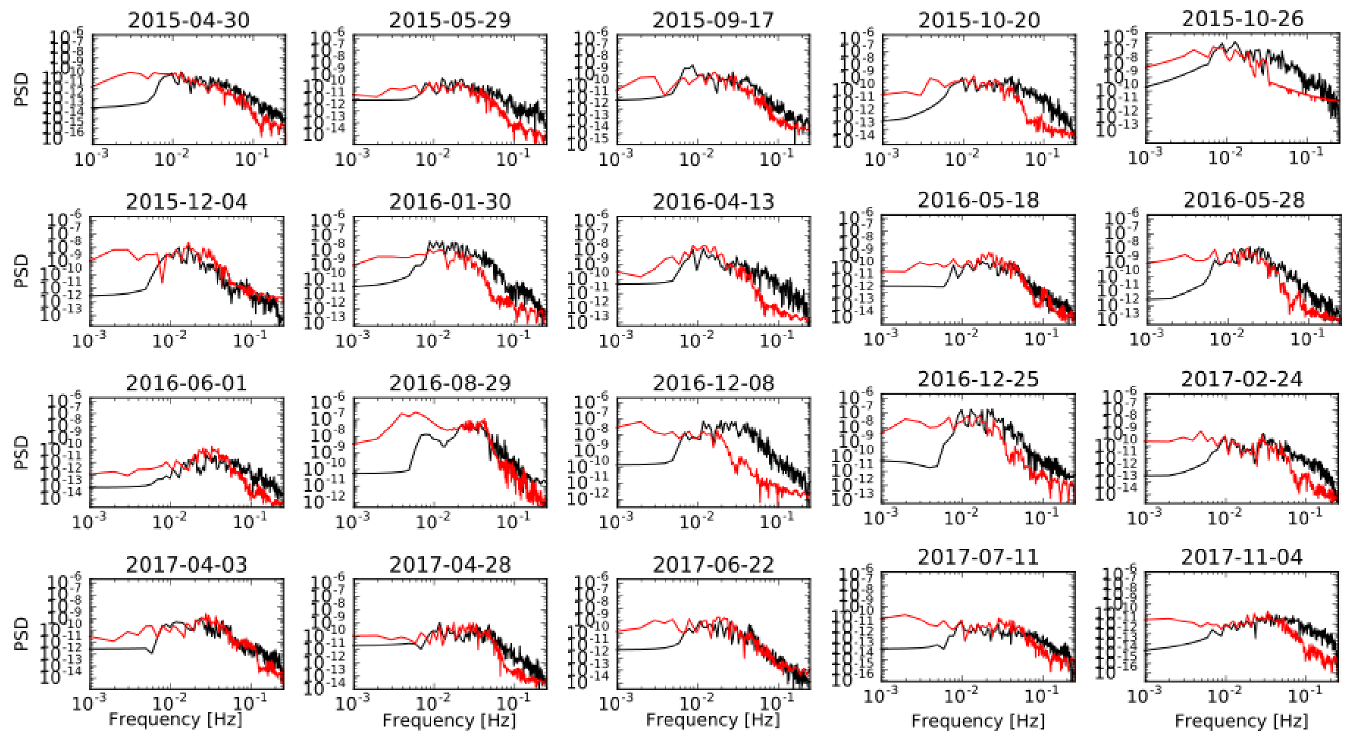
2018-01-23 09:31:42, M_w7.9, Gulf of Alaska
S phase on IV.SARZ and nearby stations



2018-02-16 23:39:46, M_w 7.2. Mexico
S phase on ZS.D125 and nearby stations

AutoStatsQ: PSDs

- Comparison of synthetic and real PSDs
- Frequency ranges in which PSDs agree well
- Check of instrument lower corner frequencies indicated in metadata



Example for synth. and real PSDs, station GR.BFO, 20 events

AutoStatsQ: PSDs – Results

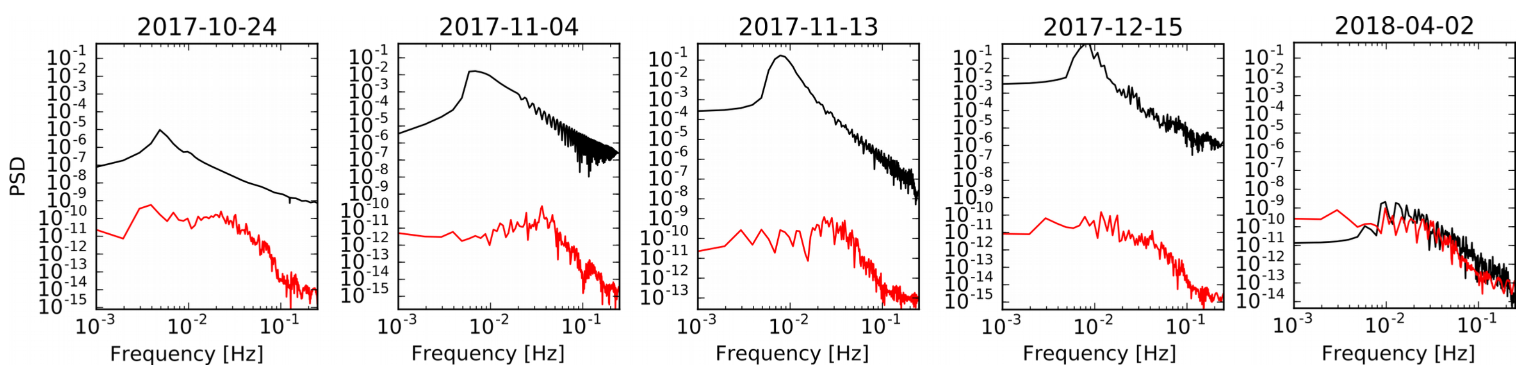
Results depend on task or chosen threshold defining the usable frequency ranges with high agreement of synth. and real data

Permanent and temporary AlpArray stations:

- (Same) stations with large gain errors detected
- Different instrument corner frequencies can be verified
- Frequency ranges for MT inversions

Swath-D:

- D046 conspicuous
- 100 s corner frequency confirmed



Synth. and real PSDs, station ZS.D046

Conclusions & Outlook

→ AutoStatsQ toolbox ←

- Gain factors – *station-to-station*
  - Reliable detection of large gain factor errors
  - TO DO: Check reliability of provided corrections & site-effect studies
- Orientation analysis – *R-to-Z-component*
  - Stable results for polarity switches and misorientations > 15°
- PSDs – *synth-to-real*
  - Instrument corner frequencies can be identified
  - Frequency ranges for e.g. MT inversions, but needs careful parameter selection

Conclusions & Outlook

→ AutoStatsQ toolbox ←

- Gain factors – *station-to-station*
  - Detection of large gain factor errors reliable
  - TO DO: Check reliability of provided corrections & site-effect studies
- Orientation analysis – *R-to-Z-component*
  - Stable results for polarity switches and misorientations > 15°
- PSDs – *synth-to-real*
  - Instrument corner frequencies can be identified
  - Frequency ranges for e.g. MT inversions, but needs careful parameter selection

→ Preliminary results: gesap@gfz-potsdam.de

→ AutoStatsQ: https://github.com/gesape/AutoStatsQ

Thanks for your attention!