Estimation of seismic network detection thresholds for Austria

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Overview

Seismic networks are expanding and changing continuously: station instrumentation breaks and improves, new stations are set up permanently and temporarily for projects, or get available online from seismological services. For routine processing, it is important to know if and where adding an existing station to processing or building or improving a station will add the most value to the detection an location capabilities.

Therefore, in this study we calculate seismic network detection thresholds for Austria using data available to us from different sources: From the Seismic Network of Austria (OE), which consists of unevenly distributed high quality low noise broadband and strong-motion stations, with station spacing up to 100 km. Cross-border from neighboring countries, where each of them operates at least one seismic network with very different station quality and coverage. As well as from temporary regional scientific projects i.a. AlpArray , the SWATH and local infrastructure monitoring.

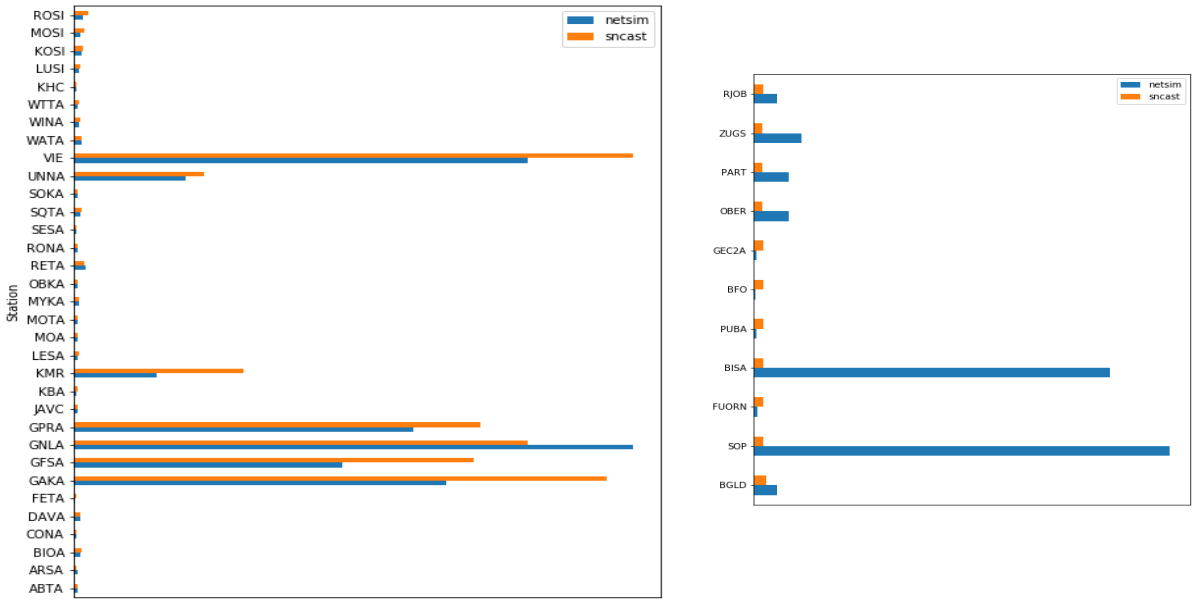
Methods

- NetSim (Sereno et al. 1990)
  median of RMS
- SN-Cast (Möllhoff et al. 2019)
  displacement calculated from 90 % percentile of PPSD
- GT-5 (Bondár et al. 2004)
  for localisation quality

We calculated detection thresholds, for similar data with similar **parameters**:

- Time period for waveforms: January to November 2019
- Stations: Broadband saved locally at ZAMG, between 1 to 10 Hz
- Hypocentral depth: 8 km
- SNR >2 at a minimum of 3 stations
- Earthquakes from Austrian Earthquakes Catalog AEC by ZAMG (2019)

Noise calculations and estimates



Due to data inconsistencies in instrument corrections, values for a number of station had to be estimated.

- For NetSim we estimated with expert knowledge for stations: BFO,BGLD,CKRC,FUORN,FUR,GEC2A,OBER,PART,RJOB,RNON,SOP,UBR,WET,ZUGS,ALBA,BISA,GILA,GUWA,MARA,PITA,PUBA,SITA,SQMD,SQTW,SQWN,VEIA,A004A,A009A,A010A,A023A,A029A,A031A,A034A,A062A.
- For SN-Cast we estimated the values with the median of available stations for BGLD,SOP,GORS,ROBS,ZAVS,PERS,GROS,FUORN,BISA,PUBA,KRUC,ABSI,BOSI,RISI,D109,BFO,GEC2A,OBER,PART,ZUGS,RJOB

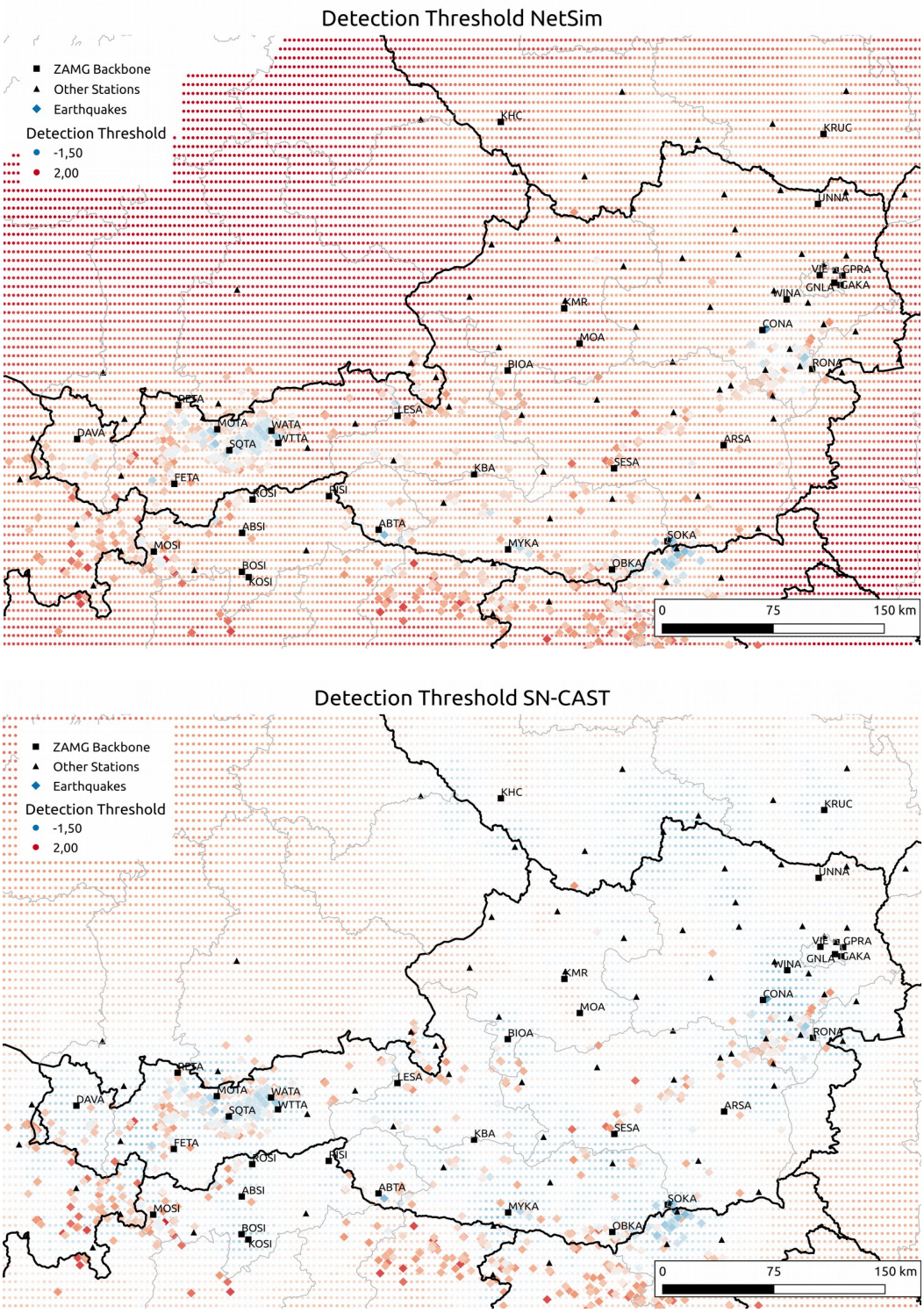
The figure on the left hand side shows relative calculated values for both methods for ZAMG Backbone Stations, the figure on the right shows estimated values.

- Broadband stations situated in or close to cities, show higher noise values (VIE, KMR; GPRA, GNLA, GFS, GAKA).

- Noise calculations for SN-Cast are higher, which can be explained with the 90 % percentile being used, instead of the median for NetSim.

- Noise estimates by expert were much higher than average station noise used for SN-Cast Noise estimates for high noise stations by SN-Cast likely to low, as most stations were build to have low noise background

Detection Thresholds



The figures above compare the calculated detection thresholds with earthquakes in the catalog. Within Austria, all earthquakes with a

local magnitude down to 1.2 according to NetSim / 0.8 according to SN-Cast

should be detectable. If only stations of the ZAMG Backbone Network are used, the threshold goes to 1.5 for NetSim and 1.0 for SN-Cast.

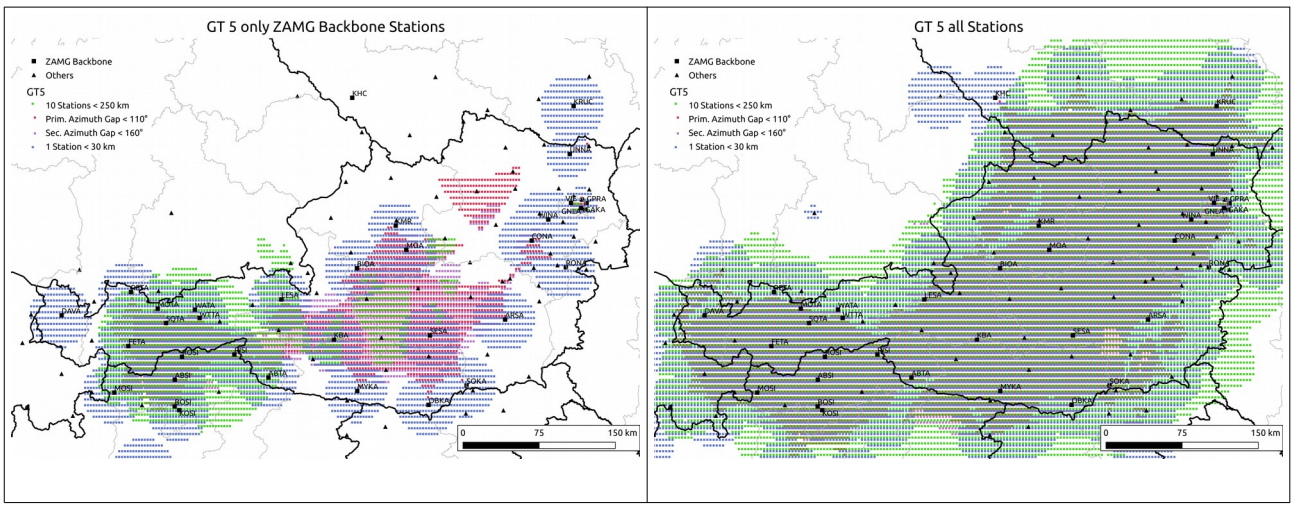
GT-5 criteria

The GT-5 criteria by Bondár et al. (2004) evaluated the quality of locations with 4 different criteria:

1. Minimum of 10 stations < 250 km
2. Primary azimuth gap < 110°
3. Secondary azimuth gap < 160°
4. Nearest Station < 30 km

Whereof the secondary azimuth gap and the nearest station are the most important to for local networks. We adapted the nearest station criterion with station noise, to reflect the very different noise levels between cities and remote stations.

For this study we compared the compliance with GT-5 for the ZAMG Backbone and all available stations. The figures show compliance for each criteria on each gridpoint for an earthquake with a local magnitude of at least 1.5.



The figure on the left shows that using only the ZAMG network, only Tirol an a few select small areas fulfill all 4 criteria. Interestingly, also a small area in Vienna fulfills all criteria, due to the local monitoring network set up for the GeoTief project.

The right hand side figure shows GT-5 for all available stations. One can clearly see that almost all of Austria is covered sufficiently with broadband stations to meet all criteria. Only small areas in Tirol, Salzburg and Burgenland are not covered.

Conclusions

- SN-Cast detection threshold closer to earthquake magnitudes in catalog
- detection threshold Ml ~1.0, using only high quality ZAMG backbone
- localization quality according to GT-5 needs the large quantity of stations available due to temporary projects

Work in Progress:

We will also analyze how strong-motion stations can be integrated in both approaches. Specifically to see how recently added stations due to the interregio project ARMONIA, improve the detection capabilities.

References:

Hetényi G., I. Molinari, J. Clinton et al. The AlpArray Seismic Network: a large-scale European experiment to image the Alpine orogeny. Surveys in Geophysics, 39, 1009-1033. doi:10.1007/s10712-018-9472-4 (Open Access) (2018):

Bondár, I., Myers, S.C., Engdahl, E.R. and Bergman, E.A. (2004), Epicentre accuracy based on seismic network criteria. Geophysical Journal International, 156: 483-496. doi:10.1111/j.1365-246X.2004.02070.x (2004)

Möllhoff, M., Bean, C.J. & Baptie, B.J. SN-CAST: seismic network capability assessment software tool for regional networks-examples from Ireland. J Seismol 23, 493–504 (2019). https://doi.org/10.1007/s10950-019-09819-0

Sereno, T.J., Jr., S.R. Bratt, G. Yee NetSim: A Computer Program for Simulating Detection and Location Capability of Regional Seismic Networks" SAIC Semi-Annual Technical Report, 90/1163, 98 pp. (1990)

Links:

AlpArray
http://www.alparray.ethz.ch/en/home/

GeoTief Explore 3D
http://www.geotiefwien.at/

interregio ARMONIA
https://www.zamg.ac.at/cms/de/forschung/geophysik/euprobe/armonia