Intro

Noise I: Anthro-pogenic Noise

Noise II: Long Term Observa-tions

Noise III: Wind-dependent Noise

CC: Cor-relation of teleseis-mic signals

Summary

Quality checks of waveform data at EIDA node BGR

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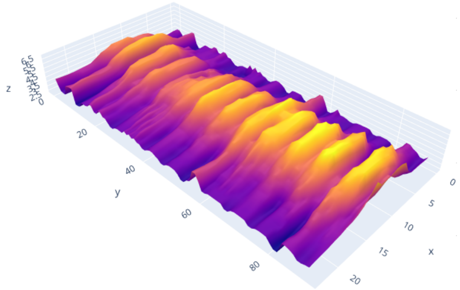
Introduction

- The data center of the EIDA node BGR hosts seismic data of more than 200 permanent stations.
- For a high data reliability it is important to find possible quality issues in the data set, in particular problems in amplitude, transfer function specification and timing.
- There are automatic processes in place addressing these issues complementing a daily manual analysis of the waveform data.
- Besides standard operation like gap detection and computation of PPSDs a large part of these processes is based on a systematic evaluation of ambient noise as well as teleseismic signals and shall be introduced in this presentation.

Noise I: Anthropogenic Noise

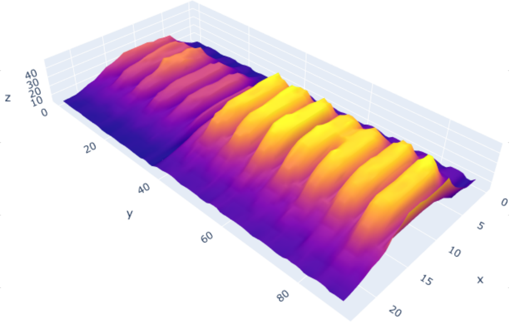
- Stations show specific anthropogenic noise patterns when observed over several weeks and daily hours.
- Data are filtered between 4 and 14 Hz, segmented into hours, taking the 75% percentile of the amplitude in each hour.
- Results plotted in 3D, x-axis: last 90 days, y-axis: 24 hours on each of these days, z-axis: amplitude.
- Slight smoothing applied and largest 3% of amplitudes cut.
- Daily updated, interactive figures for many stations available at the BGR website.



Station GR.TNS, 90 days since 13-Jan-2021

Noise I: Example

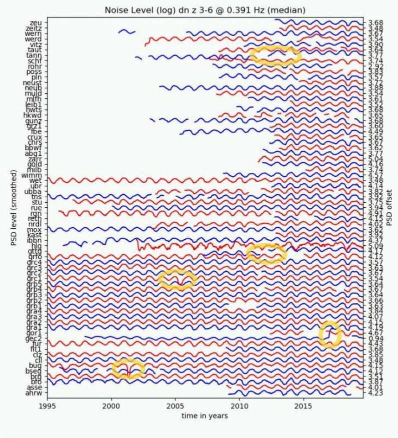
- Most stations show larger amplitude during daytime and reduced noise at night (x-direction), combined with a weekly periodicity (y-direction).
- Strong wind influence may mask such a pattern and reveal irregular structures, e.g. GR.GRB3 close to wind turbines.
- Sudden changes in the visible patterns may indicate issues with data or metadata, example shown in the figure to the right.



Station GR.BSEG, 90 days since 5-Aug-2020, visible amplitude change due to replacement of a defective seismometer.

Noise II: Long Term Observations

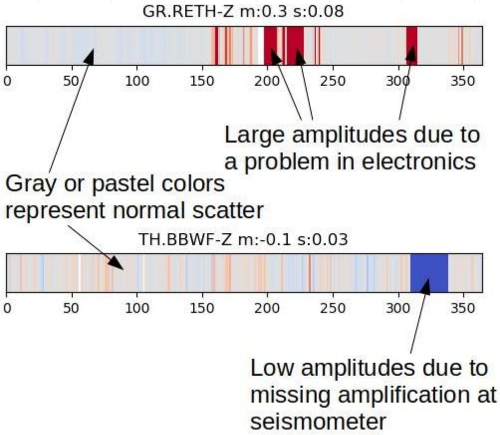
- Observation of the noise amplitude at a selected frequency over a long time period.
- Systematic hourly computation of FFT, extraction and collection of spectral amplitudes.
- Median-averaging shows evolution of spectral amplitude with time.
- Frequencies below 1 Hz are dominated by ocean microseism and quite coherent among stations.
- Abrupt changes or jumps may indicate issues with data or metadata, see yellow markers.



Average noise at 0.39 Hz observed over decades at German stations. Amplitudes logarithmic and mean removed.

Noise II: Long term observation, Color Bars

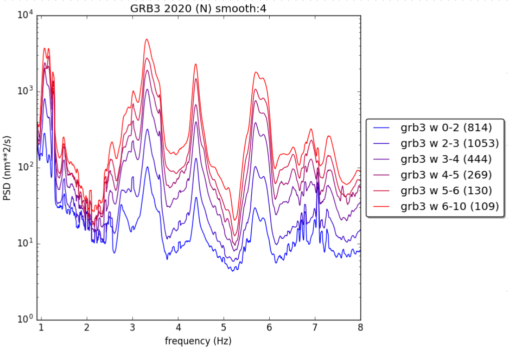
- Removing a common mean from all traces (last figure) strongly reduces the variability of the individual measurements.
- A statistical analysis of these demeaned data points identifies permanent changes of the noise level.
- A color coded bar, normalized by the standard deviation, visualizes such demeaned noise values.
- The noise color bars are daily updated and available at the BGR website (see more details there).
- For BB stations the investigated frequency is 0.15 Hz, for SP stations it is 1 Hz (less sensitive).



Color coded, demeaned noise level at two stations showing the last 365 days (x-axis).

Noise III: Wind-dependent Noise

- Compute hourly spectra depending on local wind speed.
- Wind speed taken from the ECMWF data set.
- 6 wind bins defined, spectra of one year averaged within each bin.
- Shows wind dependence of data, possible influence of forests/trees or wind turbines.
- Yearly updated data sets for selected German stations viewable at the BGR website.



Wind dependent spectra at station GR.GRB3 located next to 3 wind turbines.

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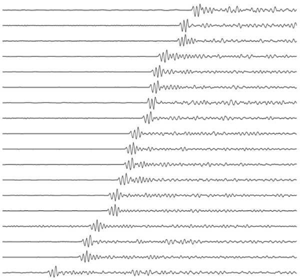
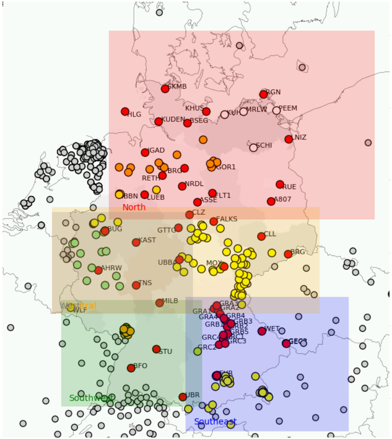
CC: Correlation of teleseismic signals

- Use teleseismic events above m_b 5.8 in distances between 35 and 80 deg.
- Correct for recording instrument by using simulation filters.
- For BB stations three different simulation filters applied (WWSSN-SP, SRO-LP and KIRNOS).
- Correlation provides: similarity (cc-coef) and residuals.
- Additionally done: determination of relative amplitudes.
- Compare each station with each other, compute average.
- All figures and results of the algorithm described in this section available at an ftp site at BGR



CC: Split observation areas

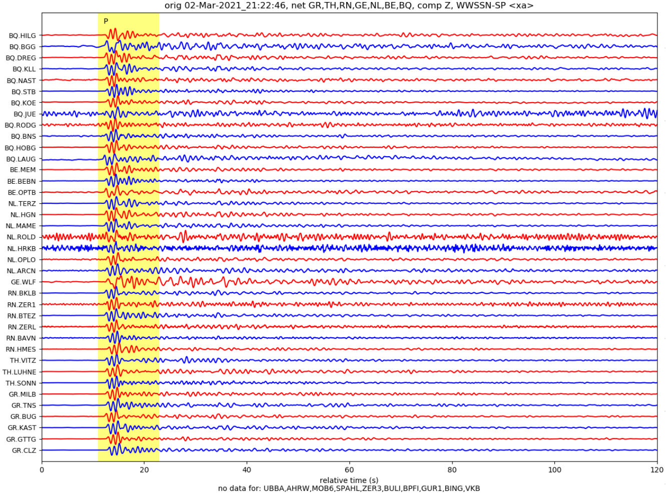
- Number of stations too large to compare with each other.
- Causes long computation time and unclear result plots.
- Therefore 5 different areas in Germany are defined, including stations from adjacent countries.
- Comparisons only within these areas.
- Two figures per area and simulation filter created. One shows waveforms the other parameter diagrams.



Observation areas: North, Central, West, Southwest, Southeast

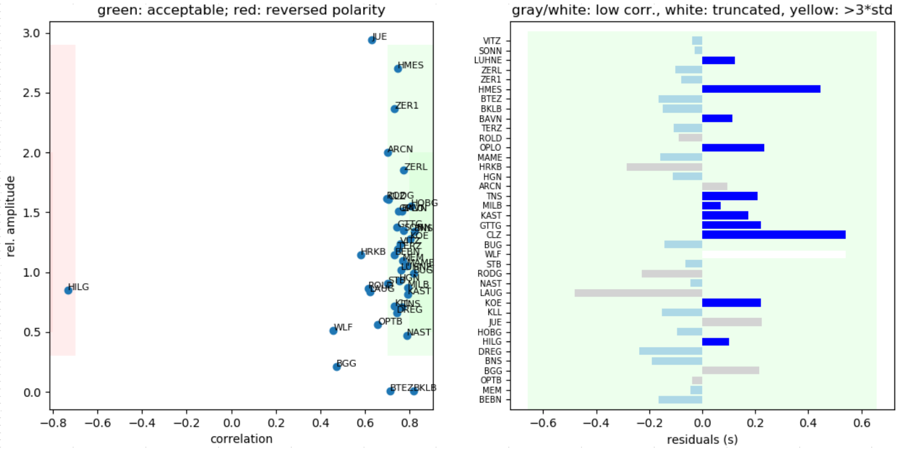
CC: Example WWSSN-SP, Area West, Kuriles Event

- Traces aligned along theoretical phase onset.
- Most records show high coherence of P-signal.
- Low similarity at GE.WLF.
- Topmost station shows reversed polarity.



P-waveforms, WWSSN-SP (Kuriles m_b 5.8)

CC: Corresponding Parameter Diagrams (SP, West)



Parameter diagrams of the same event shown in the previous figure. Left: relative amplitudes vs corr.-coefficients, right: residuals. Two stations show anomalously small amplitudes and one a reversed polarity.

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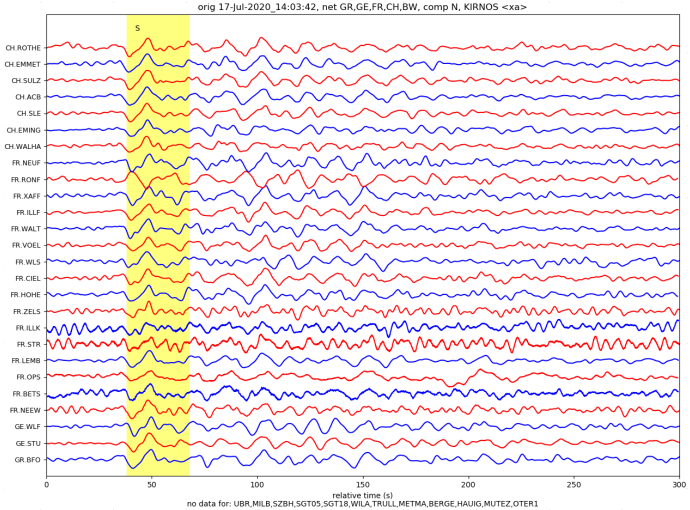
CC: Example S-wave, Area Southwest

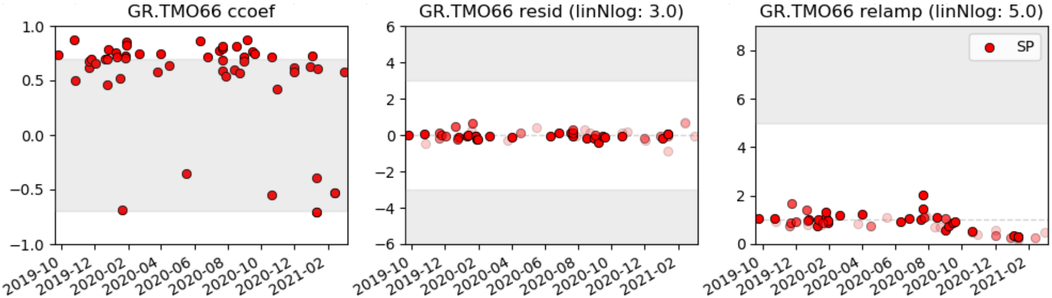


S-waves of Andaman Islands event, KIRNOS simulation. Reversed polarity at FR.RONF.

CC: Statistical analysis of the correlation parameters

- If many events are analyzed, a time-dependent view on each of the parameters can be prepared.
- Each event and simulation filter provides a point in time.
- Following similarity, residual time and relative amplitude in their course in time for each station may reveal unwanted changes in data or metadata.

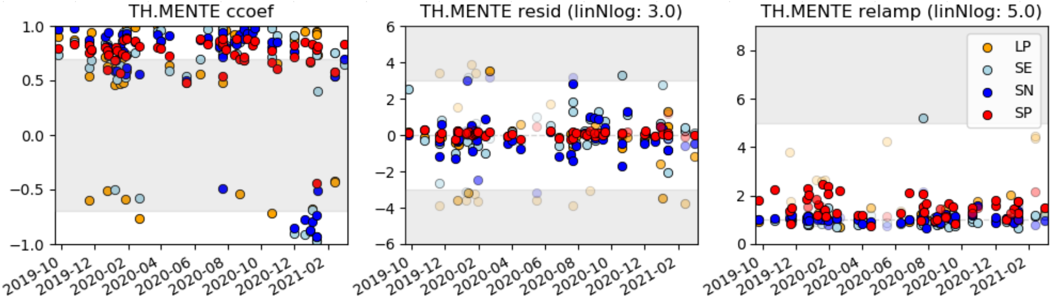
CC: Example Station GR.TMO66, short-period



Correlation coefficient (left), residual in s (Center) and relative amplitude (right) vs time

Each event analyzed sets a red dot in the diagrams. The area of low correlations below 0.7 is shaded in gray (left). The central and right diagrams show transparent dots resulting from correlations below 0.7. There, gray shaded areas indicate logarithmic scaling rather than linear. A decay of relative amplitudes is visible in the right diagram at about Oct 2020, caused by a defective instrumentation.

CC: Example Station TH.MENTE, broadband



red: WWSSN-SP Z (P-wave), orange: SRO-LP Z (P-wave), blue: KIRNOS N (S-wave), light blue: KIRNOS E (S-wave)

From about Dec 2020 until Feb 2021 the station shows reversed polarity on the horizontal components. This was caused by construction works at the site resulting in a displaced and misoriented instrument (corrected in March 2021).

Figures for all other stations available at the BGR ftp site.

Summary

- Continuous noise observations in different frequency bands help to detect amplitude changes in seismic data, possibly caused by defective instrumentation or erroneous metadata.
- Characteristic anthropogenic noise patterns help to classify the noise environment at station sites and to estimate the susceptibility for wind effects.
- Wind dependent spectral diagrams quantify the influence of local wind.
- A systematic crosscorrelation of teleseismic signals at different frequencies tests the reliability of the specified transfer functions and detects timing problems above about 1s.
- A continuous observation of signal similarity, residuals in time and relative amplitudes helps to maintain a high level of data quality at all stations.