Einstein Telescope

Avec le soutien de la Wallonie

First results of the surface ambient seismic noise characterization campaign along scan-lines around Terziet

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LIÈGE université Sciences Appliquées

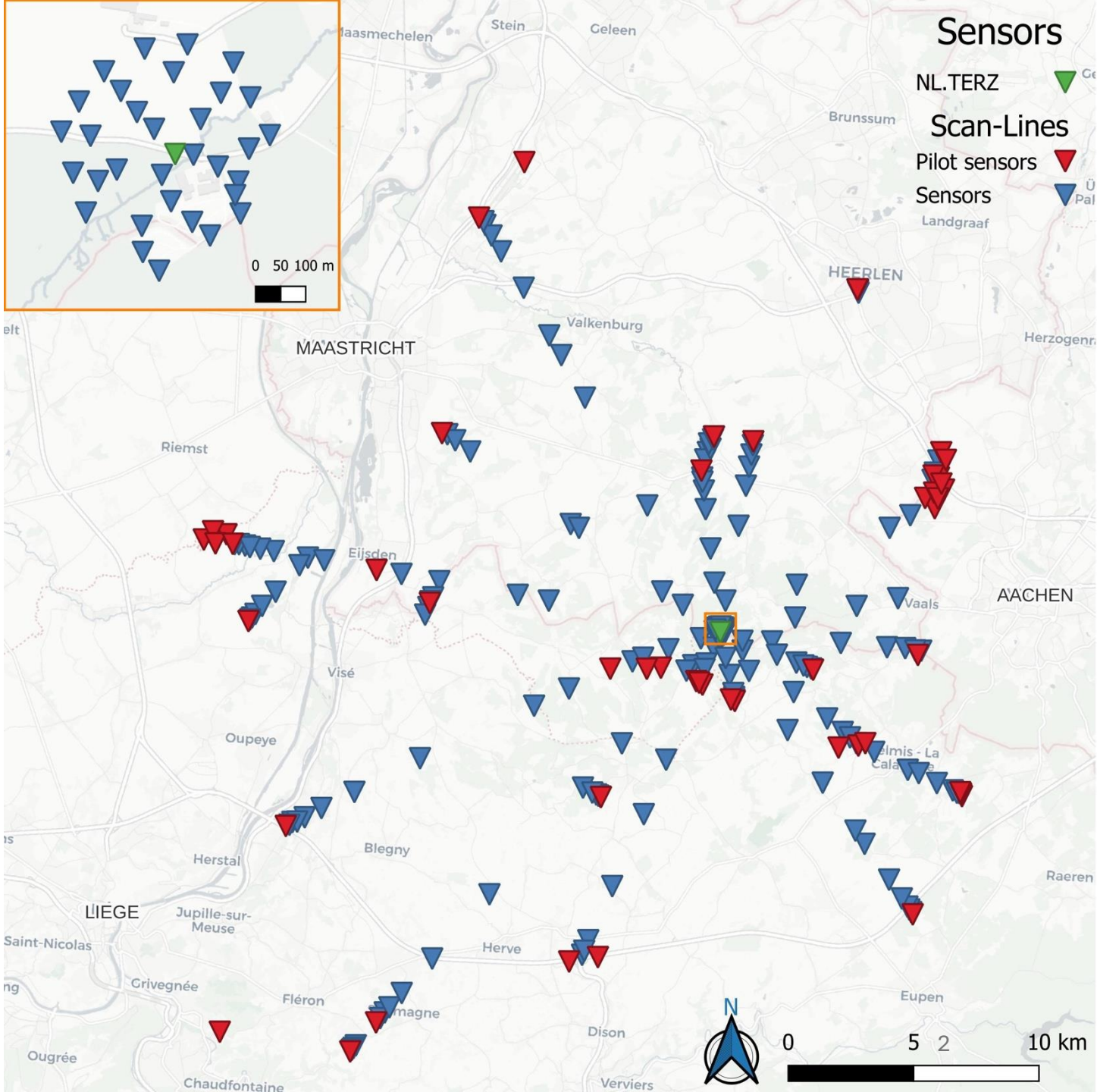
General context of the study
Numerical estimation of Newtonian Noise (NN)

Step 1	Measuring PSD at multiple locations
Step 2	Building a realistic geophysical model
Step 3	Characterizing sources to feed into the model
Step 4	Reproducing the PSD through numerical modelling of a realistic geophysical model (geometry/source)
Step 5	Numerical integration of the obtained wavefield to estimate the NN

This study focus is on the noise source characterization

Experimental design

- Array centered around Terziet (NL.TERZ)
- Scan-lines towards identified potential noise sources
  - Wind-turbines
  - Bridges/Tunnels
  - Railways
  - Airport
  - Industrial pumps
  - Etc.
- Pilot sensors: sensors positioned as close a possible from source

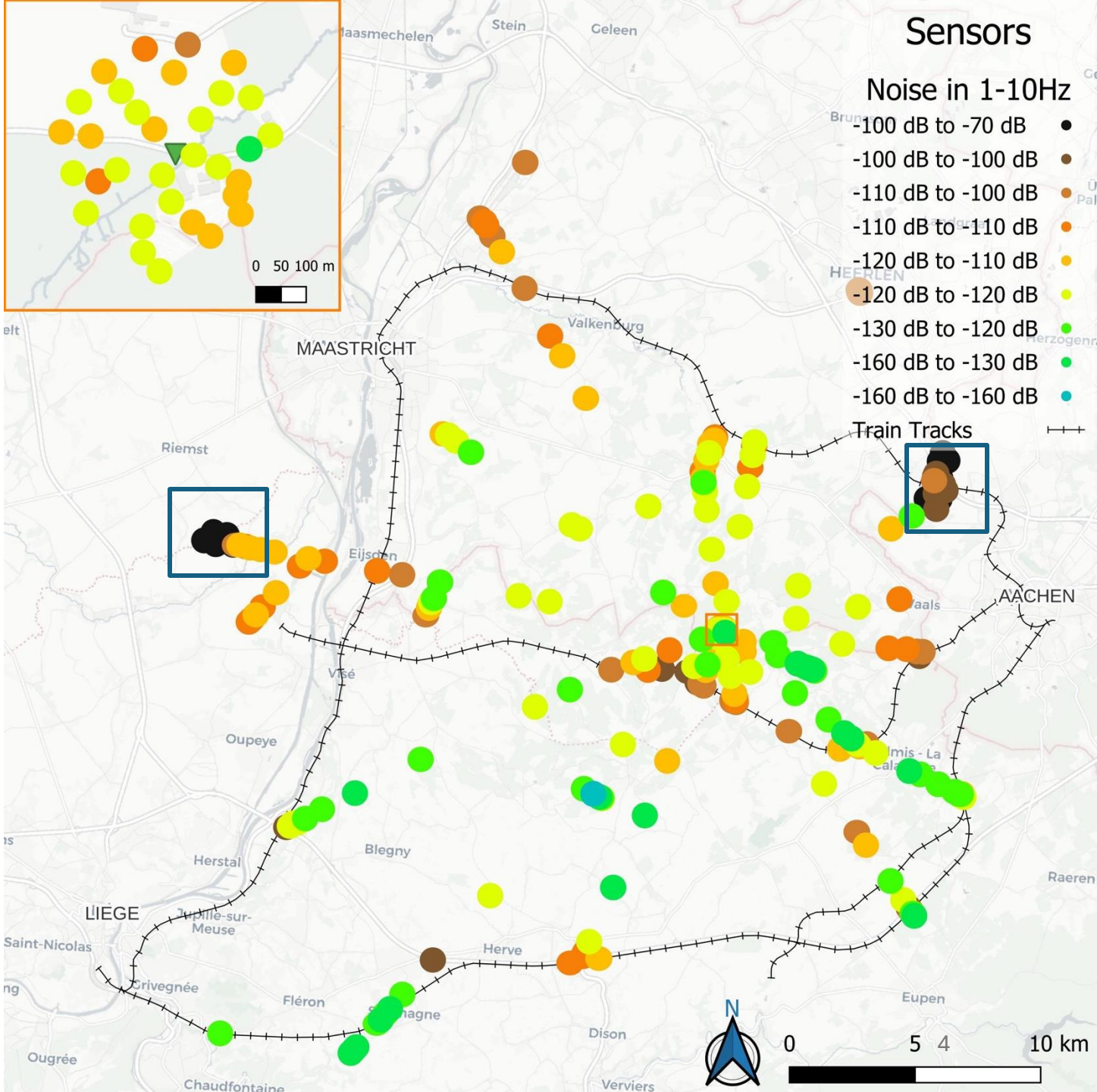


Experimental design

- 230 Smartsolo IGU-16HR 3C geophones
  - 5 Hz natural frequency
  - Signal is analyzed with the instrument response removed
- 1 month deployment
  - Installation 4th of Novembre 2024
  - Recovery 2nd of Decembre 2024
- Sampling rate: 1000 Hz

Seismic noise levels at surface

- Wind turbines are the main noise source in the area
- Train tracks (bridges/tunnels) are also significant

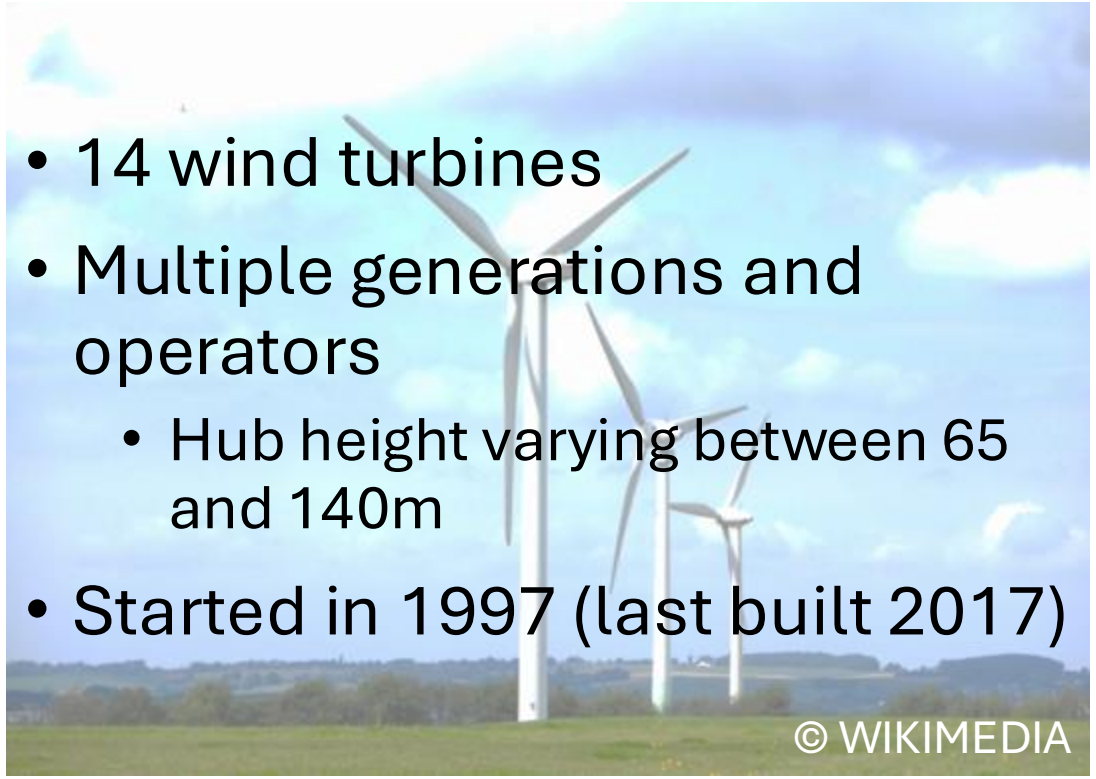


Wind turbines
Two case studies with different responses

Bassenge wind park (~ 20km away)

- 9 wind turbines
  - **Siemens Gamesa turbines**
  - **Total of 28 MW**
  - **Hub height: 93m**
  - **Tip height: 150m**
- Built in 2022

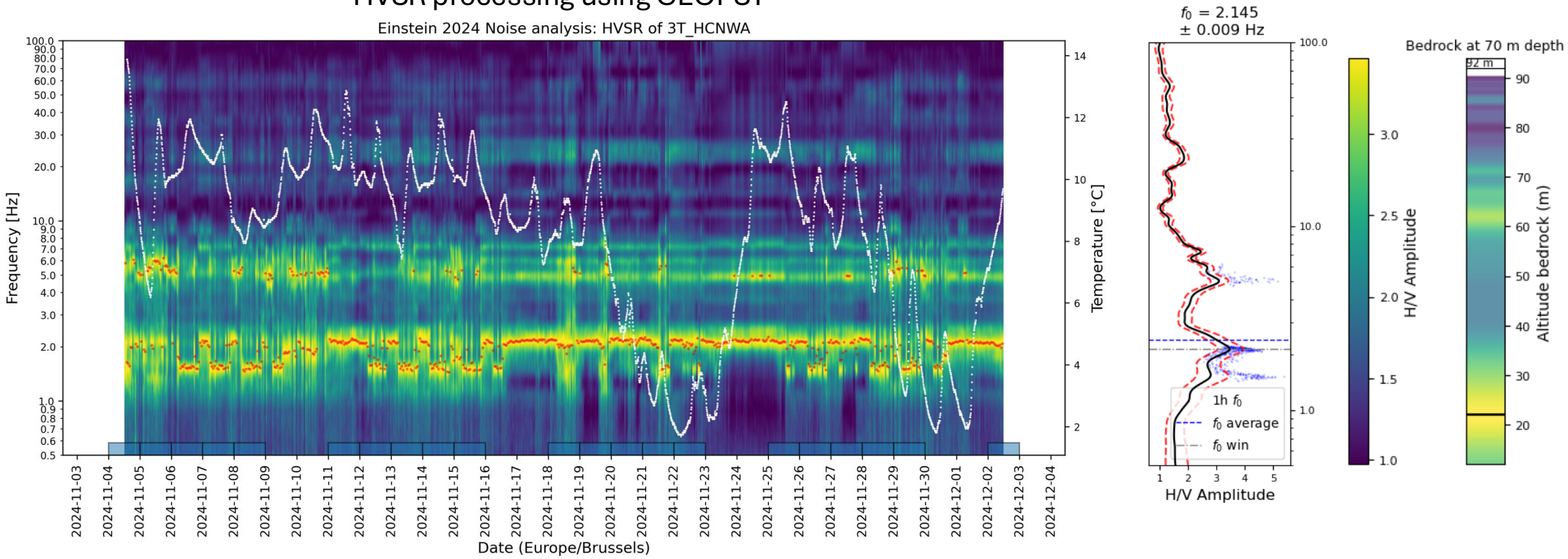
Aachen wind park (~ 10km away)



- 14 wind turbines
- Multiple generations and operators
  - Hub height varying between 65 and 140m
- Started in 1997 (last built 2017)

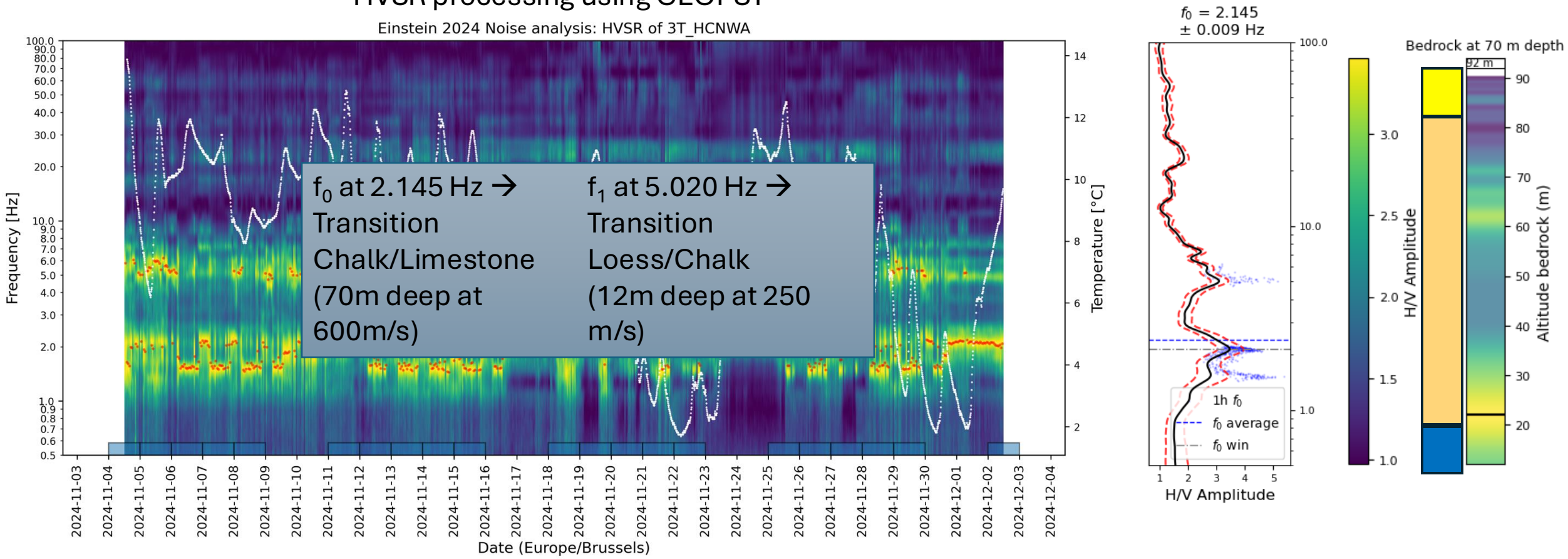
Wind turbines
Geological model from HVSR - Bassenge

HVSR processing using GEOPSY



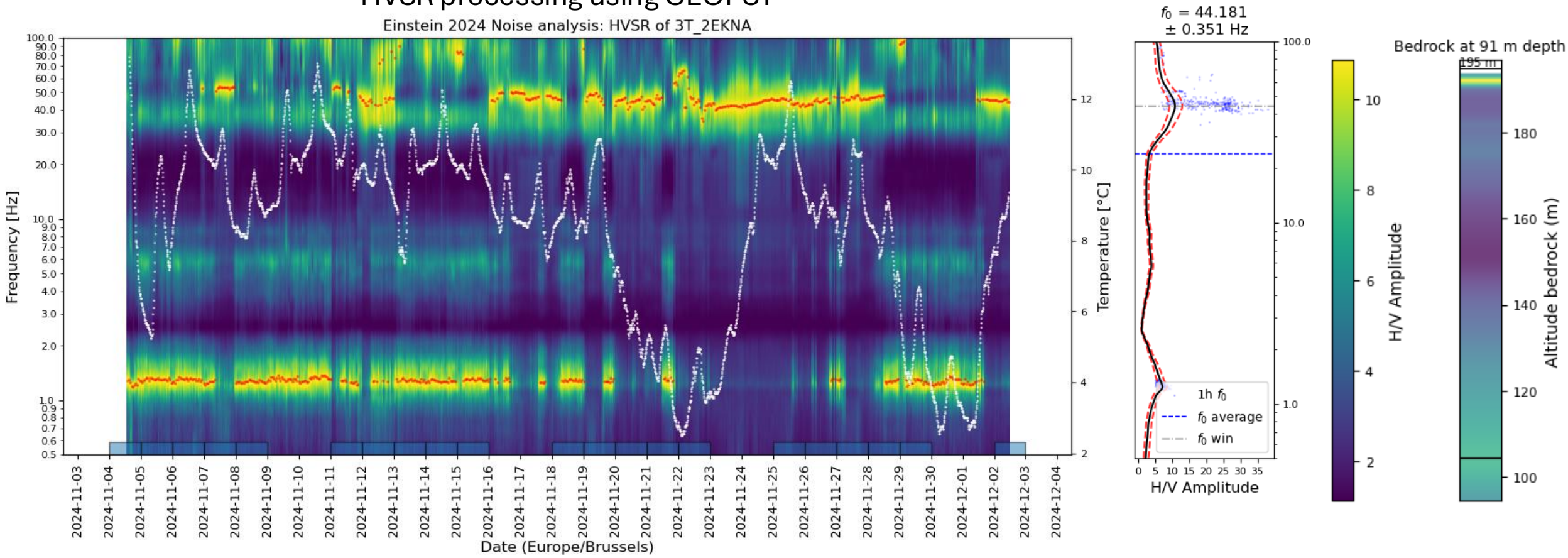
Wind turbines
Geological model from HVSR - Bassenge

HVSR processing using GEOPSY



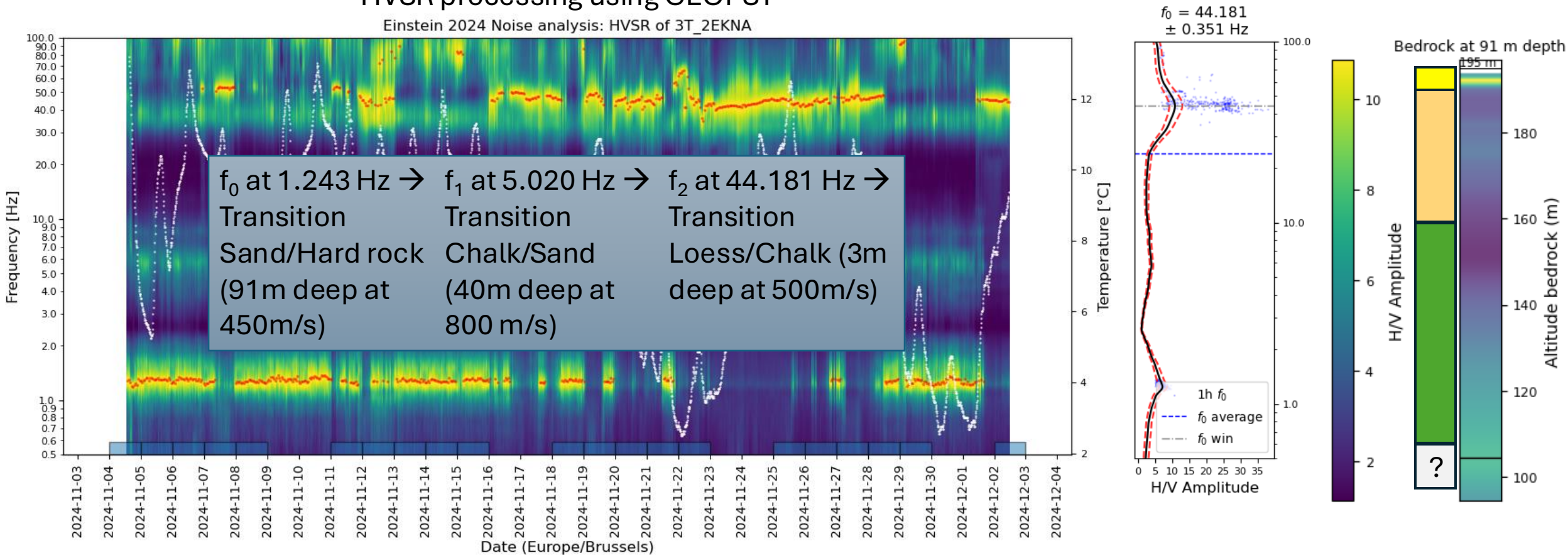
Wind turbines
Geological model from HVSR - Aachen

HVSR processing using GEOPSY

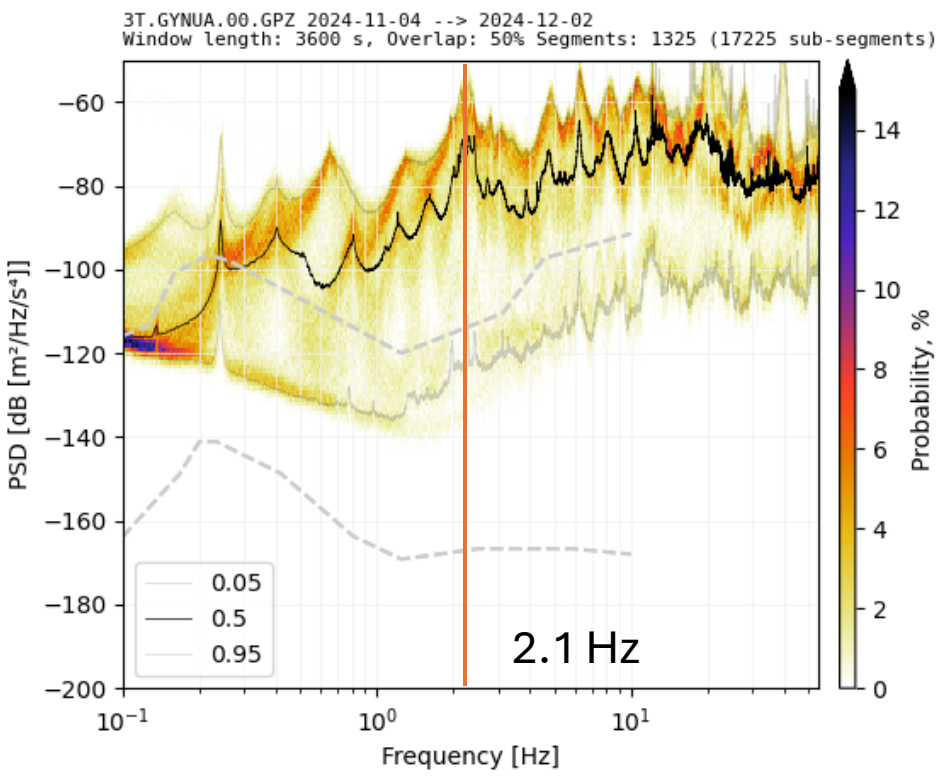


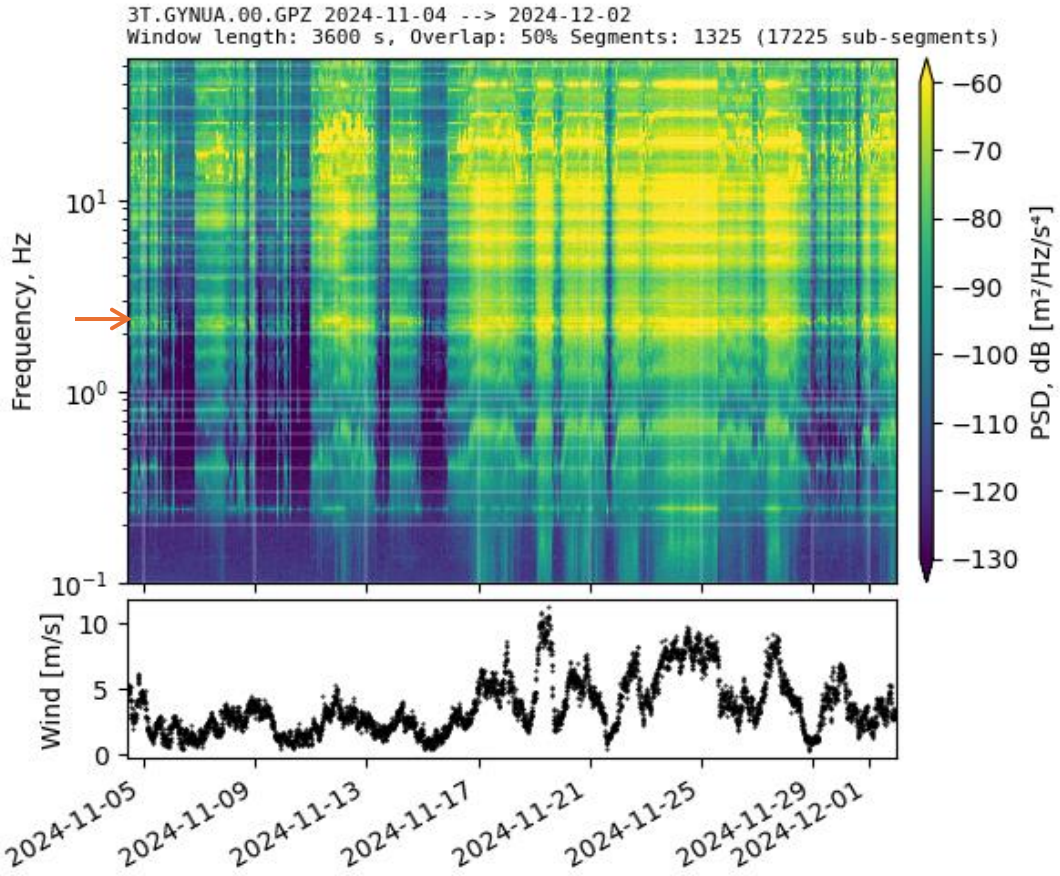
Wind turbines
Geological model from HVSR - Aachen

HVSR processing using GEOPSY



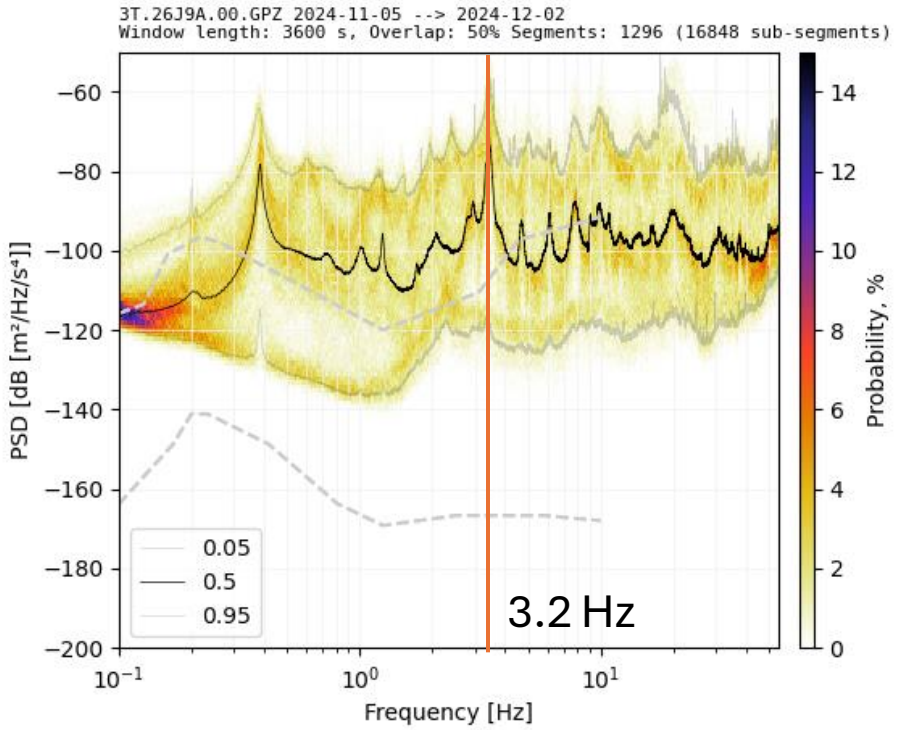
Wind turbines
Bassenge - built in 2022



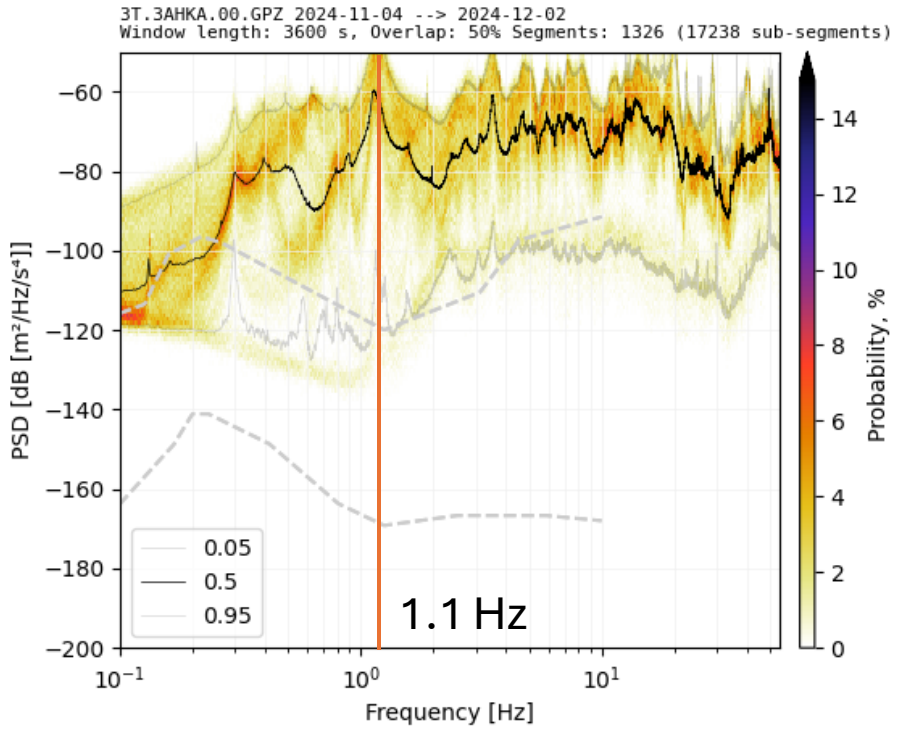


Wind turbines
Aachen – built in 1997, new WT in 2016

Older generation

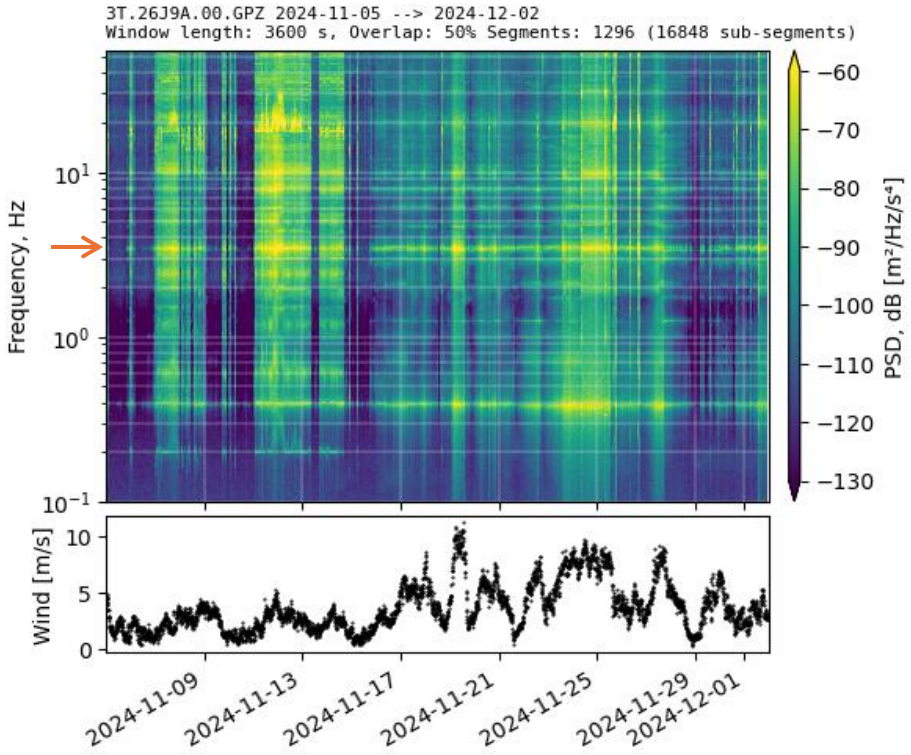


Newer generation

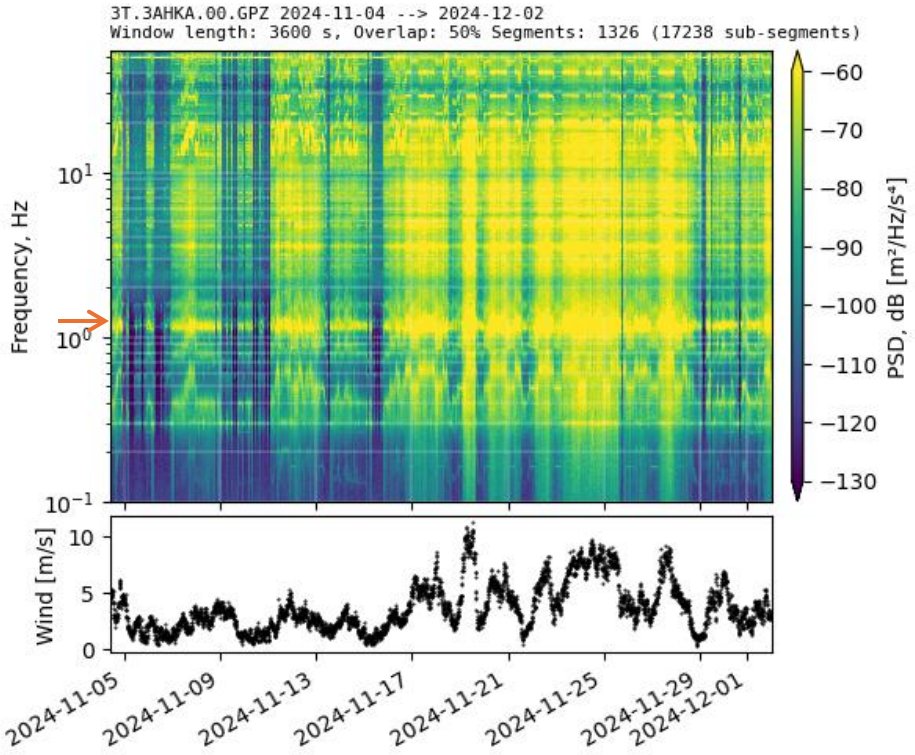


Wind turbines Spectrograms

Older generation

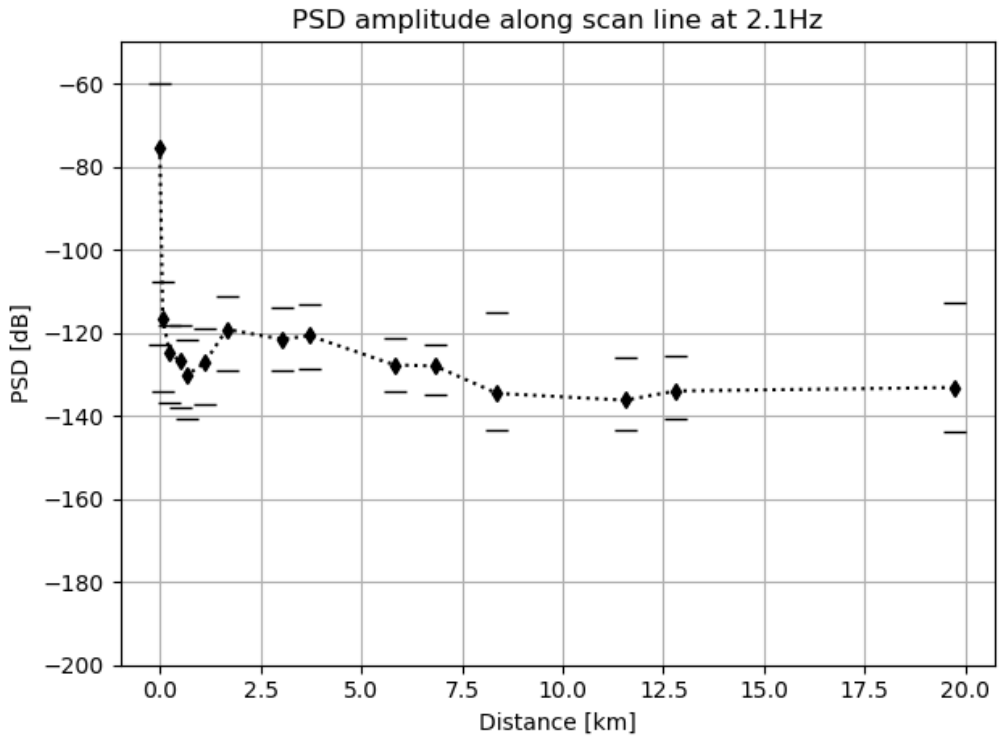


Newer generation

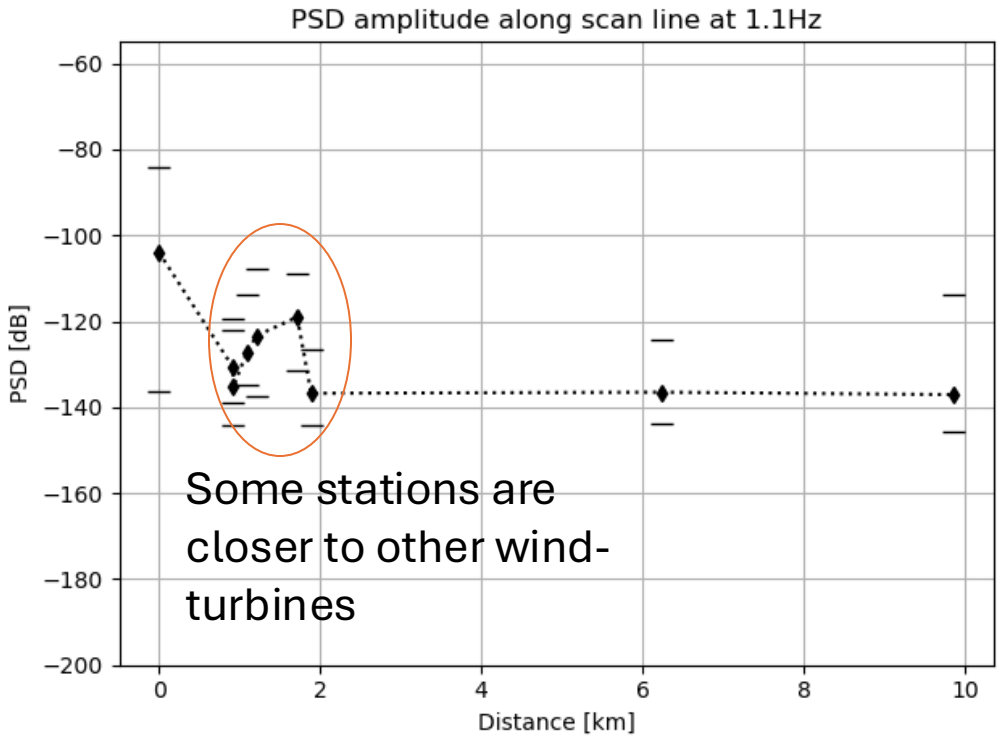


Wind turbines
Decrease of the amplitude with distance

Bassenge – Resonance at 2.1 Hz



Aachen – Resonance at 1.1 Hz

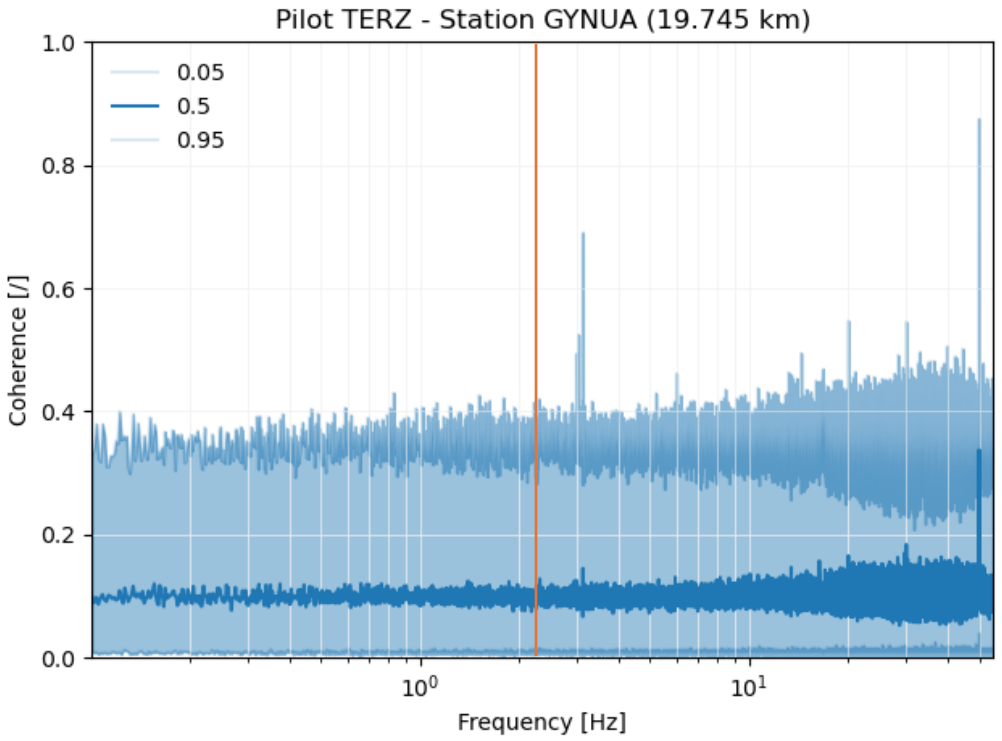


Wind turbines – at surface

- Both sites seem to show a very rapid decrease of the amplitude of the PSD around their respective resonance frequency
  - The amplitude reaches a stable value around -120dB 2.5km away from the turbines in both cases.
- What about the propagation at depth ?
  Do we see the wind-turbines in Terziet ?
  - Difficult to say as is (other noise sources).
  - Is the signal coherent ?

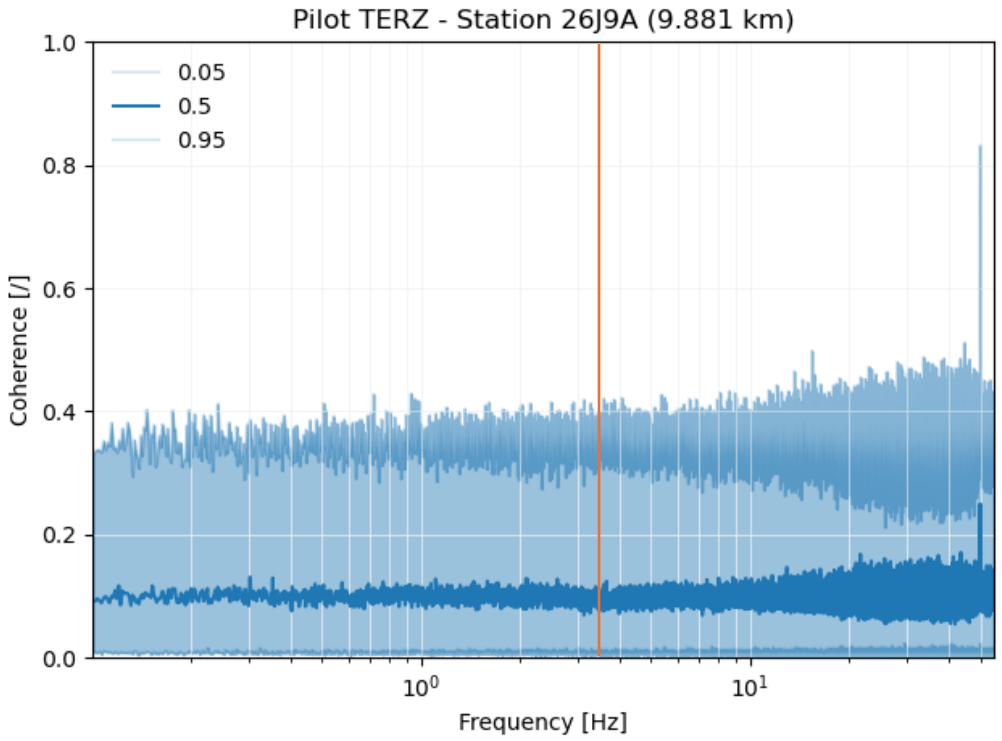
Wind turbines
Coherence with NL.TERZ (at depth)

Bassenge – Resonance at 2.1 Hz



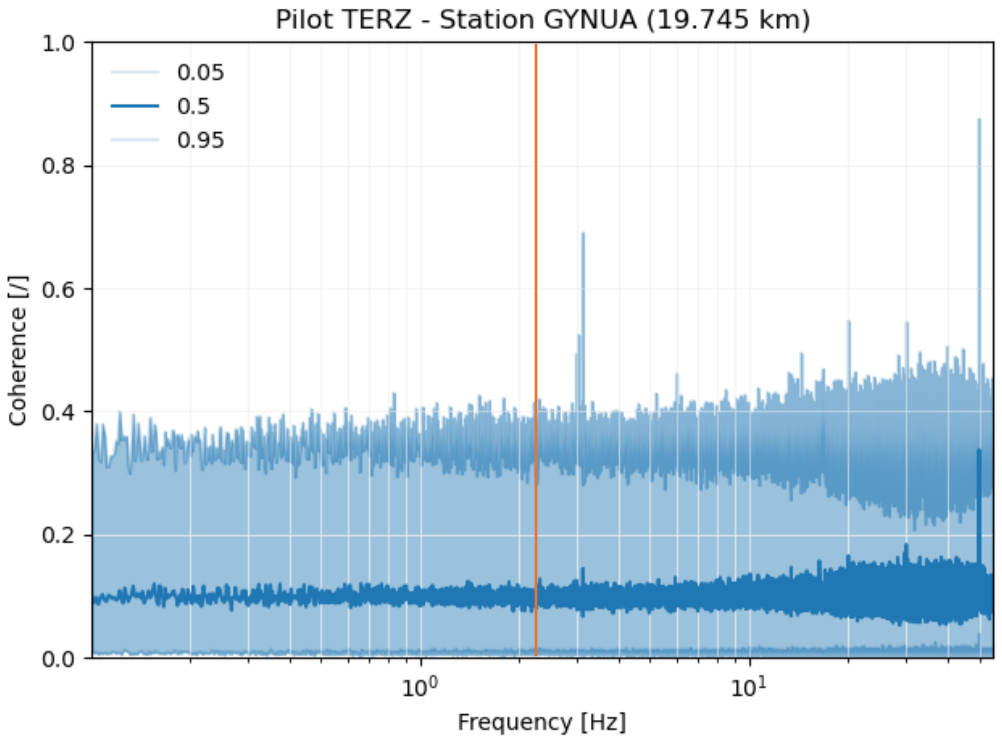
Aachen – Resonance at 3.2 Hz

Older generation



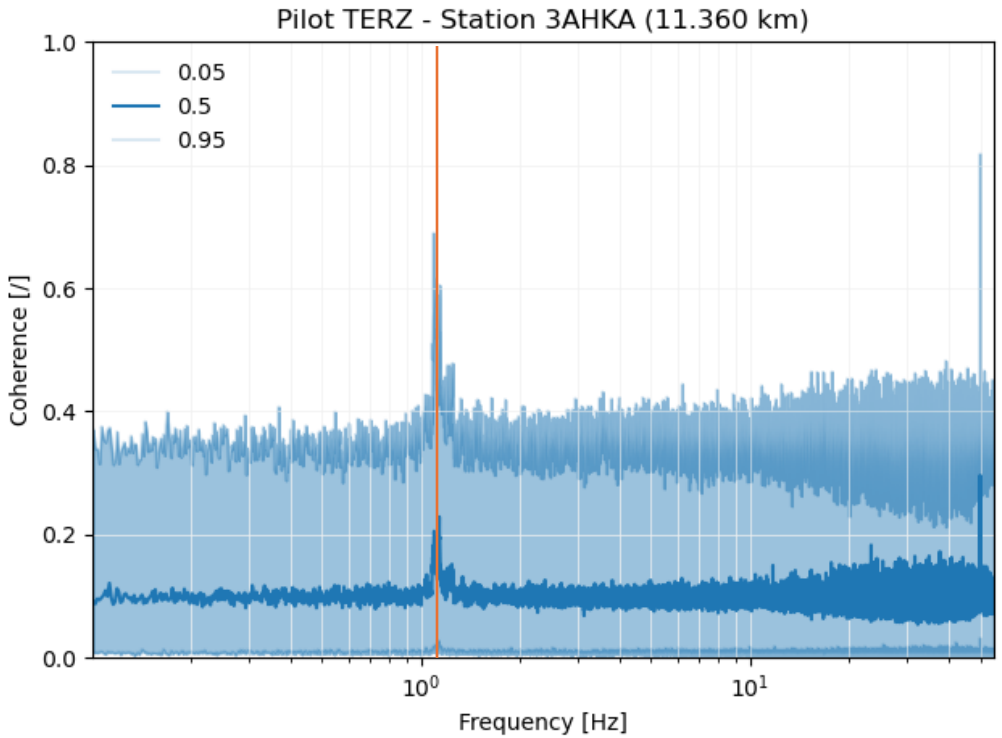
Wind turbines
Coherence with NL.TERZ (at depth)

Bassenge – Resonance at 2.1 Hz



Aachen – Resonance at 1.1 Hz

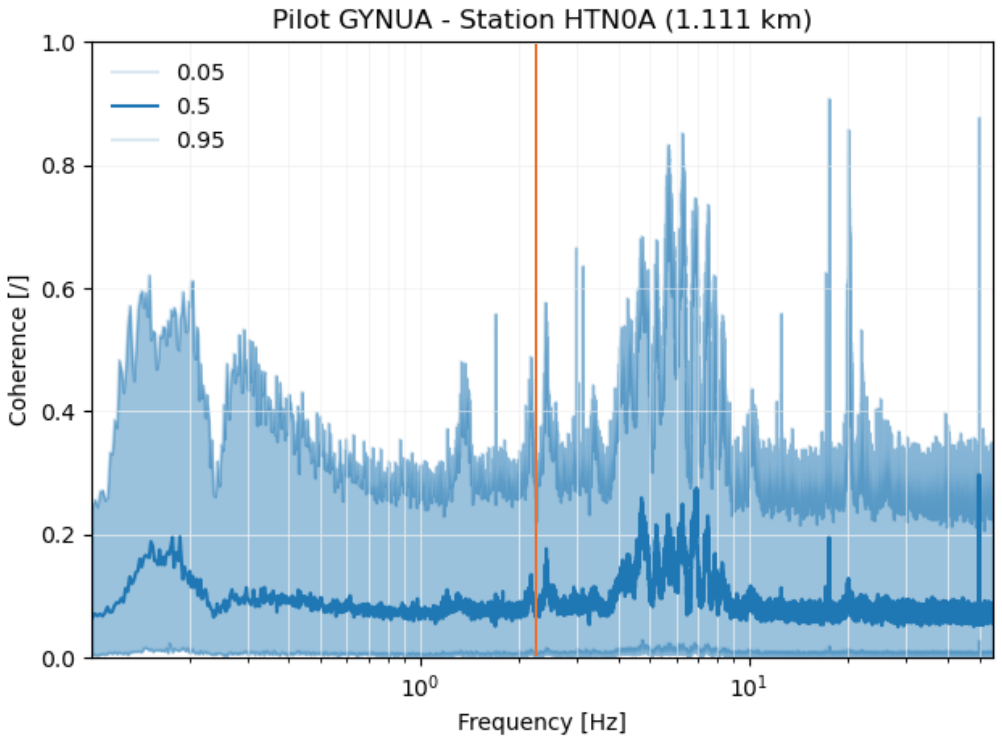
Newer generation



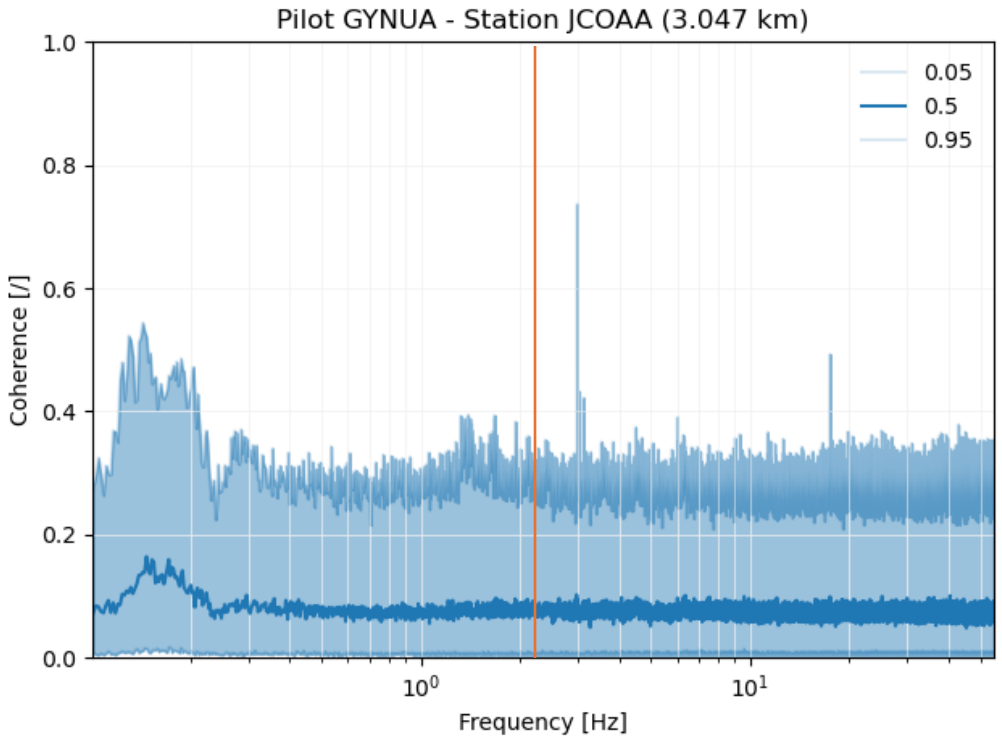
Only visible for the tallest (newest) wind turbines.

Wind turbines - Bassenge
Coherence at surface

1.1 km away

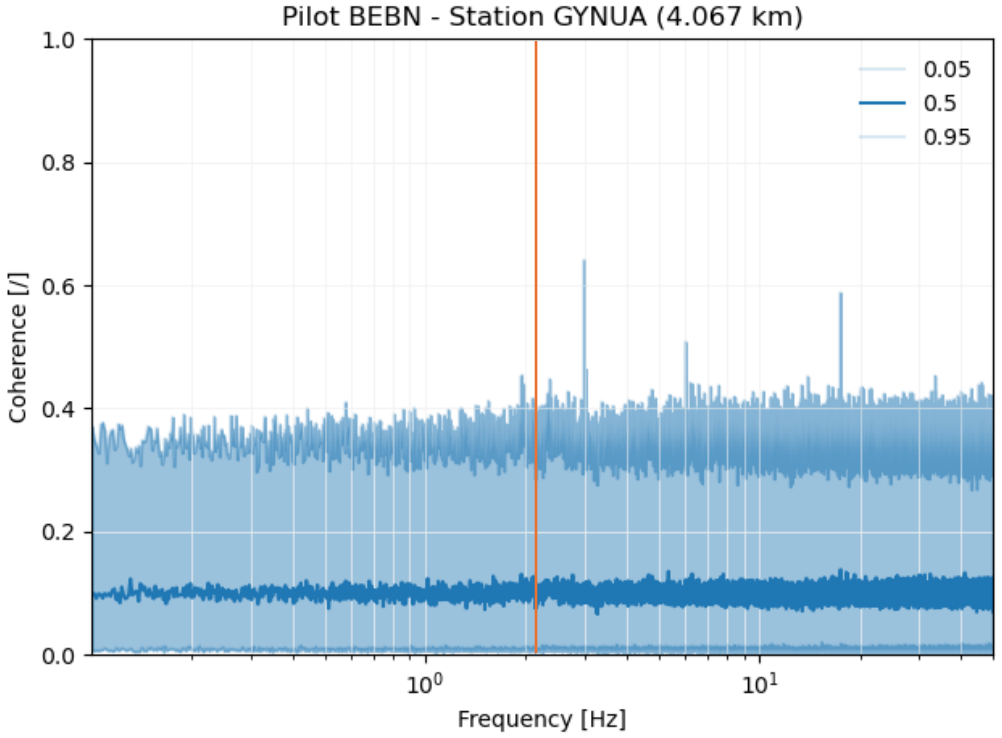


3.0 km away

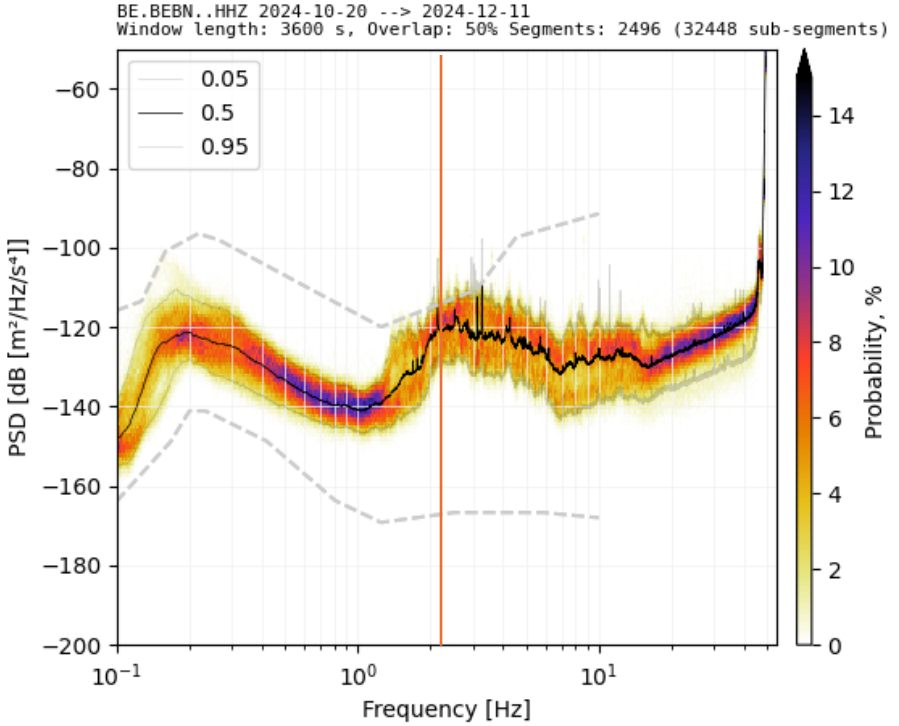


Wind turbines - Bassenge
Coherence with BE.BEBN (underground station)

4.0 km away

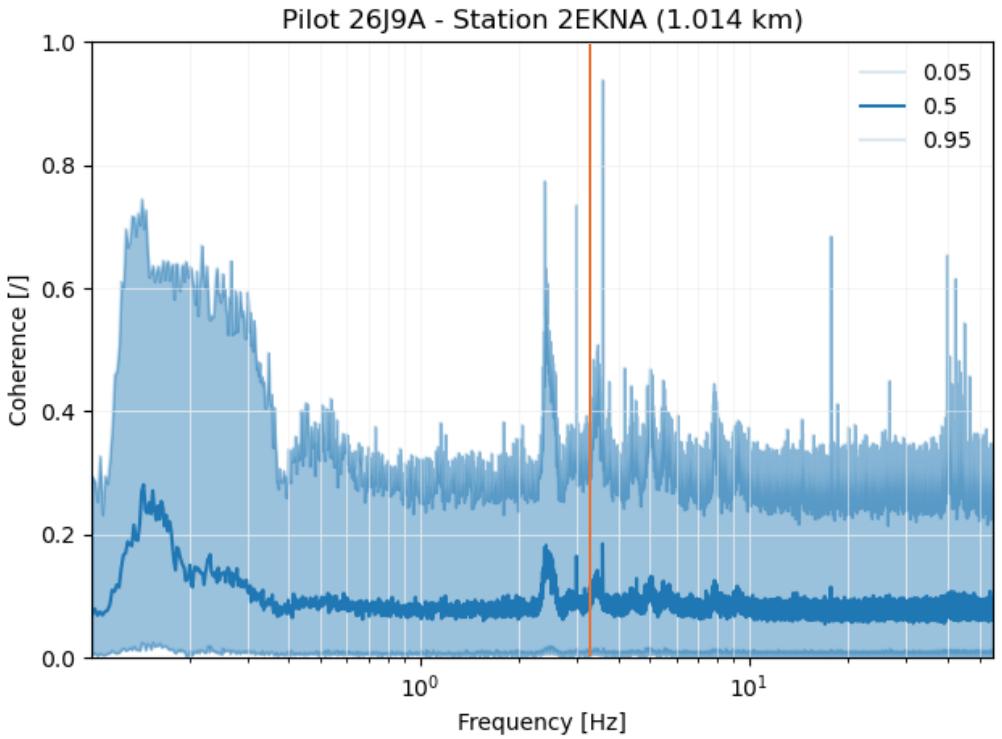


The station is located in an old underground fortress and directly coupled with the chalk

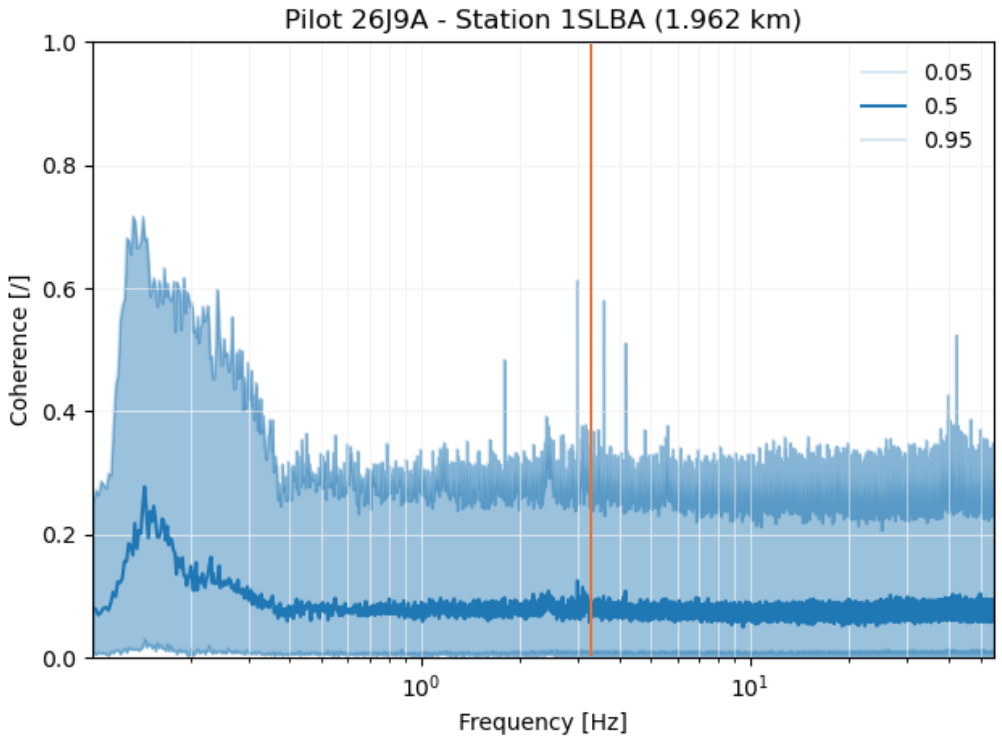


Wind turbines - Aachen
Coherence at surface (older turbines)

1.0 km away

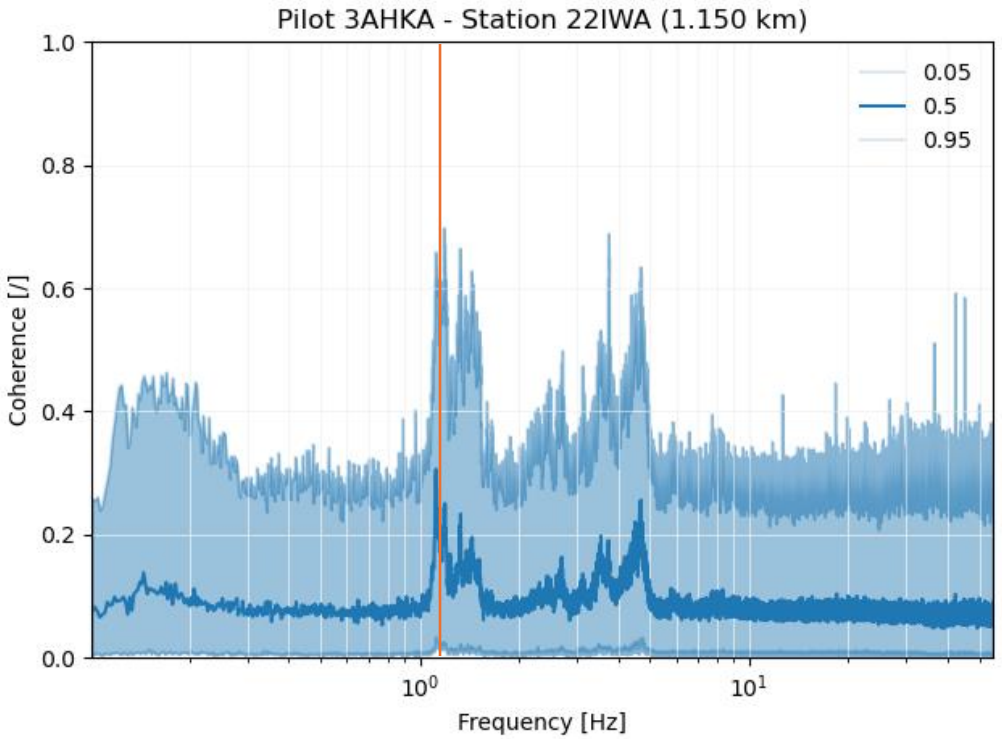


2.0 km away

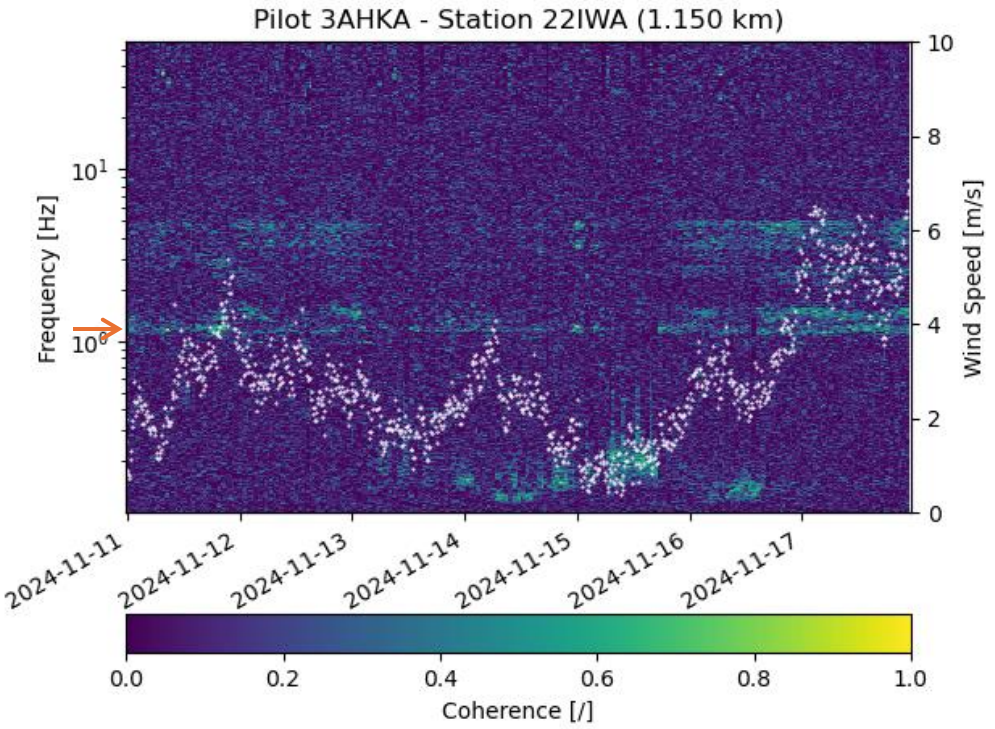


Wind turbines - Aachen
Coherence at surface (newer turbines)

1.1 km away

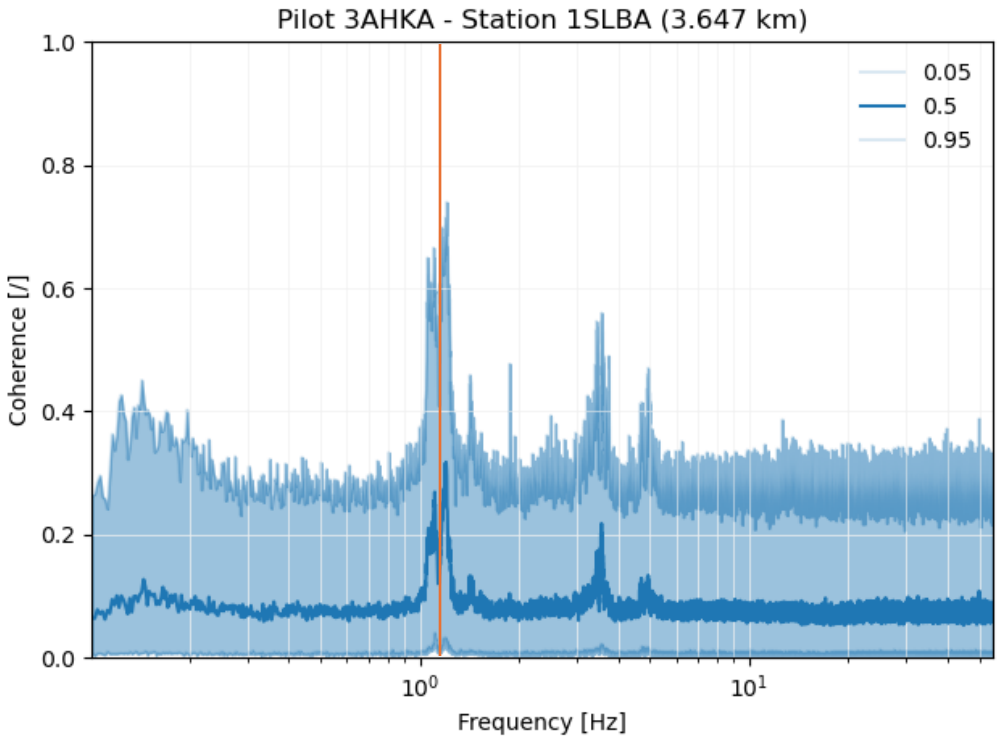


The coherence between the stations in more important during high winds

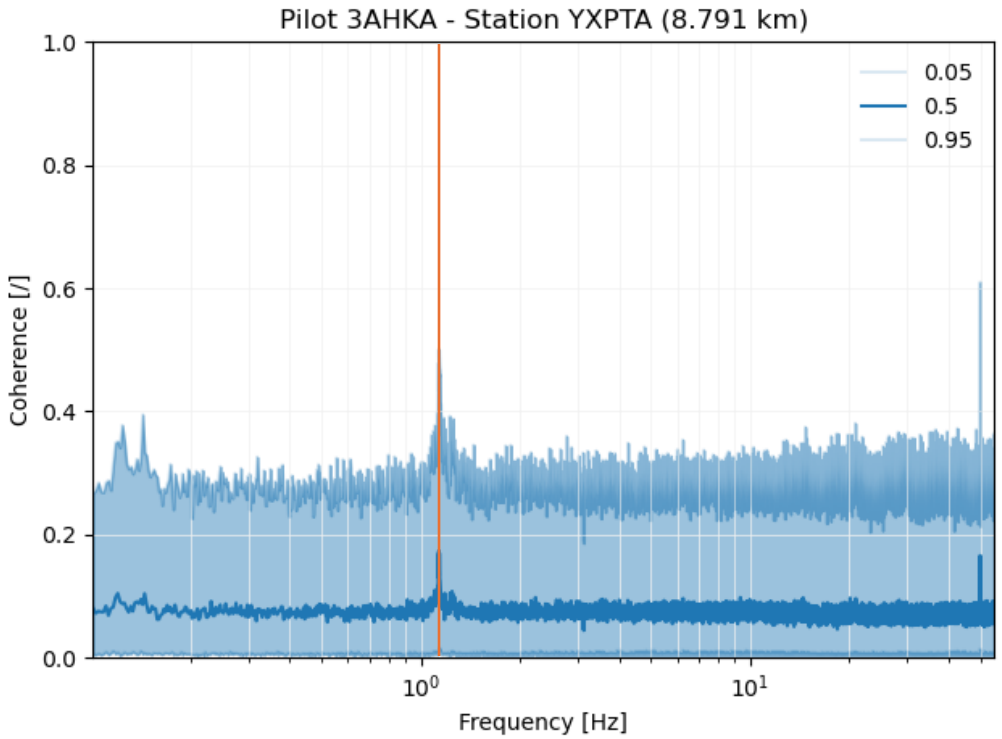


Wind turbines - Aachen
Coherence at surface (newer turbines)

3.6km away



8.8km away !



Conclusion

- Using scan-lines, we can analyze the decay of the signal amplitude towards a central location (here Terziet)
  - It helps to understand which sources are visible in the spectrum at the center.
- The case of wind turbines is very important for ET.
  - Different wind turbines have different seismic responses and attenuation with distance.
  - The turbines in Bassenge and in Aachen (newer ones) have a similar size, but have a very different response
- Repeating this process for every potential source will enable a better understanding of the wavefield and help to feed realistic geophysical models for Newtonian Noise modelling.

Future works

- Finishing all the processing of the coherence between stations, HVSR, etc.
- Beamforming on the central array (3km aperture) to confirm the identified major sources.
- Computing cross-correlations to infer the Green's function locally around Terziet (similar to S. Koley work, see: #175 in this session)
- Feed a realistic 3D geophysical model based on the dataset to model Newtonian Noise numerically.

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Questions ?

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