Local sources of seismic noise at the the Sardinia site

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Outline

- Introduction;
- Noise by local sea;
- Impact of local wind on seismic noise;
- Contribution from two road bridges to the overall seismic noise;

Introduction

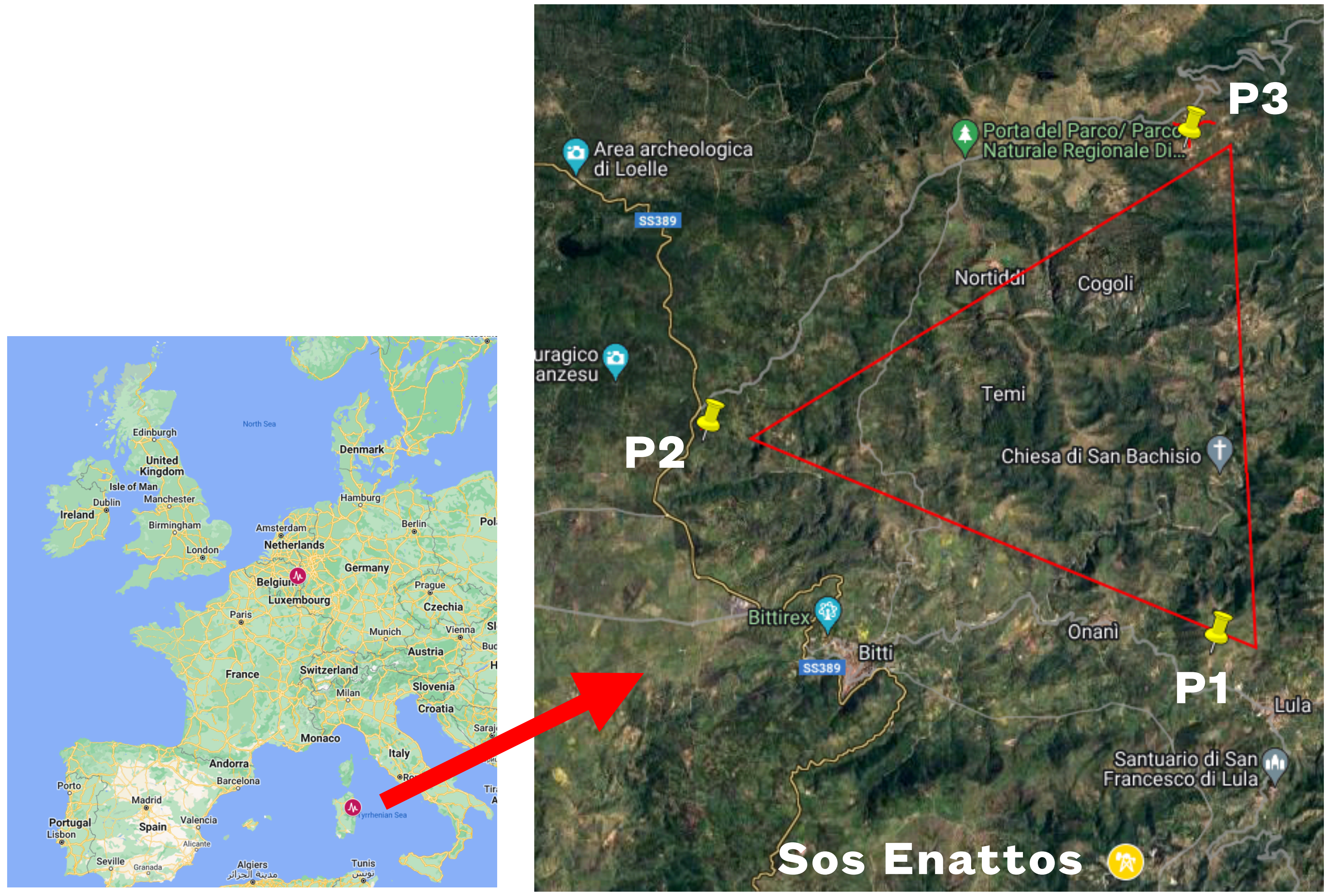
- Properties of seismic noise are influenced by local activities (natural and anthropogenic);
- Investigation of noise sources of human origin is particularly important for future decisions about exclusion zones;
- Gather useful information to adapt the detector seismic isolation and control system.

Sos Enattos

- Four permanent seismic stations at different depths (current installations):
  - SOE0 (0m): Trillium 240s;
  - SOE1 (-84m): Trillium 360s and Guralp 360s;
  - SOE2 (-111m): Trillium 360s;
  - SOE3 (-160m): Trillium 240s;
- Davis Vantage Pro2 weather station.

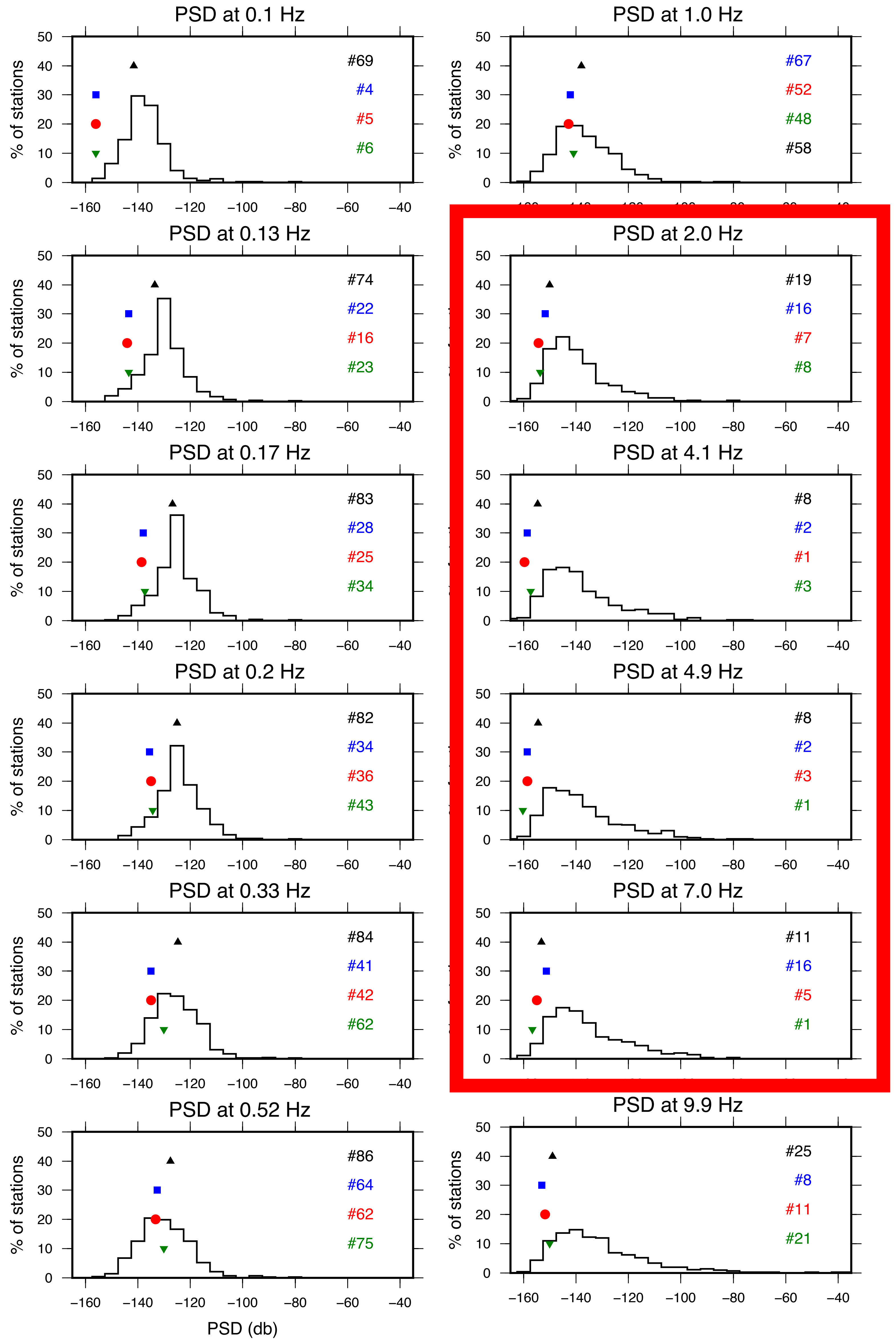
P2/P3

- Surface: Trillium 120H
- Borehole: Trillium 120Q



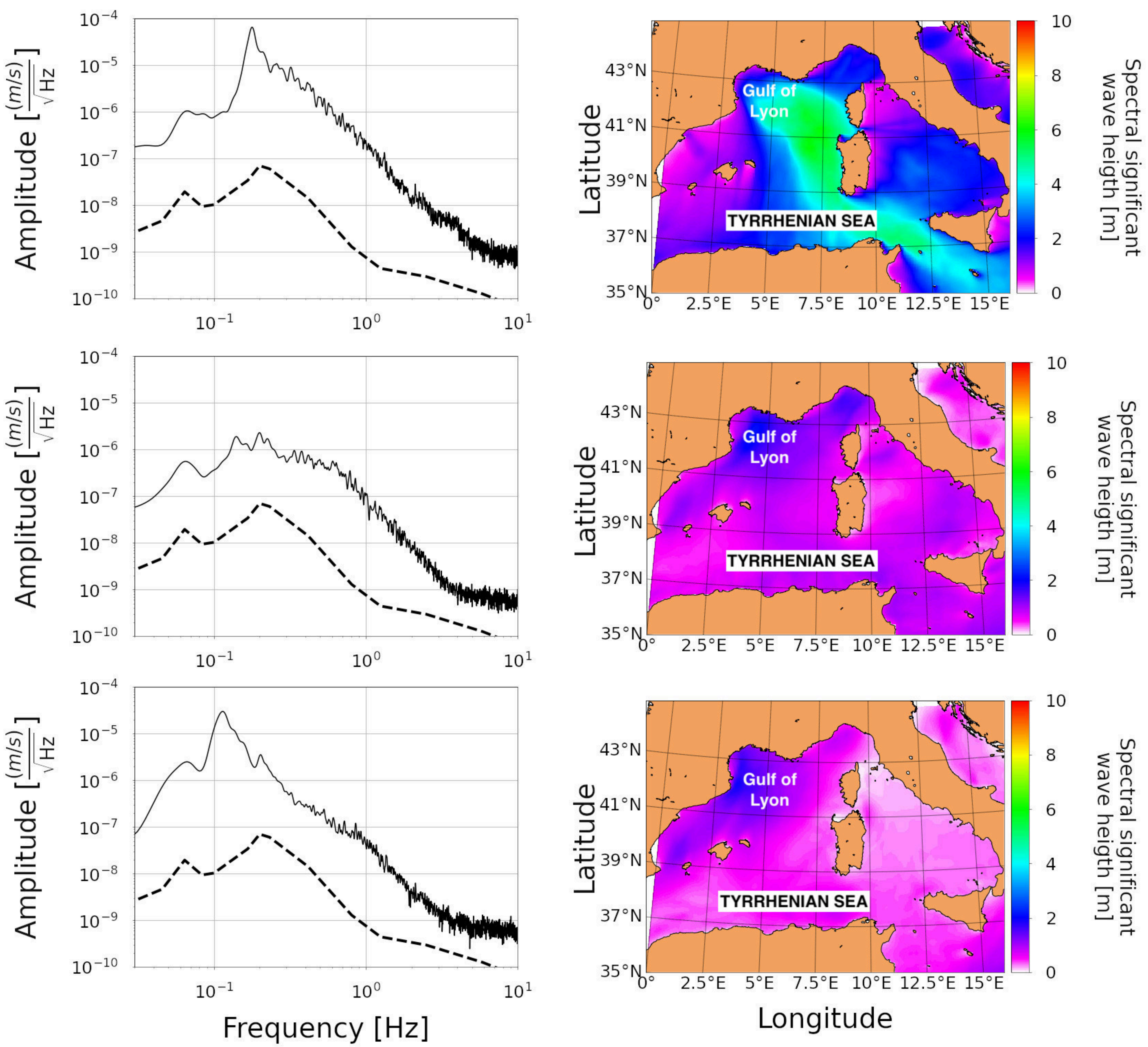
Ranking

- In *Di Giovanni et al. (2021)* we published the ranking of Sos Enattos among other seismic stations worldwide;
- We updated the ranking for SOE1, SOE2, P2 and P3;
- Data were downloaded from IRIS and they are from a subset of stations of the GSN that are considered quiet;
- In the frequency band of interest for ET the ranking is very good.



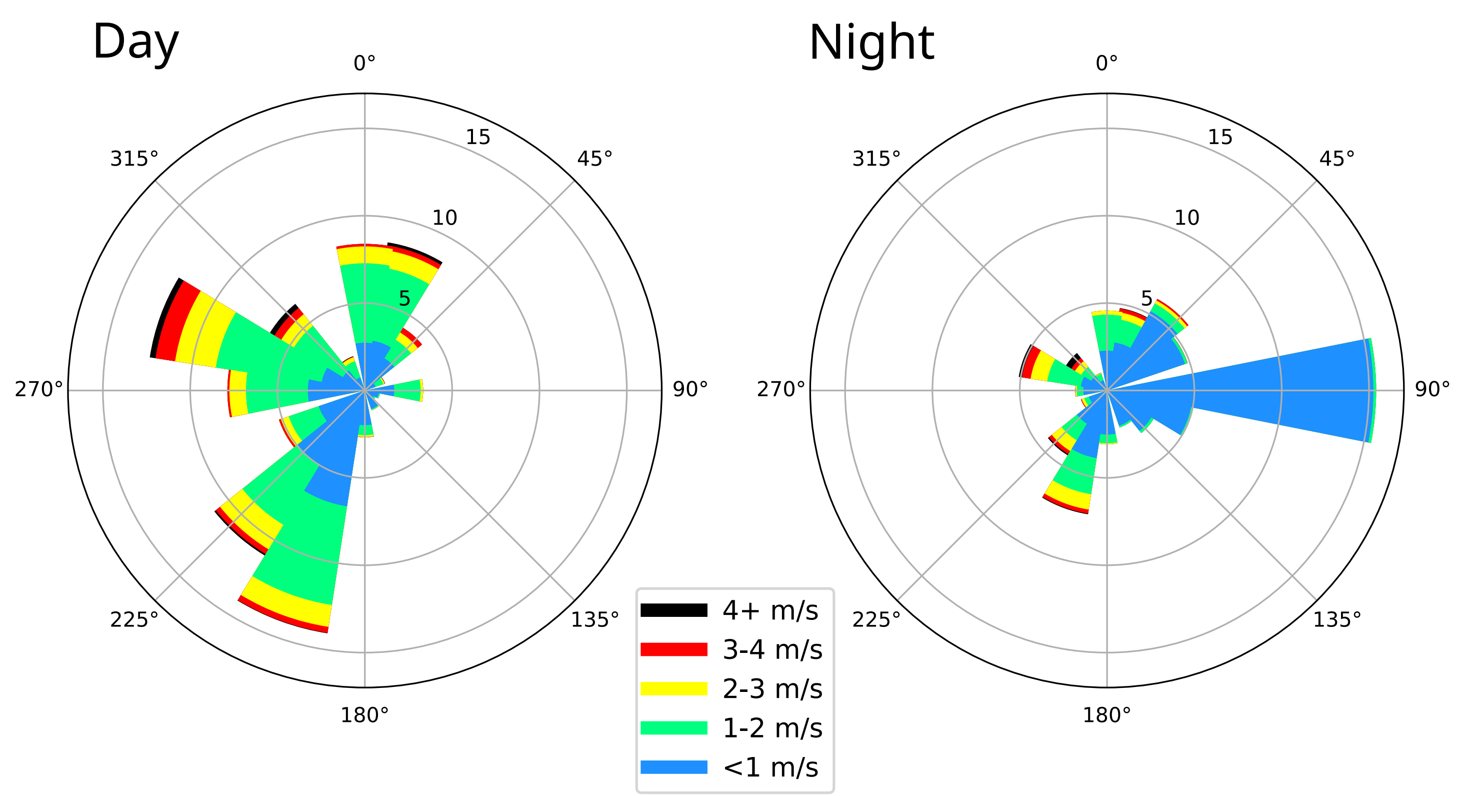
Noise by local sea

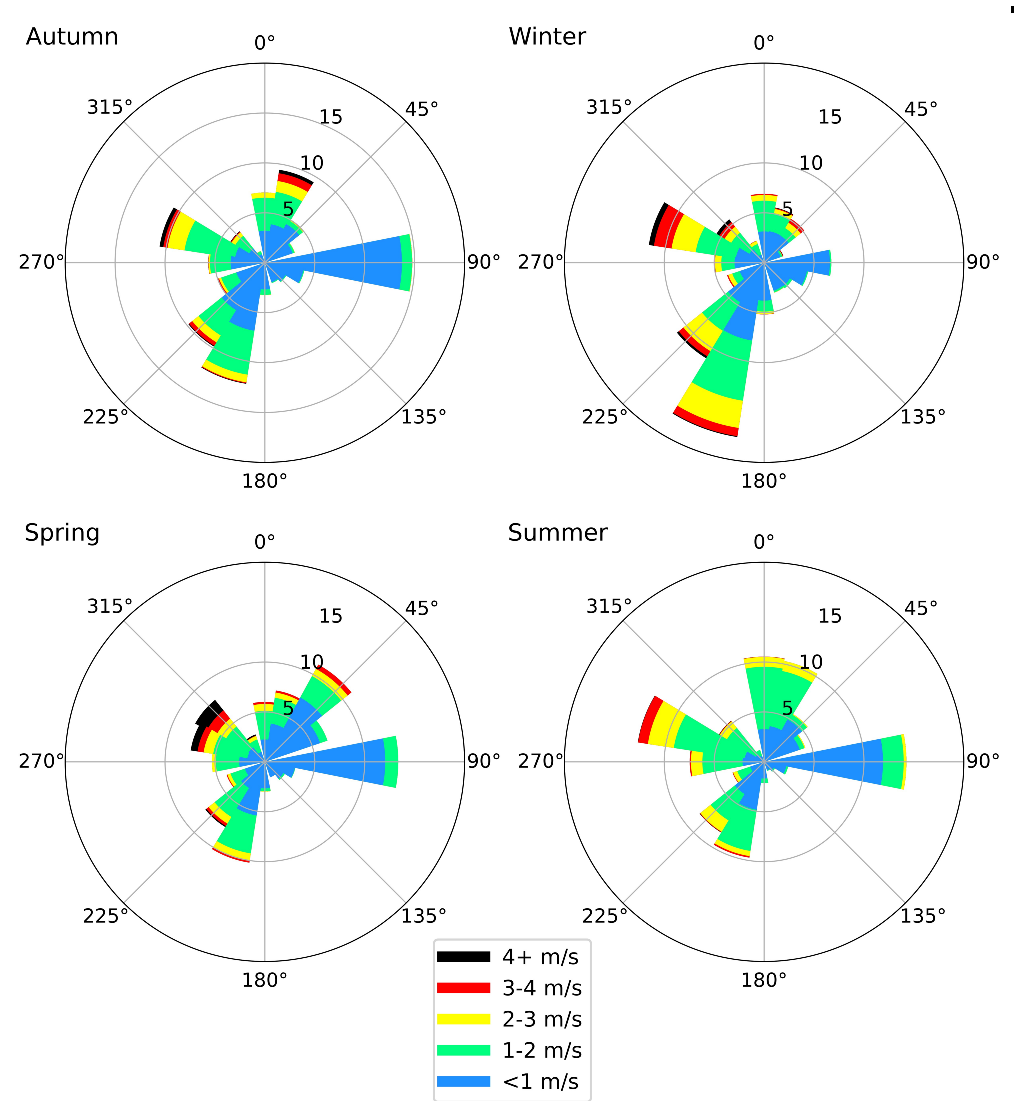
- From previous studies, we have already identified the area that generates the main contribution to microseismic noise in Sardinia;
- Further analysis revealed that rough Tyrrhenian Sea generates a spectral peak between 0.17Hz and 0.22Hz and quiet Tyrrhenian sea corresponds to spectra that are mostly flat between 0.1Hz and 0.7Hz;
- Sometimes, coincident with a quiet local sea, we observe a peak at frequencies of about 0.12Hz, this is caused by storms in the Atlantic Ocean;
- This can be explained in the framework of *Anthony et al. (2022)*, who observed how different ocean basins have distinct microseismic peaks, and of *Koper and Burlacu (2015),* who attributes the shorter period peak to the local sea and the longer period peak to more distant microseisms.

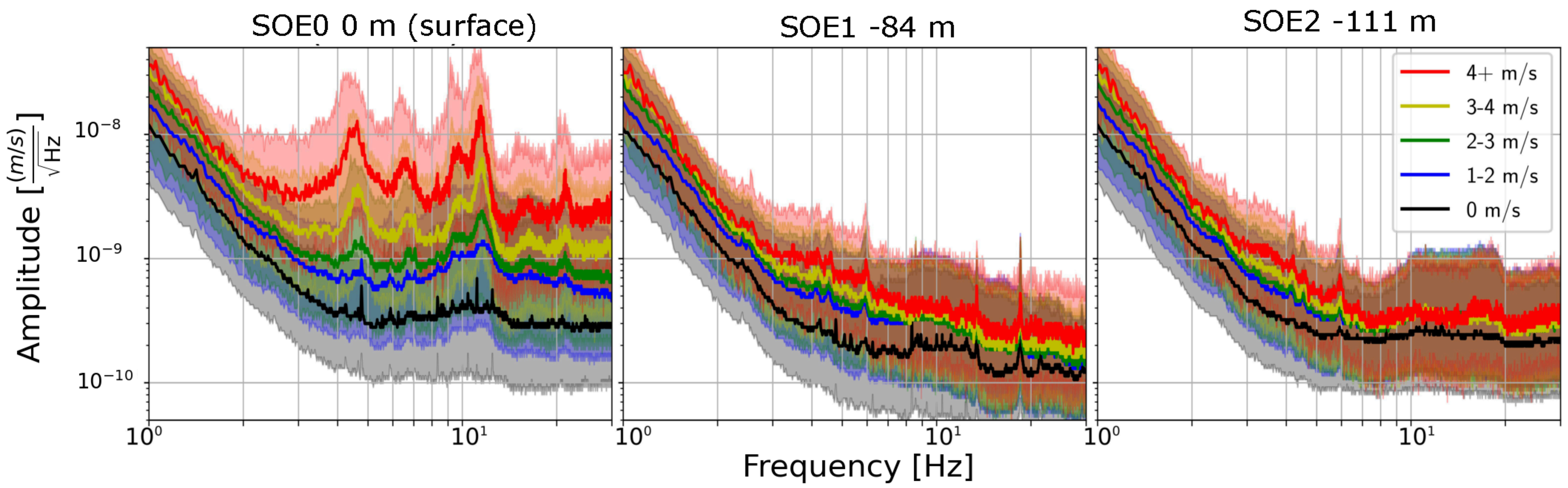


Impact of local wind on seismic noise

- Compare wind speeds with seismic data recorded in Sos Enattos;
- Wind show seasonal and day night variations;
- Effect of wind on surface seismic noise is apparent;
- Peaks whose intensity increases with wind;
- Underground, we see only a wind/no wind effect;
- Rather than excitation of structures outside, we suppose that this effect is caused by wind currents flowing inside the tunnels through the main entrance and ventilation shafts (need pressure and infrasound data to confirm);
- No correlation was found between wind direction and increase of seismic noise outside.

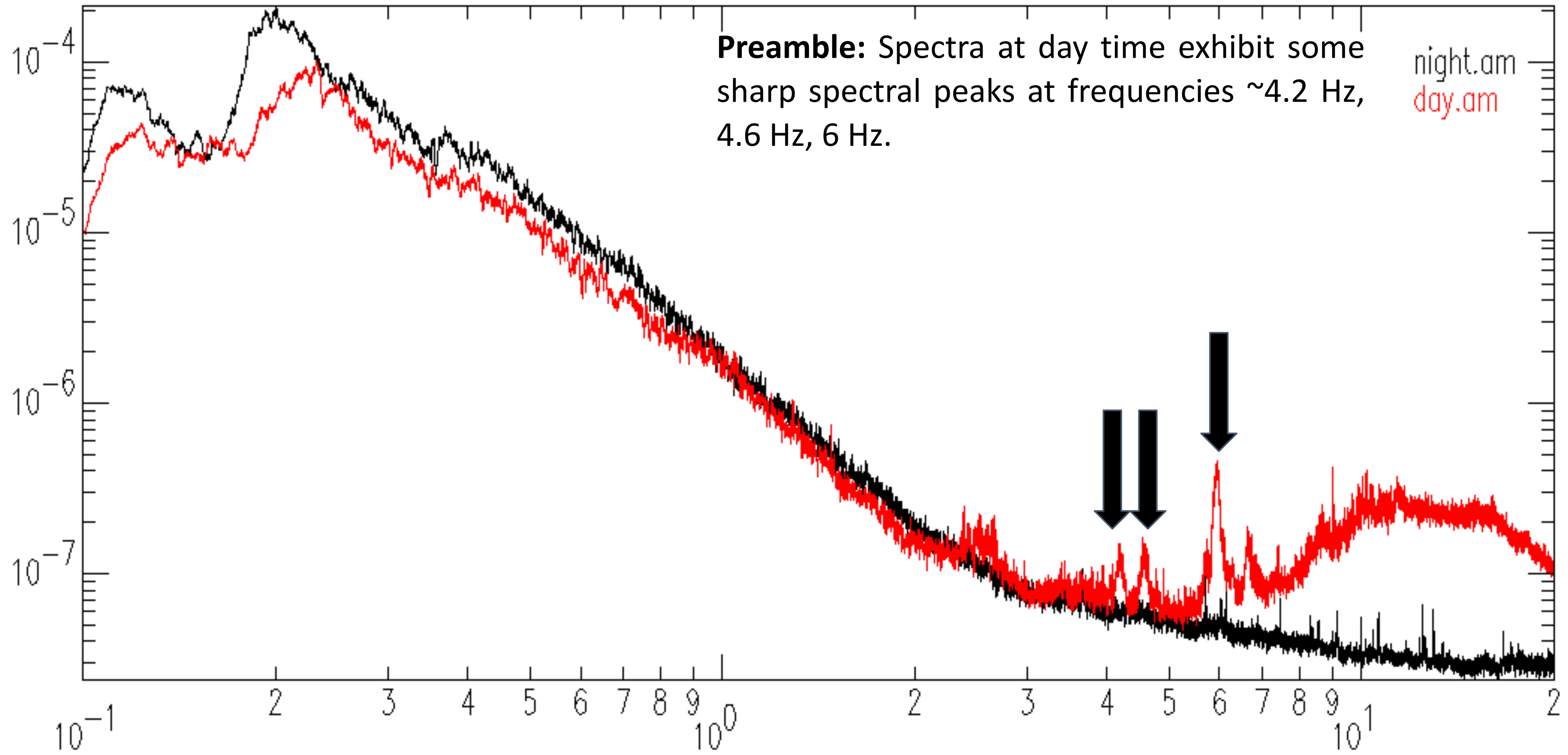


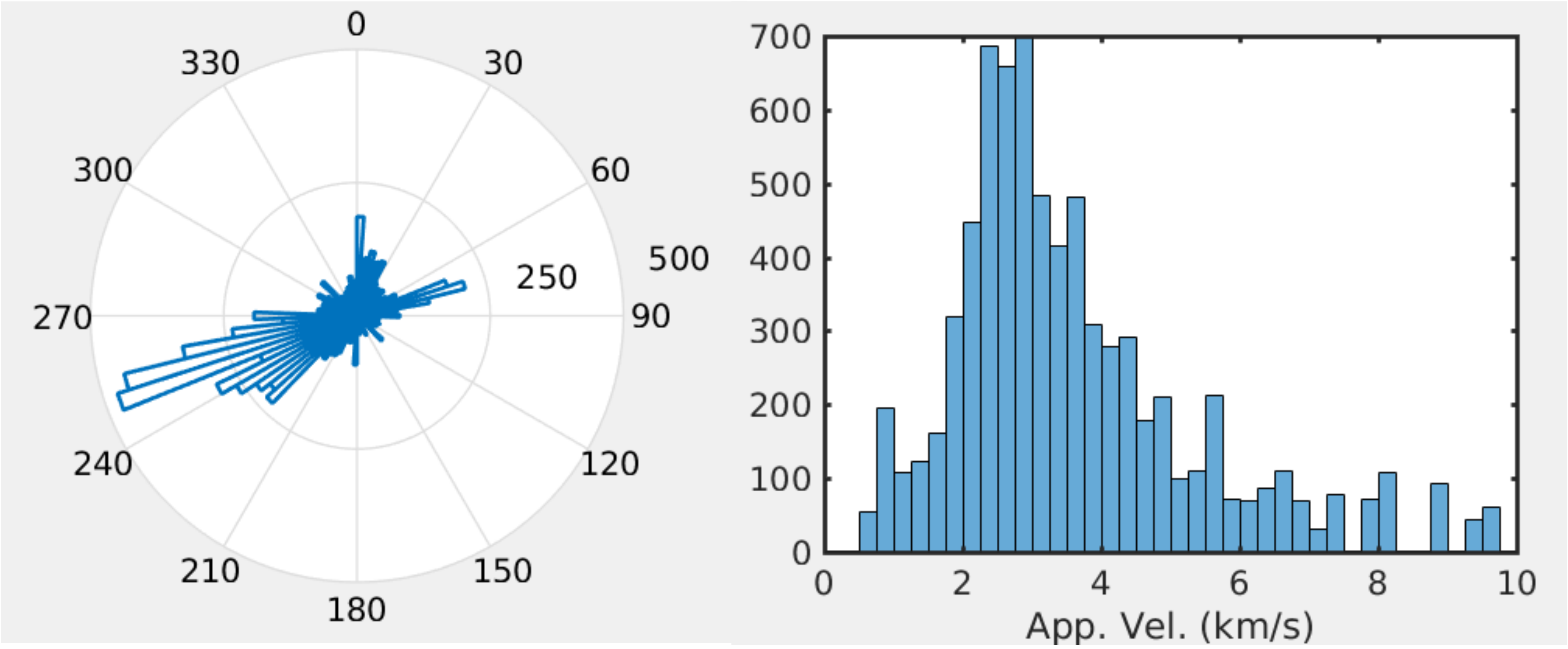




Bridge noise

- At the beginning of 2021, the deployment of a seismic array by INGV at Sos Enattos, revealed the presence of spectral peaks that seemed compatible with the presence of two road bridges nearby;



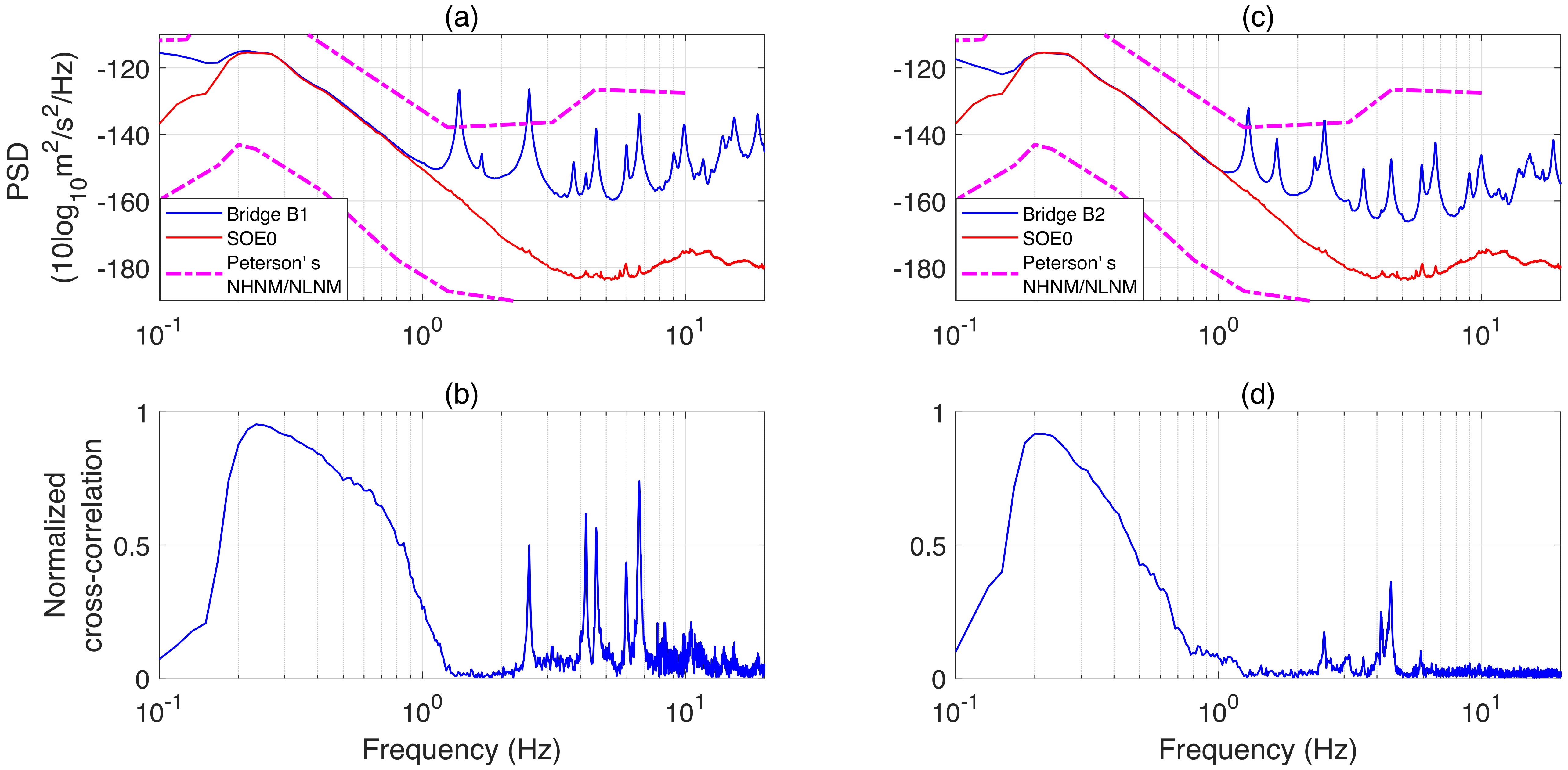


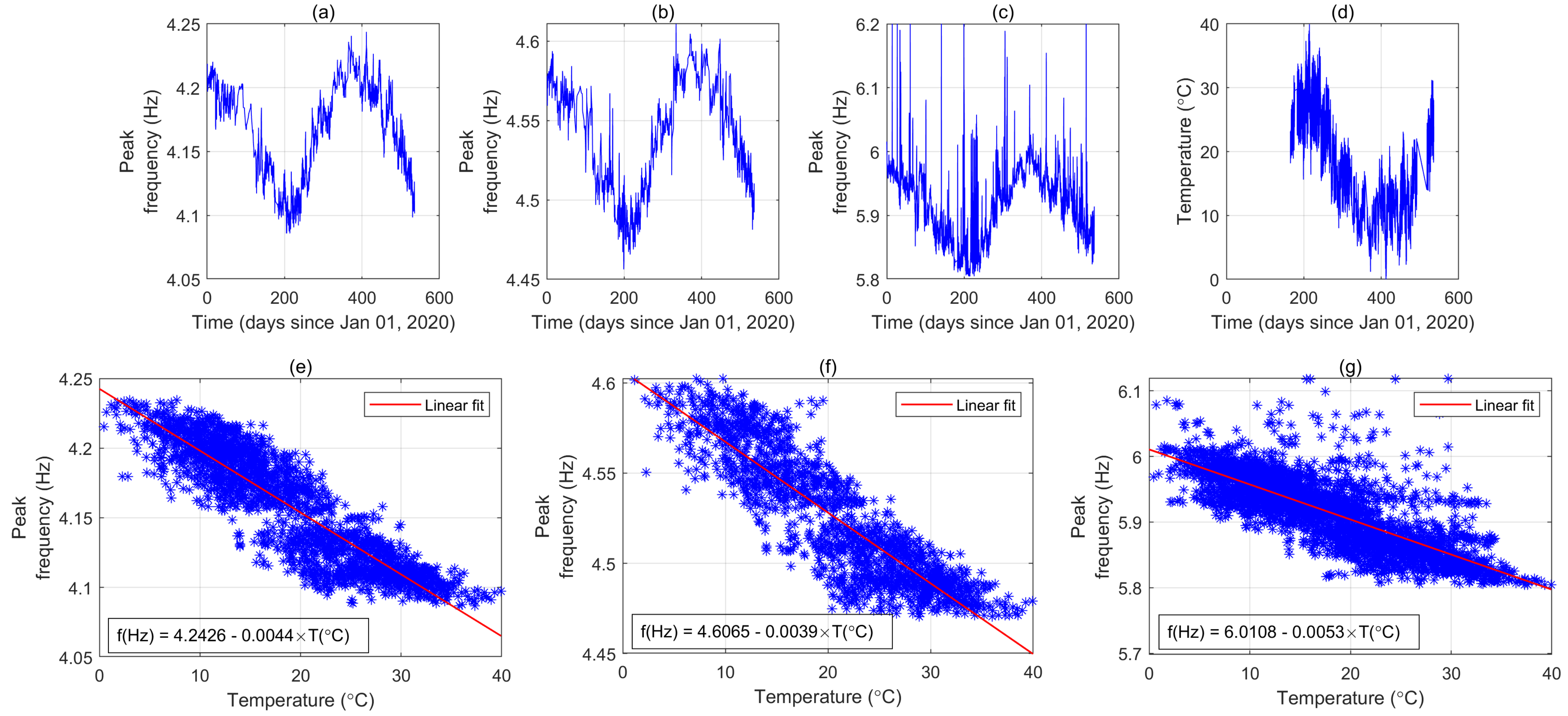
Bridge noise

- At the end of 2021, GSSI deployed 5 geophones for five days to confirm the origin of those peaks.

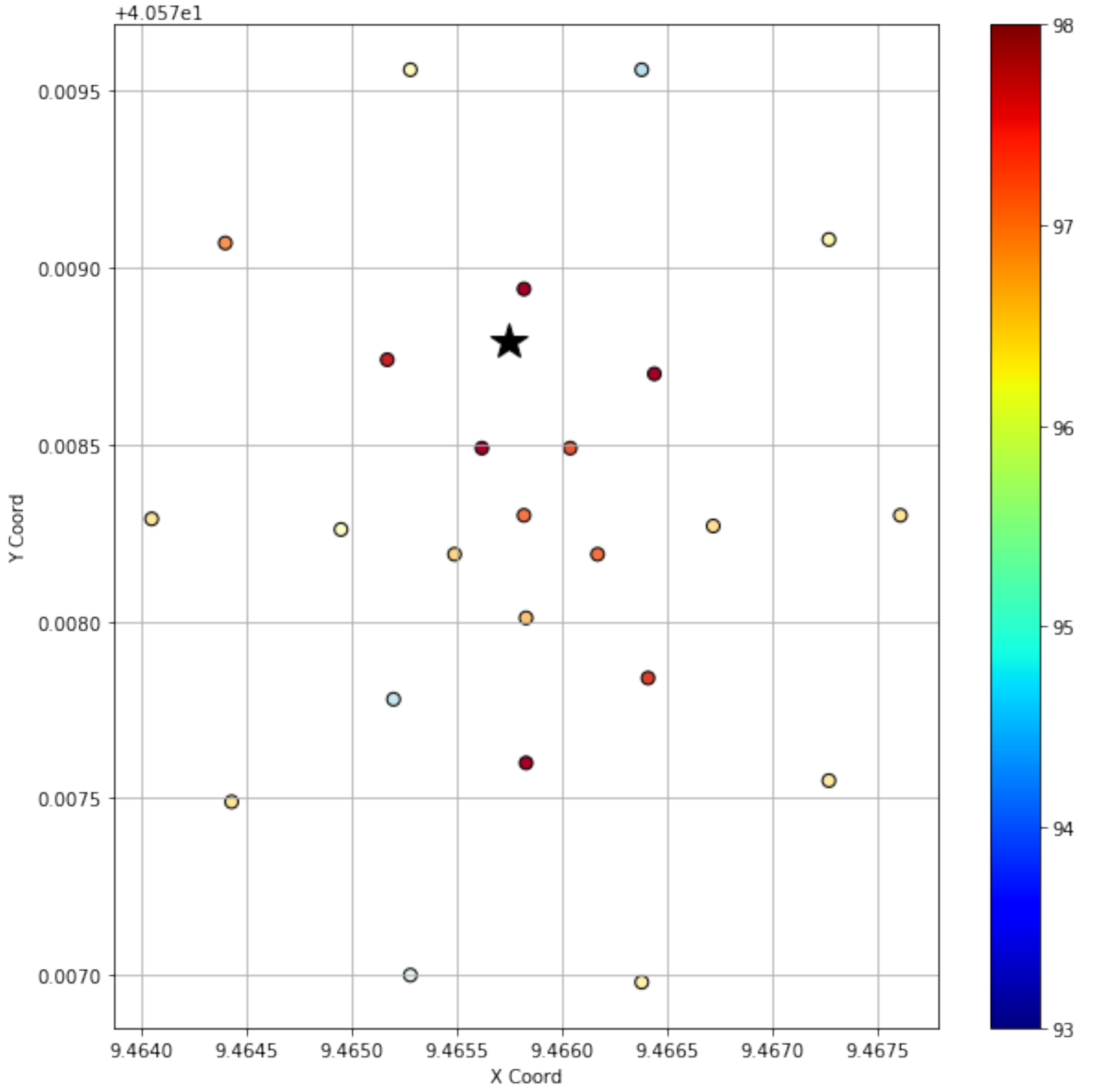
Bridge noise

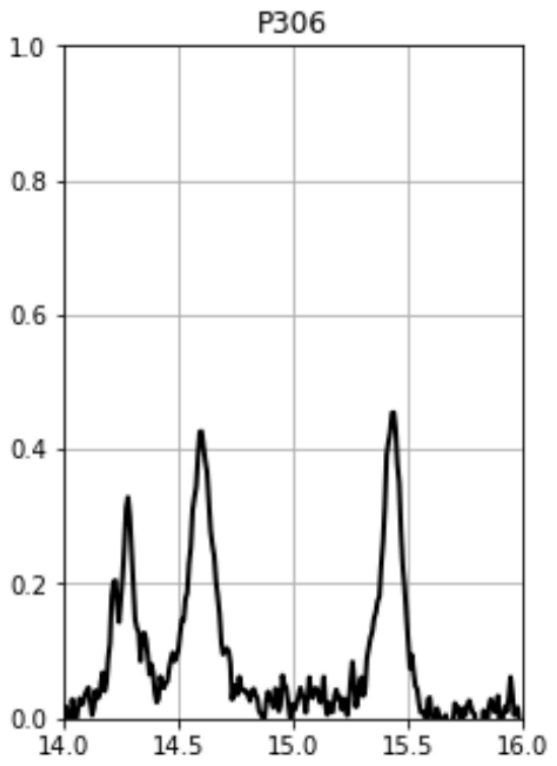
- Spectral correlation confirmed the origin of those peaks;
- The distance of the bridges from the site is no more than 1.5 km;
- Those peaks also have a seasonal frequency drift with different rates;
- This may be caused by temperature variations that change the vibrational properties of the structures;
- Engineers observe drift to lower frequencies as the temperature increases and vice-versa as the temperature decreases;



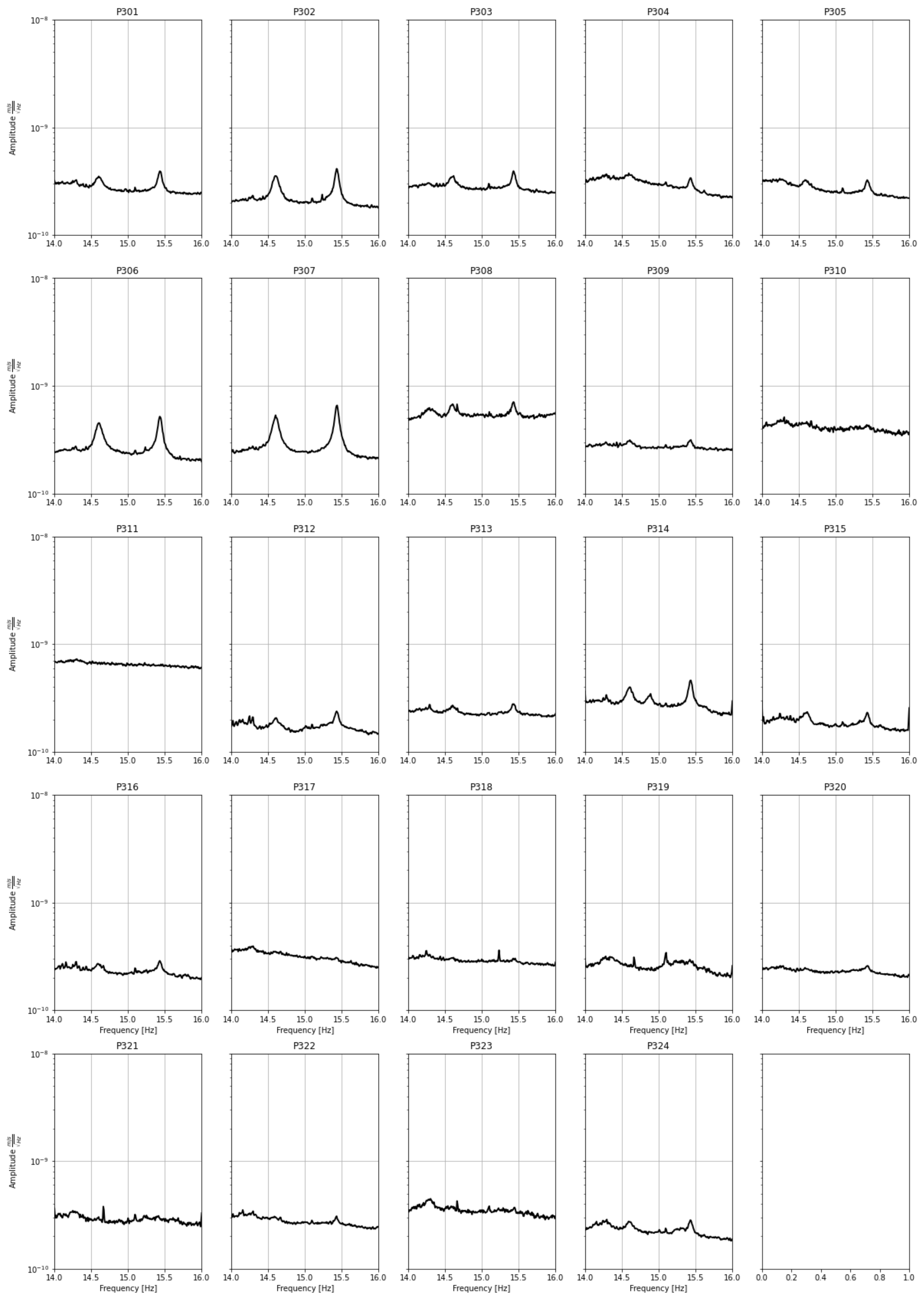


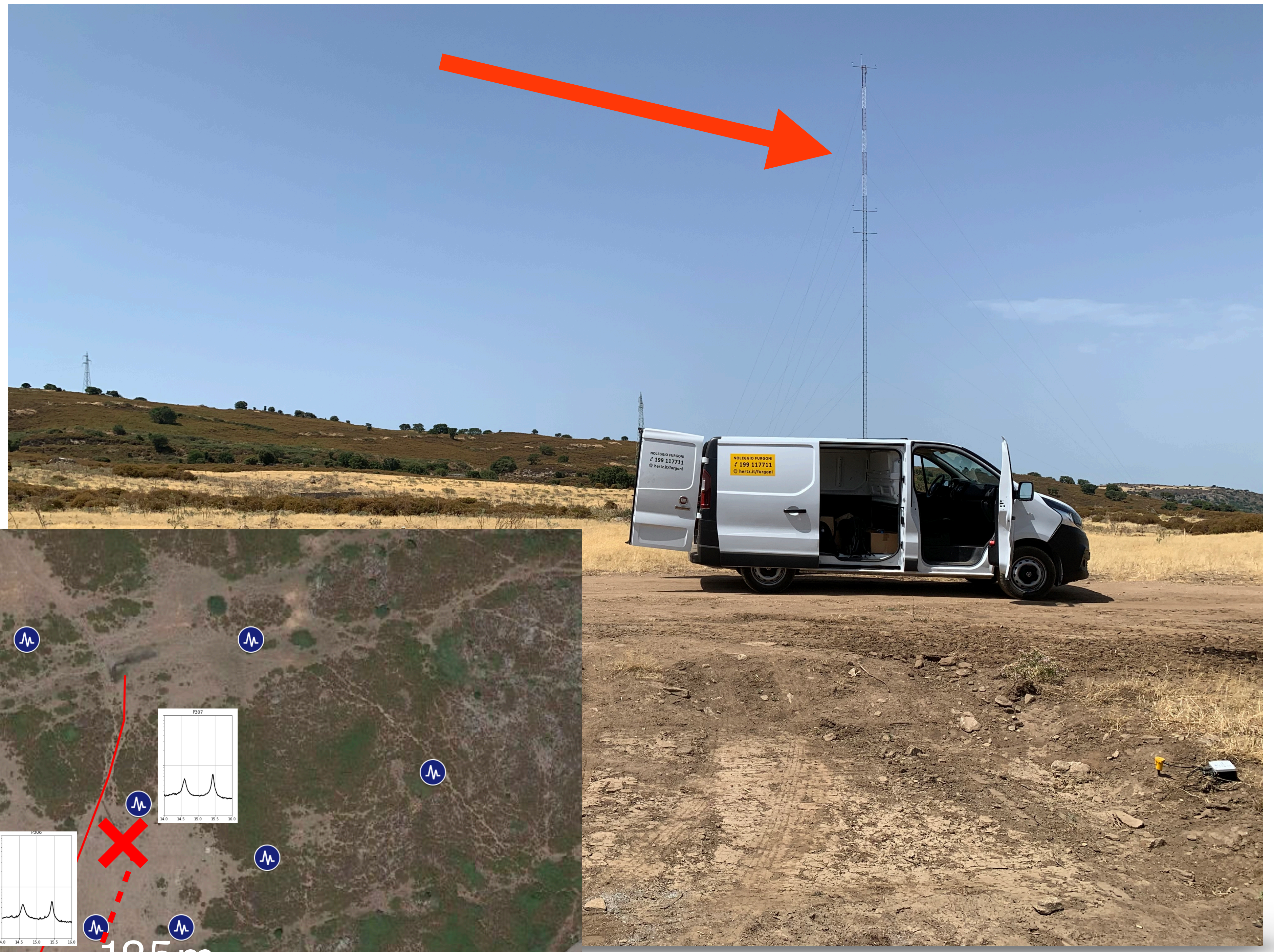
Identification of a lattice steel tower as noise source at P3

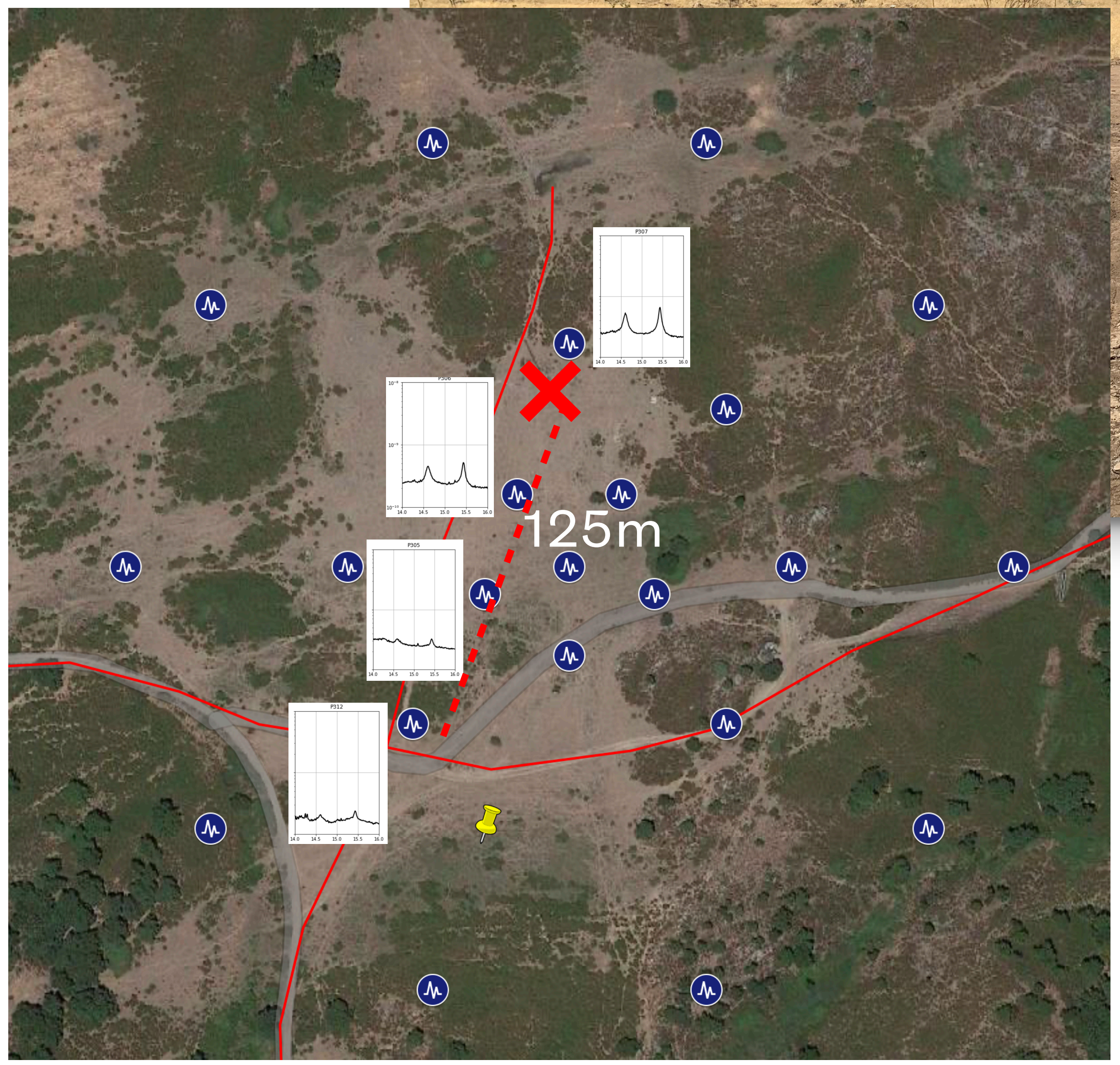


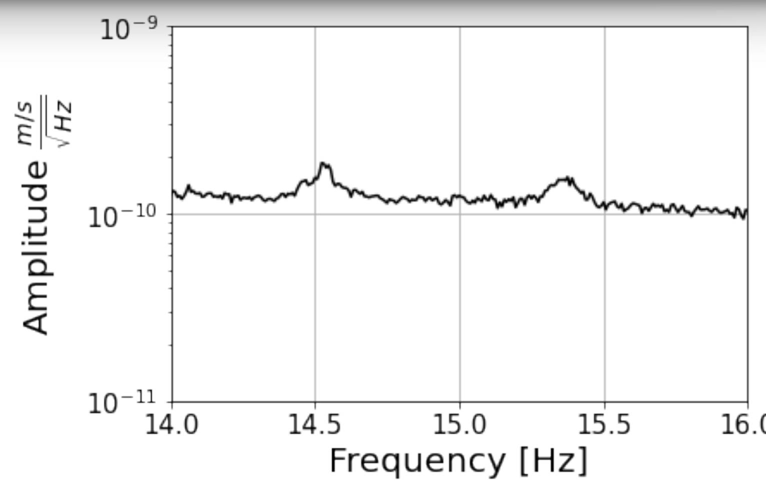


Right - spectral cross correlation between the two seismometers closest to the tower (about 20m each)





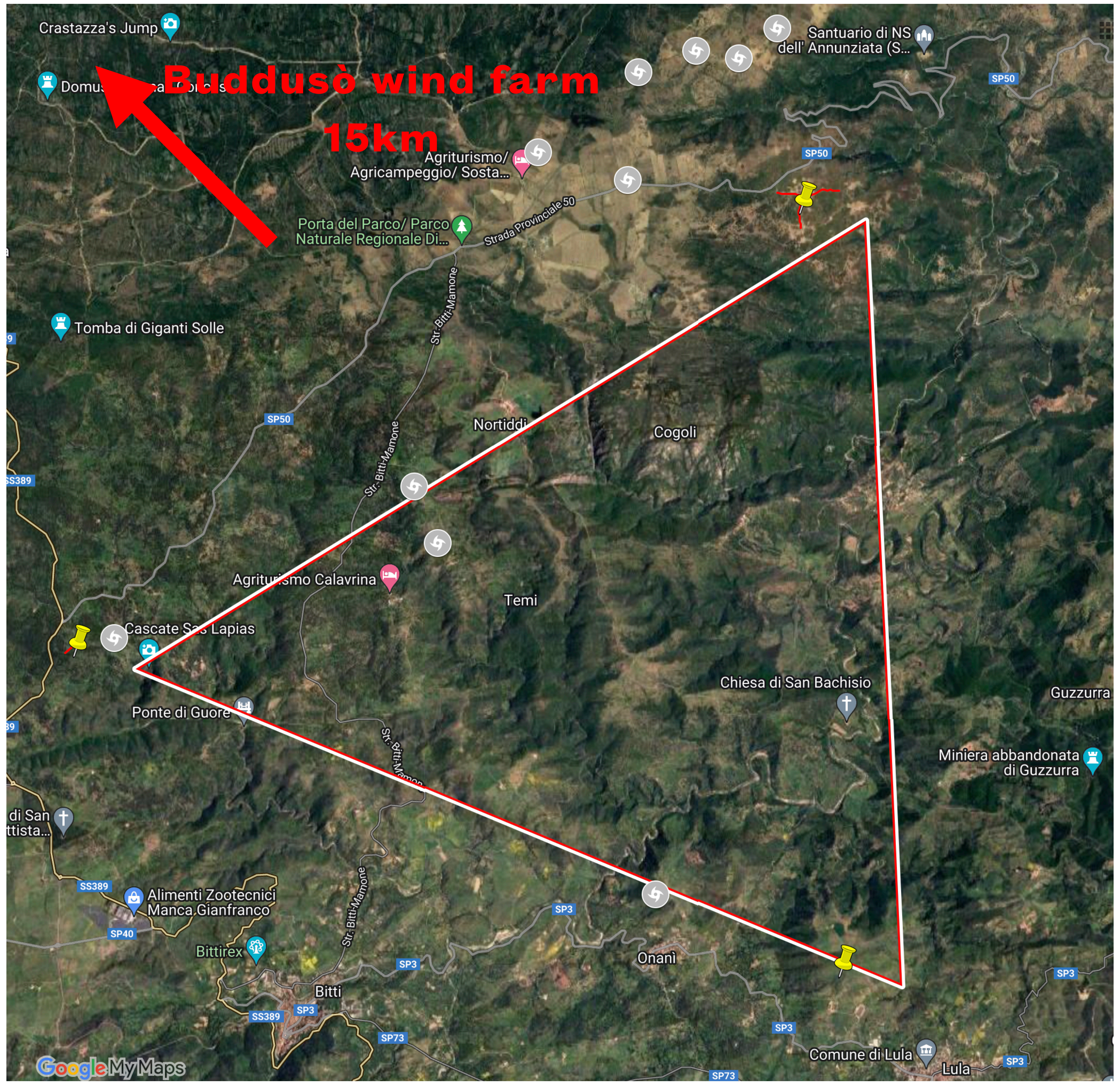




Up - Spectra from a geophone deployed in July 2021, about 15m away from the tower

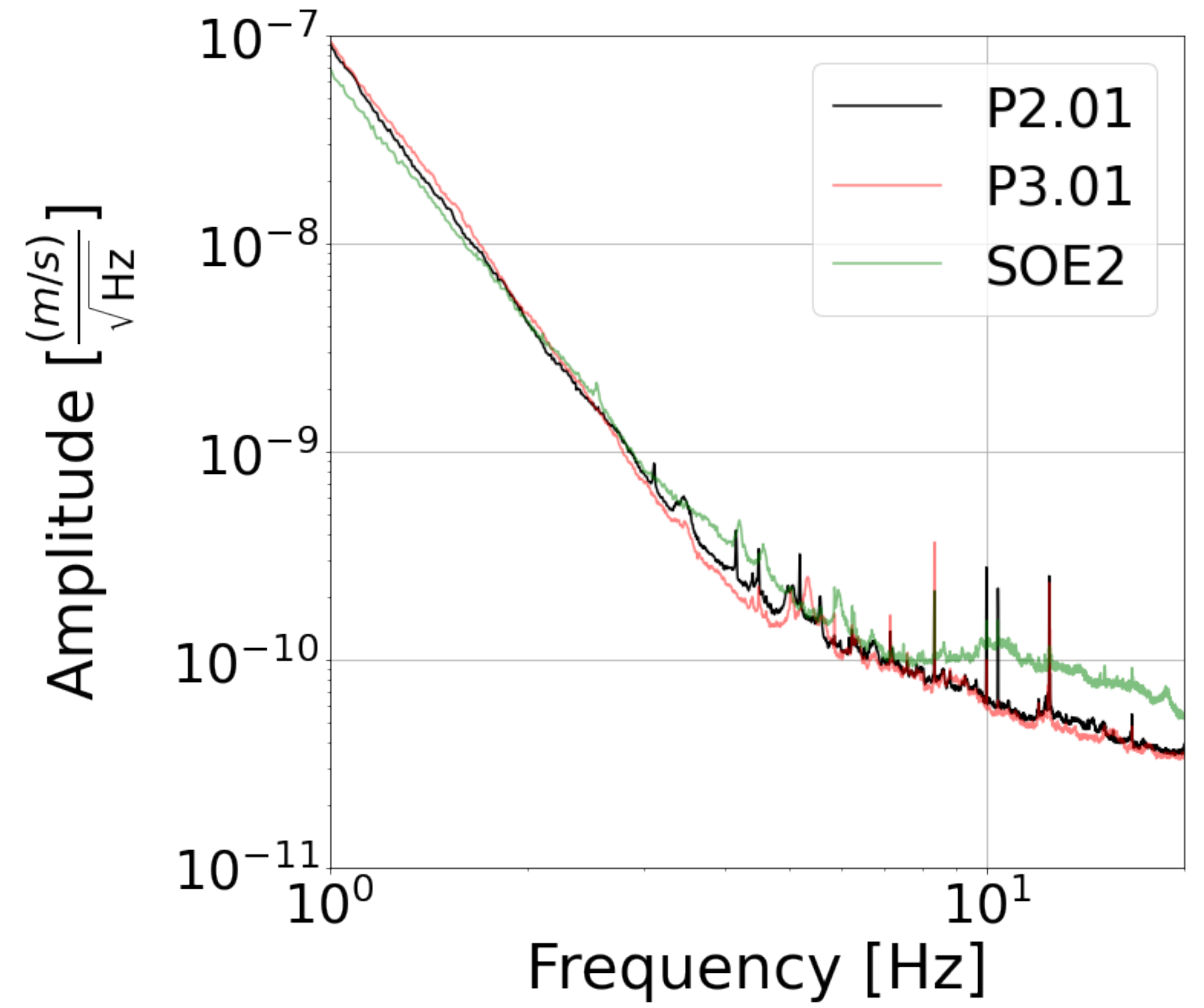
Wind turbines

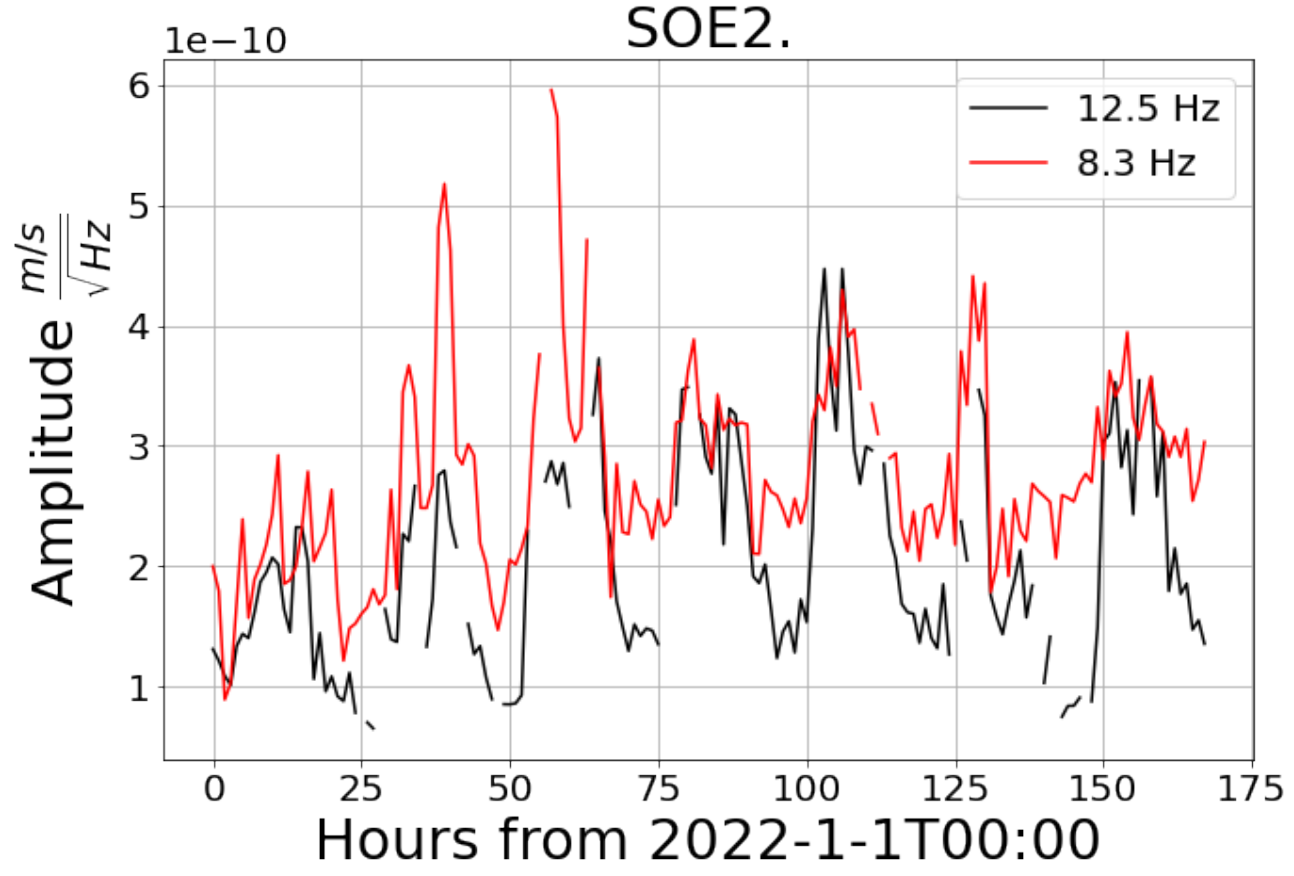
- We expect some contribution from wind turbines;
- in Virgo it is visibile at a distance of about 10km with peaks at frequencies less than 2.5Hz (*Saccorotti et al. 2011*);
- Up to now, data from P2 and P3 do not show peaks of seismic origin that can be related to wind turbines;
- The lack of weather stations at the vertexes still prevents any reliable analysis;
- Most of the turbines near the boreholes are small and there are studies that show how seismic peaks from small turbines show a significant attenuation already at 200m (*Westwood et al. 2015*);



Interference in seismic data?

- Spectra from Sos Enattos and P2/3 exhibit peaks that are too narrow and stable to be of seismic origin and at frequencies that are clearly harmonics of 50Hz;
- Are they some kind of EM interference in the data?
- During active seismic survey at one of the vertexes, the INGV team experienced strong EM interference on their devices;
- 8.3Hz is also the frequency modulation of the GSM signal;
- Possible inductive interference on the transmission line from the seismometer to the digitizer or on the digitizer itself?





Conclusions

- The Sardinia site has an excellent rating as far as it concerns low background noise environments;
- We characterized seasonal variations of local sources of ambient noise of natural origin;
- We identified and characterized the contribution of two road bridges to the overall background seismic noise in Sos Enattos;
- We identified a lattice steel tower at P3 as a possible source of local background noise.

Future actions

- Deployment of an array of seismometers between the boreholes and the Buddusò wind park to assess the presence of seismic peaks due to the wind turbines and their attenuation with distance;
- Understanding of the EM interference producing the peaks in the spectra.