# Impact of wind on ambient noise recorded by the “13 BB star” seismic array in northern Poland


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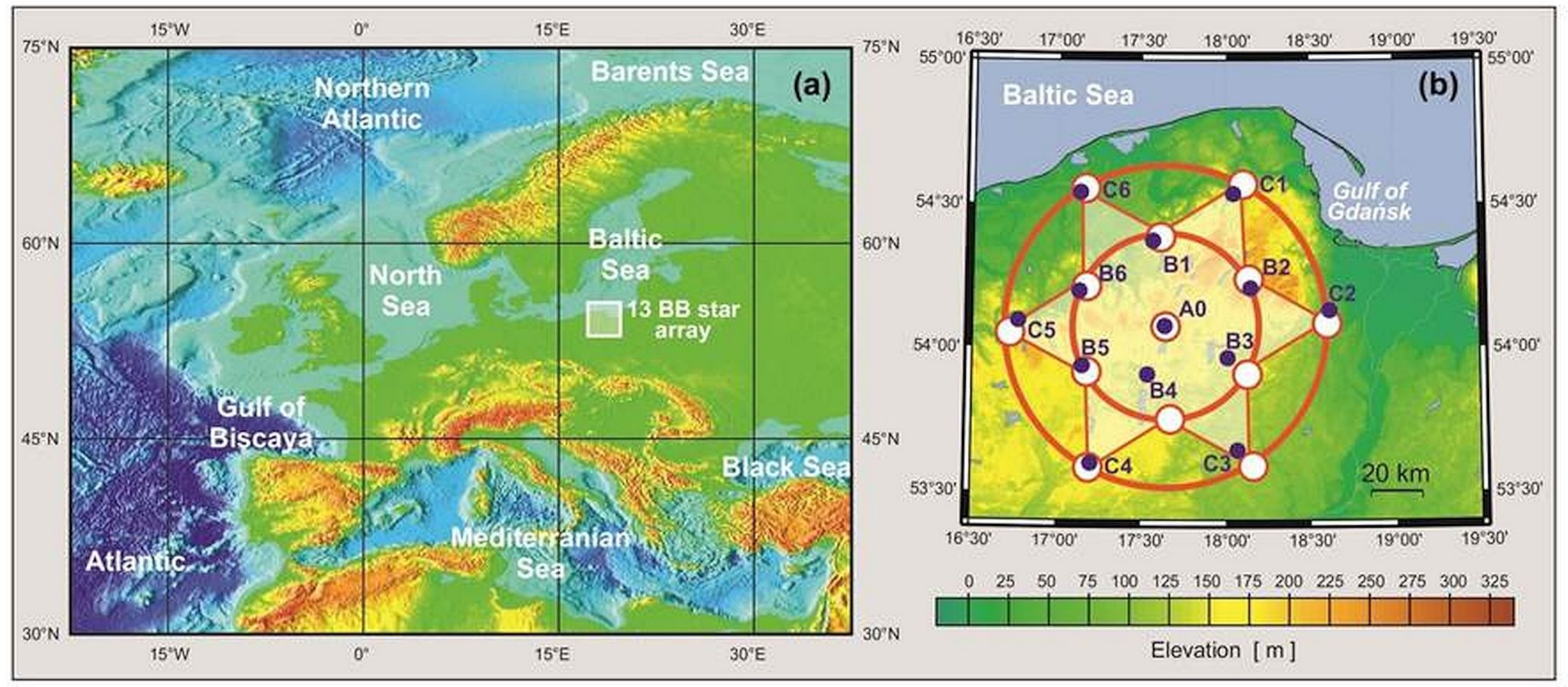
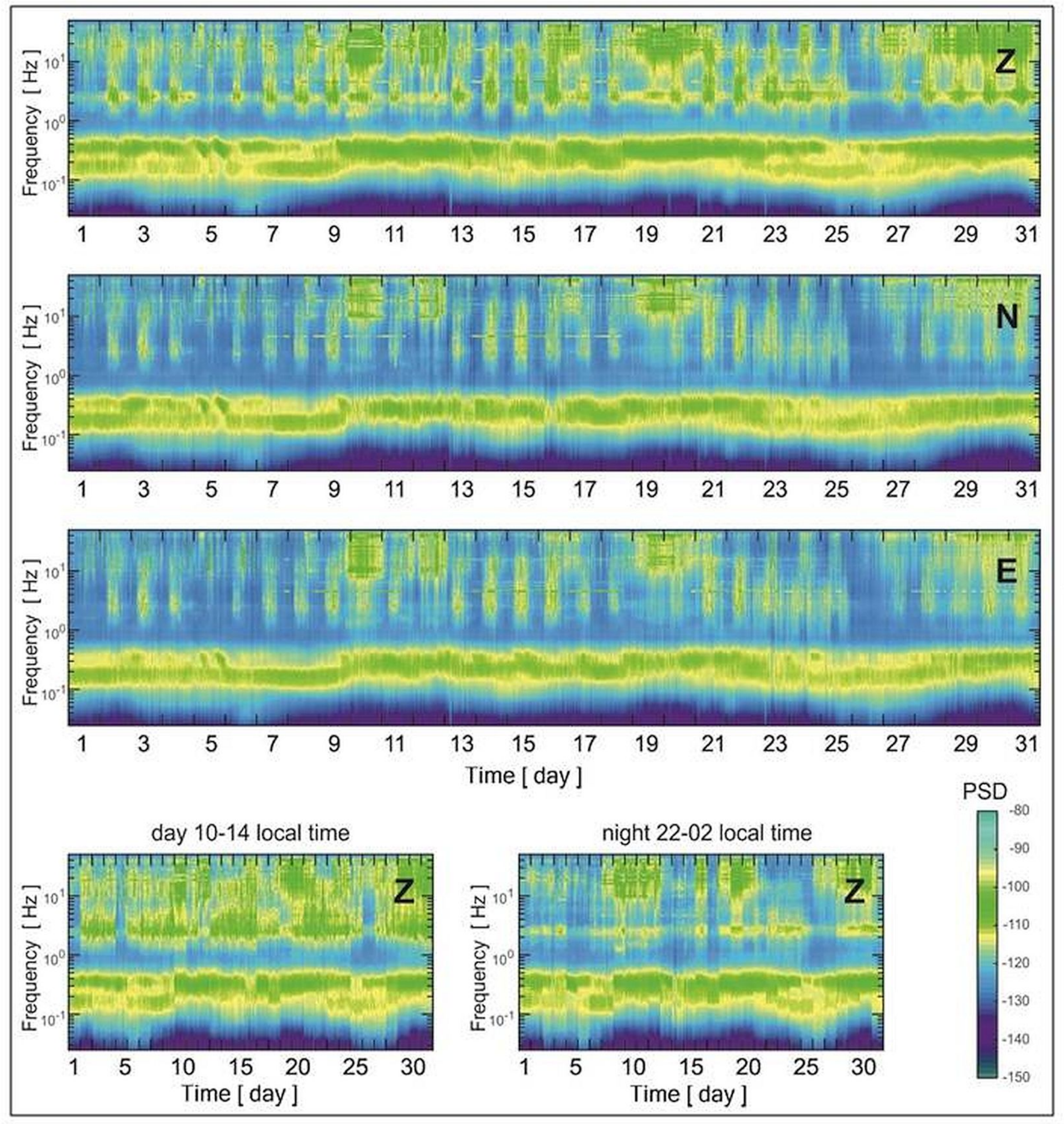
### Abstract

The relation between the velocity of wind around Europe and the ambient noise recorded during January 2014 at the “13 BB star” array, composed of thirteen seismic stations located in northern Poland, is evaluated by the application of seismic interferometry and beam-forming techniques, specifically analysing the velocity range of surface wave arrivals and the variations of the azimuth of noise sources.

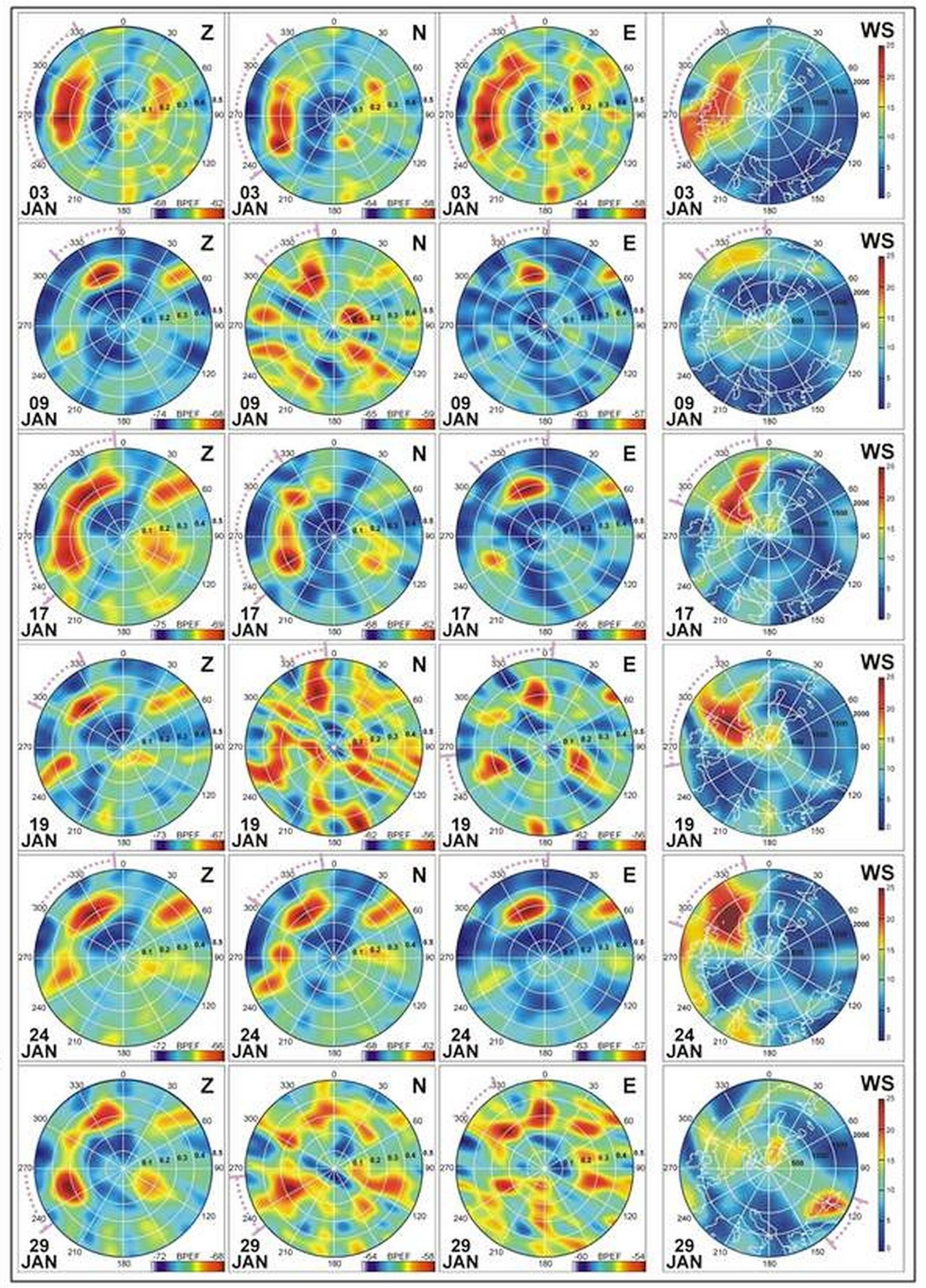

The “13 BB star” array, located in Northern Poland as shown in the part (a) of the figure, consists of thirteen stations whose arrangement is illustrated in the (b) part. The C1-C6 group is contained in the external circle and the B1-B6 set in the internal one. The A0 station is located at the centre. This geometry permits to collect the propagation features of low-frequency surface waves for any orientation and to extract the spectral properties of the noise by computing the wavefield at the central station only.

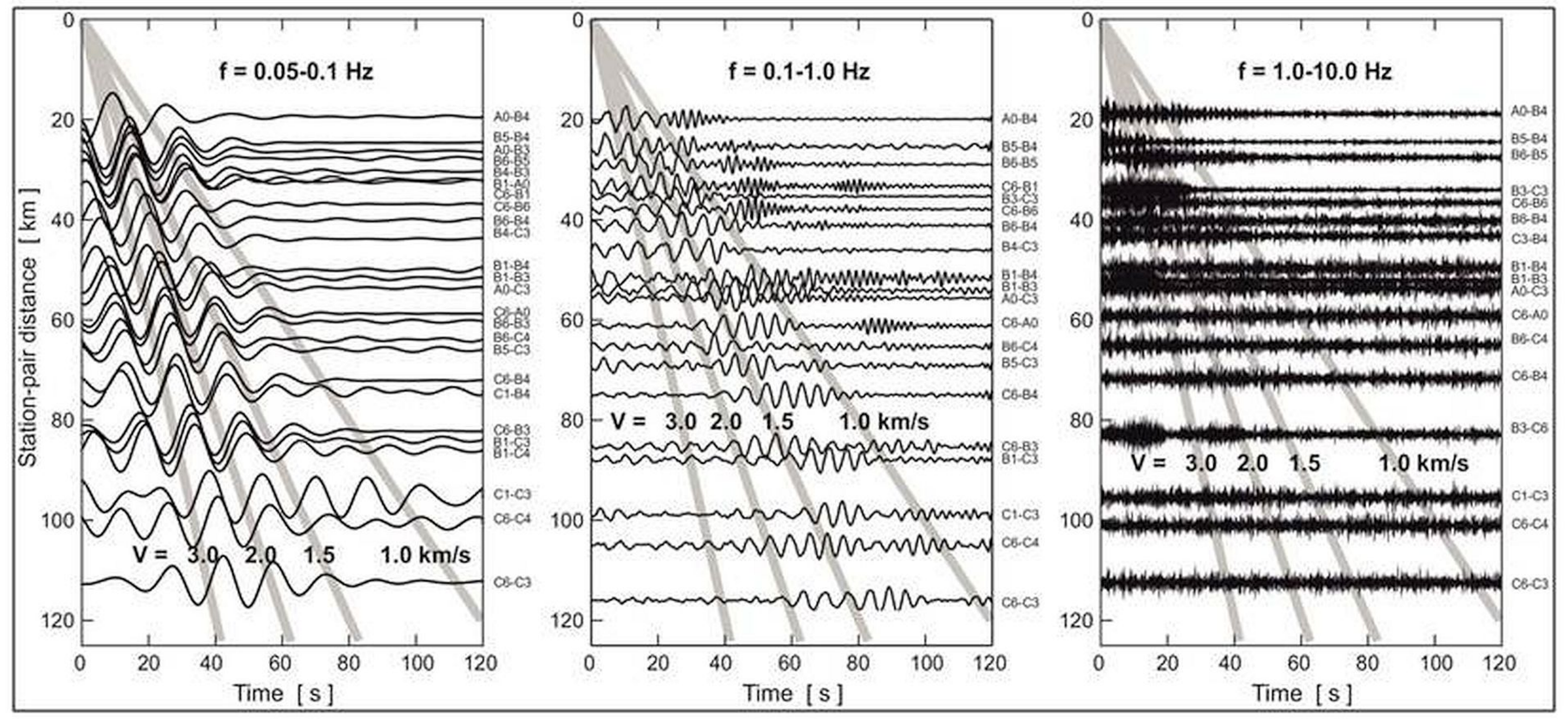
The noise spectrograms at station A0 for the whole month of January on the three components are reported in the figure. Two main frequency bands are observed in which the noise is continuously present during the whole period, namely 0.05-0.8 Hz and 1.2-30 Hz. The former frequency range, in which the noise is generated principally by wind, shows almost the same width during the whole month. The intra-station distances are longer than the wavelengths: therefore, surface waves can be retrieved. On the contrary, in the latter frequency range, where the anthropogenic sources generate the noise, night is much less noisy than the day as it is shown by the four-hour spectrograms around midday and midnight. The intra-station distances are much larger than the wavelengths: thus, the retrieval of surface waves is not to be expected.

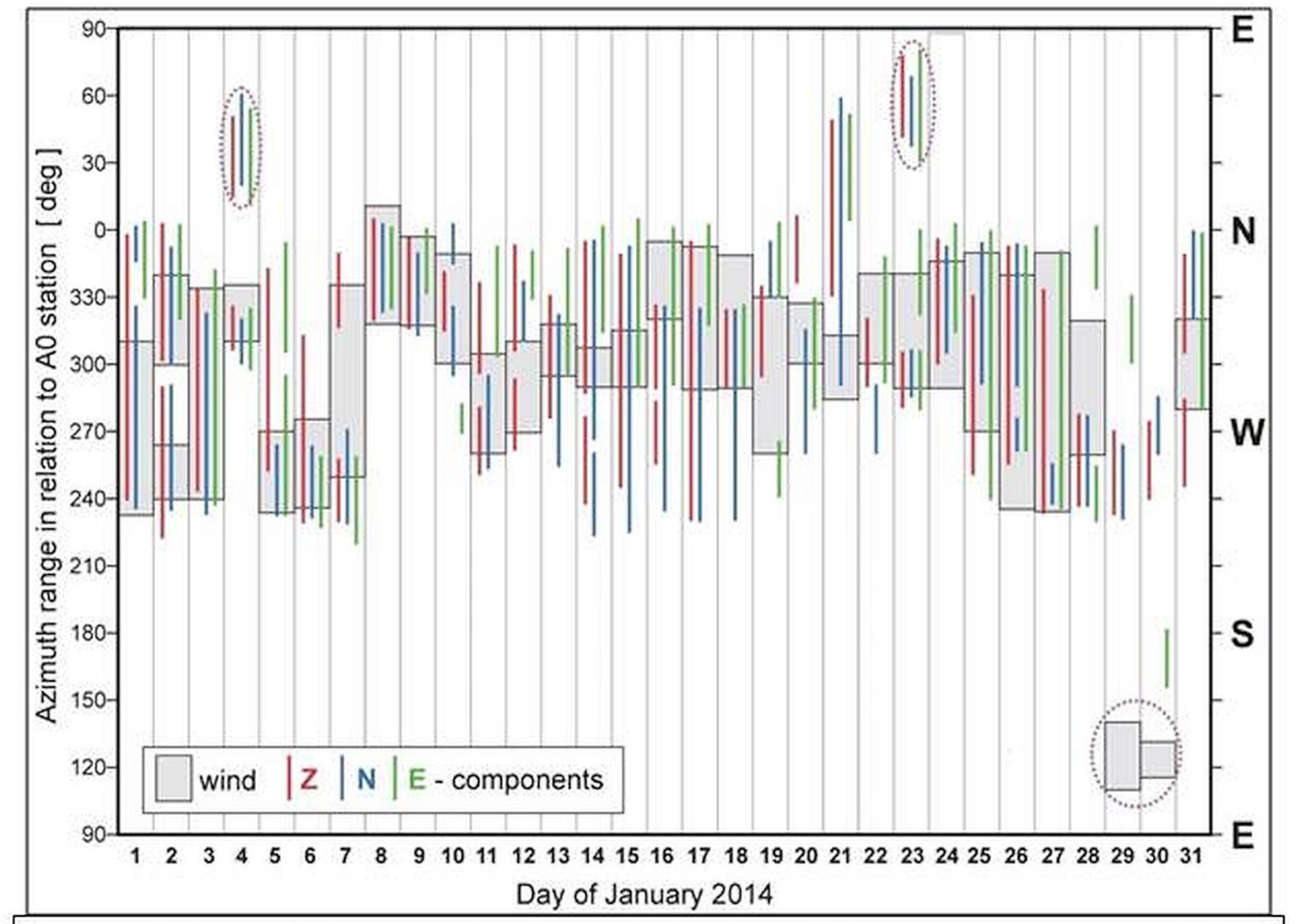



Beam-power polar plots in the 0.05-0.1 Hz frequency band for six different days of January 2014 are shown in the figure for the three components. Near the results from the BF analysis, polar plots representing the variations of wind velocity in the same days are reported. The correlation between the main azimuth of the ambient noise wavefield and the average direction of wind is well noticeable. The average azimuth of the main noise source ranges mostly between ~235° and ~5°, as observed from the purple dotted arc that indicates the angle of the strongest peak. Correspondingly, the direction of the strongest wind oscillates from the North Sea to the Baltic Sea. Only on the 29th of January the wind direction is located in the continental crust near the Black Sea: thus, surface waves are not produced and noise wavefield is not present in this direction.

To get the velocity range of surface waves arrivals the crosscorrelation between all station pairs for the whole January 2014 was analysed for the vertical component in the 0.05-0.1 Hz, 0.1-1 Hz and 1-10 Hz frequency bands. It can be easily noticed that the lowest frequency band is the most appropriate to identify the velocity range, due to the absence of spurious short period trends in the traces. In the intermediate frequency band, the visibility of the surface waves begins to reduce: indeed, some spurious trends can be noticed on the traces. In the highest frequency band, differently from the other two bands, the surface waves are barely visible on the traces, confirming that the associated energy is strongly attenuated in this band.




Plot of the wind azimuth above 15m/s and the beam-power of the ambient noise on the three components for the whole January 2014

In the case of strong wind, the correlation with the azimuth of the ambient noise is very clear for all the three components. On the contrary, when the wind is weaker, the correlation is a little less noticeable. Only in two days (29th and 30th of January) the wind azimuth falls outside the expected zone of the plot, since the wind blowing on land does not generate surface waves. Overall, the azimuth of wind varies between ~240° and ~10° which can be explained by a higher pressure gradient in the Northern Atlantic during winter, as well as by a lower friction force over the ocean corresponding to higher wind velocity. Secondary sources of noise wavefield are due to array geometry effects.

### Conclusions

The results were related to the estimates of the wind velocity performed day by day: a strong, persistent correlation was found. The main source of the ambient noise was characterized by the interaction of wind-generated ocean waves with the seafloor near the coastlines, and it was located among, the North Sea, the Northern Atlantic, and the Baltic Sea.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