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Results from WINES: Wind turbIne Noise assEsSment in the Italian site candidate for "Einstein Telescope", the third-generation gravitational wave detector.

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The area in the municipalities of Lula, Bitti, and Onanì in Sardinia (Italy) is a candidate for hosting the "Einstein Telescope" (ET, the third-generation gravitational wave detector), given the extremely low level of natural and anthropogenic seismic noise at this site. For the same unique characteristics of this area, the multi-disciplinary geophysical far-field observatory "Faber" (PNRR-Meet project) will be set up.

However, the strength and persistence of wind make this area exceptionally favorable for the exploitation of wind energy, as testified by the nearby Buddusò wind park that, consisting of 69 turbines and about 130 MW of total installed power, is the largest in Italy.

It is well known that wind turbines are an important source of seismic noise between 1 and 10 Hz, posing a relevant concern for noise contamination of ET as it will operate in the same frequency range.

In the context of the seismic characterization of such a candidate site, the WINES experiment (Wind turbIne Noise assEsSment in the Italian site candidate for the Einstein Telescope) provided a two-month-long passive seismic recording of nine broad-band stations placed at increasing distances from the Buddusò wind park. The aim of the experiment was the evaluation of the noise generated by the wind park in terms of amplitude, spectral content, and decay with distance, in relation to the wind park operation.

Analyzing the frequency spectra at all stations, the spectral imprint of the wind park manifests through sharp, well-defined spectral peaks at 3.4, 5.0, 6.8, and 9.4 Hz, even in conditions of absent or moderate wind speed (0-3 m/s). With stronger winds (>20 m/s), all spectra increase their amplitude by an order of magnitude, and the sharpest and most persistent peaks are found at 3.5, 5.2, and 6.8 Hz. In both wind conditions, the amplitude of such peaks decreases with distance, being clearly distinguishable up to 5-6 km from the wind park. We use these spectral peaks to derive an empirical relationship for their amplitude vs. distance, highlighting a well-behaved exponential decay that translates into a two-orders-of-magnitude decrease within 10 km distance.

Lastly, considering the assumption that the generated seismic noise propagates as Rayleigh waves, the continuous recordings along the array have been used for the estimation of the direction of noise arrival at each station. Signal coherence allows the recovery of this information for stations within 5 km from the wind park, showing a dominant back-azimuth of the incoming signal that is fully compatible with the position of the wind park with respect to each station.