Updates on Sos Enattos Seismic Characterization

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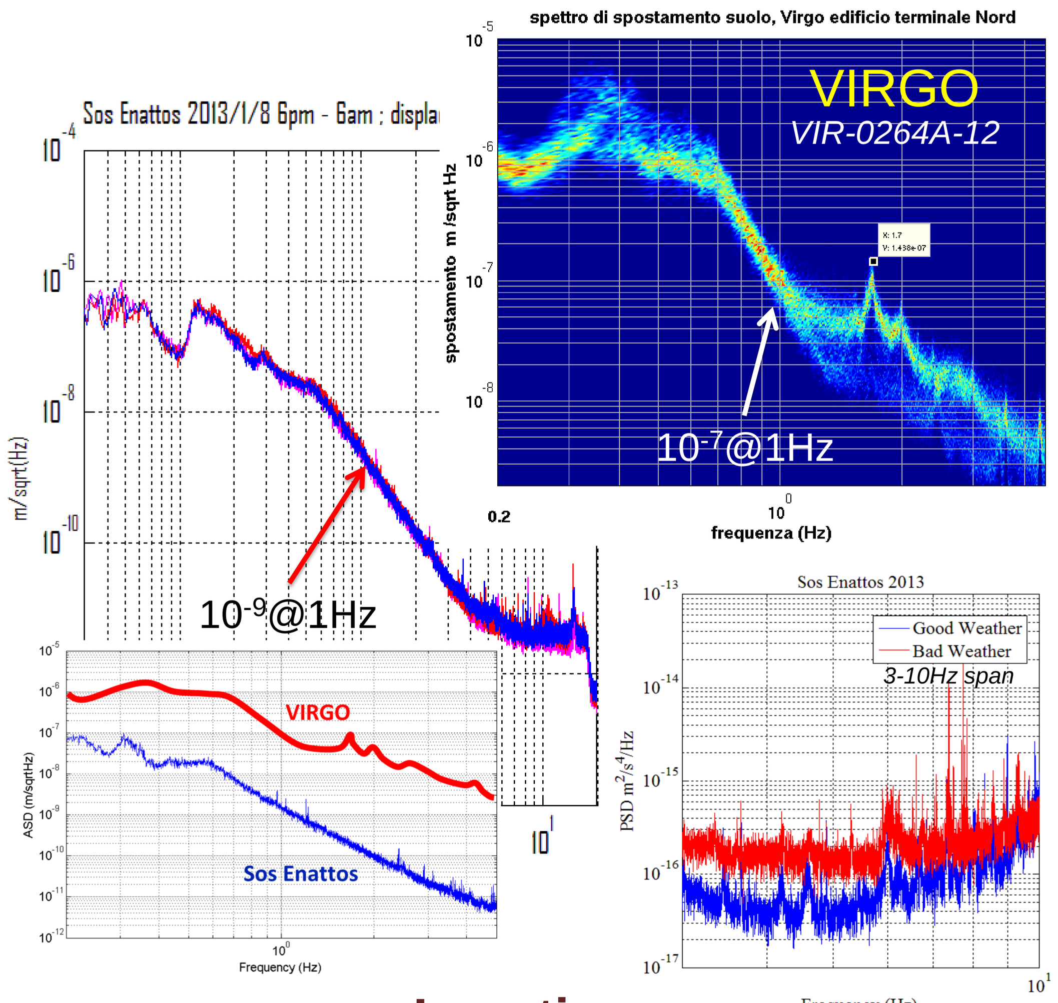
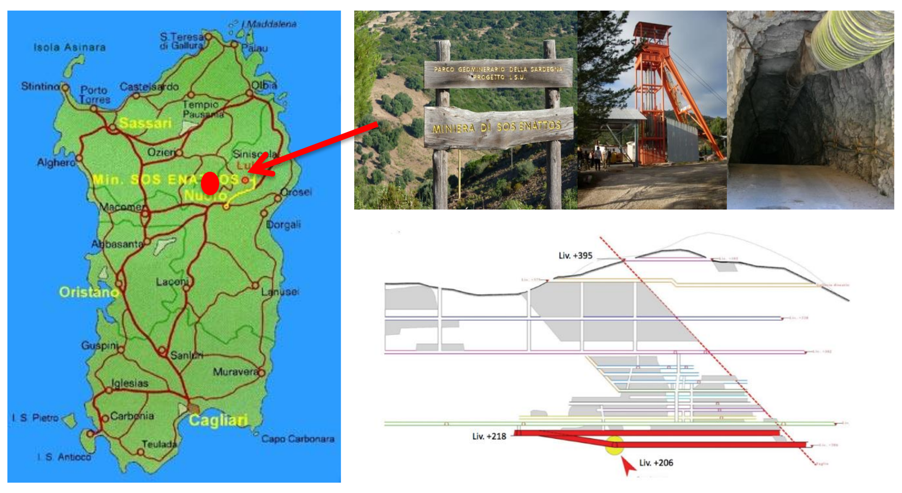
Motivation

In order to reduce seismic and Newtonian noises in the low frequency band, the Einstein Telescope will be an underground Gravitational Waves observatory. In the context of the ET design study (ET-0106C-10), local seismic measurements performed since 2010 showed that Sos Enattos former mine in NE Sardinia (Nu - Italy) was one of the best candidates.



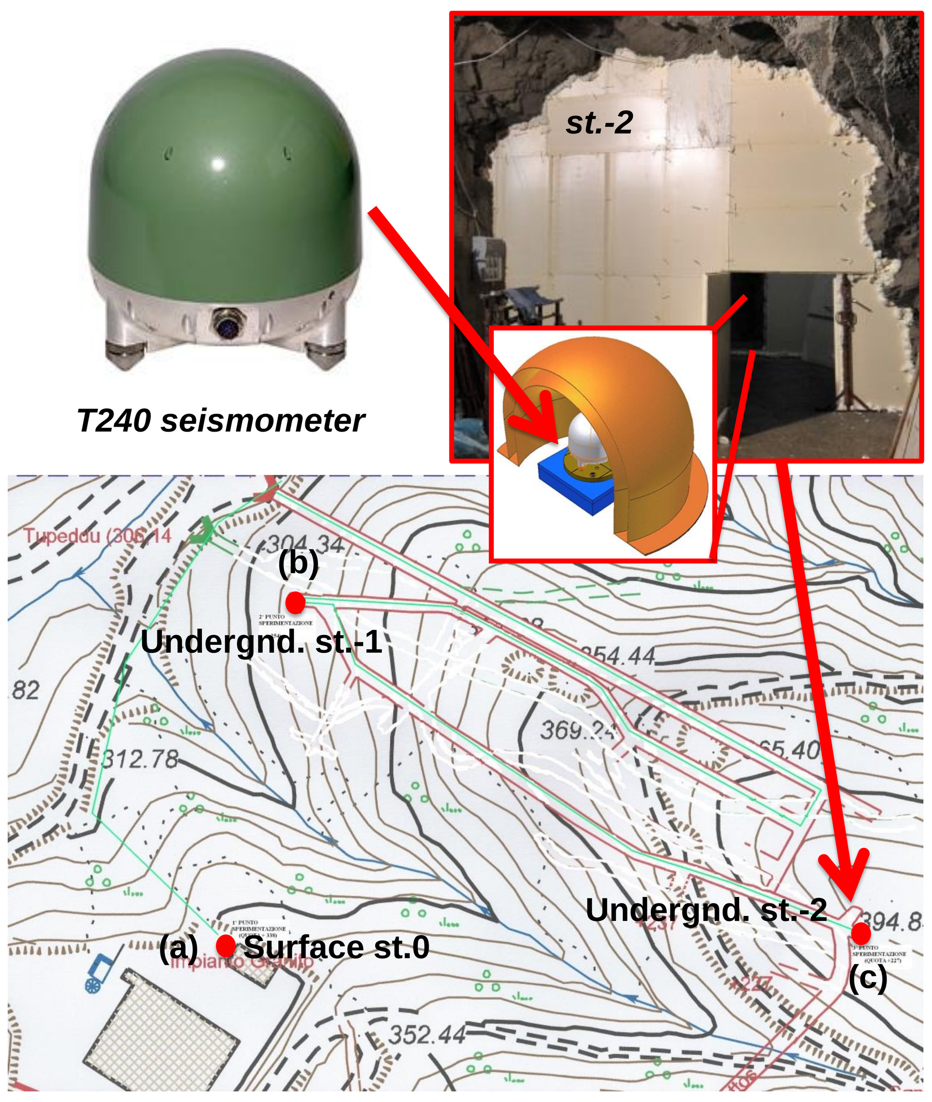
Location

Sardinia is a region seismically quiet located in the European tectonic plate, different from that of the Italian peninsula, far from the edge of many fault lines. Moreover, the island is characterized by a low population density, resulting in a limited anthropic noise. The proposed Sos Enattos site is easily accessible by highway SS 131 d.c.n.



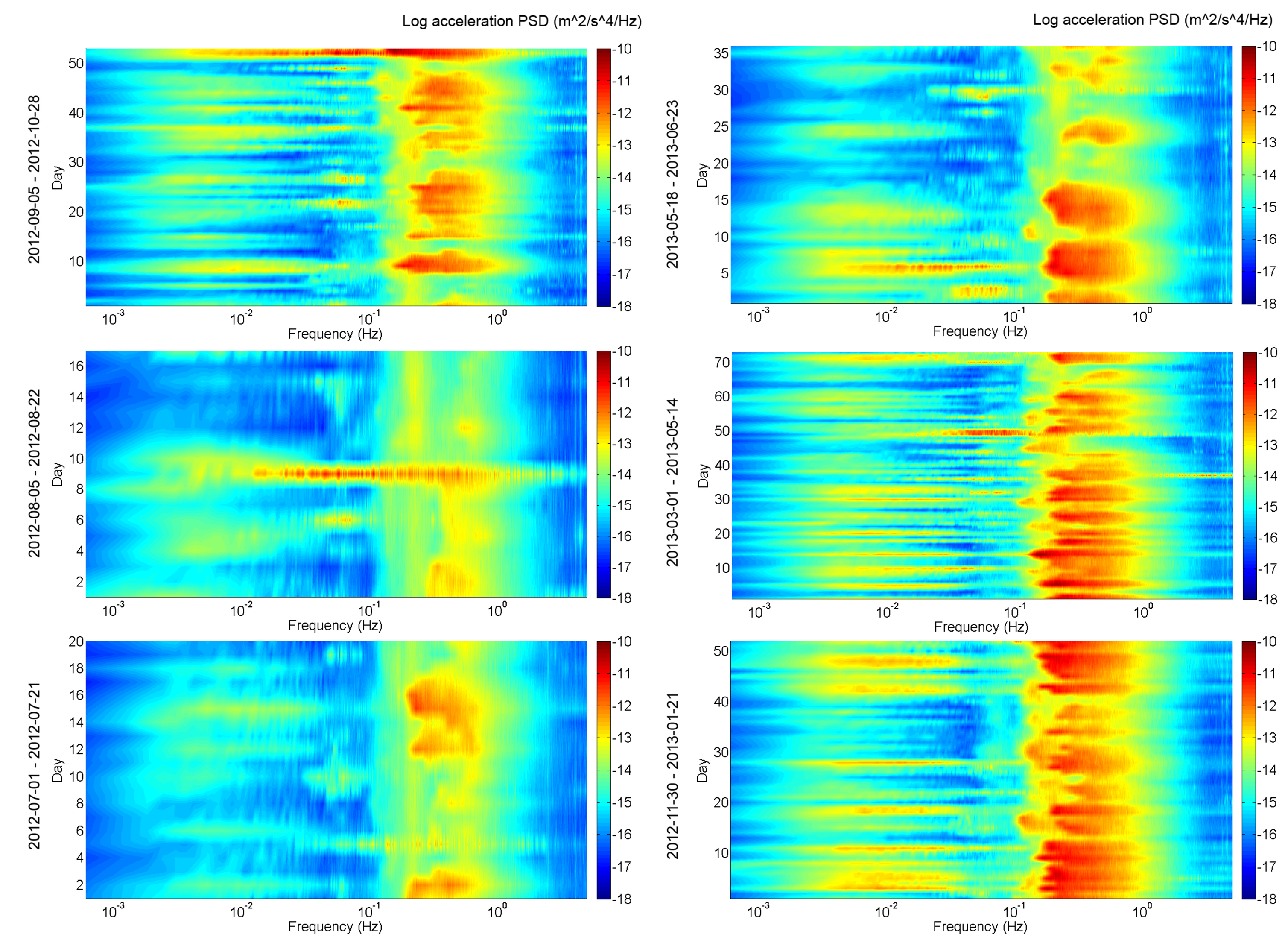
Instrumentation

In July 2012 three instrumented stations were built, in order to monitor the microseismic activity in the 30*mHz* – 5*Hz* band: (a) at ground level, i.e. 338m a.s.l.(*st.0*), (b) at an intermediate underground location, i.e. 254m a.s.l.(*-1st.*, -84m), (c) at a second underground location, i.e. 227m a.s.l.(*st.-2*, -111m). In the deeper station we installed a tri-axial seismometer Trillium 240 by Nanometrics. The sensor is placed on a granite tile cemented to bedrock and enclosed in a thermal and acoustic insulation box. The ground-level station (*st.0*) hosts the DAQ instrumentation and was used for a temporary installation of the Trillium 240 for one month of ground level seismic noise measurements. All the stations are connected by optical fiber link. Moreover, in parallel with the seismic measurements, we monitor the sea activity in five points of the Tyrrheinian sea and in one point of the Atlantic Ocean, using the data provided by the weather forecast service of Italian *Aeronautica Militare*.

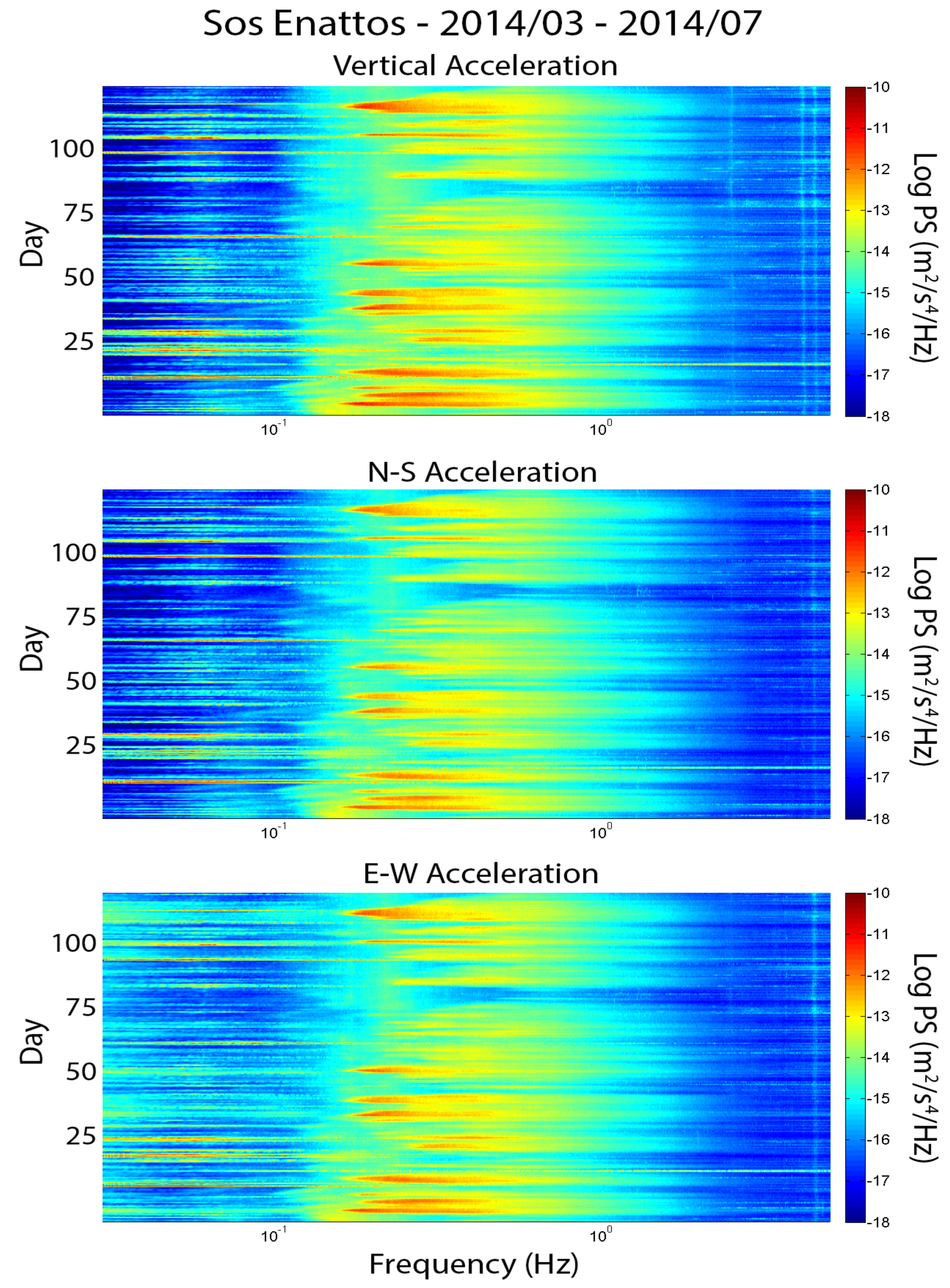


Long-Term seismic survey

We monitored the microseismic noise levels almost continuously for about one year of observation, from July 2012 to June 2013 (*L. Naticchioni et al., Microseismic studies of an underground site for a new interferometric gravitational wave detector, Classical and Quantum Gravity, vol. 31, 2014*), checking the seismic stability within and below the low-frequency sensitivity band of a third generation gravitational observatory, and verifying the correlation between the microseismic spectral structures and the weather conditions, in particular the sea wave motion. After the maintenance activity that took place in the end of 2013, we extended our seismic survey to an additional period between March and July 2014, measuring the seismic noise level with the Trillium 240 seismometer temporarily placed in the surface station (*st.0*) for about a month, and subsequently placed in the deepest station (*st.-2*).



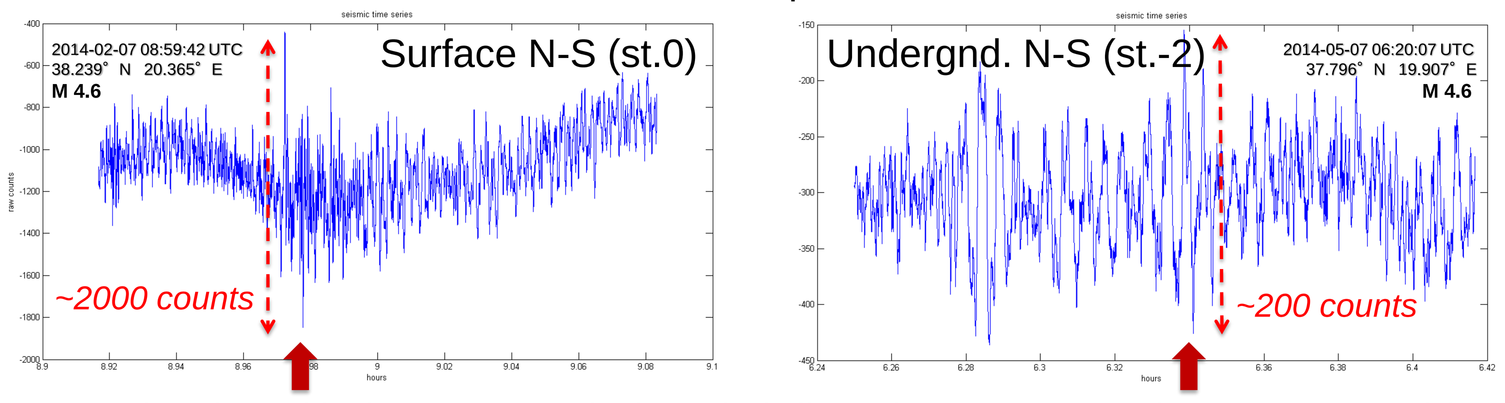
Acceleration power spectrograms (vertical axis) measured in six long acquisition between July 2012 and June 2013. Seasonal effects related to the weather status are evident in the microseismic band (30 mHz – 3 Hz).



Tri-axial acceleration power spectrograms measured between March 2014 and July 2014. The microseismic noise has about the same magnitude along the three spatial directions.

Transient seismic events underground attenuation

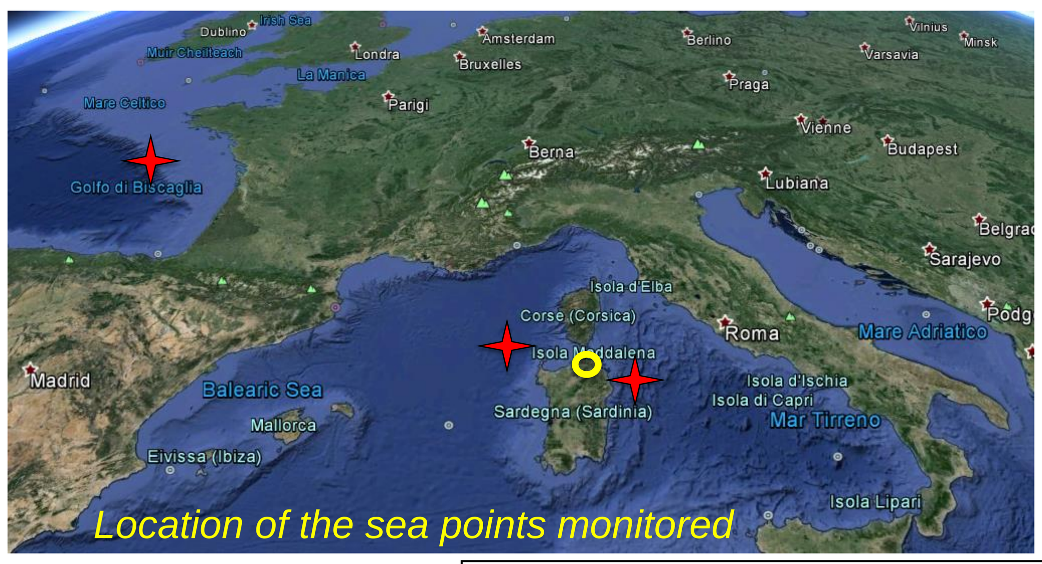
Seismic and Newtonian noises are attenuated in an underground site since the amplitude of Rayleigh waves decreases exponentially with depth. This attenuation can be observed measuring the amplitude of two earthquakes in the surface and underground stations, given the same magnitude at the epicenter and a similar distance from the site. We analyzed two couples of seismic events with similar magnitudes and epicenters that toke place next to the Greek coast, obtaining a transfer function between the st.0 and st.-2 stations that is TF~0.1. Measurements were made with the same sismometer T240, placed in the two stations.

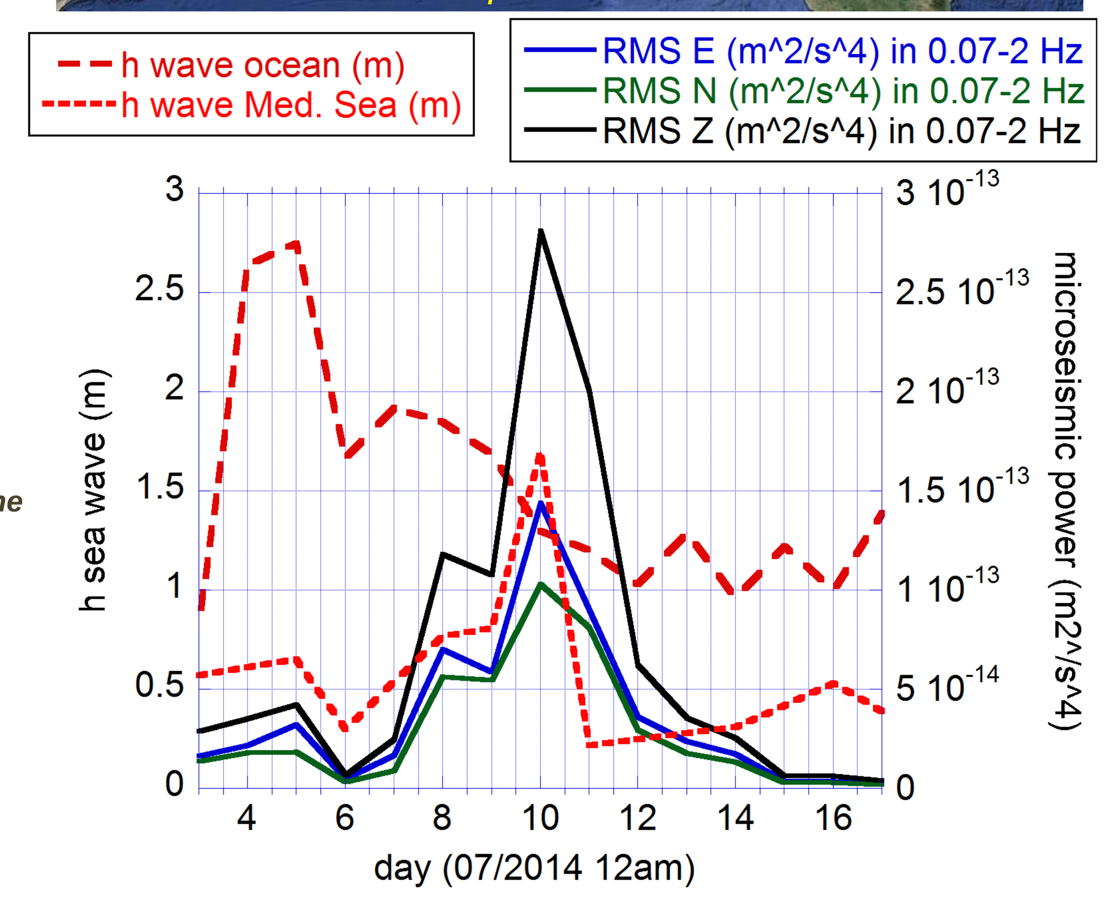


Two earthquakes with the same magnitude and similar epicenters measured at Sos Enattos (about 1000km from the epicenters) at the surface station st.0 and the deepest underground station st.-2 with the Trillium 240 seismometer. A transfer function TF~0.1 between the two stations can be estimated.

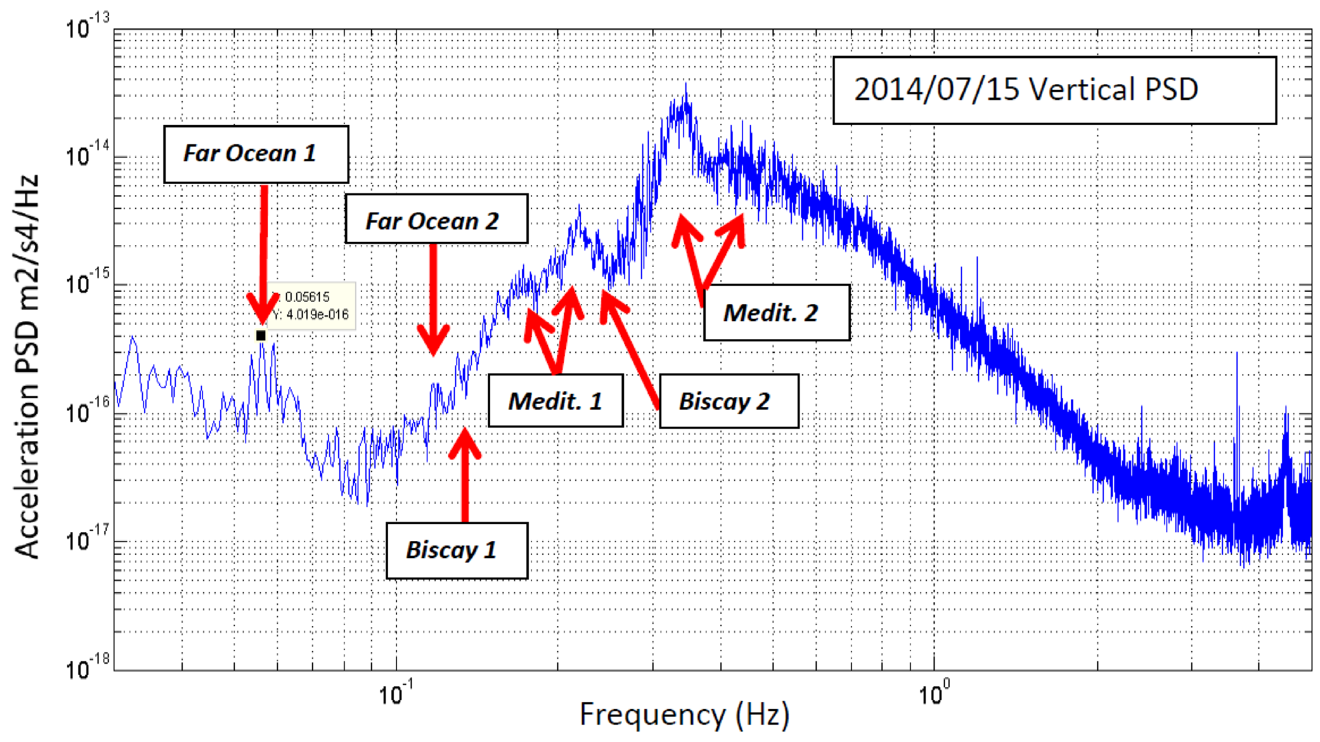
Sea influence on the seismic noise

We monitored the evolution of heights and periods of sea waves in five points located around the site in the Mediterranean Sea and one point in the Bay of Biscay (Atlantic Ocean), comparing them to the microseismic noise power integrated in the frequency band between 70 mHz and 2 Hz. The most important effect on the seismic noise increase in such a band comes from the Mediterranean Sea waves, in a band which spans from 0.1 Hz to 0.6 Hz (primary and secondary peaks). Waves in the Bay of Biscay have frequencies compatible with less prominent clustered peaks in the 0.1 Hz – 0.2 Hz band. At lower frequencies the typical far oceanic swell-produced peaks are often observed at 60-80 mHz (primary) and 0.12 Hz – 0.20 Hz (secondary), superposed to the other spectral structures.

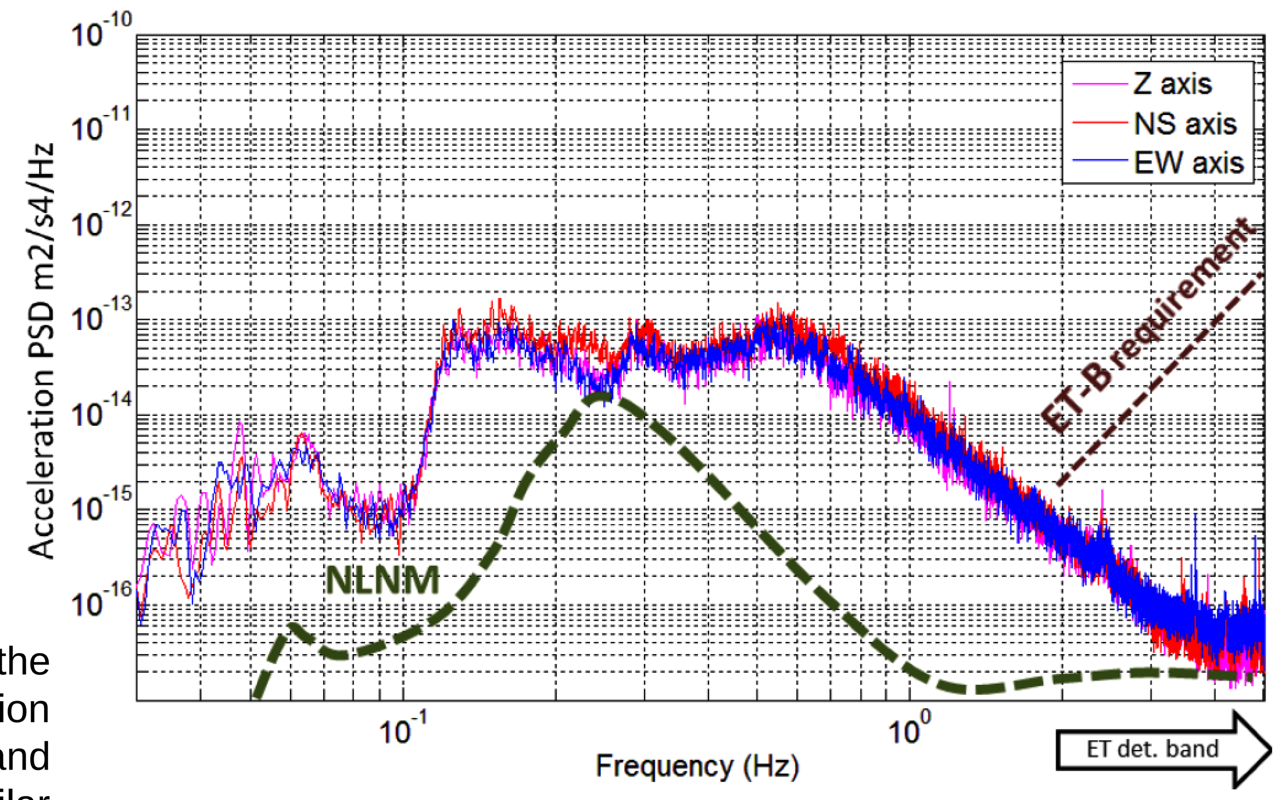




Microseismic noise power compared to the sea wave height



Microseismic peaks produced by the sea waves. The good weather conditions permit us to distinguish the superposition of spectral structures in the resulting quiet spectrum.



A typical quiet spectrum of the seismic noise measured at Sos Enattos former mine compared to the Peterson's New Low Noise Model (NLNM) and to the ET-B requirements as given in the ET Design Study.

Acknowledgements

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