Infrasound noise at SosEnattos

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The plan

- Atmospheric infrasound noise long term monitoring
- Noise variation
- Estimate of the atmospheric Newtonian noise

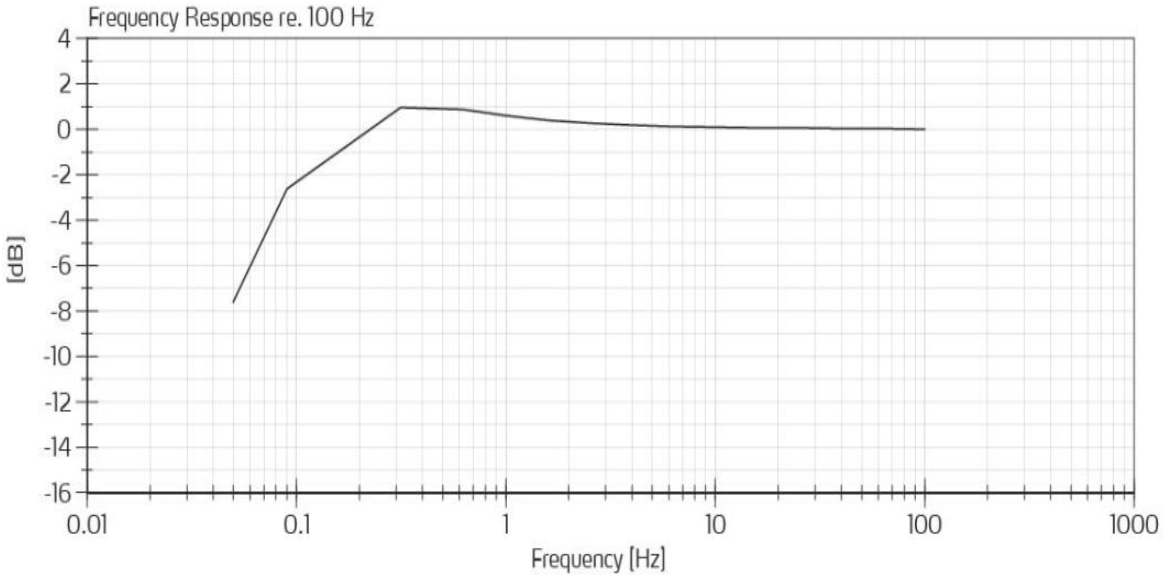
Microphone specification:

- commercial GRAS 47 AC, sensitivity 8 mV/Pa, frequency from 0.09 Hz to 20 kHz
- “Astrocent” microphones developed by us 2.5 mV/Pa, frequency from 0.1 Hz to 15 kHz
- data period over 2 years
- some failures due to power failure

GRAS 47AC 1/2" CCP Infra-Sound Microphone Set

Condenser microphone set for infra-sound measurements in open acoustic fields

- frequency range: **0.09 Hz** to 10 kHz
- dynamic range: 20 dB(A) to 148 dB
- sensitivity: **8 mV/Pa**

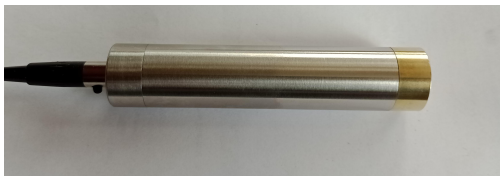


Microphones developed

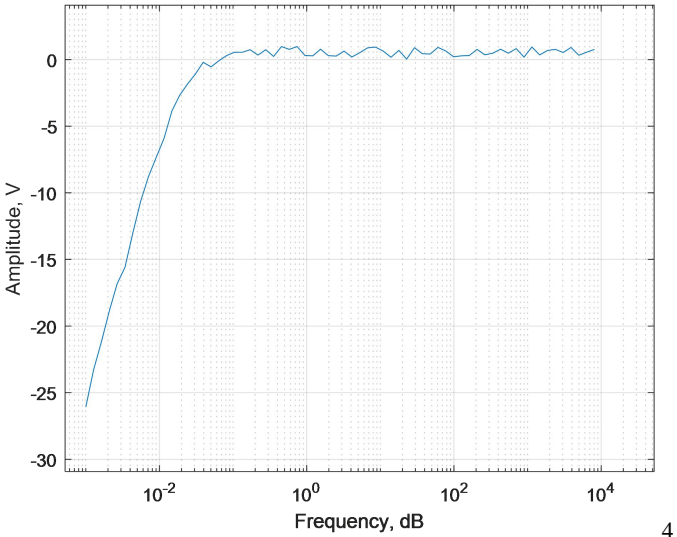
Developed sensor:

- frequency range from 0.04 Hz to 120 Hz (commercial devices starts from 0.09 Hz to 20 kHz)
- sensitivity: prototype 2.5 mV/Pa (secon version 25.5 mV/Pa)
- distortion max. 1 dB

New version (final release)



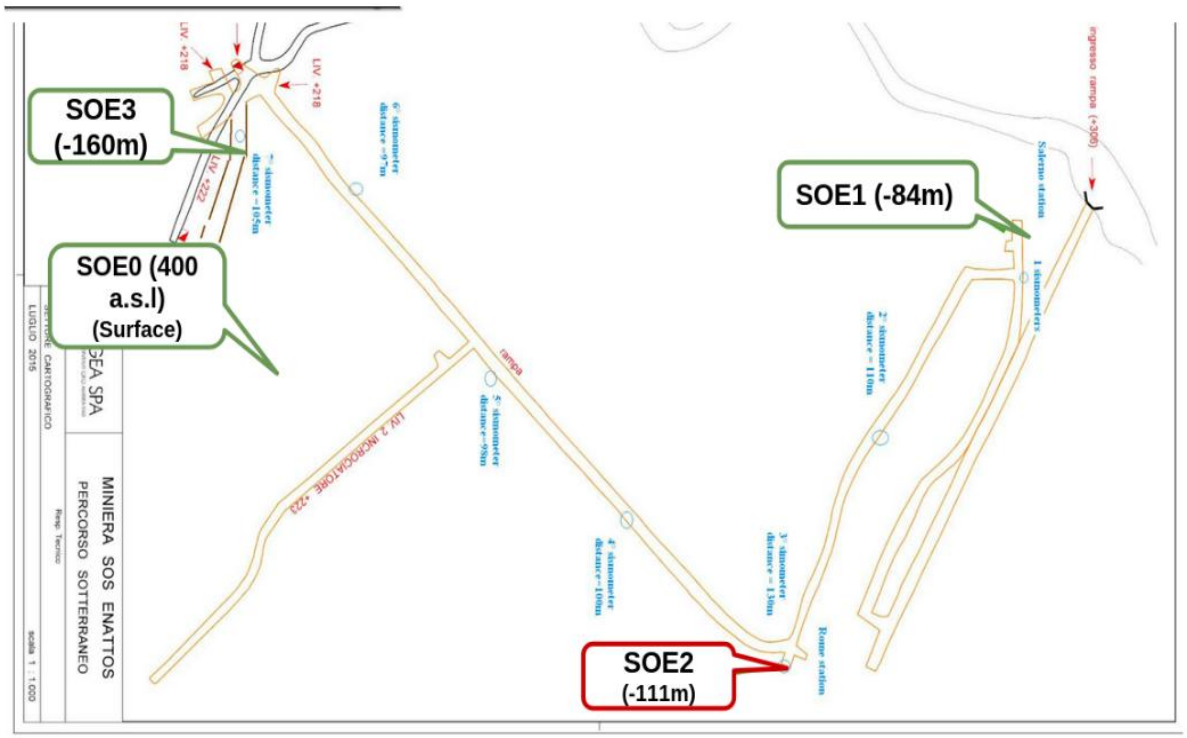
Prototype



Sites

- **SOE0:** surface station
- **SOE1:** shallow installation
- **SOE3:** underground station (~160 m depth)
- Continuous monitoring from around **2022/11 to 2024/09**

Microphone locations



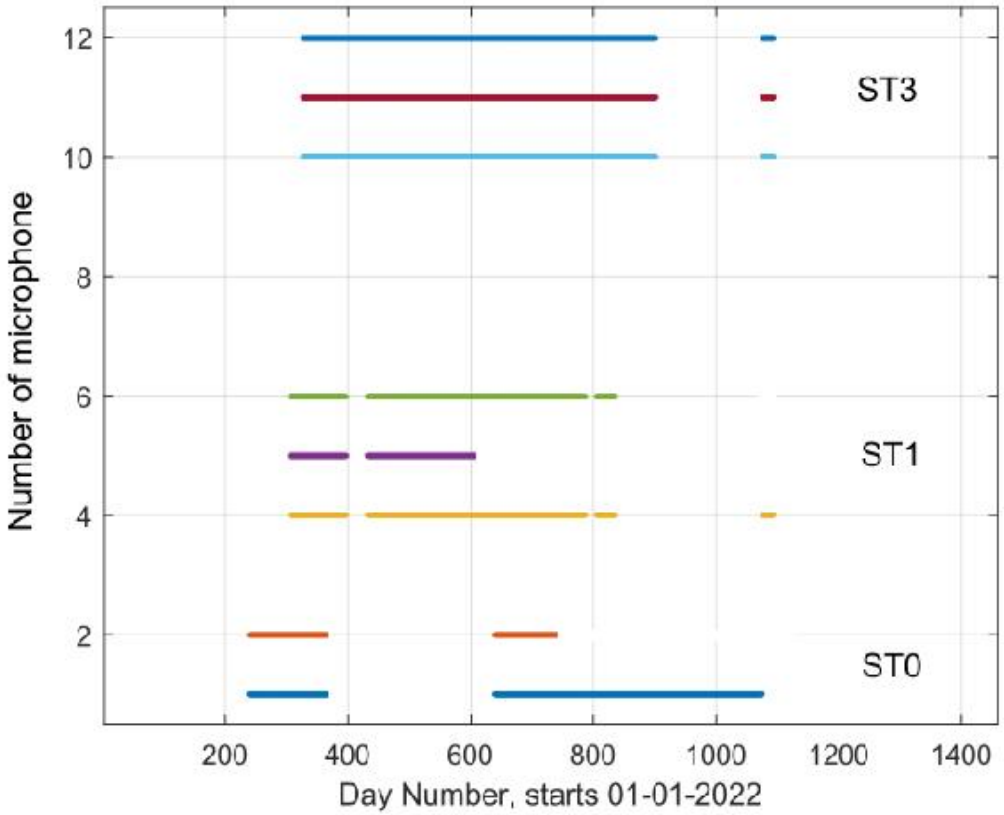
Stations

ST0 - Surface Station

SOE1 Underground station

Available infrasound data

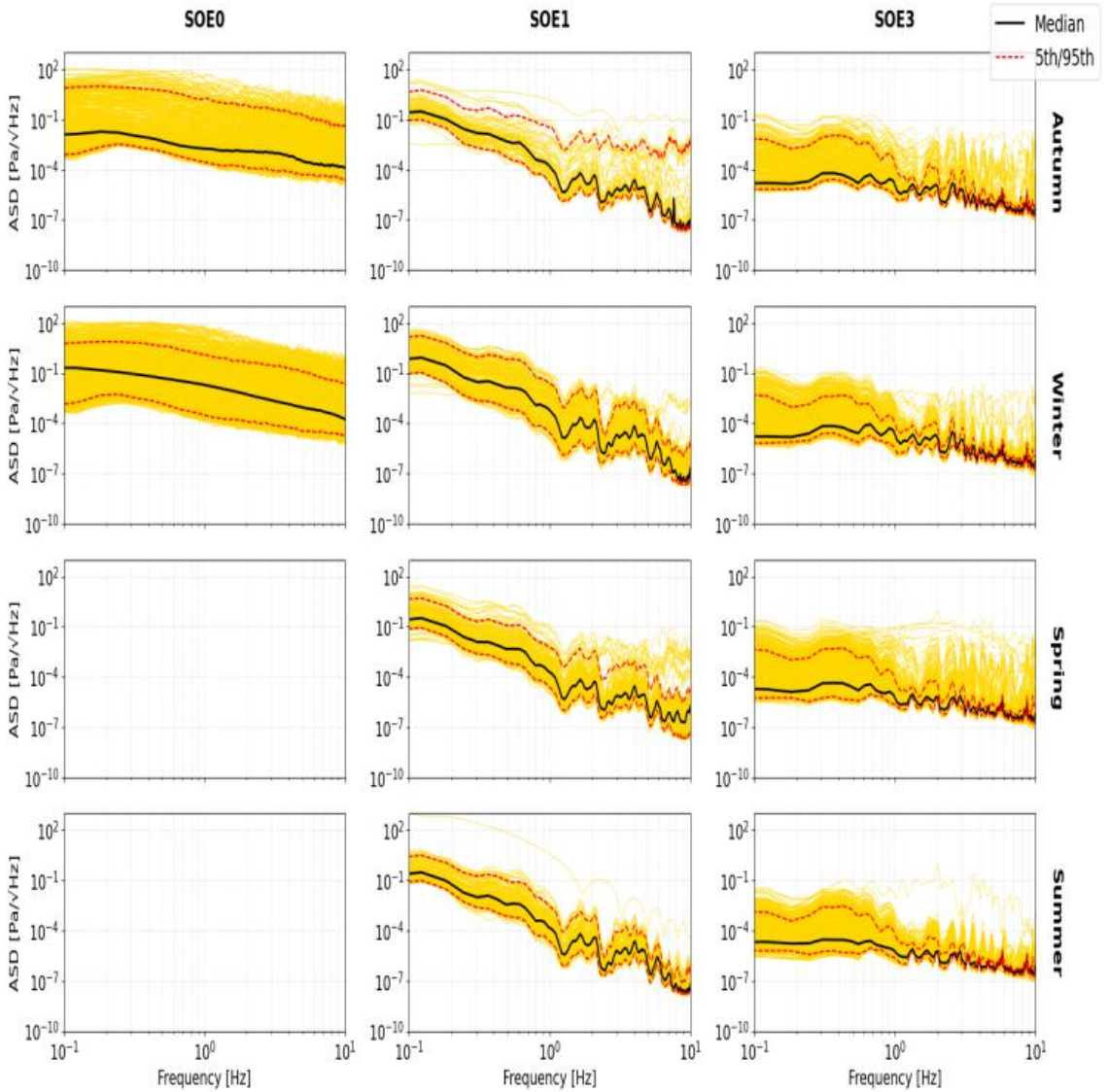
- More than 2 years of data (since 21st Nov. 2022 till now 12th Dec 2024)
- Data stored at public: **https://intra.astrocent.camk.edu.pl/sos_enattos/**
- Data miniseed format
- ST0: 1608 days of data 2x microphones (804 per mic.)
- ST1: 1540 days of data 3 microphones (513 per mic.)
- ST3: 1812 days of data 3 microphones (604 per mic.)
- data till 19.02.2025



Seasonal ASD Analysis

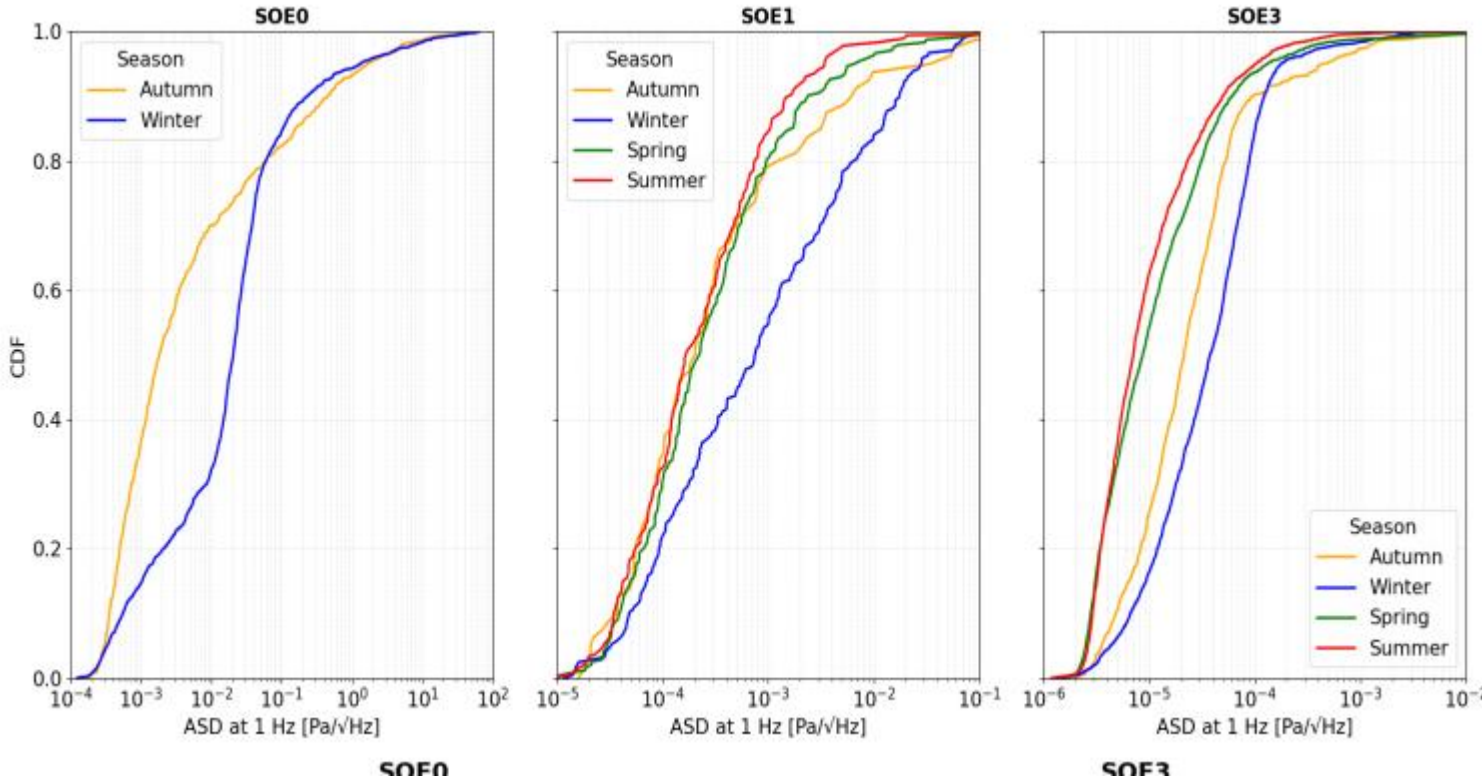
- Median (black) and 5th/95th percentiles (red dashed) for each season and sensor

- Seasonal dependence visible in SOE0 and SOE1 spectra



Seasonal variation

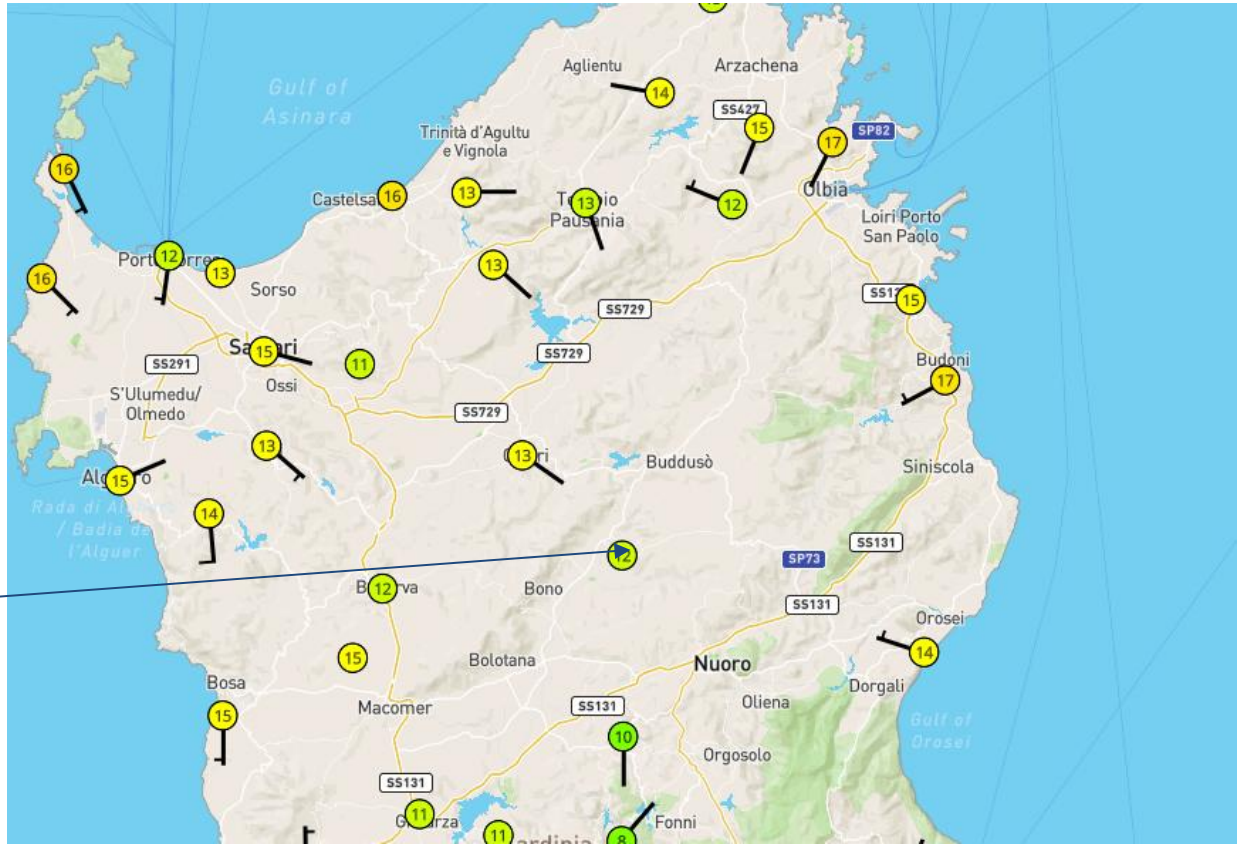
- **Cumulative Distributions of ASD at 1 Hz**
- Seasonal CDFs reveal **higher noise levels in winter**.
- SOE0: moderate seasonal variability.
- SOE3: strong contrast between quiet winter and noisy summer



Weather data

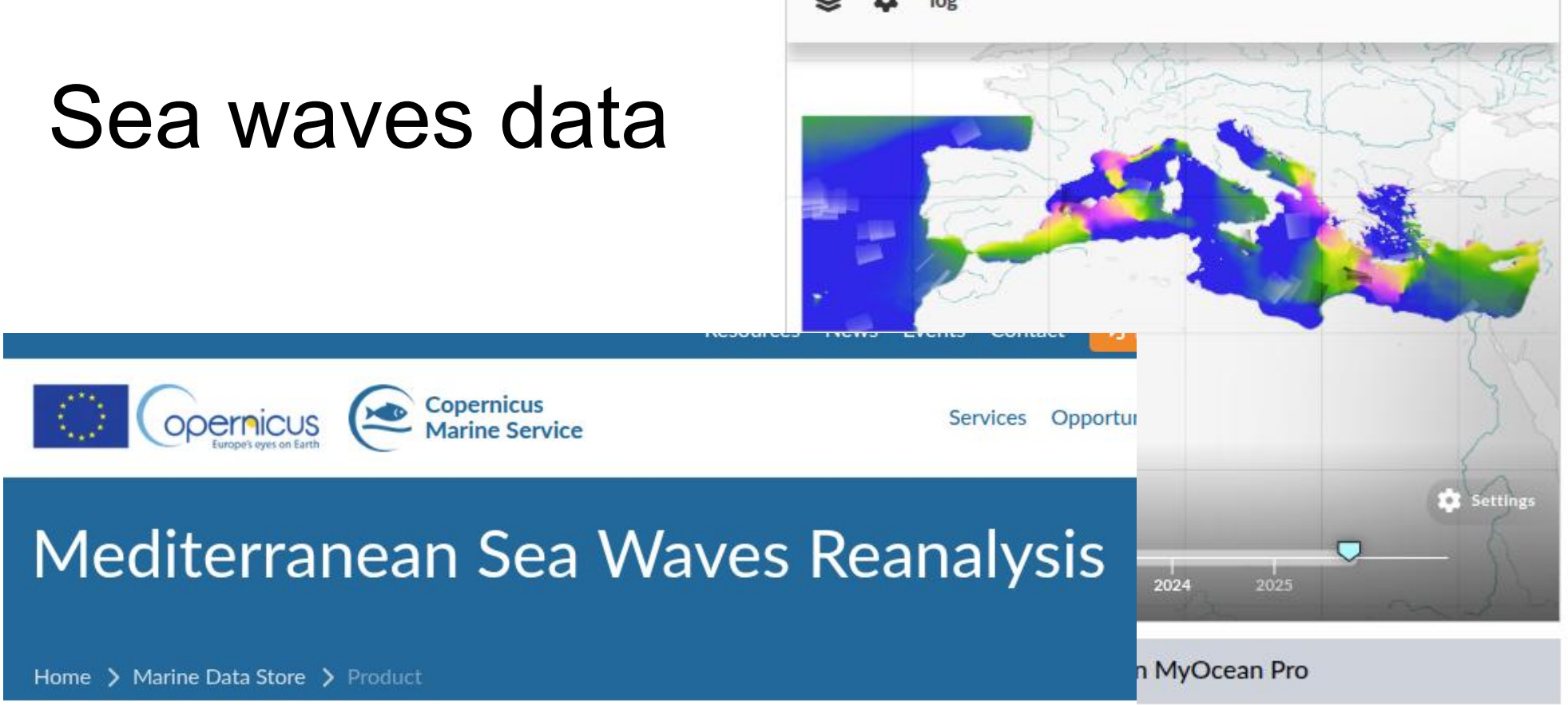
Weather Wunderground network

IBENETT13 station
in Benetutti



https://www.wunderground.com/weather/IBENET13

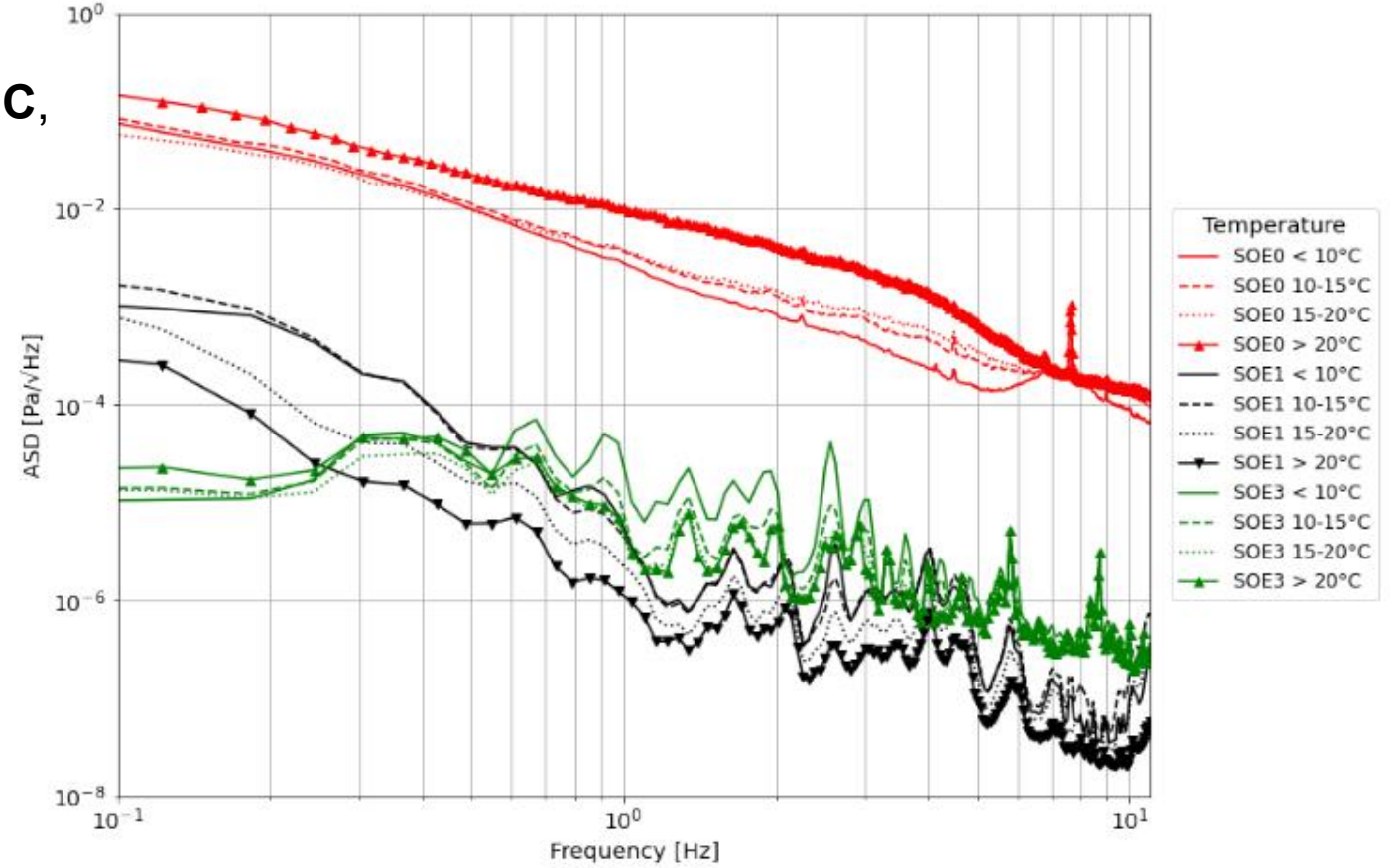
Sea waves data



https://data.marine.copernicus.eu/product/MEDSEA_MULTIYEAR_WAV_006_012/description

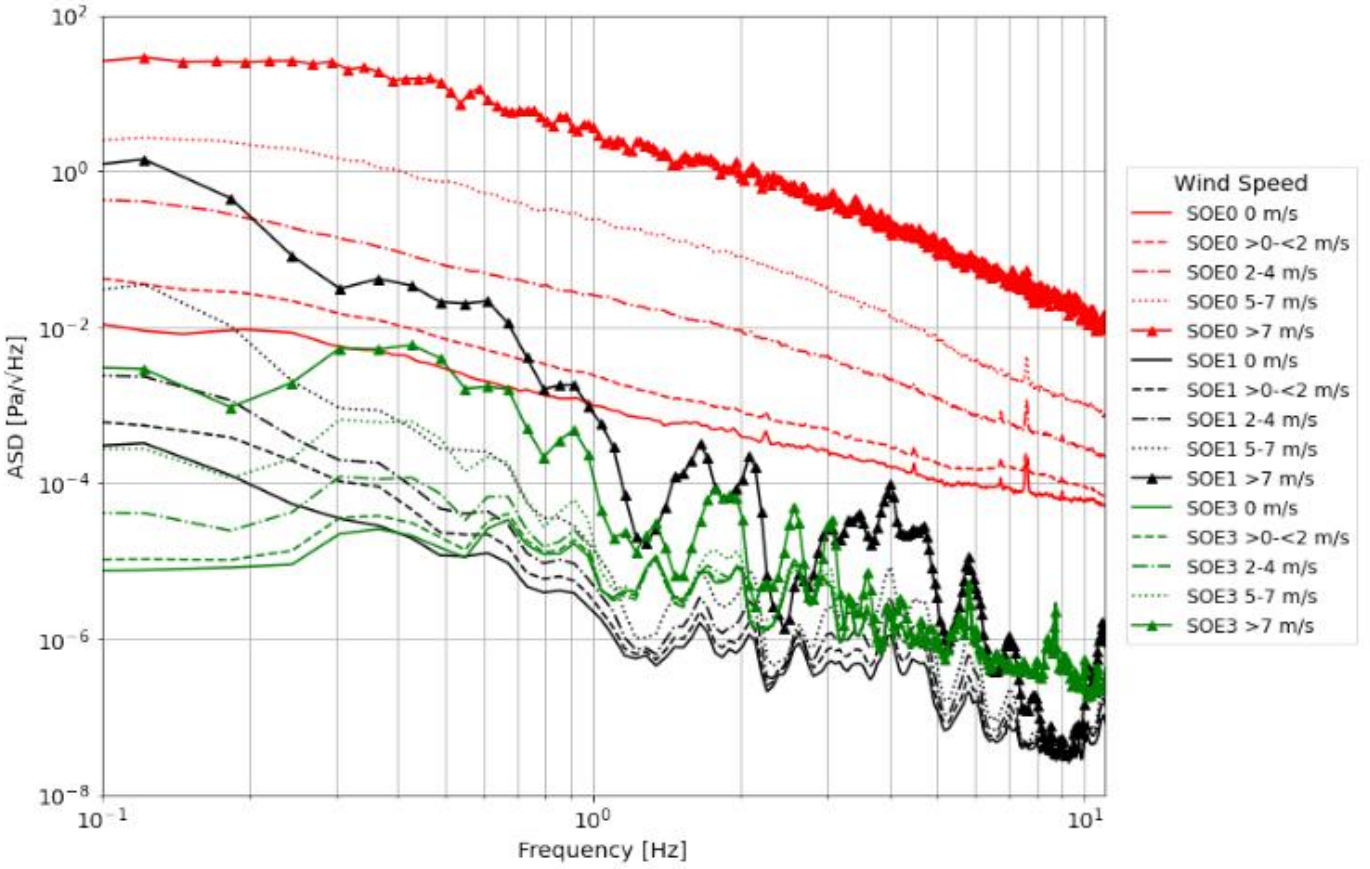
Temperature dependence

- SOE0: higher amplitudes above **20 °C**, quieter below **10 °C**
- SOE1: weaker but similar trend
- SOE3: largely insensitive boundary-layer effects limited to surface



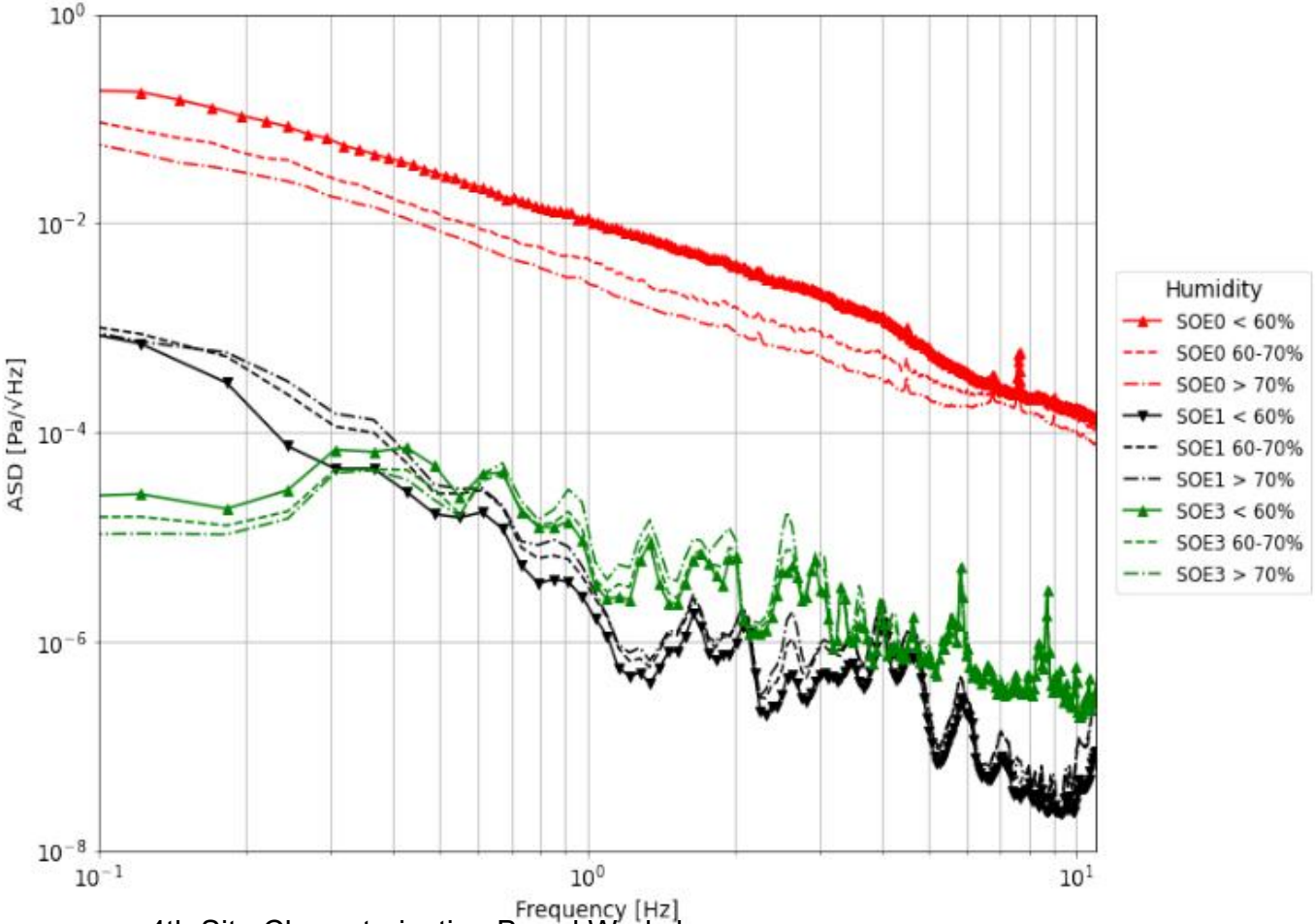
Wind speed dependence

- **Dominant control parameter** across all sites
- SOE0: several orders-of-magnitude rise between calm and >7 m/s winds
- SOE1: similar but weaker response
- SOE3: least sensitive yet systematic increase



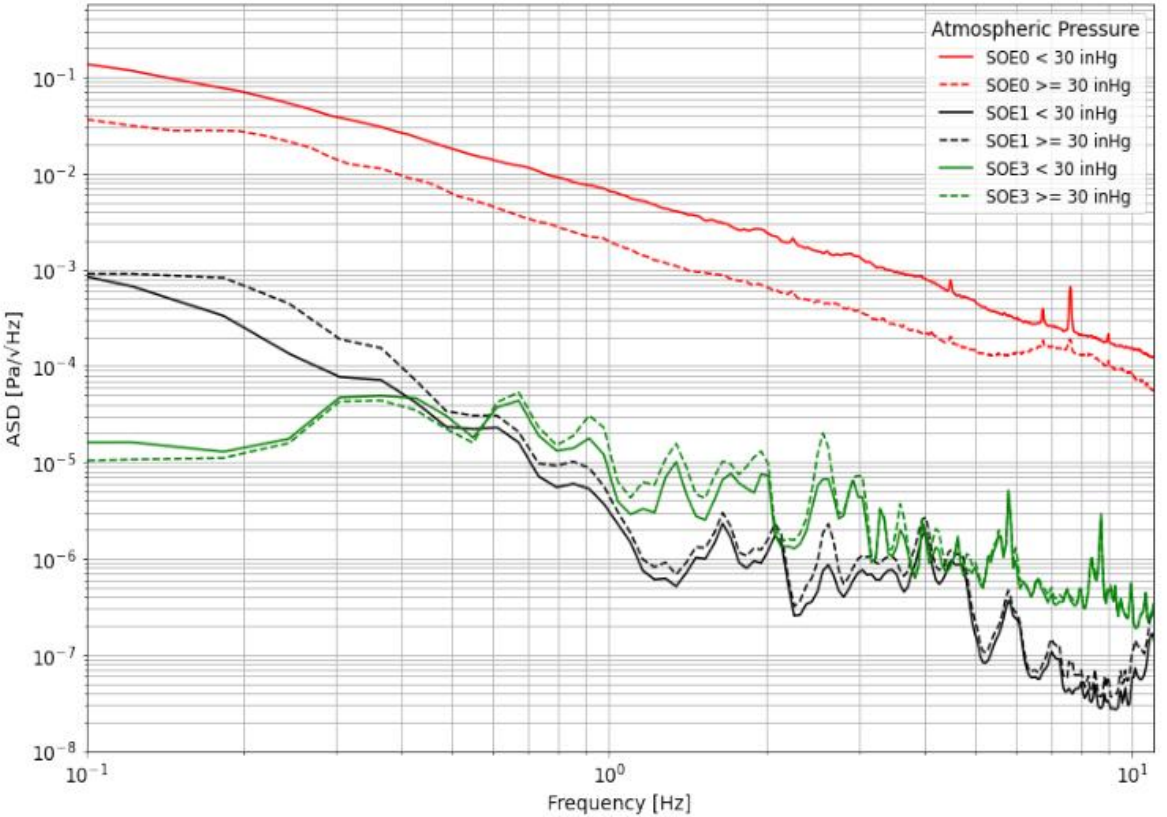
Humidity dependence

- **Humidity:** SOE0 shows rising noise above 70%; SOE3 nearly constant
- **Pressure:** Enhanced amplitudes during low-pressure (storm) conditions
- Correlations consistent with meteorological forcing



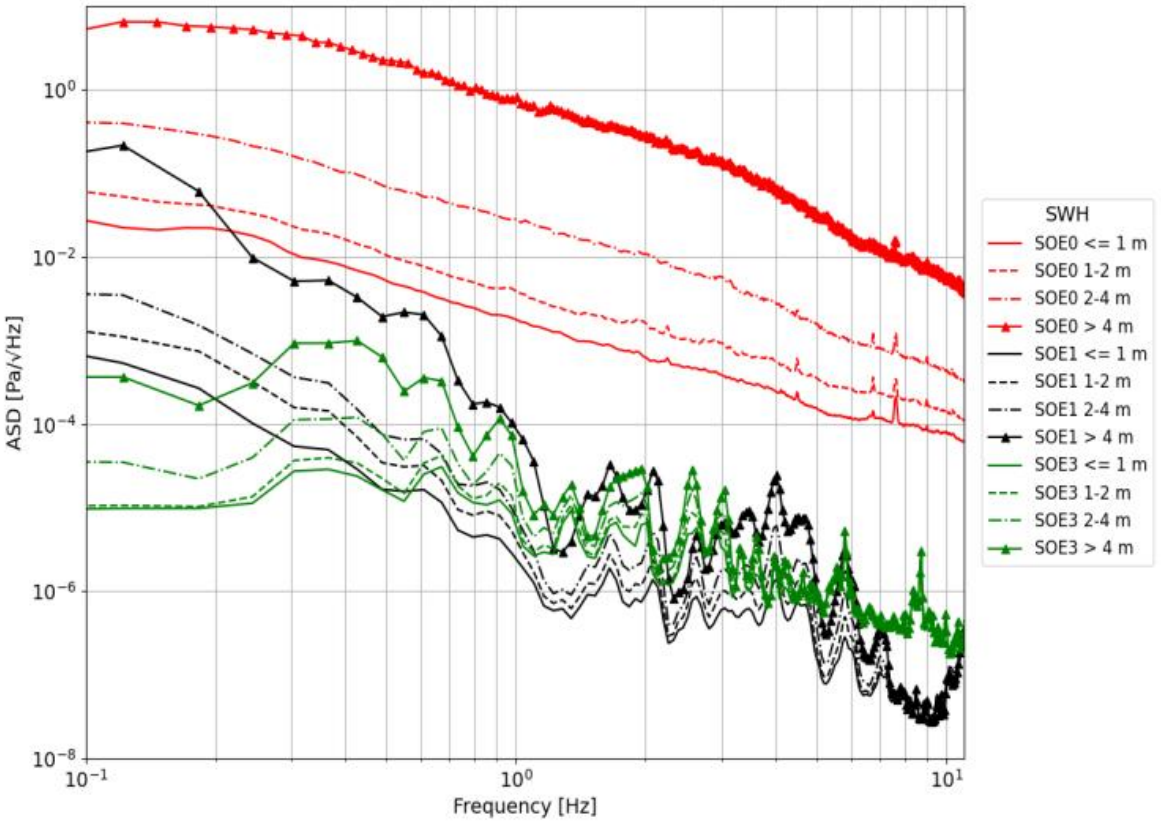
Atmospheric pressure dependence

- Median ASD curves analyzed as a function of **atmospheric pressure**
- **SOE0:** noticeable increase in amplitudes during **low-pressure conditions (<30 inHg)**, consistent with storm activity and enhanced turbulence
- **SOE1 & SOE3:** only minor variations, indicating weaker coupling between local pressure fluctuations and subsurface acoustic fields
- Suggests that **synoptic-scale weather systems** influence surface infrasound levels, while underground sites remain largely isolated



Sea wave height dependence

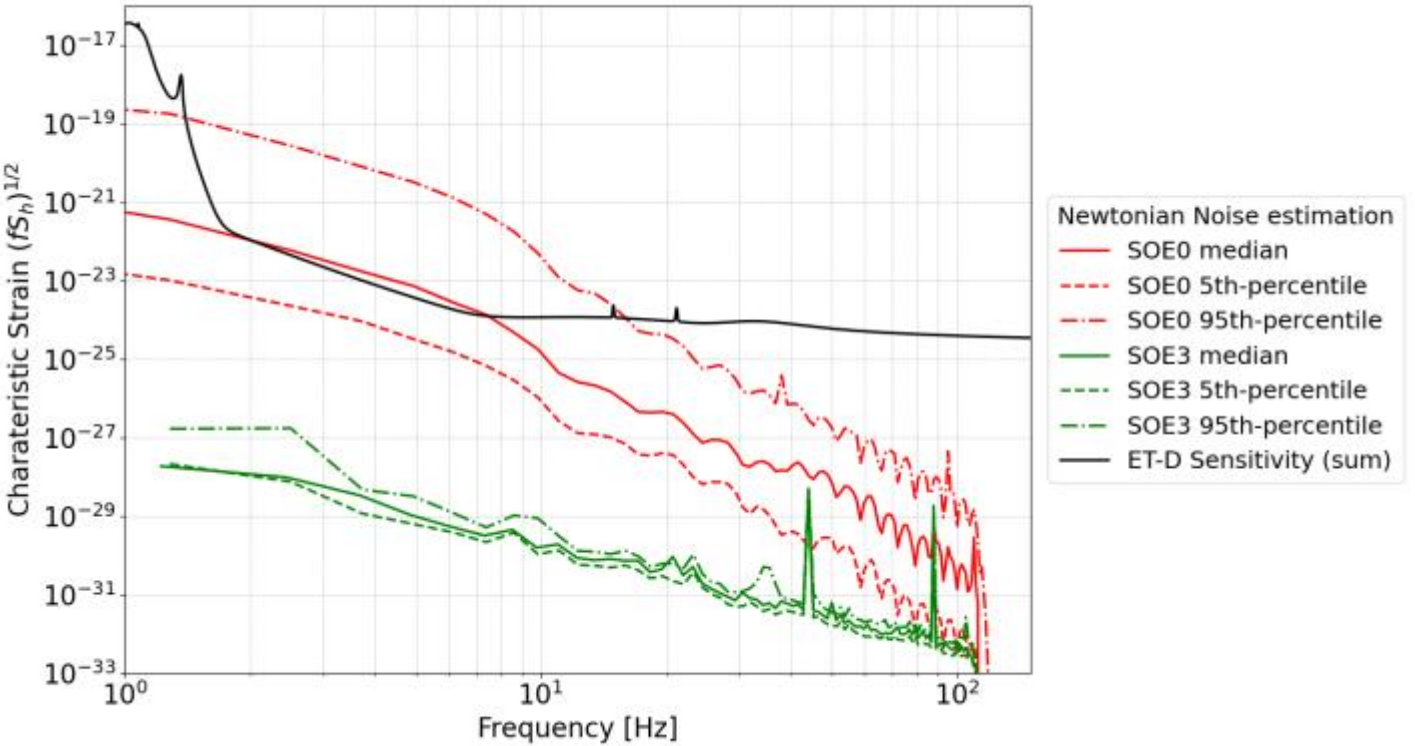
- Median ASD spectra evaluated versus **significant wave height (SWH)** derived from nearby marine data
- **SOE0:** strong sensitivity, amplitudes rise by **>2 orders of magnitude** when SWH exceeds **4 m**, confirming microbarom generation under stormy seas.
- **SOE1:** weaker but consistent trend
- **SOE3:** only moderate response due to depth and partial decoupling.
- Demonstrates that **marine microbaroms** are a major contributor to surface infrasound at SosEnattos



Acoustic NN

Characteristic Strain Spectra

- Red: SOE0 (surface), Green: SOE3 (underground)
- Black: ET-D reference sensitivity
- SOE3 suppression by several orders of magnitude



Conclusions

- Long-term infrasound monitoring at SosEnattos reveals strong seasonal and meteorological variability
- Wind speed and marine activity (SWH) are the dominant factors controlling infrasound noise levels
- Low-pressure systems enhance surface noise, while underground sensors remain unaffected

- Underground noise (SOE3) small contribution to atmospheric Newtonian noise
- Surface atmospheric NN noise can affect ET sensitivity in the loud periods
- Underground noise can be mitigated by small cavities.

Thank you for your attention

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