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
- data period ~ 2 years
- some failures due to power failure, internet access problems…

Measurement Sites

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

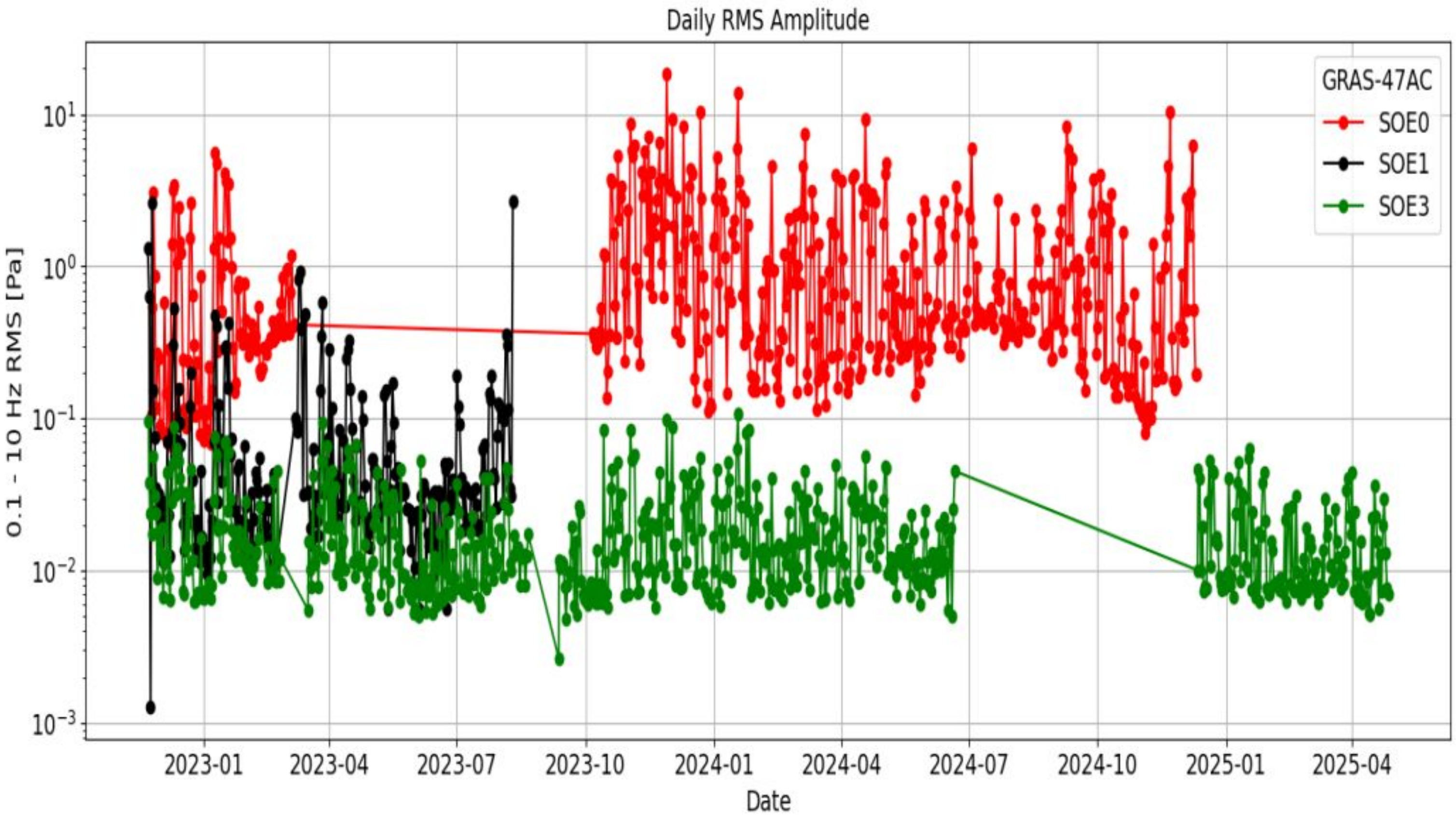
Microphone locations

Stations

ST0 - Surface Station

SOE1 Underground station

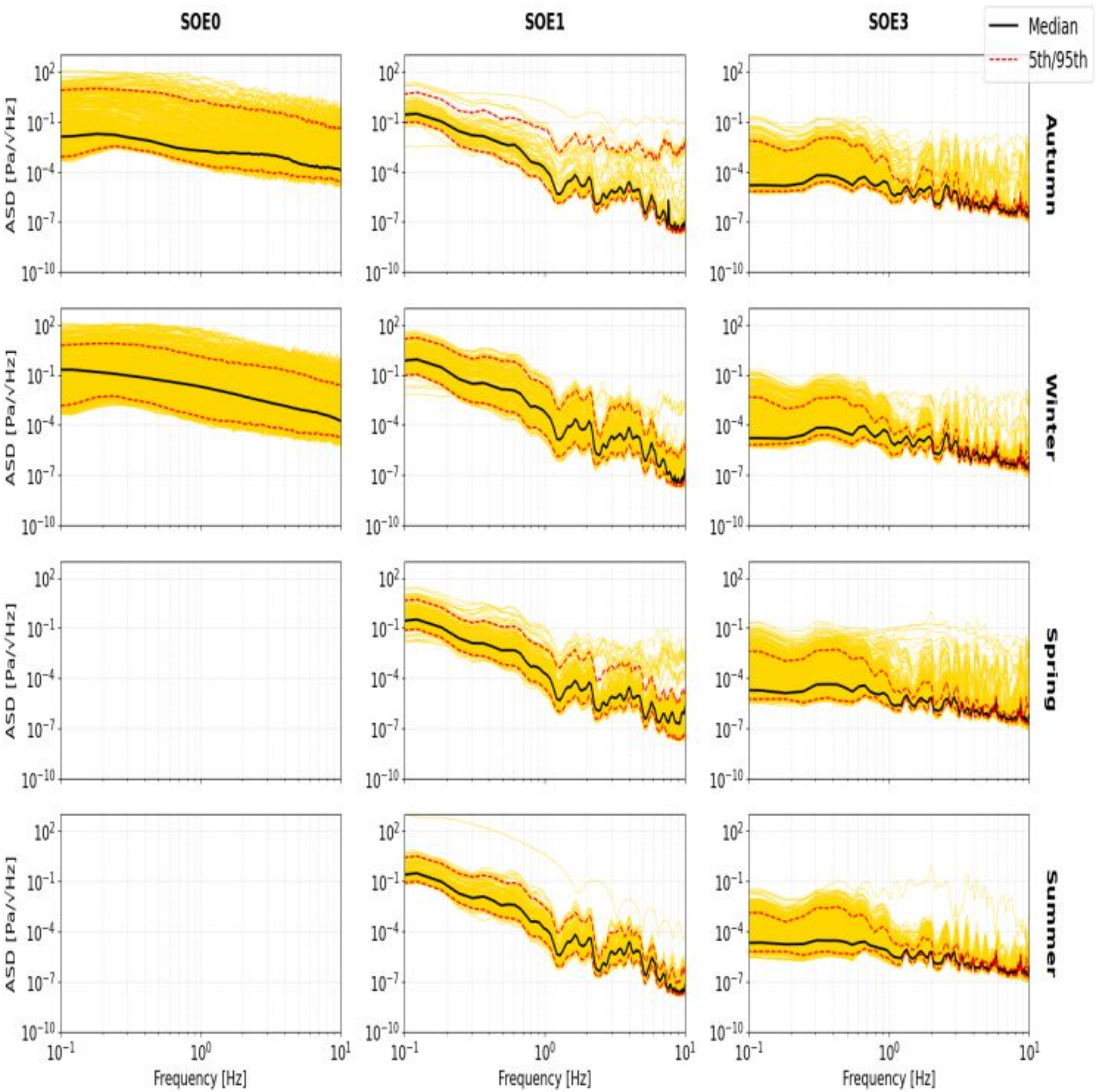
Available infrasound data



Seasonal ASD Analysis

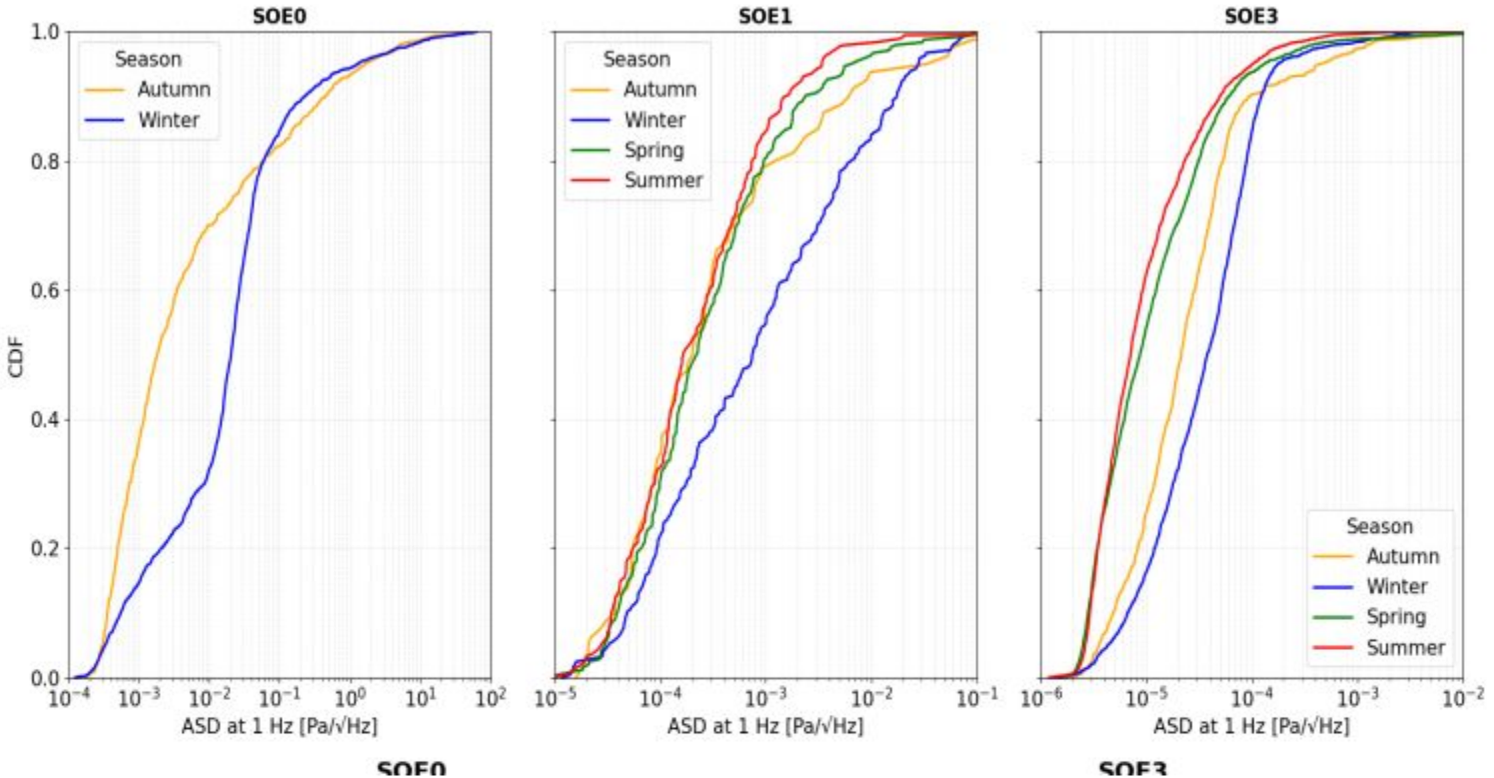
- Median (black) and 5th/95th percentiles (red dashed) for each season and sensor.

- 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

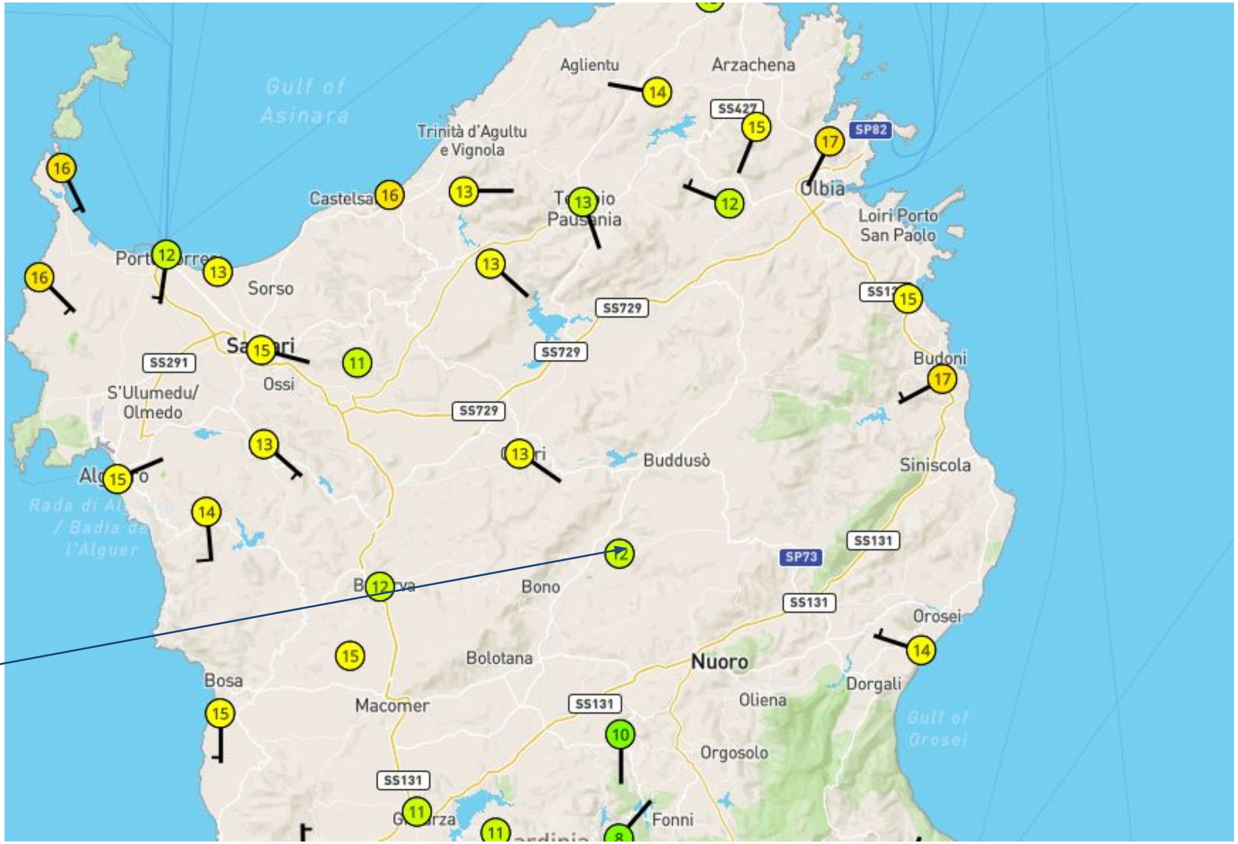


Weather data

Weather:

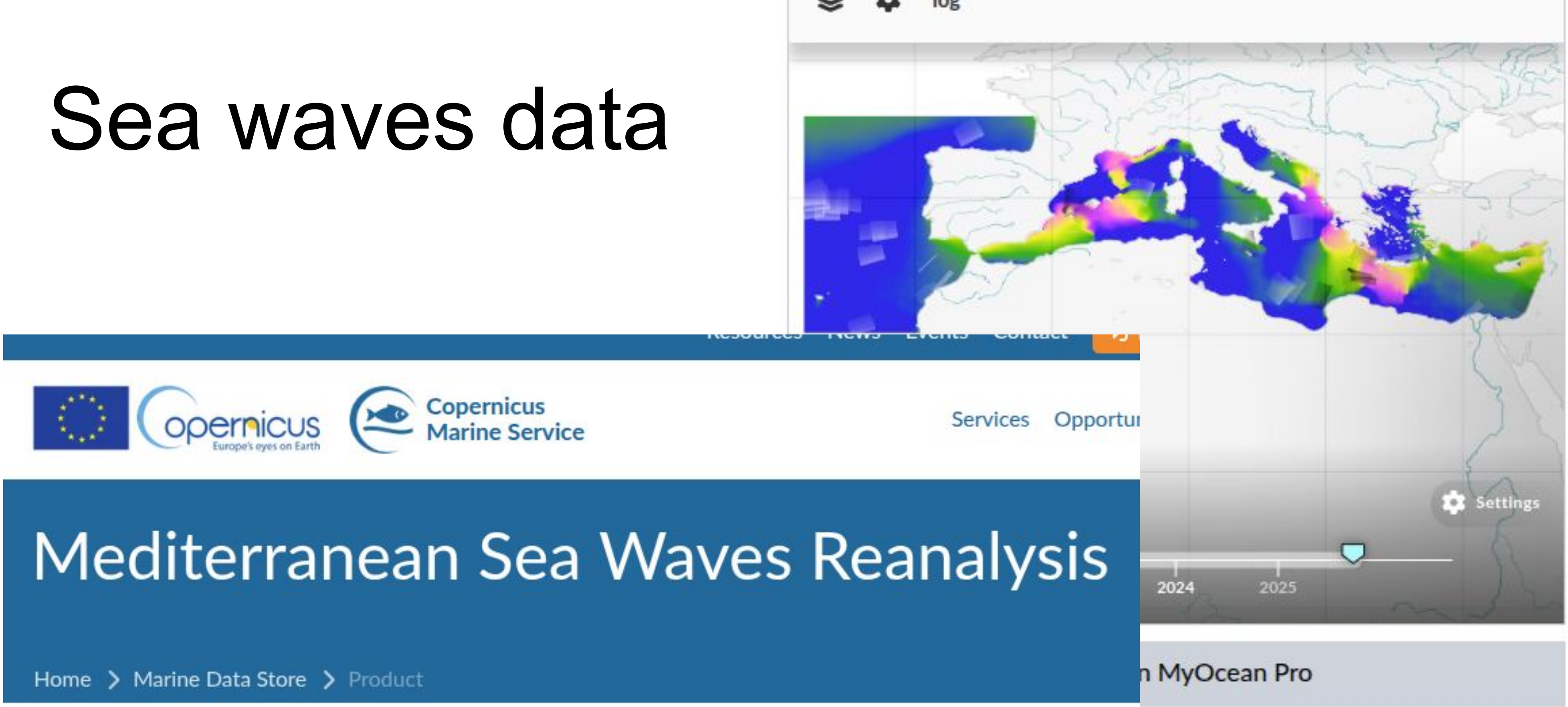
Wunderground network

IBENETT13 station
in Benetutti



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

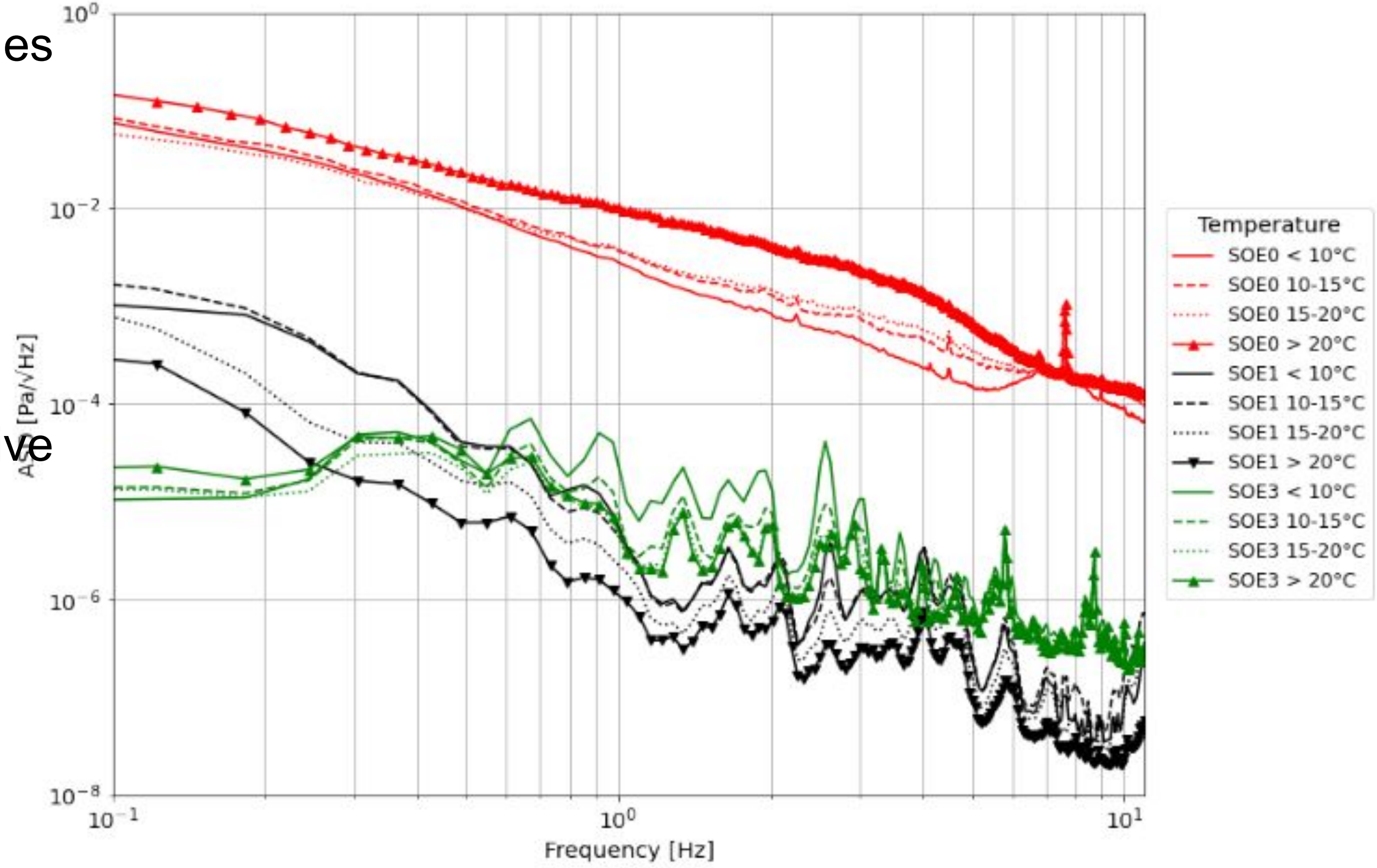
Sea waves data



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

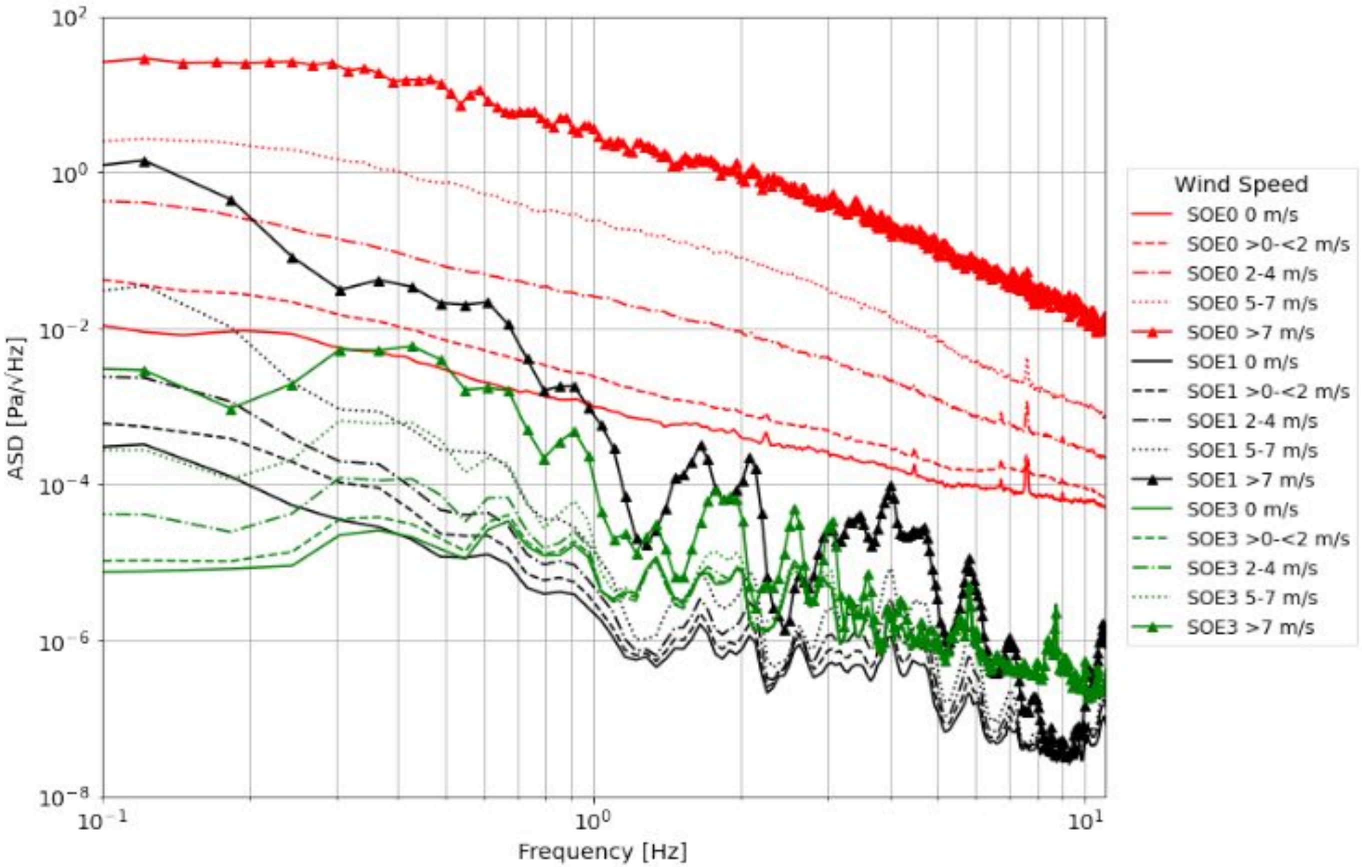
Temperature dependence

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



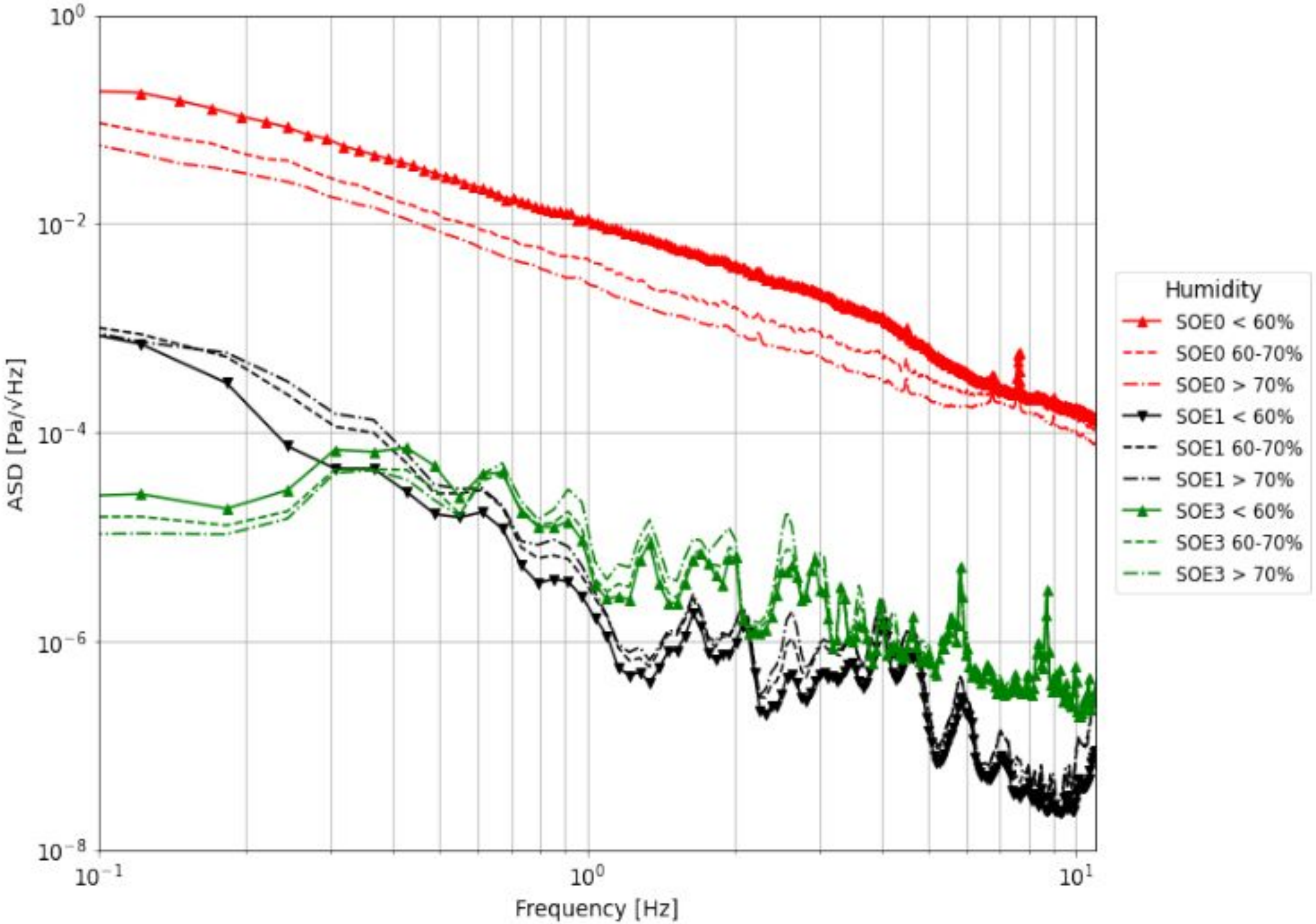
Wind speed dependence

- **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



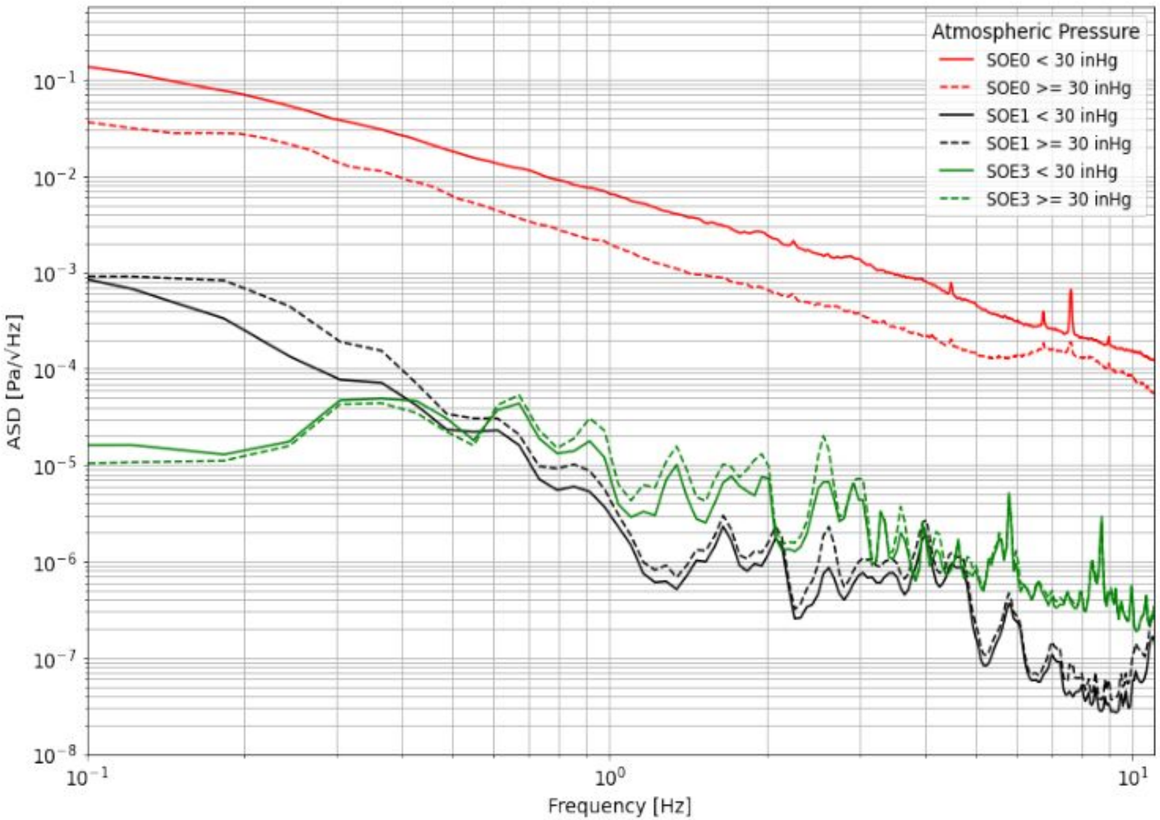
Humidity dependence

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



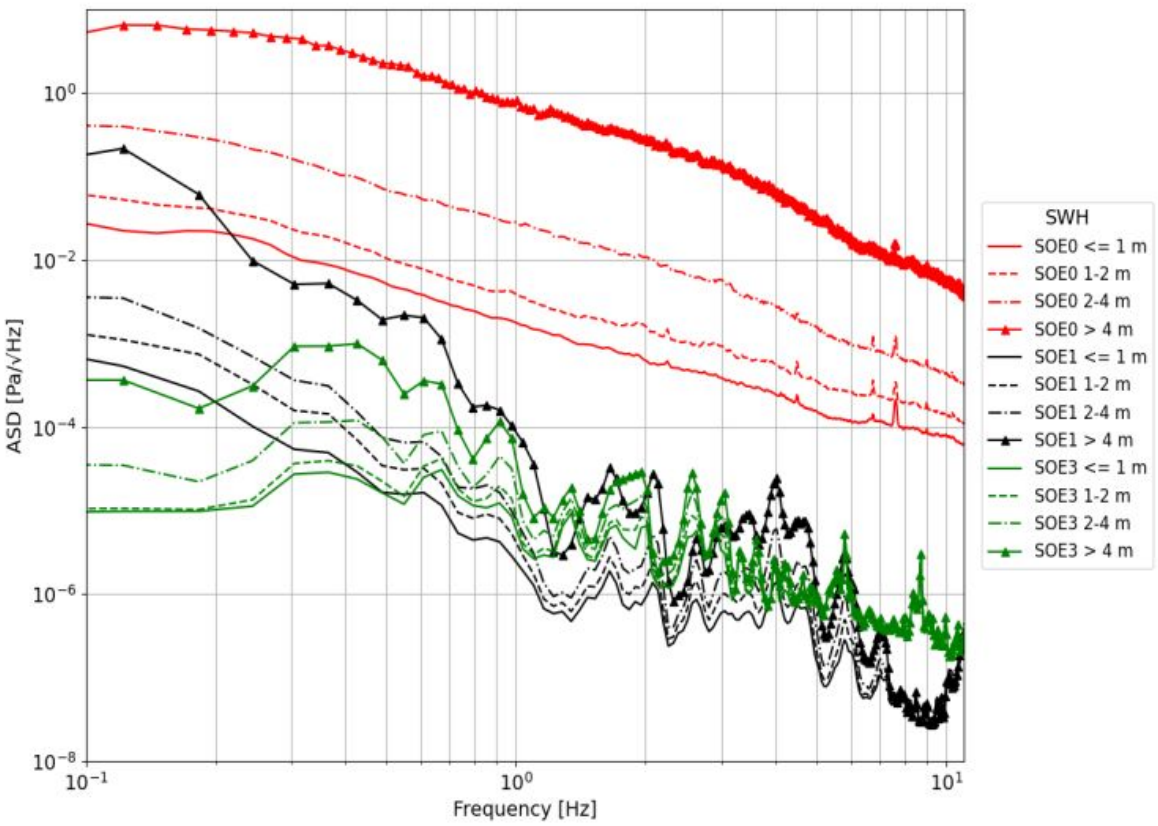
Atmospheric pressure dependence

- 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



Newtonian noise calculation

Estimating Atmospheric NN

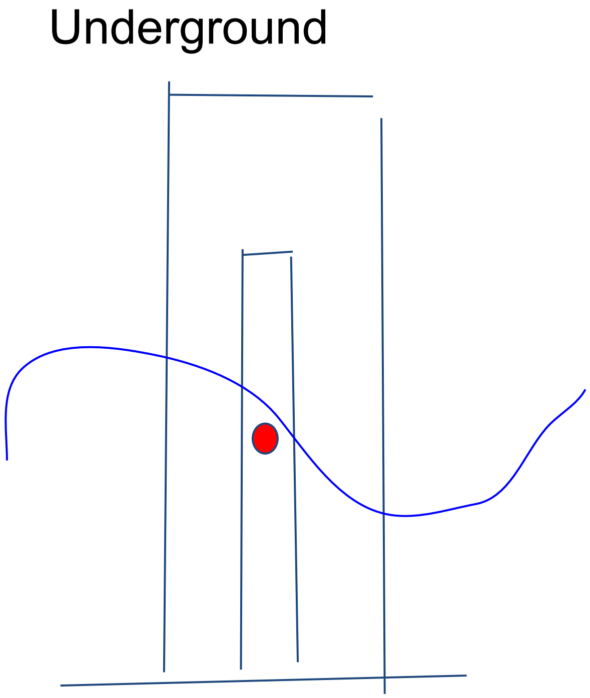
from “Pressure fluctuations” to “density perturbations” finally to “gravitational acceleration”, linear-acoustic approximation:

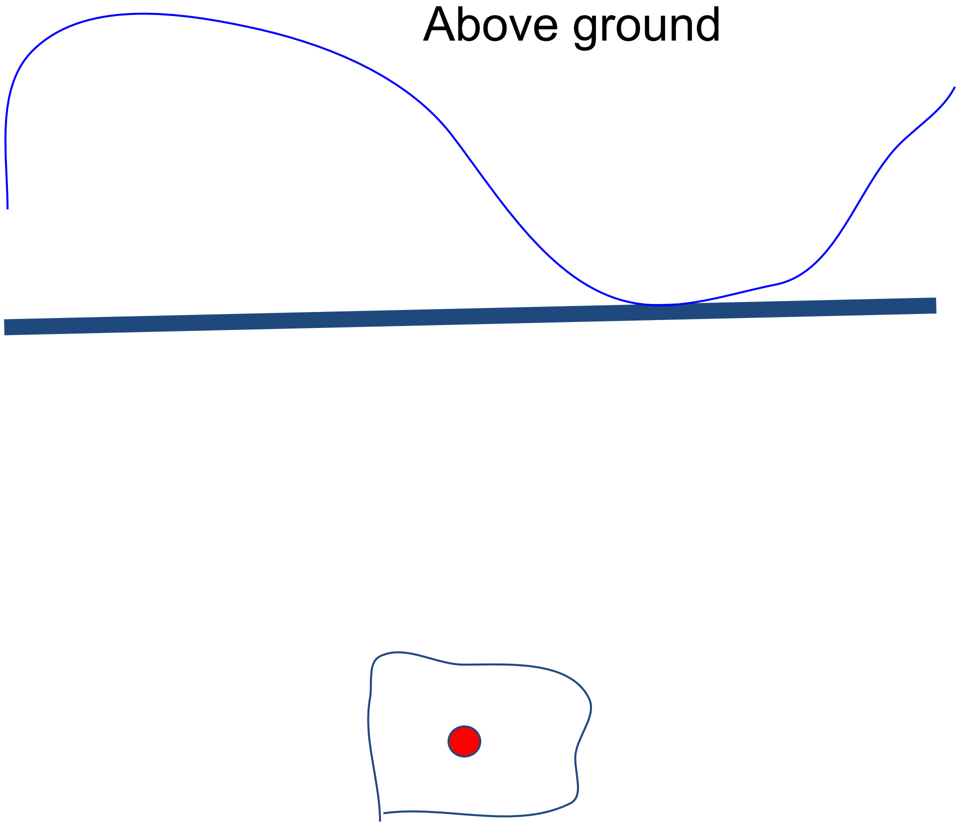
$$\delta\rho = \frac{\delta p}{v_s^2}, \quad Sa(f) = |A(f)|^2 S_p(f)$$

Conversion to **strain-equivalent PSD:**

$$S_h(f) = \frac{|A(f)|^2 S_p(f)}{(2\pi f)^4 L^2}$$

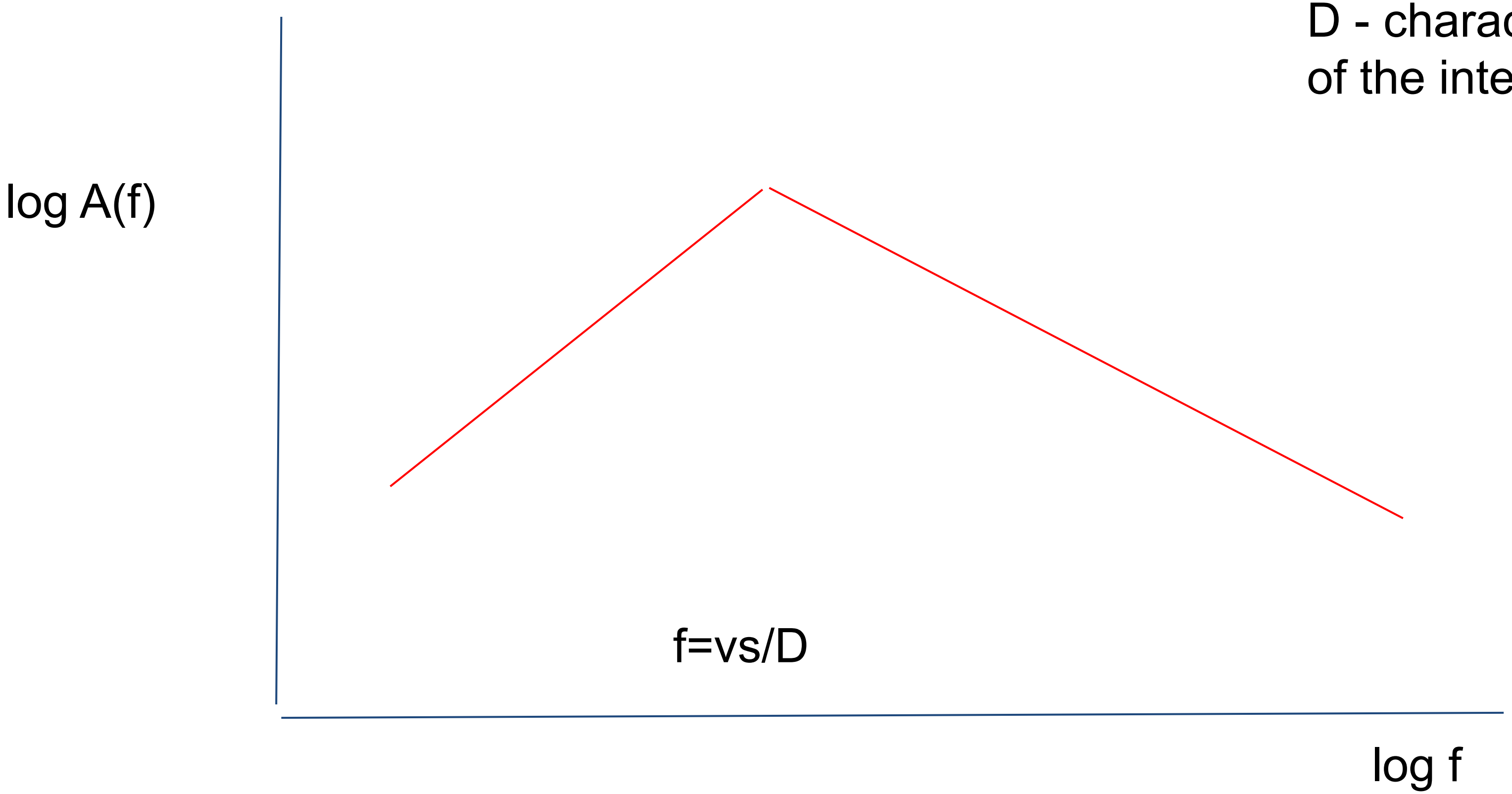
Calculating A(f) -the importance of integration limits





The A(f) function

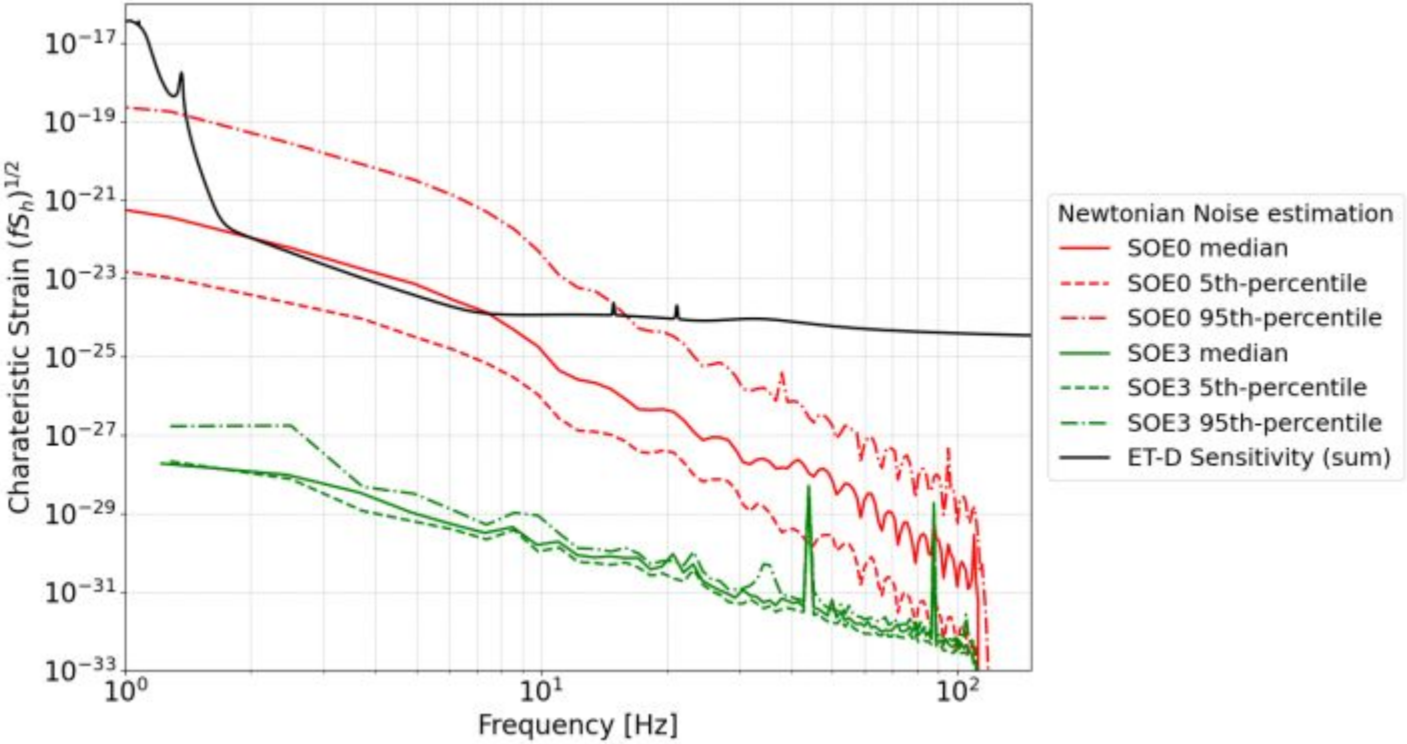
D - characteristic length
of the integration geometry



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 largely unaffected
- **Underground noise (SOE3) small contribution to atmospheric Newtonian noise (but real noise may be different). Small cavities are better!**
- **Surface atmospheric NN noise can affect ET sensitivity in the loud periods**
- **Needed: detailed investigation of the atmospheric infrasound noise contribution, coherence length on the surface, height(?).**
- **Underground noise can be mitigated by small cavities.**

Thank you for your attention