



OBSERWATORIUM ASTRONOMICZNE UNIWERSYTETU WARSZAWSKIEGO

## **Infrasonic Noise Analysis at Sos Ennatos**

# Wathela Alhassan<sup>1</sup>, D. Rosińska<sup>2</sup>, M. Cieslar<sup>2</sup>, M. Suchenek<sup>1,2</sup>, E. Fenyvesi<sup>3</sup>, T. Bulik<sup>2</sup>

<sup>1</sup> Nicolaus Copernicus Astronomical Center, Bartycka 18, 00-716 Warsaw, Poland <sup>2</sup> Astronomical Observatory of the University Warsaw, Al. Ujazdowskie 4, 00-478 Warsaw, Poland <sup>3</sup> HUN-REN Wigner Research Centre for Physics, Konkoly-Thege Miklós út 29-33., 1121 Budapest, Hungary

### XV ET Symposium, May 26 – 30, 2025 CNR - Bologna, Italy

#### Infrasound and Gravitational Wave Detection

Infrasound is a significant contributor to Newtonian Noise (NN) in gravitational wave detectors.

Atmospheric infrasound waves induce local air density fluctuations, which cause variations in the gravitational potential.

These fluctuations couple directly to the test masses, introducing noise that can mimic or obscure true gravitational wave signals.

This effect is most pronounced below ~10 Hz — a critical frequency band for next-generation detectors such as the Einstein Telescope and Cosmic Explorer.

#### **Objectives:**

- Long-term infrasound monitoring and analysis at Sos Enattos for Newtonian noise characterization.
- Assess how weather conditions influence infrasound noise.



Credit: vlf.it

## Sos Enattos Map



### The Setup

One GRAS 47-AC mic was installed at each station.

Frequency Range: 0.09 Hz to 10 kHz | Our focus 0.1 to 10 Hz

Sensitivity: 8 mV/Pa

**Dynamic Range**: 20 dB(A) to 148 dB

**Output**: Constant Current Power signal



### SOE0















# SOE0: 2022-11-24 - 2024-12-11

**#** SOE1: 2022-11-22 - 2023-08-10

# SOE3: 2022-11-22 - 2025-04-27



# Part 1: 2022-11-22 - 2023-09-22

**#** Part 2: 2023-09-23 - 2024-09-22

Part 1

#### Seasonal Analysis



Part 1

ASD Distribution at 1 Hz



Part 2

Seasonal Analysis



Part 2

ASD Distribution at 1 Hz



#### Weather Underground Station IBENET13

- Station ID: IBENET13
- Location: Benetutti, Giuncana, Sardinia, Italy
- ≈ 23 km west of the Sos Enattos mine
- Network: Part of the Weather Underground personal weather station (PWS) network — a global community of volunteers contributing real-time weather data.
- Data Provided: Temperature, dew point, humidity, wind speed, pressure, and rainfall at 5 minute temporal resolution

Date	Temperature_C	Wind_Speed_ms	Humidity	Pressure
2022-11-22 09:54:00	11.22	13.32	68.0	29.41
2022-11-22 09:59:00	11.06	11.80	70.0	29.41
2022-11-22 10:04:00	11.06	13.81	70.0	29.41
2022-11-22 10:09:00	10.94	14.04	72.0	29.42
2022-11-22 10:14:00	10.28	11.40	76.0	29.42



#### Weather Impact on Infrasound:

- Data Source: weather data from IBENET13 station (22 Nov 2022 27 Apr 2025).
- Method:
  - For each hour, **5 minutes** of infrasound data (e.g., 12:00–12:05) were matched with simultaneous weather parameters. This resulted in **24 samples per day over 536, 270, and 675 days** for SOE0, SOE1, and SOE3, respectively.
  - Parameters: **Temperature**, **Humidity**, **Atmospheric Pressure**, and **Wind Speed**.
- Analysis:
  - Weather parameters were **binned into intervals** based on their full distribution.
  - For each bin, the **median Amplitude Spectral Density (ASD) curve** of infrasound was computed

#### Median ASD curves: Temperature



#### Median ASD curves: Wind Speed





#### Median ASD curves: Atmospheric Pressure



## Mediterranean Sea Waves Reanalysis (MEDSEA\_MULTIYEAR\_WAV\_006\_012)

• Source & Provider:

Copernicus Marine Service (CMEMS)

• Model & Method:

Wave model **WAM 4.6.2** using nested grids to capture swell propagation from the Atlantic through the Strait of Gibraltar.

- Coverage & Resolution:
  - Time period: Since January 1985
  - $\circ$  Spatial resolution: 1/24° (~4 km) in the Mediterranean
  - **Temporal resolution:** Hourly
  - **Geographic extent:** Mediterranean Sea + up to 18.125°W in the Atlantic
- Assimilation:

Uses satellite altimeter data to assimilate parameters (Sentinel-1 from 2017).

• Key Output Parameter: Significant Wave Height (SWH) among others, modeled across 24 directions.



#### Mediterranean Sea Waves Reanalysis

MEDSEA\_MULTIYEAR\_WAV\_006\_012 Models Med Sea, 0.042° × 0.042° 1 Jan 1985 to 1 Apr 2025, hourly, monthly Velocity, wave





Available data





## Conclusion

- No significant seasonal variability is observed at SOE0 and SOE3. However, more data is required to verify trends at SOE1.
- There is a clear impact of wind speed and wave height on the ASD at both the surface and subsurface levels.
- $\succ$  The influence of temperature tends to diminish with depth.
- Low humidity appears to correlate with elevated ASD at the surface and at SOE3 (below 0.4 Hz).

## > Future Work:

Quantify the infrasound contribution to Newtonian noise in the Einstein Telescope (ET).

## Thank you!

## walhassan@camk.edu.pl





OBSERWATORIUM ASTRONOMICZNE UNIWERSYTETU WARSZAWSKIEGO