



ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

# Ambient Noise Tomography of Campi Flegrei caldera (Naples, Italy): High Frequency Phase-Velocity Anomalies beneath the Solfatara-Pisciarelli Hydrothermal System

Ciro Di Dato<sup>1,2</sup>, Anna Tramelli<sup>2</sup>, Luca De Siena<sup>1,2</sup>

<sup>1</sup>Dipartimento di Fisica e Astronomia "Augusto Righi", Alma Mater Studiorum, Università di Bologna, Bologna, Italy

<sup>2</sup>Istituto Nazionale di Geofisica e Vulcanologia-Sezione di Napoli Osservatorio Vesuviano, Napoli, Italy



ciro.didato4@unibo.it

## 1 – Introduction & Setting

Campi Flegrei caldera (CFc) (Naples, Italy) (Fig. 1) is one of the most active volcanic systems worldwide, continuously monitored by INGV-Osservatorio Vesuviano (INGV-OV). The area is characterized by intense hydrothermal activity, recurrent seismicity, and a significant ground uplift (bradyseism), all related to the dynamics of a complex magmatic-hydrothermal system. The Solfatara-Pisciarelli region (Fig. 2) is a key zone of active fluid migration (Calò & Tramelli, 2018; Petrosino & De Siena, 2021; Calò & Tramelli, 2025), gas release, and strong small-scale heterogeneities (Gammaldi *et al.*, 2018).



Fig. 1 – Campi Flegrei Caldera (Naples, Italy)



Fig. 2 – Solfatara-Pisciarelli Hydrothermal System

In this work, we perform an Ambient Noise Tomography with Rayleigh waves, using the SeisLib Python package (Magrini *et al.*, 2022), to highlight surface structures and velocity anomalies of CFc and of the Solfatara-Pisciarelli Hydrothermal System.

## 2 – Data & Methods

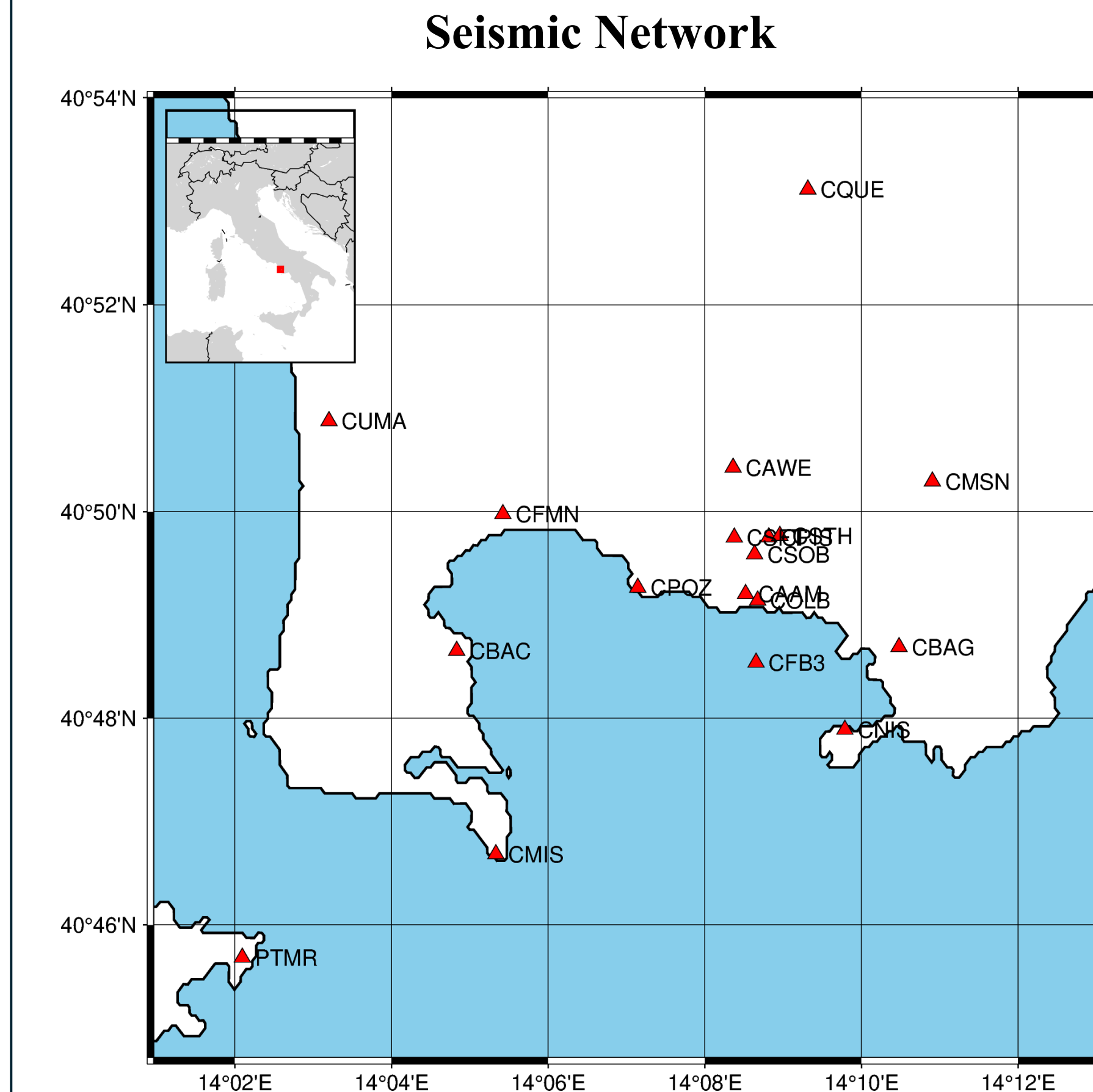
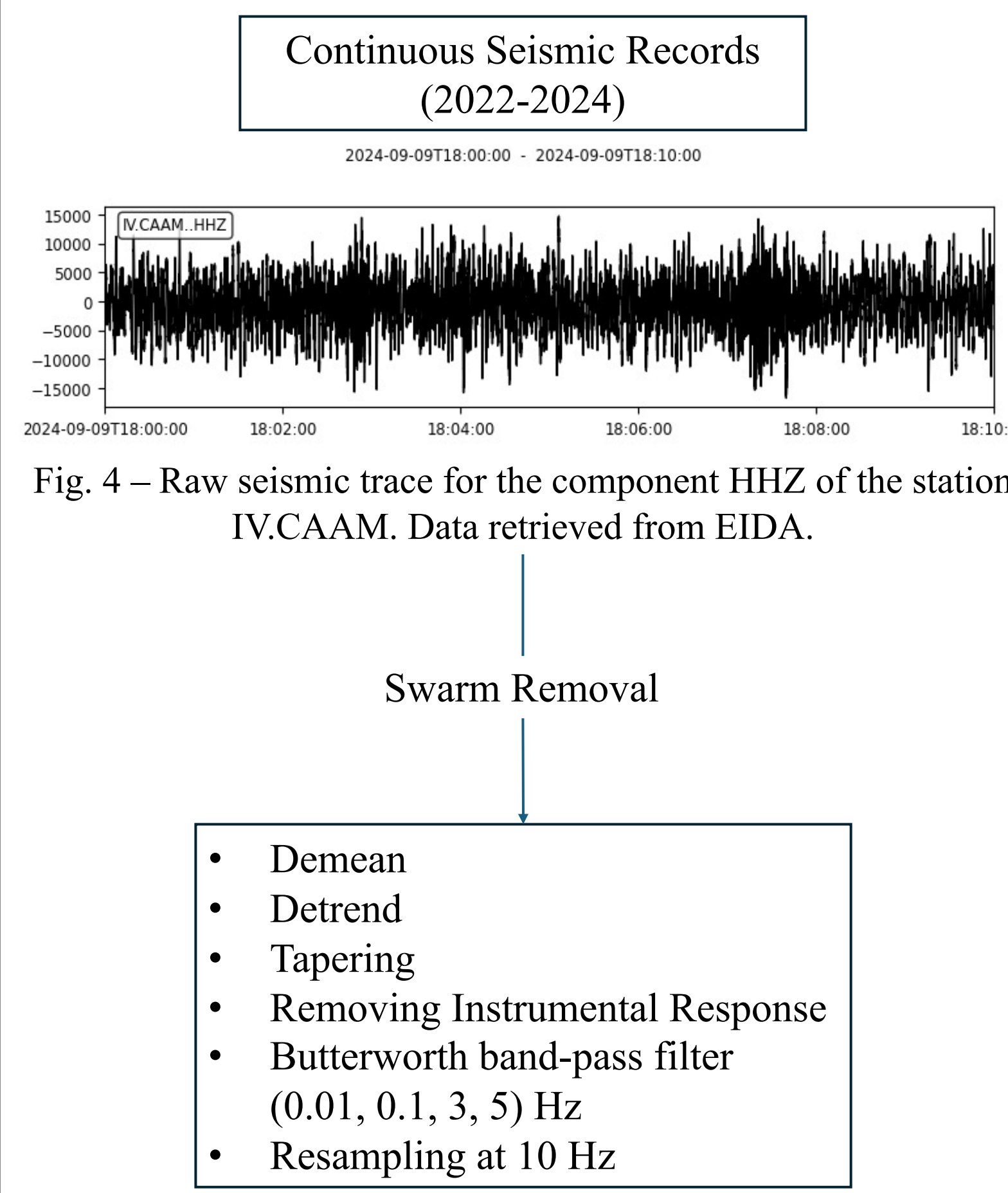


Fig. 3 – Seismic Network managed by INGV-OV with the used stations (red triangles) composed by 18 seismic stations: 17 from IV network and 1 from Medusa Network (CFB3)

### Seismic Data Pre-Processing Workflow



### Post-Processing Analysis

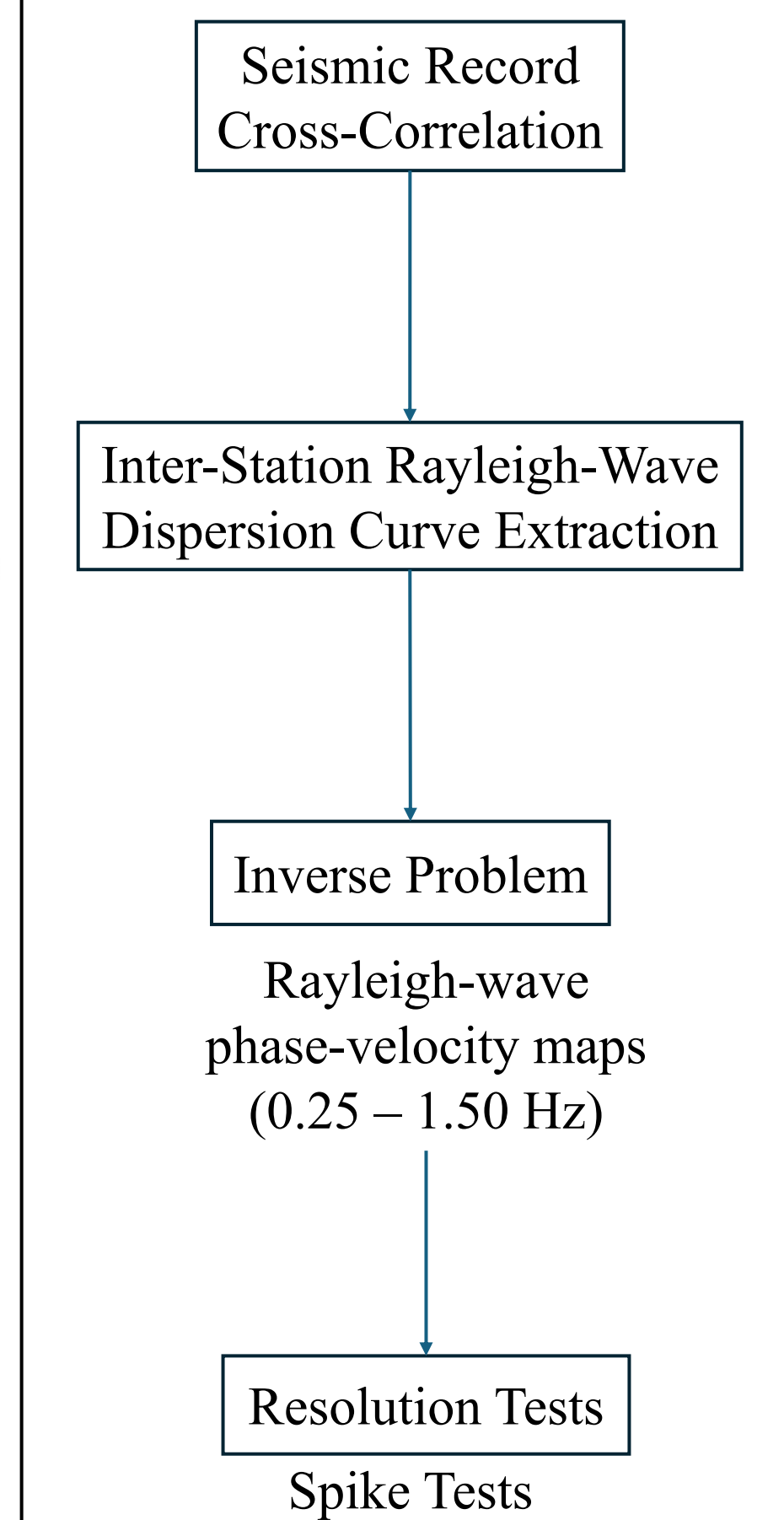


Fig. 4 – Raw seismic trace for the component HHZ of the station IV.CAAM. Data retrieved from EIDA.

## 4 – Conclusions

- High-velocity anomalies in the Solfatara–Pisciarelli area with values ~100 m/s above average velocities, with sensitivity extending to a few hundred meters of depth.
- Consistency with the presence of a shallow hydrothermal system, comprising aquifer and shallow faults (Akande *et al.*, 2019).
- Consistency with geophysical models indicating the presence of a clay cap atop a highly resistive plume, constrained by faults, feeding fumaroles on the surface (Siniscalchi *et al.*, 2019).
- High-frequency Rayleigh-wave phase velocities consistent with the presence of an elongated shallow zone of high rigidity.
- Consistency with the interpretation that shallow faults act as preferential conduits for ascending gases and hydrothermal fluids (Tan *et al.*, 2025).

## 5 – Future Works

- AMBIENT NOISE TOMOGRAPHY WITH LOVE WAVES
- JOINT INVERSION RAYLEIGH-LOVE WAVES
- TRANS-DIMENSIONAL BAYESIAN INVERSION
- PETROPHYSICAL INVERSION

## References

• Calò, M., & Tramelli, A. (2018). Anatomy of the Campi Flegrei caldera using enhanced seismic tomography models. *Scientific reports*, 8(1), 16254.

• Petrosino, S., & De Siena, L. (2021). Fluid migrations and volcanic earthquakes from depolarized ambient noise. *Nature Communications*, 12(1), 6656.

• Calò, M., & Tramelli, A. (2025). Evidences of the structures controlling the unrest in Campi Flegrei, Italy: Joint interpretation of ambient noise and local earthquake tomography. *Journal of Volcanology and Geothermal Research*, 457, 108236.

• Gammaldi, S., Amoroso, O., D'Auria, L., & Zollo, A. (2018). High resolution, multi-2D seismic imaging of Solfatara crater (Campi Flegrei Caldera, southern Italy) from active seismic data. *Journal of Volcanology and Geothermal Research*, 357, 177-185.

• Magrini, F., Lauro, S., Kästle, E., & Boschi, L. (2022). Surface-wave tomography using SeisLib: a Python package for multiscale seismic imaging. *Geophysical Journal International*, 231(2), 1011-1030.

• Akande, W. G., De Siena, L., & Gan, Q. (2019). Three-dimensional kernel-based coda attenuation imaging of caldera structures controlling the 1982-84 Campi Flegrei unrest. *Journal of Volcanology and Geothermal Research*, 381, 273-283.

• Siniscalchi, A., Tripaldi, S., Romano, G., Chiodini, G., Improta, L., Petrillo, Z., D'Auria, L., Caliro, S., & Avino, R. (2019). Reservoir structure and hydraulic properties of the Campi Flegrei geothermal system inferred by audiomagnetotelluric, geochemical, and seismicity study. *Journal of Geophysical Research: Solid Earth*, 124(6), 5336-5356.

• Tan, X., Tramelli, A., Gammaldi, S., Beroza, G. C., Ellsworth, W. L., & Marzocchi, W. (2025). A clearer view of the current phase of unrest at Campi Flegrei caldera. *Science*, 390(6768), 70-75.

## 3 – Results & Resolution Tests

For each frequency: (left) Rayleigh-wave phase-velocity map; (top right) input synthetic spike for resolution test; (bottom right) recovered anomaly

