ÉCOLE DOCTORALE
SCIENCES DE LA TERRE ET DE L'ENVIRONNEMENT
ET PHYSIQUE DE L'UNIVERS, PARIS

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Titre du sujet : Analysis of the eruptive activity of the Stromboli volcano using a network of fibre optics and short-period seismic sensors

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Stromboli is primarily characterized by small-volume explosions characterized by explosions ejecting small volumes (<10^1 m^3) of incandescent material (scoria) at 100-300 m height at a rate of ~13 events per hour (Ripepe et al., 2008). However, this volcano sporadically produces major and paroxysmal explosions accompanied by magmatic flows in the Sciara del Fuoco graben. These events pose significant threats due to the dispersal of ballistic materials and the emission of lava and pyroclastic flows, which can produce tsunamis directly when flows enter the sea, or indirectly, as a result of landslides (Ripepe and Lacanna, 2024).

Effusive and explosive activity at Stromboli is characterized by very long period (VLP) seismic transients (0.01-0.5 Hz) and tremors (~1-4 Hz) (Chouet et al., 1997). These are permanent seismological markers of the volcanic activity revealing an efficient magma-gas dynamic interaction, where seismic VLPs are linked to the explosive eruptions and tremor to active degassing (puffing) of the magma column.

Stromboli is equipped with a monitoring permanent network maintained by LGS (Laboratorio Geofisica Sperimentale) of the University of Florence and INGV comprising broadband seismic stations, infrasound sensors, borehole inclinometers, optical and thermal cameras, and multigas sensors.

Between 2020 and 2023, the IPGP seismology team and the LGS will be burying a 4 km fibre optic network in the east-south-east part of the volcano. It includes various geometric layouts, linear sections, triangles with openings ranging from 30m to 100m, and a grid with an extension greater than 100m. Four DAS measurement campaigns were carried out, the longest of which lasted 5 months continuously. Each campaign was carried out with the joint installation of short-period sensors near the fibre network to calibrate the deformation signal recorded by the fibre with seismic sensors. In 2023, we also deployed 260 nodes around la Sciara to increase the resolution of observations of eruptive activity in the individual craters and the rock falls to the sea. This work was carried out as part of the ANR Monidas project.

A PhD funded by Monidas ends in 2024. It has led to the development of a series of tools for the rapid and efficient reading of strain-rate data and the calibration of strain-rate signals using co-located seismic sensors (Trabattoni et al., 2023). The application of beamforming analysis methods applied to explosions and tremor using fibre-optic sections and co-located seismic sensor antennas has validated the use of DAS for locating seismo-volcanic sources (Biagioli et al., 2024).

Data recorded in 2022 also made it possible to track pyroclastic flows by using array processing techniques applied to DAS, seismic, and infrasonic measurements (Biagioli et al., 2023).

In light of these results, we are proposing a new PhD topic in which we aim to use all available DAS fibre data (equivalent to 2000 sensors for 4 km of cable) and to:

- To improve source location, estimation of subsurface velocity models using phase coherence and the phase-weighted stack method (Schimmel et al., 2011). These velocity models will then be used to simulate wave propagation in the 3D structure of the volcano with Specfem 3D.

- Refine the high-frequency sources' location corresponding to puffing activity in the craters and rock falls and lava flows in the sciara del fuoco. To do this, we will use cross-correlation-based strategies with the DAS and nodes data.

A new ANR project has been submitted in 2024 for 4 years. If funded, the Ph.D. student will be able to take part in field campaigns to expand the fibre network on land and at sea. The new data could be used as part of the thesis, in addition to that acquired by Monidas, which is nevertheless sufficient for this PhD.

References:

Biagioli, F.**,** Array analysis of seismo-volcanic activity with distributed acoustic sensing, *GJI*, 10.1093/gji/ggad427, 2024

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Schimmel, M., Polarized Earth's ambient microseismic noise, *GGG*, doi:10.1029/2011GC003661, 2011.