Monitoring the seismic activity of Mayotte through image processing of fiber optic signals.

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Motivations

In may 2018, a strong episode of seismicity started in Mayotte (Comoros archipelago), which was widely felt by the inhabitants of the island. It was associated with a new volcano east of the island (MAYOBS1, Feuillet et al., 2019). The seismicity is on-going to this day and is analyzed daily to monitor the activity of the volcano and its potential consequences. Retailleau et al. (in review) developed a process to automatically detect and locate seismic events in real-time. This method has been used to analyze the seismicity in real time. This process helped greatly to increase the number of earthquakes detected and located. However, the quality of data recorded by the land stations suffers a lot from anthropic noise. This means that many earthquakes are still missed and are only observed using ocean bottom seismometers, whose data can be obtained only every few months.

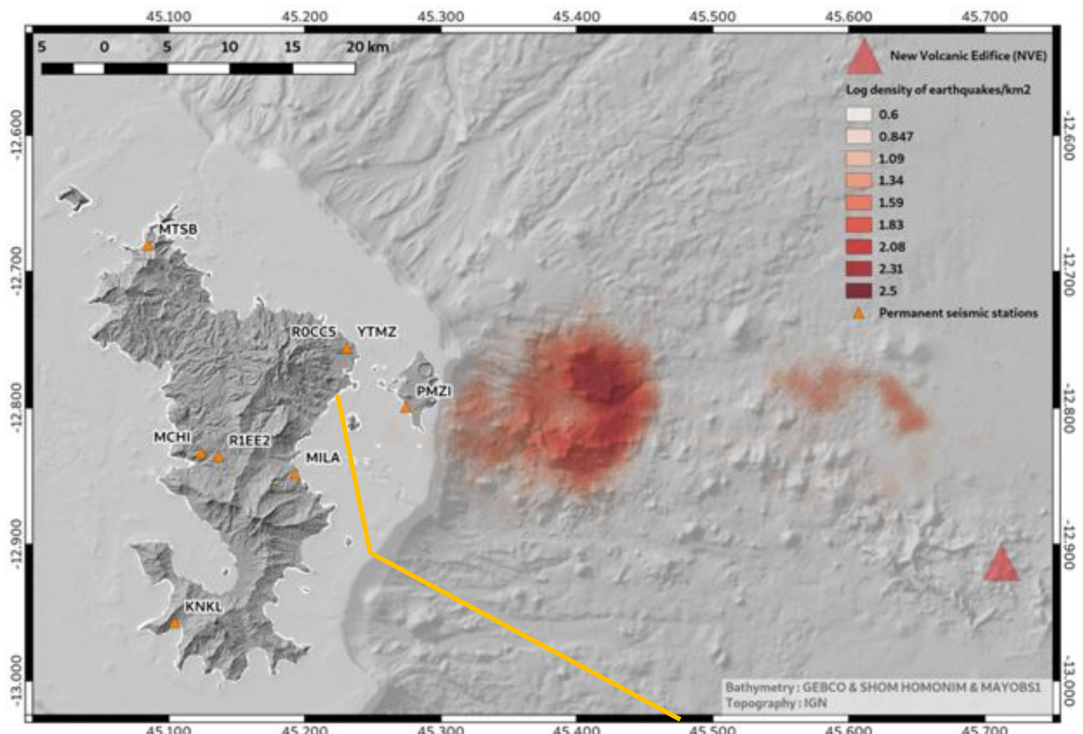

Figure 1: Seismicity repartition in Mayotte, and fiber optic cable. Modified from Saurel et al., 2021

Problem statement

Using a DAS (Distributed Acoustic Sensing) interrogator, a fiber optic cable can be used as a high sampling seismic network line, leading to an equivalent of a seismic sensor every 10m. Measurements have also been made on fiber optic cables deployed on the seafloor, permitting to observe its subsurface as well as the signals generated by ocean waves (Lindsey et al., 2019). These recordings have the great advantage to not suffer from human activity effects since the cable is deployed offshore. This methods permits to record data all along a fiber optic cable thus increasing greatly the sampling of measurements, consequently increasing the precision of earthquakes monitoring. However, it also implies that large datasets need to be analysis and the need for developments of methodologies to analyse data in real time. We proposed to test pattern recognition methodologies to implement a new earthquake detection process.

Dataset Description

We recorded 10 days of DAS measurements in Mayotte on a fiber starting on the island and extending 40km offshore (yellow in Figure 1). With the seismicity still very active in the area numerous events were recorded with this high sampling method. The extent of the fiber cable offshore also leads to measurements closer to the seismic activity linked to the Mayotte volcanic structure. Finally, the high density of measurements will permit highlighting small amplitude signals by combining the different arrivals.

#Volcanic seismicity #DAS #Pattern recognition

Methodology

An example provided in Figure 2 shows the envelope of the signals of an earthquake recorded along the fiber using DAS. This images can be exploited for earthquake analysis and highlight different features.

The proposed work will be based on several incremental steps:

- Study of active contour models (Niu et al., 2017) to locate the wavefronts. Such models are widely used to extract regions in noisy images (e.g. in biomedical images, Lidar).
- Automatic localization of the starting points by considering a progressive search area (vertical patch) from the left to the right using homogeneous area criteria.
  - Other effective strategies to approximate waves (Haar wavelet and multi-scale edge detectors) can also be studied.
  - They could also be extended to process a series of consecutive wavefronts (fast events).
- Finally, we also plan to explore deep learning approaches (Khan et al., 2020) by considering ground truths (for instance from an expert evaluation of results achieved at the previous step) or an augmentation process by defining a set of possible wavefronts.

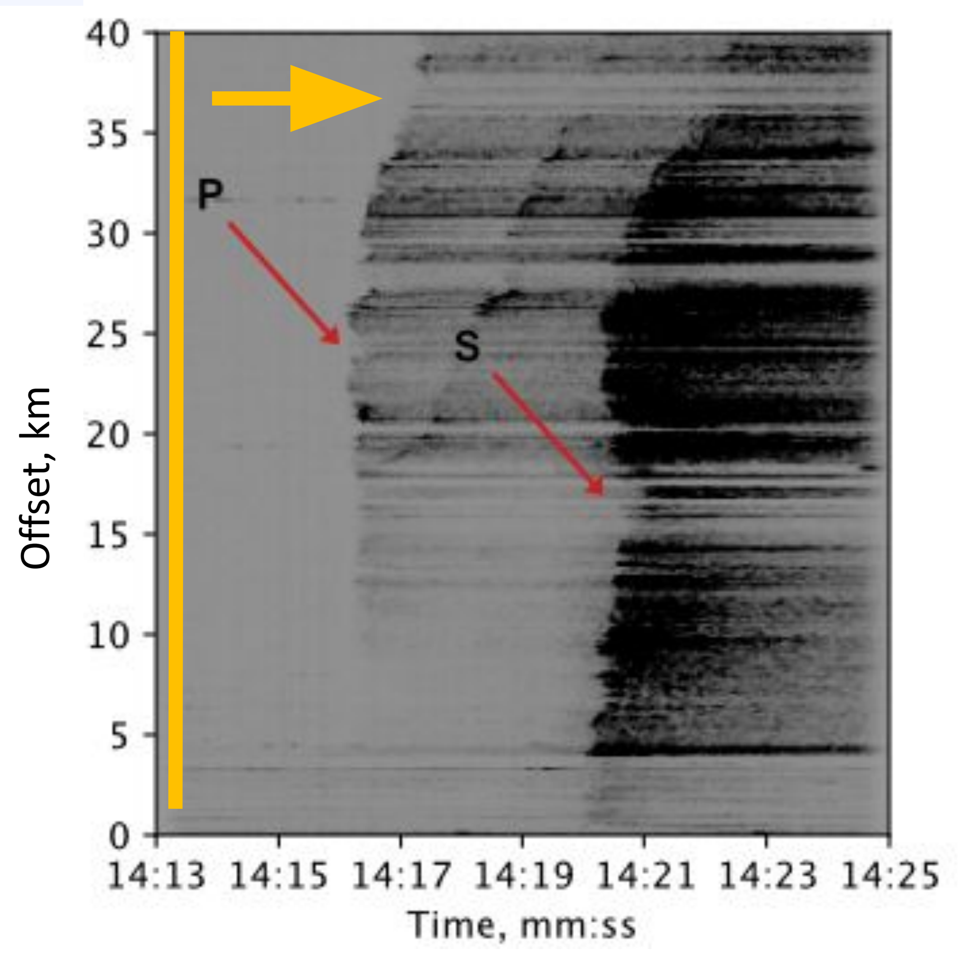

Figure 2: Signal amplitude recording of an earthquake by DAS measurements.

Expected Results

This internship will lead to the development of a wavefront detection process for the identification of the seismicity recorded along a fiber optic cable. It will be used to identify the Volcano-Tectonic and Long Period seismicity generated by the volcanic activity in Mayotte as well as more distant events (tectonic…).

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