Deployment of a portable low-cost infrasound array on Terceira Island, Azores, Portugal

Silva, L.[(1)], Matos, S.[(1)], Jesus, M. C.[(1)] & Wallenstein, N.[(1)]

(1) Instituto de Investigação em Vulcanologia e Avaliação de Riscos (IVAR), Universidade dos Açores, Rua da Mãe de Deus, 9500-321 Ponta Delgada, Açores, Portugal (linda.i.silva@azores.gov.pt).

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ABSTRACT

Two seismo-volcanic crises are ongoing on the Azores. A volcanic unrest on a fissural system begun on March 19, 2022, on São Jorge Island. On June 24 seismicity increased in Santa Bárbara central volcano, on Terceira Island, followed by ground deformation. A portable four-element infrasound array (SJ1) was deployed on São Jorge Island in collaboration with the University of Florence. Learning from this experience, a six-element portable infrasound array (TER) was designed, built and deployed on Terceira Island, in April 2024.

TER is composed of differential sensors, five with a sensitivity of 800 mV/Pa (0.04-100 Hz) and one with a sensitivity of 25 mV/Pa (0.1-100 Hz). The potential locations were selected mainly based on its distance from the volcano, the SNR, and mobile network coverage. However, due to noise sources, terrain surface and land-permits, the array deployment was not located on none the planned sites.

The array is located 6 km apart from the volcano caldera, although, without the ideal SNR. TER has a centred pentagonal geometry, with a maximum aperture of 105 m, positioning the less sensitive sensor at the centre.

Background noise was evaluated, and efforts are being made to move the array to a less noisy site.

Keywords: Infrasound, Portable Array, North-Atlantic, Azores, Seismo-volcanic Crisis.

Azores infrasound network

The infrasound network in the Azores currently consists of three arrays (Figure 1): a permanent station, IS42, located on Graciosa Island, which is part of the CTBTO's International Monitoring System (IMS), and two portable arrays, one on São Jorge Island (SJ1) and another on Terceira Island (TER). The SJ1 portable array was deployed in 2022 during the onset of volcanic unrest on São Jorge Island, in collaboration of University of Florence (UNIFI) (Jesus *et al*., 2024). TER array was developed later, using the knowledge acquired from the deployment of SJ1, to monitor the ongoing seismo-volcanic crisis on Terceira Island, and to improve the infrasound monitoring coverage of the Azores. This array is operational since April 2024.

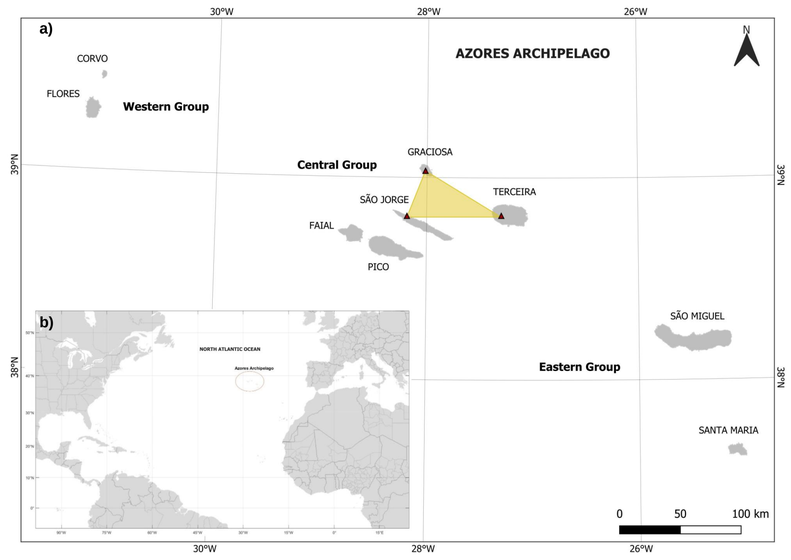

Figure 1 – a) Location of the Azores infrasound network; b) Location of the Azores Islands.

TER – Site survey

The site selection for the TER portable array was based on the parameters defined by Jesus (2022), such as terrain forest coverage and accessibility, the surrounding environment, the gradient, the mobile network coverage, the land ownership and the security of the site.

Three sites were pre-selected in the lab using aerial photographs. During the first mission all sites were exclude, one due to human activities and other was too tight for the array configuration. For the third, with the best terrain conditions (Figure 2a), we are still waiting owners' permission.

The site location was facilitated by the Municipality of Angra do Heroísmo (CMAH), which provided a location for the array: the Matela municipal botanical forest (Figure 2b, c), further away from the area of interest, at the SW sector of the central part of the Terceira Island.

This location is ~6 km from the centre of the Santa Bárbara Volcano Caldera, on top of a lava flow and under dense vegetation, at an altitude ~370 m asl. It has good road access and a good mobile network coverage.

The most significant issue with the site is its proximity to noise sources, such as farms in the SE sector, fortunately in the opposite direction of the volcano.

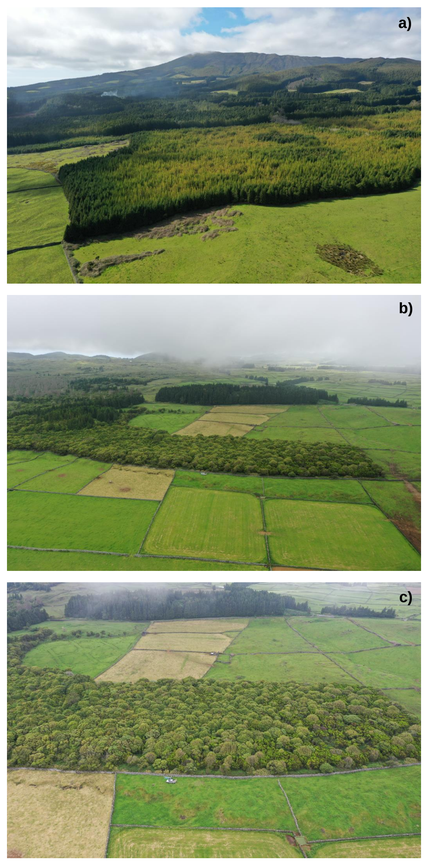

Figure 2 – a) Santa Bárbara central volcano view and ideal terrain; b) and c) Site view.

TER – Deployment of the portable array

The array was deployed on April 18th, 2024, in a pentagonal geometry with one sensor (the least sensitive sensor) in the middle (Figure 3). However, since October 2nd, the geometry was changed to improve the correlation of the signal and to reduce the noise. The new diamond geometry has two sensors located in the centre, one with a sensitivity of 800 mV/Pa and the other with 25 mV/Pa (Figure 4).

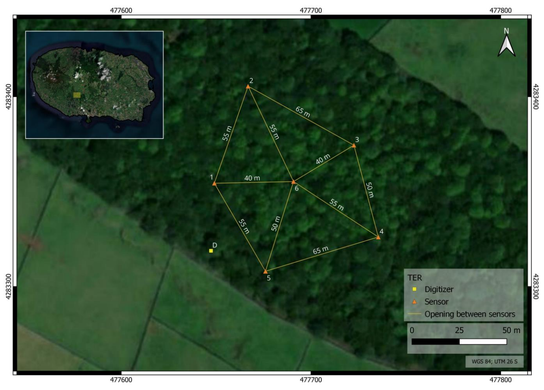

Figure 3 – Location of TER array and its geometry between April and October in Terceira Island.

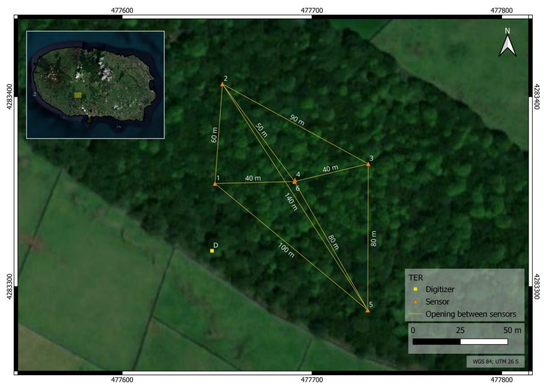

Figure 4 – Location of TER array and its geometry since 2nd October in Terceira Island.

The TER portable array consists of six sensors connected to a digitizer by 100 m copper wires inside a plastic protection tube. Five of the six sensors have a sensitivity of 800 mV/Pa (0.04-100 Hz) and one a sensitivity of 25 mV/Pa (0.1-100 Hz). It also includes a wind noise reduction system for each sensor, a router for data transmission, an GPS antenna, two solar panels, and two batteries (Figure 5) (See poster #168, this workshop). The array had to be deployed closer to the southern edge of the forest to collect solar energy.

Figure 5 – Details of TER portable array.

TER - Detections

Due to energy problems, the TER portable array was down most of the time until the end of May. Thus, figure 6 displays the detections from June 1st to October 17th.

During the summer months, the back-azimuth of detections varied mostly between 50 and 150, while during the autumn equinox, it mostly ranges from 200 to 350. This variation has been previously observed in data from the IMS IS42 station (Wallenstein *et al*., 2018).

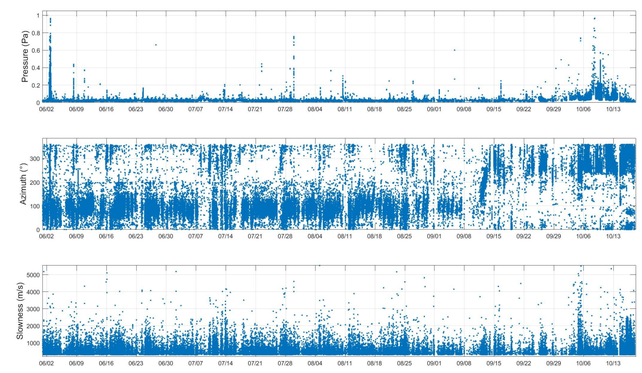

Figure 6 – Pressure (Pa), azimuth (º) and slowness (m/s) of the TER portable array detections between 1st June and 17th October 2024.

Local Earthquakes

Frequent local earthquakes occur in the Azores, and since the ongoing seismo-volcanic crisis at Santa Barbara volcano, several were recorded at the TER portable array. Figure 7 shows an event that occurred on June 10th (~8 km NW of TER portable array) with a local magnitude of ML 3.0 and an estimated time at origin of 17:08:53 UTC (IVAR/CIVISA data).

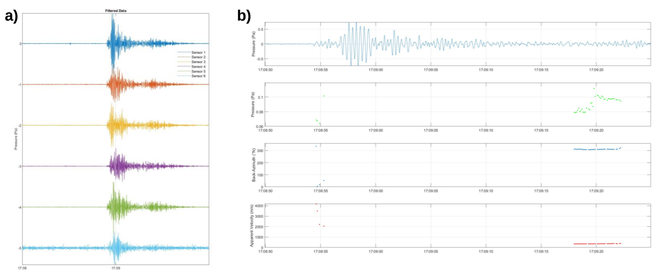

Figure 7 – Seismic arrivals at TER portable array recorded on 2024/06/10. a) Filtered data; b) Wave form correlation, pressure (Pa), back-azimuth (ºN) and slowness (m/s) of the event.

Airplanes

The TER portable array is located ~16 km SW of the Terceira airport (TER) which comprises an International Civil Terminal and an USAF and Portuguese Military Air Base, therefore the recording of aircraft flights can be very recurrent. Figure 8 shows the route of an aeroplane flying from NW to SE.

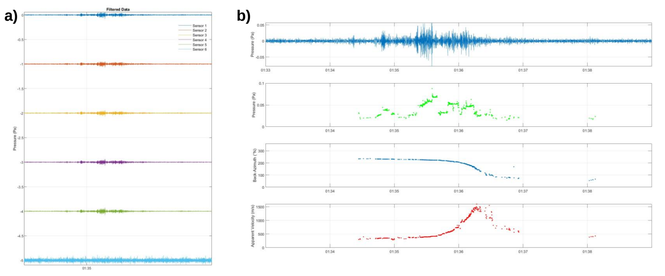

Figure 8 – Airplane record at TER portable array on 2024/09/16. a) Filtered data; b) Wave form correlation, pressure (Pa), back-azimuth (ºN) and slowness (m/s) of the event.

CONCLUSIONS

The TER portable array is an experimental array developed based on insights gained from the deployment of the SJ1 portable array. Due to lack of land permits the array was deployed further away from our area of interest, the Santa Barbara volcano. The actual location, in the Matela municipal botanical forest is a dense forest that offers easy access, reliable mobile network coverage, and a southern exposure for the installation of solar panels. However, the proximity to several anthropogenic noise sources present us with several challenges. Nevertheless, data collected has been of high quality, recording multiple local earthquakes associated with the ongoing seismo-volcanic crisis, as well as air traffic. Modifications to the initial configuration have successfully mitigated some noise. Further enhancements are underway, alongside negotiations for relocating the array to a better site.

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REFERENCES

JESUS, M.C. (2022) - *Site surveys for the deployment of infrasound mobile stations in the Azores Islands*. Dissertação de Mestrado em Vulcanologia e Riscos Geológicos, Faculdade de Ciências e Tecnologia, Universidade dos Açores, 129p.

JESUS, M.C., Belli, G., Gheri, D., Matos, S., Wallenstein, N., Marchetti, E. (2024) - The use of a low-cost, small-aperture array as an auxiliary tool to improve infrasound monitoring in the Azores region. *Pure and Applied Geophysics*, doi:10.21203/rs.3.rs-3442956/v1.

WALLENSTEIN, N., Campus, P., Matos, S., Ripepe, M., Marchetti, E. (2018) - Monitoring on the North Atlantic Region with IS42: results of the IVAR-UniFi collaborative research under the ARISE2 Project. *ARISE2 Final Workshop*, Hamburg (Germany), 14-17 May 2018.