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Mysterious Seismoacoustic Signals of Eastern Helwan Quarry Blasts, 2022

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INTRODUCTION AND MAIN RESULTS

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In early 2022, a series of mysterious seismoacoustic events were detected near Helwan, Cairo, with unknown origins. To investigate, we deployed a temporary infrasound array and combined array processing with seismic data and satellite imagery to characterize the sources. Our results revealed that the signals came from major construction activities, showing the effectiveness of the low-cost infrasound sensors for monitoring mega civil projects.

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P2.2-671

Introduction:

At the start of 2022, a series of mysterious seismoacoustic signals puzzled researchers near Helwan, Cairo. To uncover their origin, a temporary infrasound array was deployed, and advanced detection and array analysis techniques were applied. This approach allowed us to successfully trace and characterize the hidden sources behind these unusual signals.
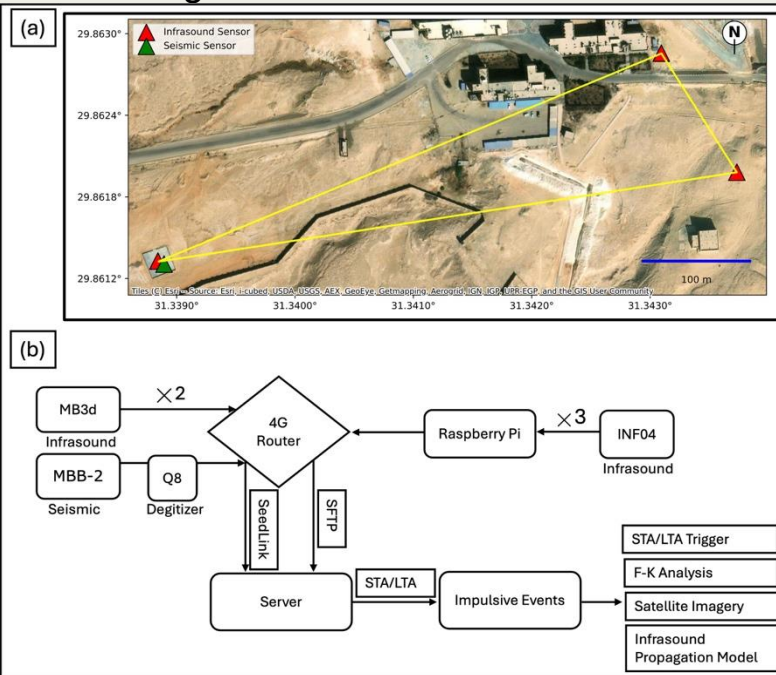
(**a**) Setup of the Helwan array and distribution of infrasound and seismic sensors. (**b**) Flowchart of data analyses.
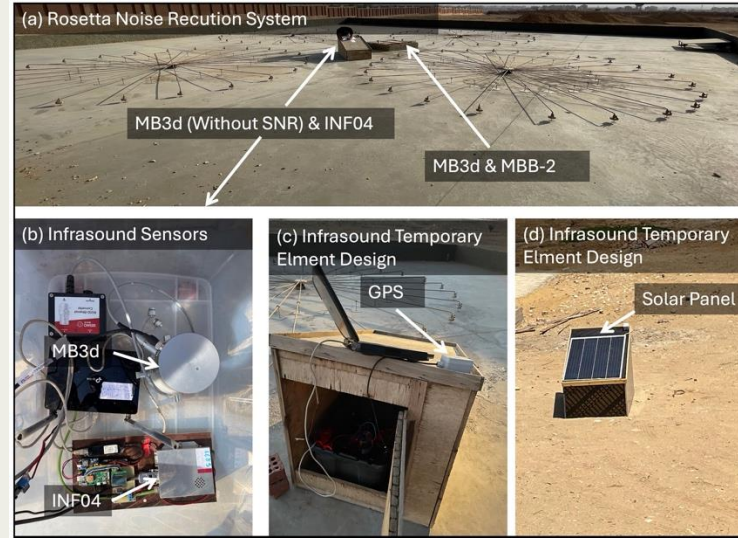
(**a**) Deployment of a noise-reduction system with an MB3d sensor near the HLW element. (**b**) Establishment of the MB3d (HL1) and INF04 (668S) infrasound sensors. (**c**, **d**) Design of the temporary infrasound sensors.

Methods:

Recursive STA/LTA:

- A recursive STA/LTA method was applied to continuous infrasound data from May to December 2022 to efficiently detect impulsive signals. Events were declared when at least three sensors triggered within 2 seconds, and validation was performed against the 2022 ENSN quarry bulletin.

Power spectral density:

- The Welch method was applied using Scientific Python with 512-sample segments and 128-sample overlap to estimate the power spectral densities (PSDs) of the five infrasound sensors.
- By averaging modified periodograms with the fast Fourier transform, this approach provides a robust representation of power distribution across frequencies.

Frequency-wavenumber (F-K) analysis

- Frequency–wavenumber (F–K) analysis was applied using the ObsPy array processing function to determine the direction and propagation characteristics of infrasound signals.

Infrasound propagation modelling

- 1D parabolic equation (PE) modelling of daily atmospheric profiles at 9:00 UTC (May–December 2022) toward the Helwan array over the quarries was applied to estimate infrasound transmission losses using the ePape module of the NCPAprop package, and statistical analyses of the results were performed.

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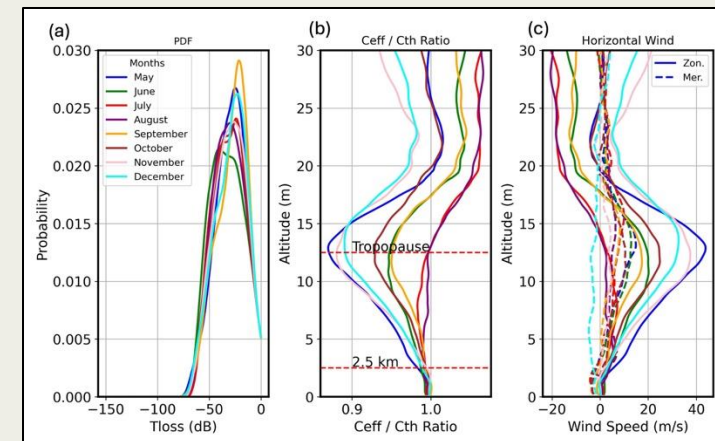
P2.2-671

Results:
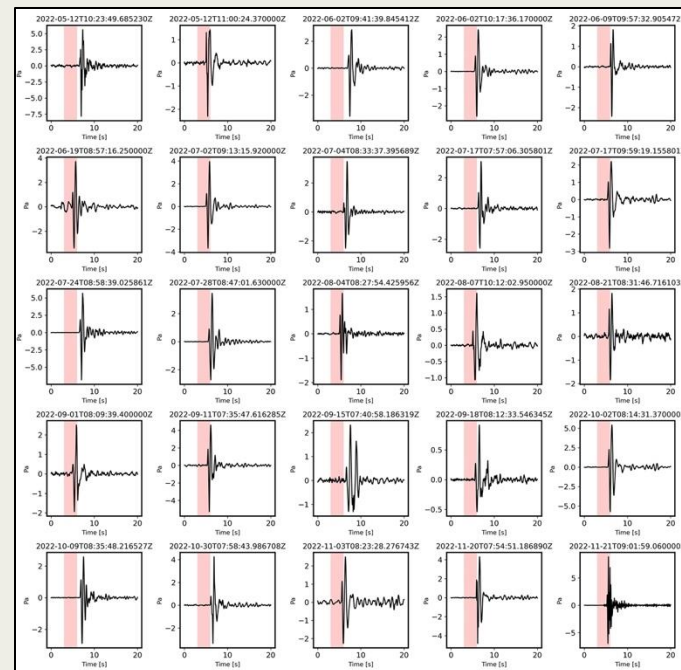
Examples of the impulsive signals detected after applying the STA/LTA recursive algorithm. The signals were filtered between 0.5 and 6 Hz.
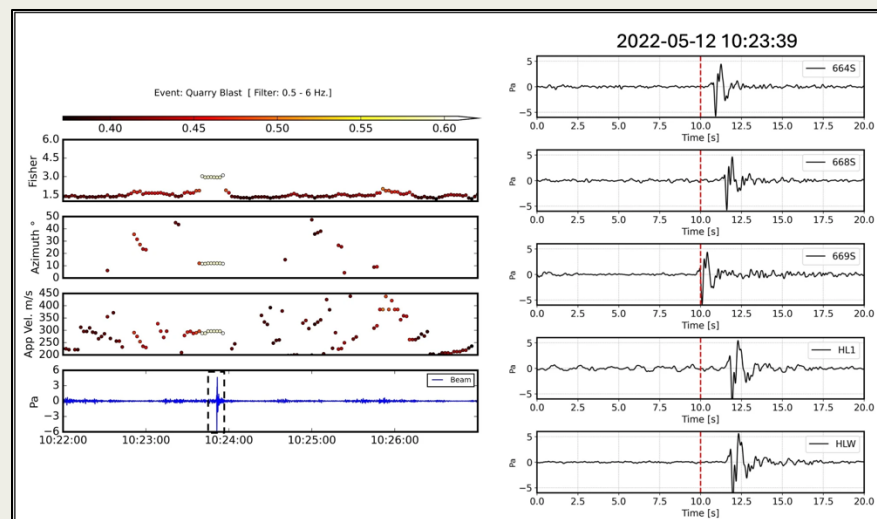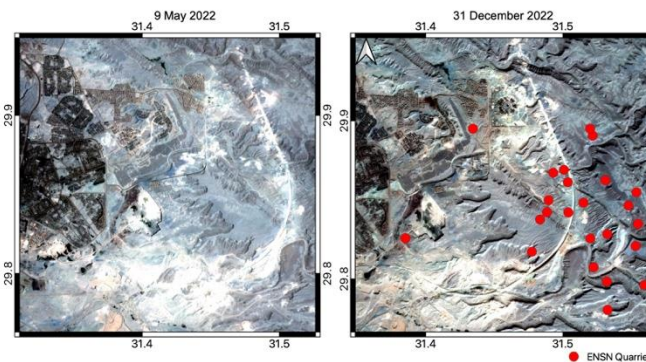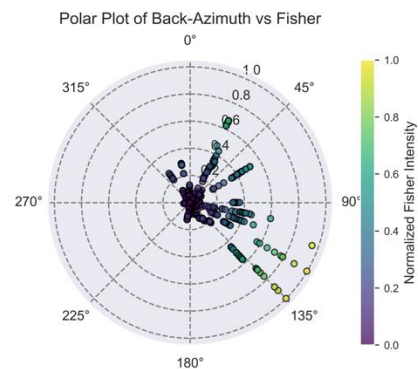

F-K analysis of the event observed on 10:23:49.6 UTC 12 May 2023. Right panel shows a zoomed view of the 20 s surrounding the trigger time, and the signals are filtered between 0.5 and 6 Hz.

(a) Polar plot of back-azimuth directions with normalized Fisher intensities for all detected infrasound triggers.
(b) The two panels refer to satellite images captured on 9 May and 31 December 2022.

(**a**) Monthly average PDFs derived from the PE model at 4.5 Hz and a propagation distance 50 km. (**b**) Average monthly ratio of and toward the Helwan array. (**c**) Average monthly horizontal wind speed for the daily atmospheric profiles over the area of the detected events.

Conclusions:

Seismoacoustic analyses combined with satellite imagery revealed that the mysterious signals were quarry blasts from Egypt's high-speed railway construction, showing the effectiveness of infrasound for monitoring civil activities.