

From errors to insights: the role of Infrasound Calibration in improving troubleshooting activities and system knowledge

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INTRODUCTION AND MAIN RESULTS

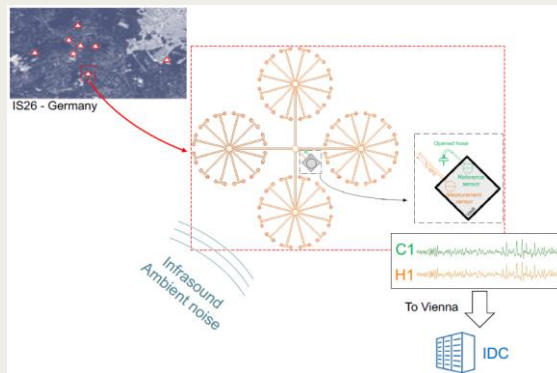
Calibration is essential for IMS infrasound stations. Upgrades carried out under the sustainment plan - including next-generation sensors, WNRS, and passive calibration - improve data quality. Using CalxPy, deviations from theoretical responses are detected precisely. This poster presents two use cases from field and yearly calibration routines.



Background

The International Monitoring System (IMS) operational manuals for waveform stations require that IMS stations be calibrated regularly. A part of the geophysical community, including Station Operators, has started performing regular **calibrations by comparison against a co-located reference**.

This method, proposed by Tom Gabrielson in 2011 for the infrasound technology, allows a more systematic and centralized approach to calibration. Over the past few years, it has been increasingly used at IMS stations.



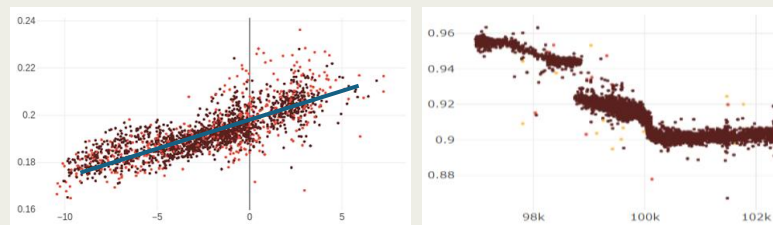
Progressively, infrasound stations are being equipped with **calibration capabilities**. Each system includes a reference sensor, pipe, and inlet port, generating an additional data stream transmitted to Vienna. These data are **centrally processed** by dedicated software. This **continuous** process enables systematic monitoring, early anomaly detection, and the accumulation of long-term information on sensor behavior.

Disclaimer: The views expressed in this presentation are those of the authors and do not necessarily reflect the view of the CTBTO

Use case 1 – Improving sensor design through long-term calibration insights

Long-term calibration analysis revealed:

- Consistent variations in frequency response across three infrasound sensor models.
- Anomalies undetected in standard testing, only visible through accumulated calibration data after deployment.
- Gradual response drift over time and under varying environmental conditions, indicating sensitivity to factors not captured during initial qualification.



Left: Sensitivity dependence on temperature (IS53)

Right: Sensitivity dependence on atmospheric pressure (IS37)

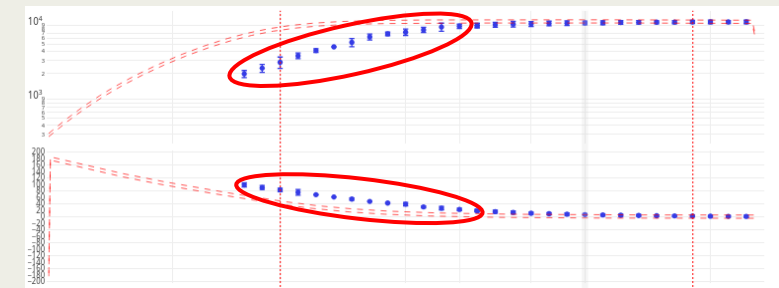
Follow-up investigation:

- Coordinated with expert laboratories ([Bosca 2019](#), [Merchant 2024](#)).
- Identified design-related causes for the observed drift.
- Manufacturers implemented design improvements to enhance long-term stability.

→ **Calibration insights drive improved sensor qualification, metrology, and deployment reliability**

Use case 2 – On-site sensor diagnostics after flooding

At station IS05, calibration by comparison identified the wind noise reduction system (WNRS) as non-compliant. Later, during its upgrade, flooding was discovered, prompting detailed evaluation of the connected infrasound sensors affected by water ingress. Using a simplified calibration setup validated with a known-good spare sensor, degraded low-frequency response were identified on several units.



Sensor degraded low-frequency response (amplitude/phase)

Actions:

- 1 sensor replaced (persistent anomalies)
- 1 sensor scheduled for replacement (suboptimal performance)

→ **On-site calibration diagnostics reduced uncertainty, avoided unnecessary lab work, and preserved mission capability**

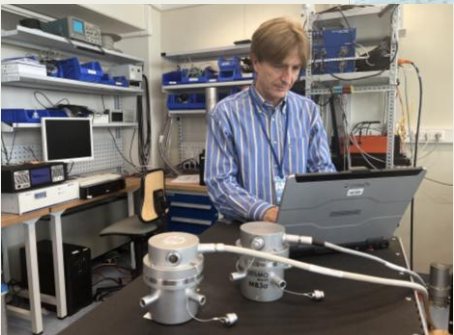
One method, many applications

From troubleshooting in the field to design improvements, the use cases show how the method of calibration by comparison supports diverse applications.

At PTS Headquarters –
Centralized data processing and analysis



In laboratory –
Sensor qualification and testing



Field Operations –
On-site diagnostics and verifications



CalxPy: the tool for calibration-by-comparison analysis

The PTS has developed a software tool to simplify the analysis of calibration-by-comparison data.



With CalxPy, users can:

- **Calculate, store, and display** the system response over a selected period
- **Track response evolution** over time or against environmental variables
- **Support calibration processes:** initial calibration and annual on-site checks
- **Contribute to data quality control**
- **Deploy flexibly:** in the IDC pipeline, in NDC-in-a-Box, or as a standalone field tool

Version 1.18, released February 2025, includes improvements enhancing user experience and technical documentation

CalxPy is under active development with many new features to come soon:

- Version 1.19 to be published end of Q4 2025
- Version 1.20 planned for Q2 2026

From version 1.19, CalxPy will be published in the **main NDC-in-a-Box repository**.

The PTS thanks to the following alpha testers for their invaluable feedback and suggestions, which enhanced the accuracy and robustness of CalxPy:



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EXPLOSIONS

