InfraAUV-project: Metrology for low frequency sound and vibration

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InfraAUV-project: Metrology for low frequency sound and vibration

https://www.ptb.de/empir2020/infra-auv

Our consortium is a mix of

- **National Measurement Institutes** providing leading-edge input on metrology, standardization, and sensors
- **Station Operators** as well as **NDCs** providing application-specific knowledge and insight into operational requirements and issues
- A **Scientific Consultant** managing stakeholder engagement
- **PTB** (Germany) is the project leader

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Infra-AUV(**A**coustic, **U**nderwater, and **V**ibration) Rationales:

Acoustic and seismic monitoring are key technologies in many geophysical applications including CTBT activities, however;

- In the frequency range of interest there is little or no provision of measurement traceability to enable measurement data to be physically meaningful
- While sensor calibration methods are implemented both in the laboratory and in the field, they cannot yet be linked to a primary measurement standard
- The performance of infrasound sensors, hydro-acoustic sensors and seismometers needs to be characterized over the wide range of environmental conditions found in operational conditions
- The Infra-AUV project was formulated to address these measurement needs

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Infra-AUV is a new EU project that will establish primary measurements standards for low frequency phenomena across the fields of airborne and underwater acoustics and vibration (seismology). Combining expertise from the national measurement institutes and geophysical monitoring station operators, it will develop both high-precision laboratory-based methods of calibration and methods suitable for field use. Infra-AUV will also address requirements for reference sensors that link laboratory calibration capabilities to field requirements for measurement traceability.

To establish standards in the three technical areas, a variety of calibration principles will be employed, including extension of existing techniques such as reciprocity and optical interferometry, and development of new methods. There will also be an investigation of the potential for in-situ calibration methods, including use of both artificially generated and naturally occurring stimuli such as microseisms and microbaroms. The influence of calibration uncertainties on the determination of the measurands required by the monitoring networks will also be studied.

The project was strongly motivated by the CTBTO strategy to drive new metrology capability to underpin IMS data. The intention is to maintain interaction with stakeholders, not only in connection with the IMS, but with the broad range of users of low frequency acoustic and vibration data.

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PTB | BGR Bundesanstalt für Geowissenschaften und Rohstoffe | cea | DFM Danmarks Nationale Metrologiinstitut | le cnam Conservatoire national des arts et métiers

Laboratoire National de Métrologie et d'Essais LNE | NPL | acoustic sensor networks | TÜBİTAK | Brüel & Kjær an HBK company

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Rationales – AUV (Acoustic, Underwater, and Vibration)

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Objectives

- To develop primary and secondary calibration methods in the low frequency range
- To specify devices suitable for transferring measurement traceability to sensor deployed in the field, e.g. at IMS monitoring stations
- To develop new methods or augment existing methods of on-site calibration, incorporating full measurement traceability
- To illustrate the impact of metrology considerations, such as traceability and measurement uncertainty, in AUV monitoring
- To maximize impact by engaging widely with stakeholders
  - station operators and other scientific users of data
  - sensor manufacturers
  - standardization committees & regulators

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Work packages

WP1	**Development of primary low-frequency calibration methods for sound in air, under water acoustic and vibration metrology**	LNE, PTB, DFM, BKSV, CNAM, TÜBİTAK, CEA, NPL, ASN
WP2	**Dissemination of primary standards: Secondary calibration and test methods for environmental measurement infrastructure**	PTB, LNE, DFM, BKSV, TÜBİTAK, CEA, NPL, BGR
WP3	**Traceability for global seismic and acoustic environmental sensor networks by novel on-site calibration and improved knowledge about operational sensor behavior**	BGR, PTB, LNE, TÜBİTAK, CEA, NPL
WP4	**Improvements in current deployment strategies gained by traceable calibration, reliably known measurement uncertainty and improved knowledge about operational sensor behavior**	CEA, PTB, LNE, TÜBİTAK, BGR, NPL, BKSV, CNAM, DFM, ASN
WP5	**Creating impact**	ASN, LNE, PTB, DFM, BKSV, CNAM, TÜBİTAK, CEA, NPL, BGR
WP6	**Management and coordination**	PTB, LNE, DFM, BKSV, CNAM, TÜBİTAK, CEA, NPL, BGR, ASN

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WP3 – Goals & Tasks

- maintain traceability for permanently deployed sensors within regional and global networks (IMS, GSN)
- look for feasible excitation sources for performing on-site, develop strategies and analysis procedures for that purpose and, ultimately and where possible, perform an exemplary calibration for testing and demonstration purposes (Task 3.1)
- once some calibration methods are in place, they will provide the base for further evaluation of properties like stability, drift or self-noise of the monitoring station's sensors, which are mission-critical for the work (Task 3.2)
- those properties will be characterized in relation to the variability of the on-site environmental conditions like temperature, ambient pressure or humidity (Task 3.3)

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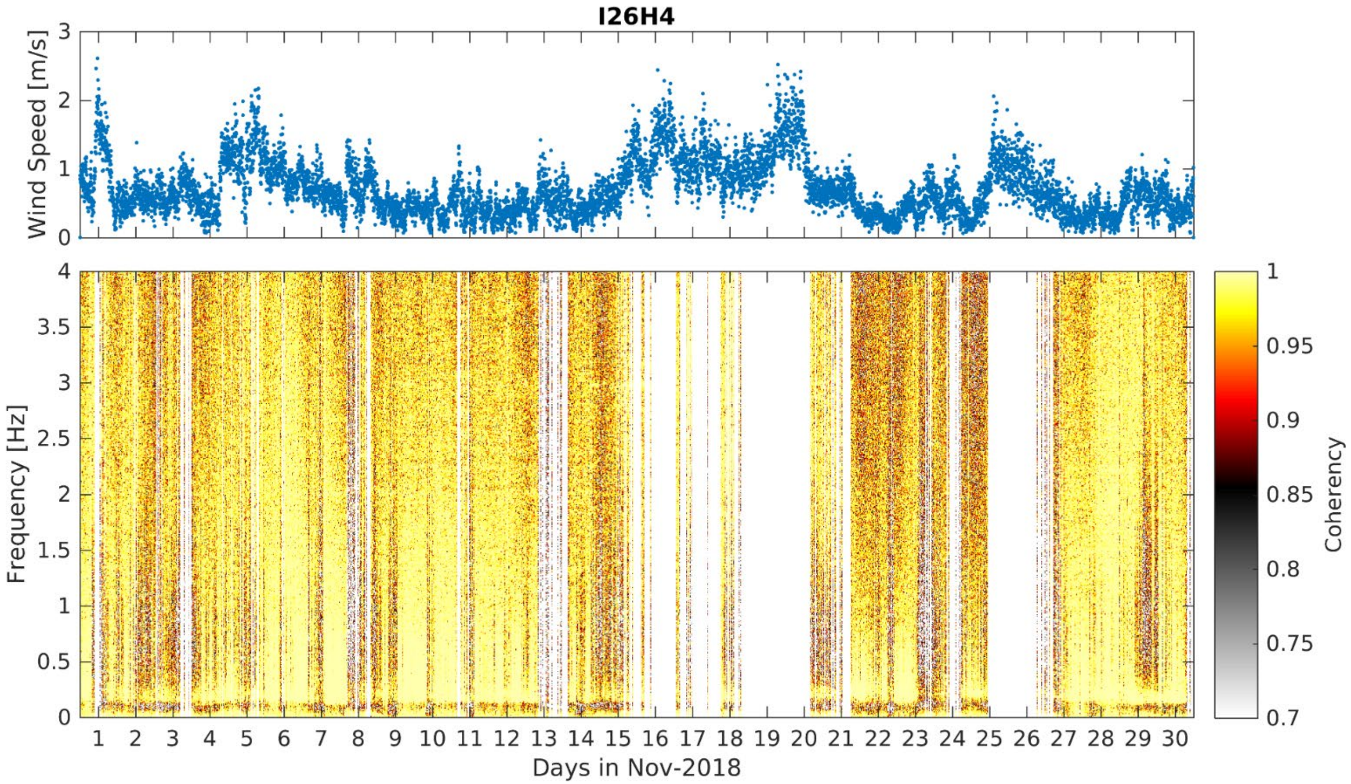
Examples – Infrasound



- low coherence between standard and reference sensor for time segments with high wind speeds, which is measured at element H1

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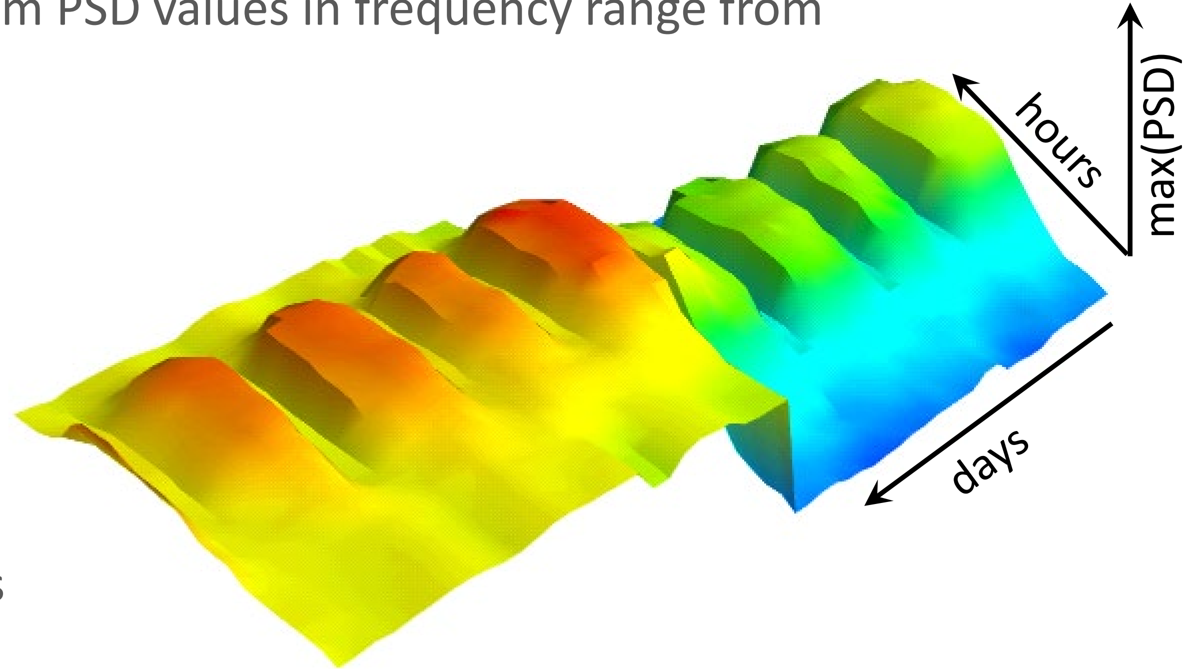
Examples – Seismic

- Continuous monitoring of maximum PSD values in frequency range from 4 to 14 Hz at seismic stations
- Hourly basis
- Daily variations
- Weekly variations
- Indicator for instrumental changes
- Here: instrument change without adjusting the n-calib value in the database



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Impacts – Anticipated Outcome

- New primary and secondary calibration capability
- Procedures and transfer standard devices for establishing measurement traceability for data from AUV monitoring
- Case studies demonstrating the impact of measurement traceability and measurement uncertainty considerations
- Guidance on measurement uncertainty principles applied to AUV monitoring in geophysical applications
- Good practice guide for on-site calibration with recommendations for improved data quality and monitoring outcomes
- Recommendations for new IEC and ISO standards on calibration methods

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Summary

- Develop **primary calibration** methods and devices for airborne acoustics, underwater acoustics, and vibration (seismic) sensing systems at the low frequency range down to 0.1 Hz or below, needed for environmental measurements but not yet covered by global calibration capabilities.
- Develop **secondary calibration** methods for airborne acoustics, underwater acoustics and vibration (seismic) sensing systems as the first step in transferring new primary calibration capability to working standard devices.
- Develop facilities and methods for the dissemination of traceability through specific methods of **on-site calibrations**.
- **Evaluate the outcome improvements** and impacts in current sensor networks deployment strategies, and propose optimization of the models and parameters in the applications, leading to increased confidence in measurements.
- **Engage with stakeholders** to facilitate the take-up of the project results.

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