A Study of Defects on Infrasound Wind-Noise-Reduction Systems (WNRS) Using In-Situ Calibration

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Infra-AUV Project

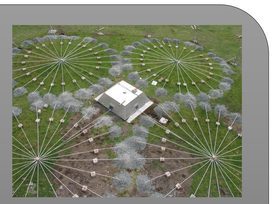
- Development of primary low-frequency calibration methods for sound in air, underwater acoustics and vibration metrology
- Dissemination of primary standards: Secondary calibration and test methods for environmental measurement infrastructure
- Traceability for global seismic and acoustic environmental sensor networks by novel on-site calibration and improved knowledge of operational sensor behaviour
- Improvements in current environmental measurement station deployment strategies gained by traceable calibration, known measurement uncertainties and improved knowledge of operational sensor behaviour

Objectives

- In-situ calibration of the Wind-Noise-Reduction System (WNRS)
- Comparison with an electro-acoustic model of the WNRS
- Test the effects of pipe blockages on the WNRS – both modelled and experimental

Wind Noise Reduction System

- WNRS reduces the wind generated noise in the band of interest (0.01 to 4 Hz)
- Correlation analysis between sensor elements is used to calculate the speed and back azimuth.
- Very sensitive to phase errors
- Passive on-site calibration techniques measure the system response.



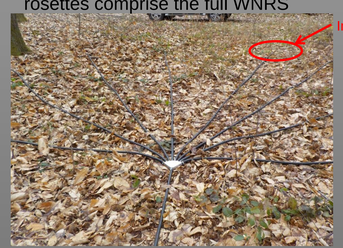
Arrays of infrasound station IS49, Tristan da Cunha, United Kingdom. https://www.ctbto.org/verification-regime/monitoring-technologies-how-they-work/infrasound-monitoring/

In-Situ Calibration

- Based on the approach first used by Gabrielson (https://doi.org/10.1121/1.3613925).
- A reference sensor (shown in green) is placed near the centre of the WNRS.
- The gain of the WNRS is determined relative to the reference sensor when the coherence is high (>0.98).
- An 18 m WNRS was installed – 4 primary pipes and 8 secondary pipes (32 total inlets)

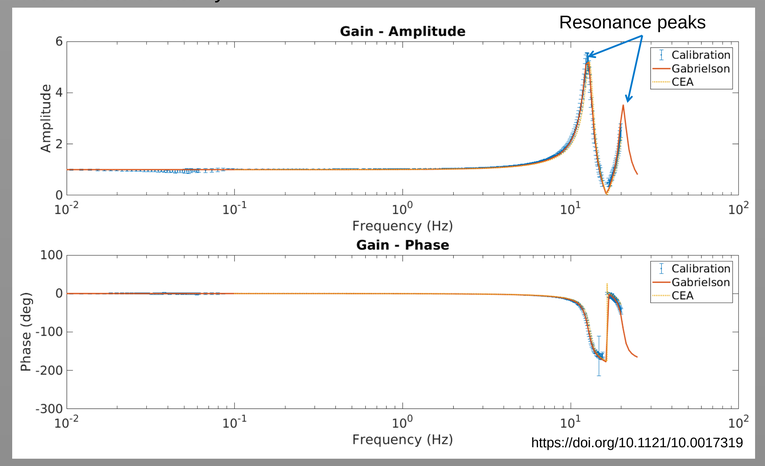
WNRS Microbarometer

Single rosette with 8 inlets. 4 similar rosettes comprise the full WNRS



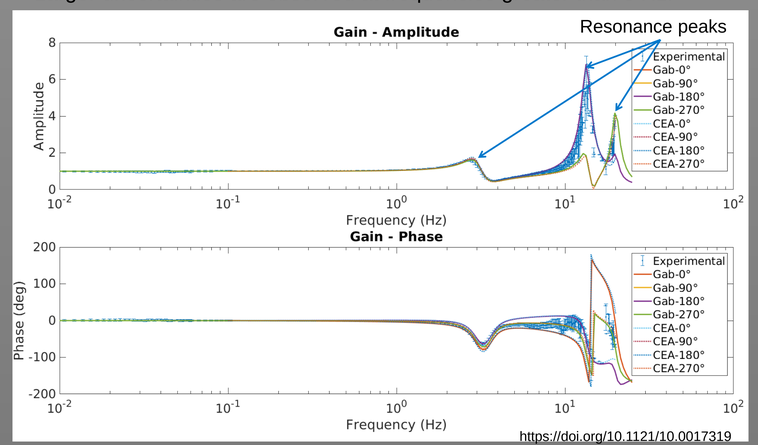
Calibration Results

- Amplitude and phase are close to 1 and 0° in band of interest (0.01-4 Hz).
- Resonances peaks are observed in coincidence in both the model and the calibration curves.
- Partially coherent wind-noise at low frequency causes dip artefact and increased uncertainty



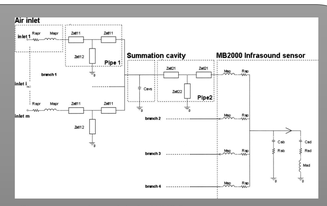
8 Blocked Inlets

- 8 inlets (1 rosette) were blocked with rubber stoppers.
- Gain is well reproduced in the model.
- Larger uncertainties are observed at frequencies greater than 3 Hz.



Electro-acoustic model of WNRS

- Fluids can be treated in a similar fashion to electric currents.
- Disconnected elements and blocked elements can be simulated by setting element admittances to 0 (impedances to infinity)



Electro-acoustic model of a WNRS
Benoit Alcoverro and Alexis Le Pichon, "Design and optimization of a noise reduction system for infrasonic measurements using elements with low acoustic impedance", The Journal of the Acoustical Society of America 117, 1717-1727 (2005) https://doi.org/10.1121/1.1804966

Summary

- On-site calibration experiments were completed at the CEA
  - Simulation tool has been consolidated to predict the full frequency response of WNRS
  - Analysis demonstrates synergy between model and calibration data, such as the blocked inlet scenario
  - WNRS response curves (with uncertainties) have been measured and introduced into an uncertainty analysis
- Ongoing/Future Work
  - Temporary WNRS was installed at IS26 (Germany) to provide cross-array coherence measurements.
  - Us of the co-located IS26 detector to provide 'ground-truth' measurements will allow for a quantification of the errors introduced by the defective systems to the PMCC results. See presentation in AS4.9 EGU23-8239 Thursday 8:30 am.

References

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2. Thomas B. Gabrielson, "In situ calibration of atmospheric-infrasound sensors including the effects of wind-noise-reduction pipe systems", The Journal of the Acoustical Society of America 130, 1154-1163 (2011) https://doi.org/10.1121/1.3613925
3. Thomas B. Gabrielson, "An acoustic model for wind-noise-reduction pipe systems", Penn State Unviersity (2012)
4. David N Green, Alexandra Nippress, David Bowers, Neil D Selby, Identifying suitable time periods for infrasound measurement system response estimation using across-array coherence, *Geophysical Journal International*, Volume 226, Issue 2, August 2021, Pages 1159–1173, https://doi.org/10.1093/gji/ggab155
5. Samuel K. Kristoffersen, Paul Vincent, Alexis Le Pichon, Stéphane Denis, Franck Larsonnier, Benoit Alcoverro, and Thomas B. Gabrielson, "Modelling and validation of defects on infrasound wind-noise-reduction pipe systems", The Journal of the Acoustical Society of America 153, 1272-1282 (2023) https://doi.org/10.1121/10.0017319

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