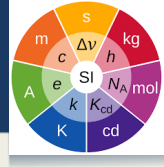
SnT 2025
8 SEPTEMBER ONLINE DAY
9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE



Side event on metrology
SE01-O8

Exploiting very low noise spectra below 1 kHz in a natural lake for free-field hydrophone calibration

Silvano Buogo [a], Junio Fabrizio Borsani [b], Valentina Caradonna [c]

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Presentation Date: 10 September 2025

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Silvano Buogo, Junio Fabrizio Borsani, Valentina Caradonna

Overview

A natural lake of suitable size was chosen for free-field calibration of autonomous recorders from 63 Hz up to 20 kHz.

A new scheme was adopted to implement the comparison method with reduced logistic effort using compact equipment.

The lake featured sustained low ambient noise in the entire frequency band for several hours daily.

A comparison with ambient noise in a laboratory tank showed significant advantage below 1 kHz, mostly in the [10 – 100] Hz band with at least -15 dB difference.

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Lake Bracciano

Natural volcanic lake

30 km NW of Rome

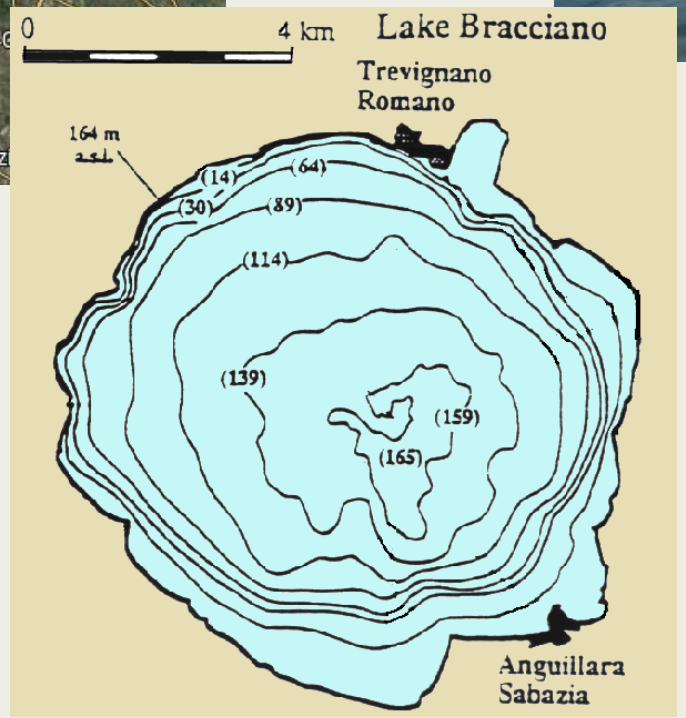
8 km diameter

165 m deep

Soft silt bottom

Mild climate, wind often absent in the morning

No motor boats allowed (except occasional ferry, coast guard)



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Free-field comparison method

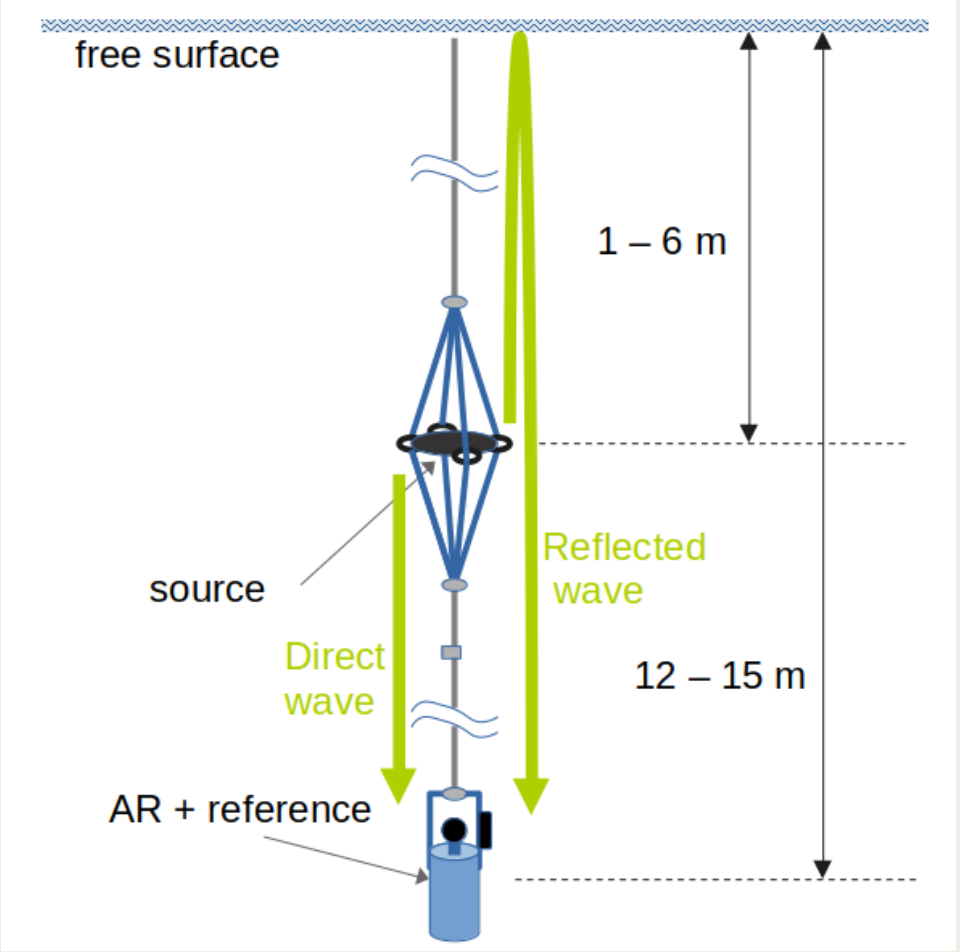
Frequency range from 63 Hz to 20 kHz

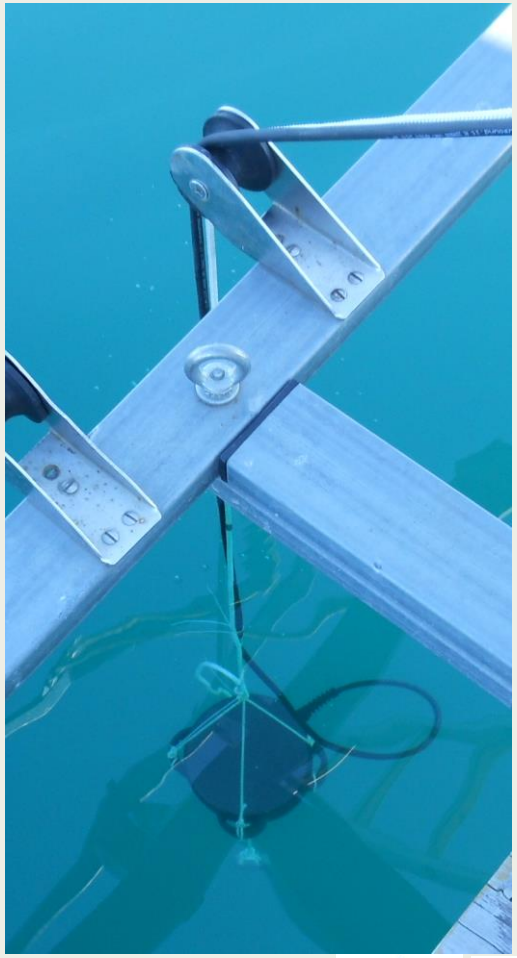
Source and receivers suspended in 100 m deep water from pontoon

Free surface reflection added coherently for frequencies below 1 kHz (Lloyd's mirror)

About 125 ms free-field time, 8 cycles at 63 Hz

Calibration setup





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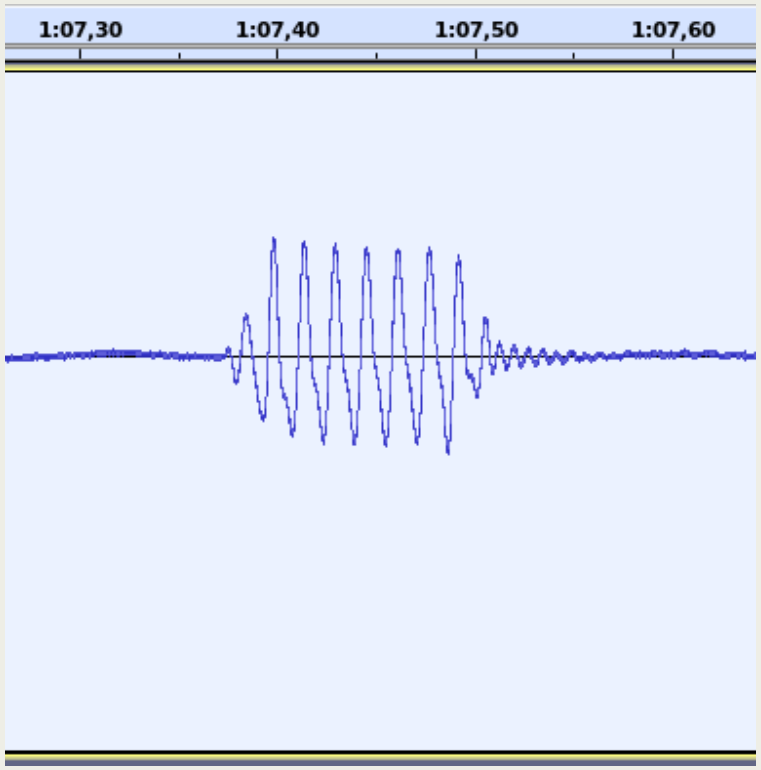
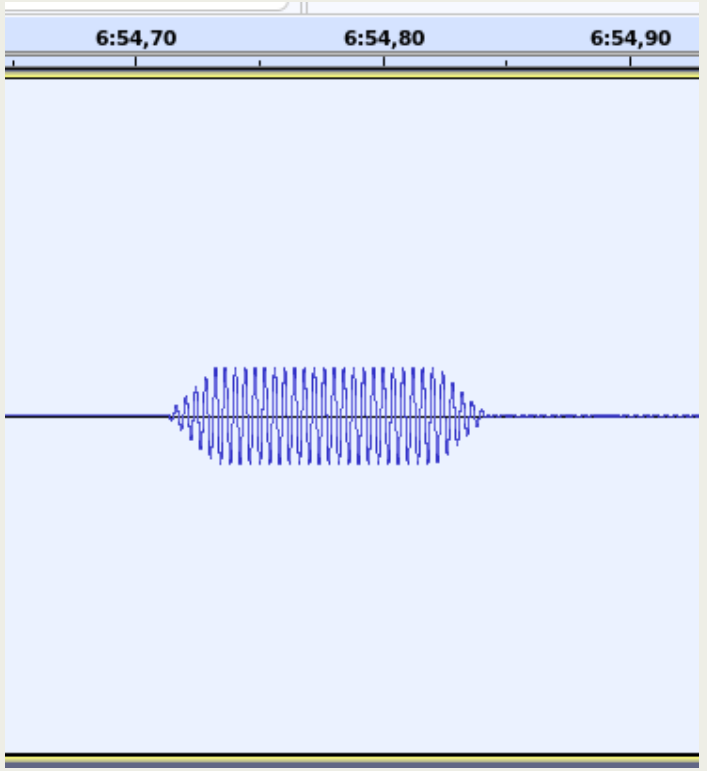
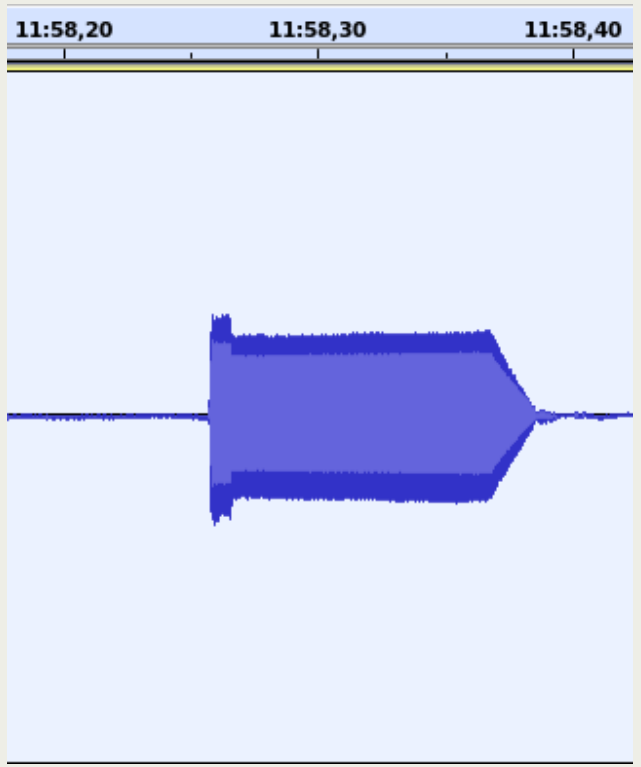
Received signals



63 Hz



250 Hz



10 kHz

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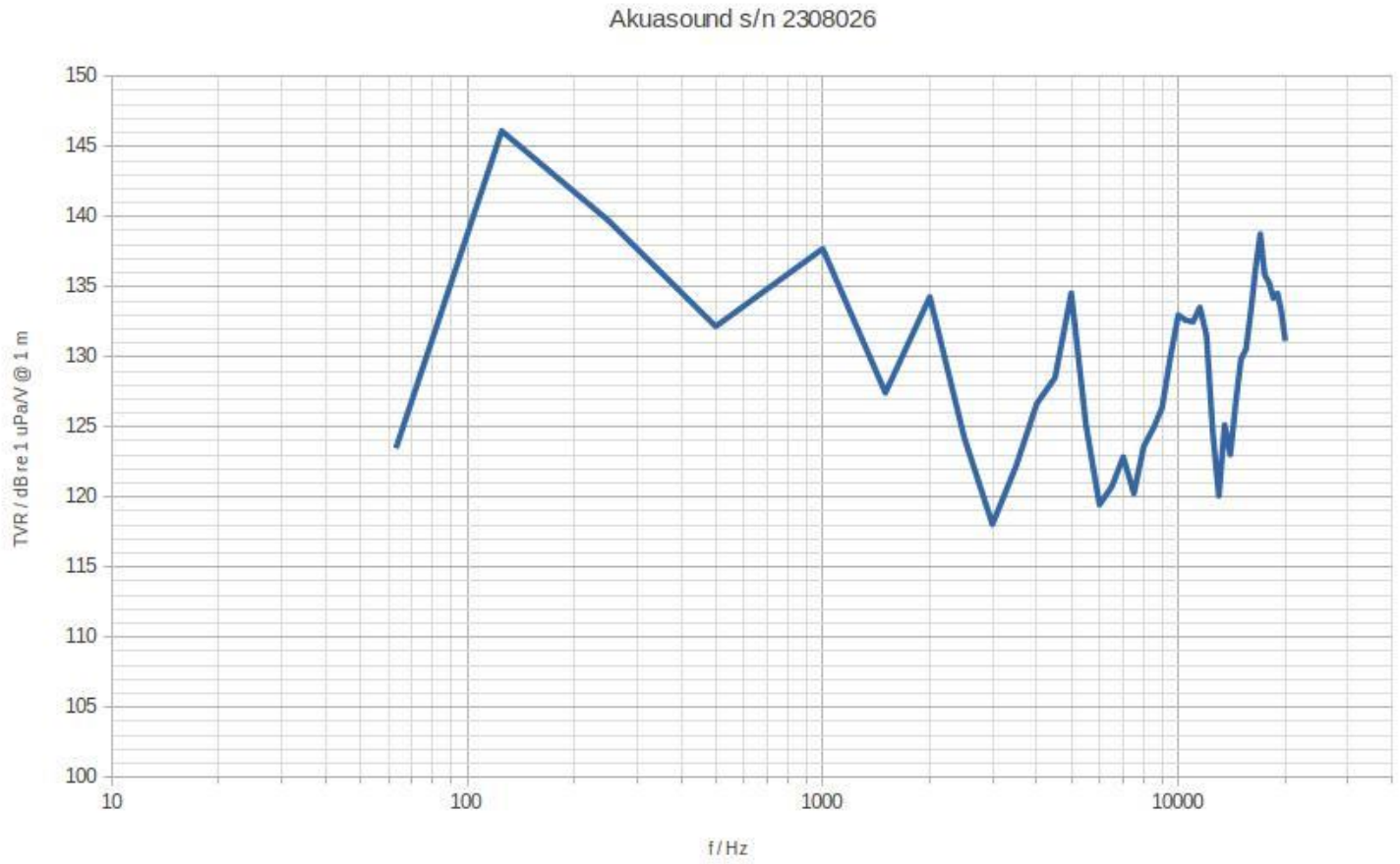
Source Transmit Voltage Response



Electrodynamic moving-coil underwater speaker, two opposite 18 cm dia. carbon fibre membranes

Drive voltage 17 V rms

Source-receiver distance between 9 m and 14 m

Resulting SPL between 125 and 145 dB

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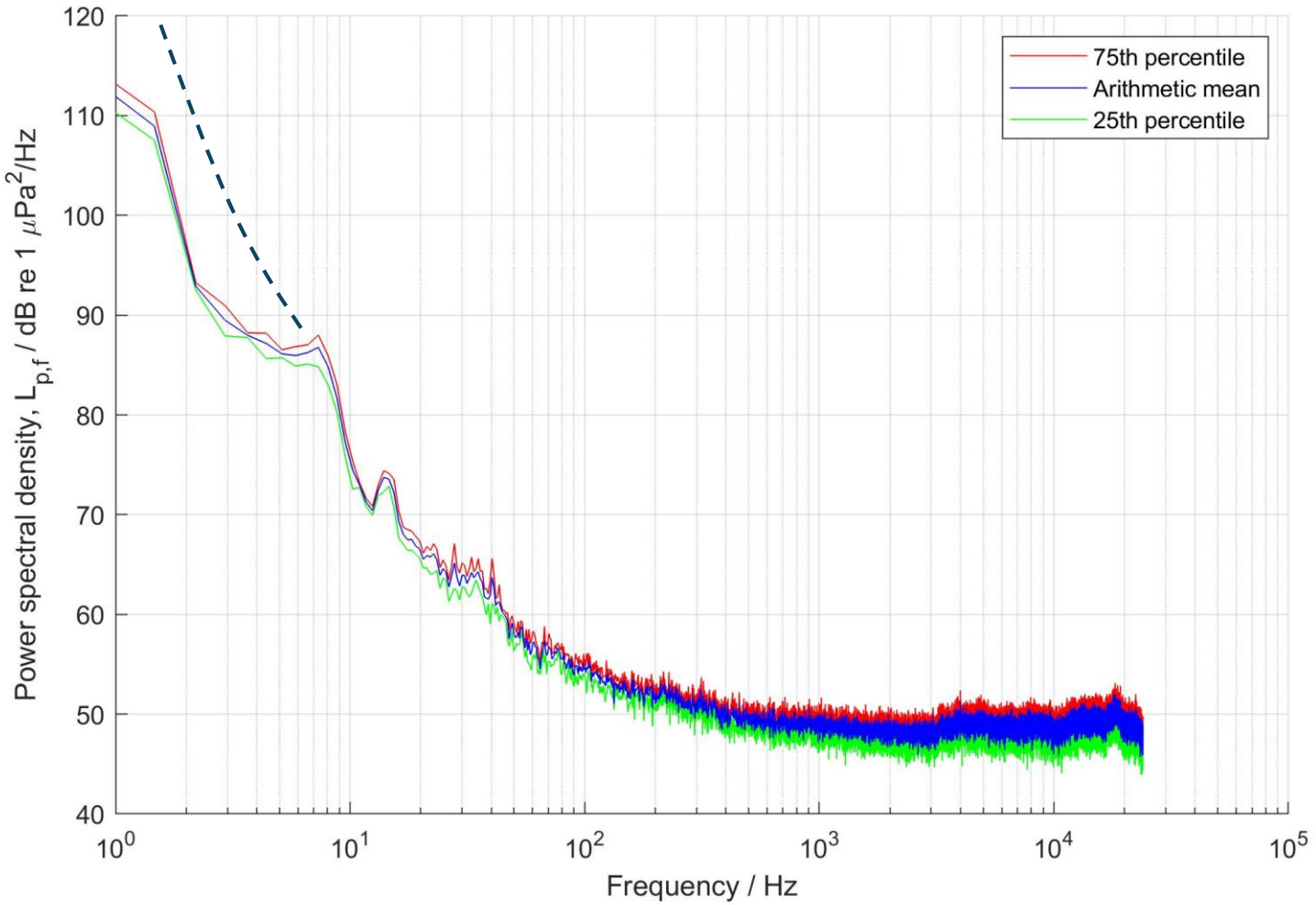
Lake ambient noise spectrum



10 s averaging time

48 kHz sampling f

65536 pts FFT

16 bits WAV format

Dashed line: no 10-Hz high-pass

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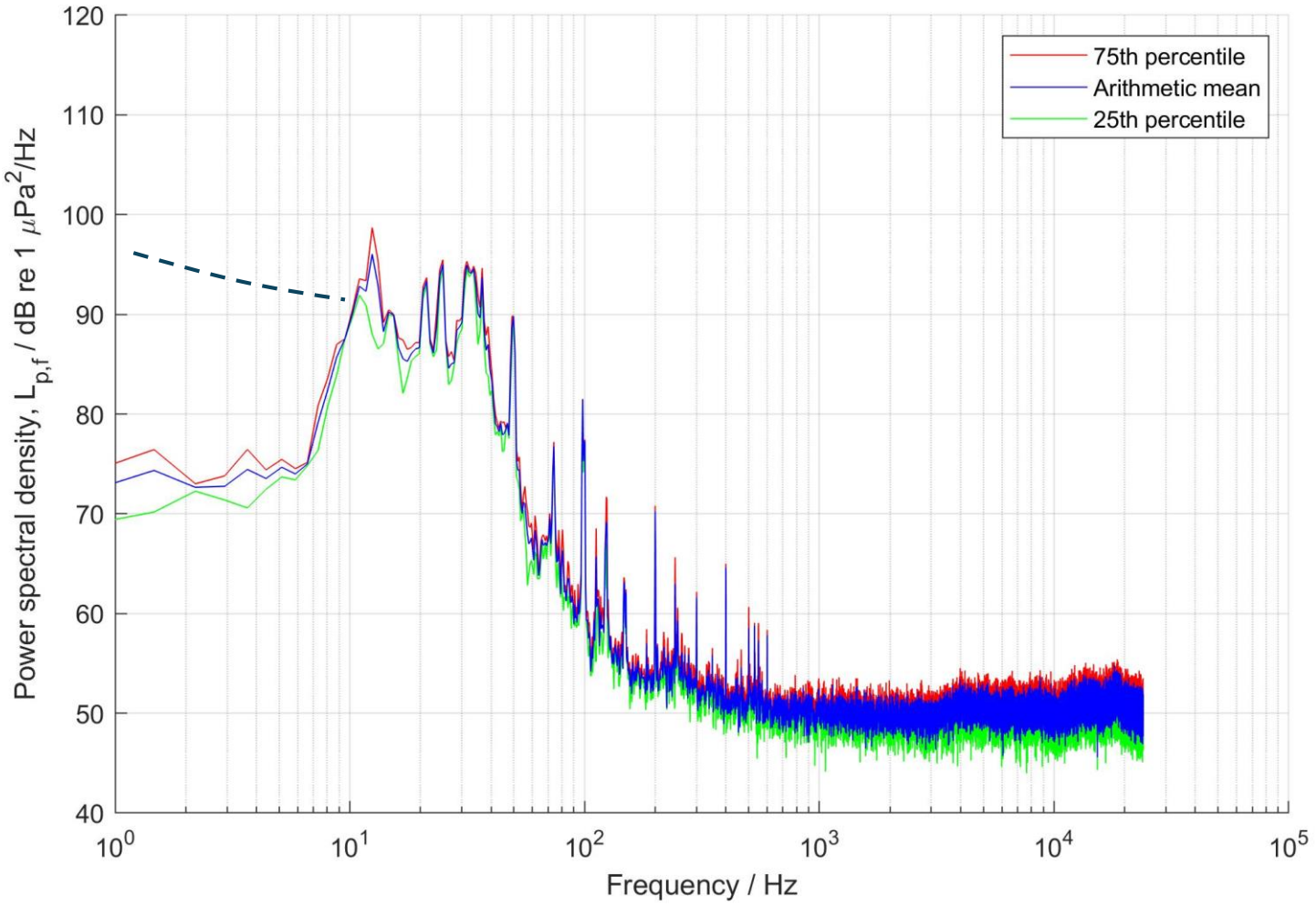
Indoor tank ambient noise spectrum



10 s averaging time

48 kHz sampling f

65536 pts FFT

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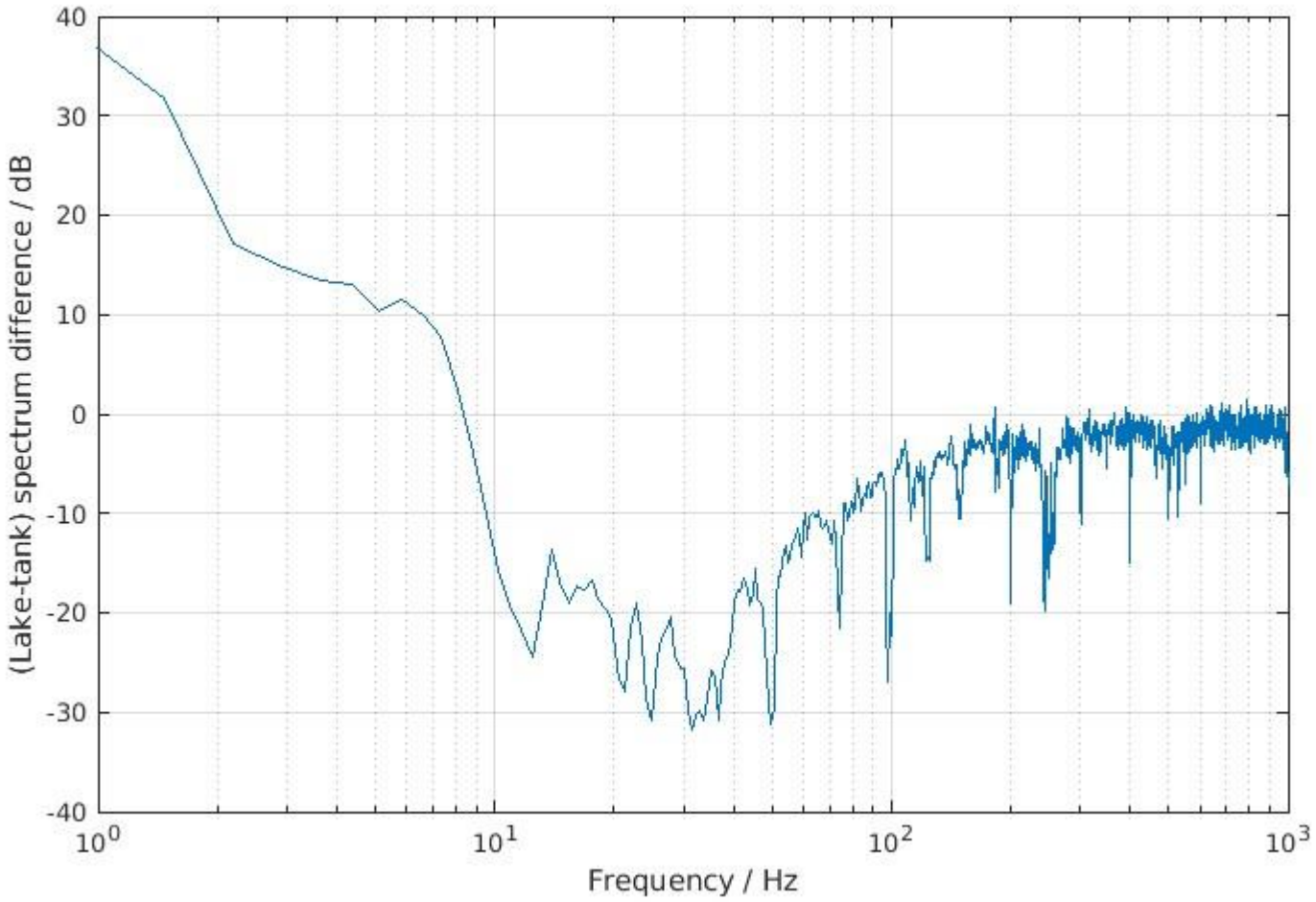
Ambient noise spectrum difference (lake – tank)



Broadband PSD

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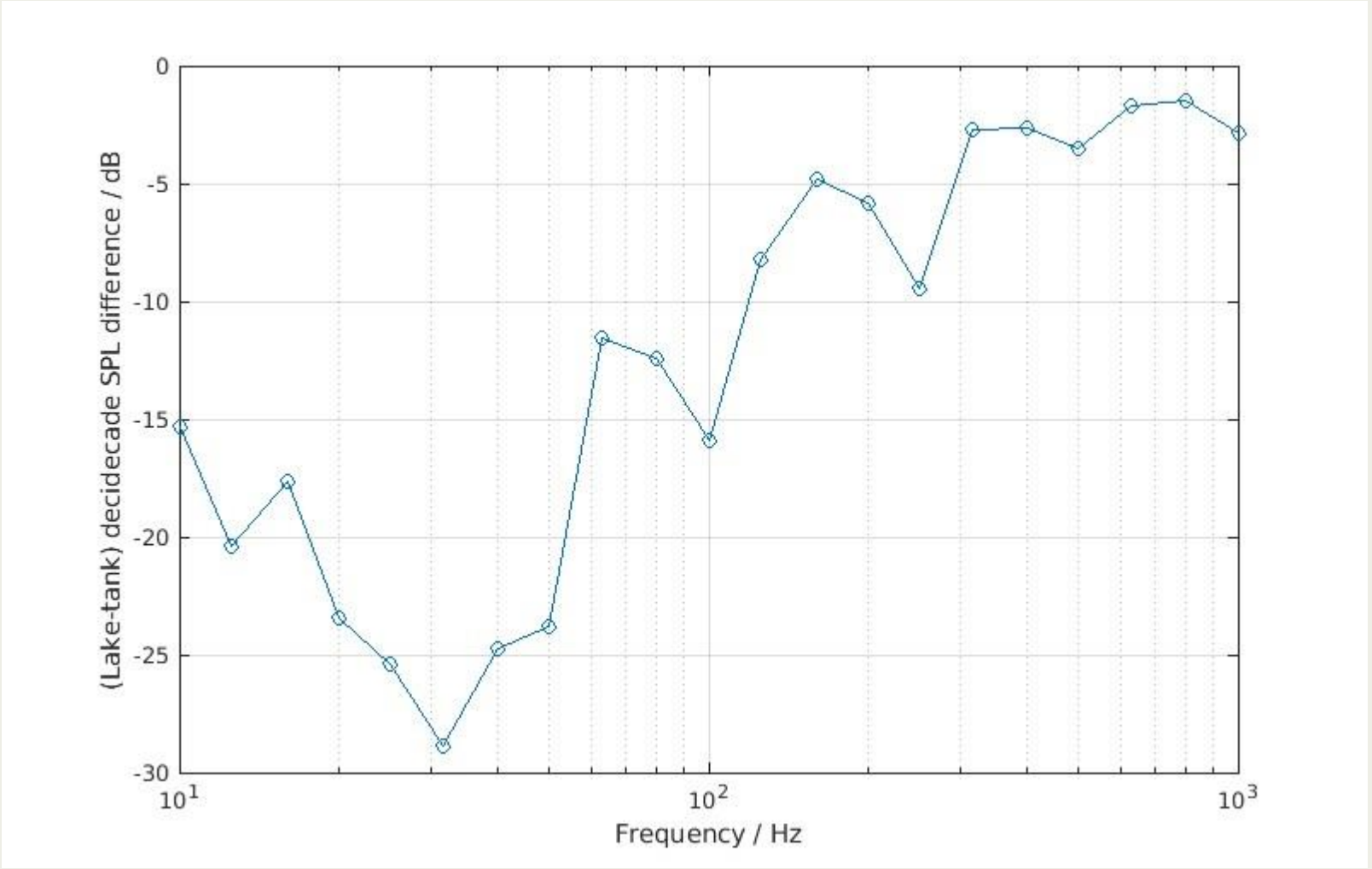
Ambient noise spectrum difference (lake – tank)



Decidecade SPL

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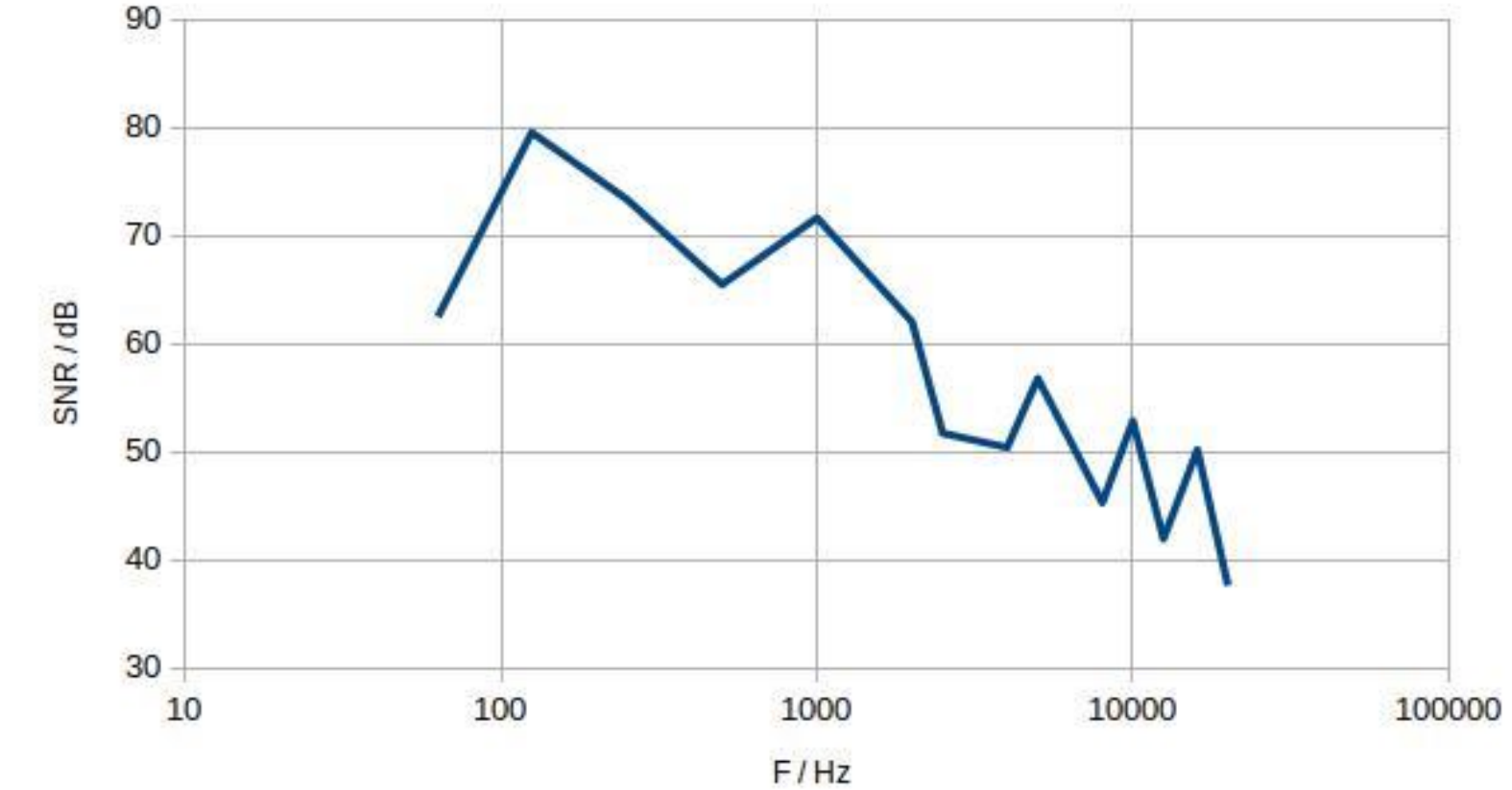
Lake calibration signal/noise ratio



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Conclusions

Free-field calibration of autonomous recorders was performed in a 165 m deep, 8 km diameter natural lake in the frequency range from 63 Hz to 20 kHz.

The lake features very low ambient noise levels for several hours daily due to absence of wind and man-made activities (decidecade SPL below 80 dB between 10 Hz and 5 kHz).

Compared with indoor tank noise levels, the lake was at least 6 dB quieter from 9 Hz up to 1 kHz, and at least 20 dB quieter in the [200 – 500] Hz band (typical of machinery noise).

Comparing lake vs tank noise in the [1 – 10] Hz band is not straightforward as very low frequencies appear to be highly suppressed in the tank.

Lake calibration SNR was at least 40 dB in the entire band, peaking 80 dB around 100 Hz.