A Noise Model for the German OBS pool

New Advances in Geophysics: The Future of Passive Seismic Acquisition

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Team

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- Prof. Dr. Celine Hadziioannou (University of Hamburg)
- Dr. Mechita Schmidt-Aursch (Alfred-Wegener-Institute)
- Robert Mars (Leibniz Institute for Baltic Sea Research)

Outline

Introduction

- Situation: high long periodic noise levels on German OBS
- Experiment at Darss Sill
  - Study area
  - Instruments

Part 1: instrument noise

- Self-noise model

Part 2: harmonic noise

- Theory
- Head-buoy cable strumming
- Current estimation from harmonic signals

Outlook

- Periodicity in harmonic noise from tidal bottom currents

Introduction

High long periodic noise levels on German OBS

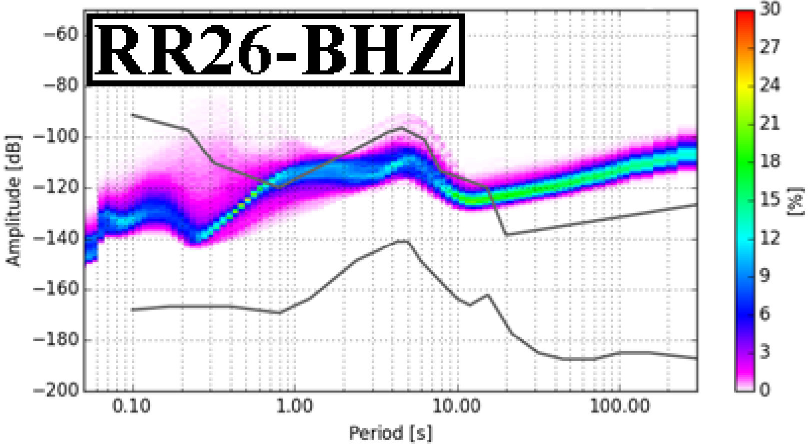


Figure 1: PPSD of a German OBS

High long periodic noise levels on German OBS

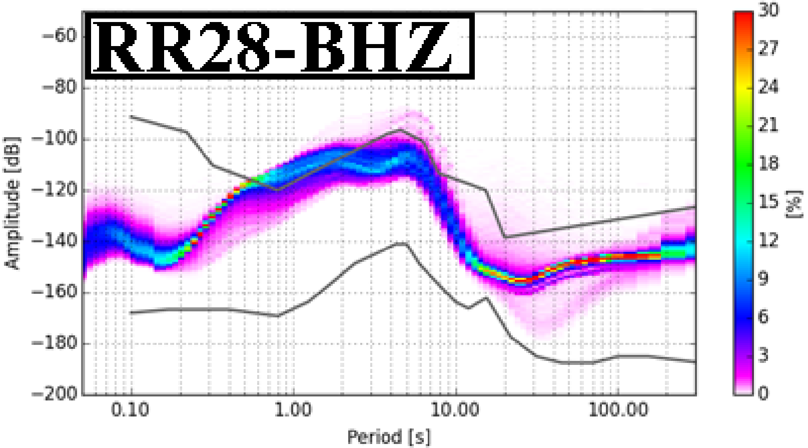


Figure 1: PPSD French of a French OBS

High long periodic noise levels on German OBS

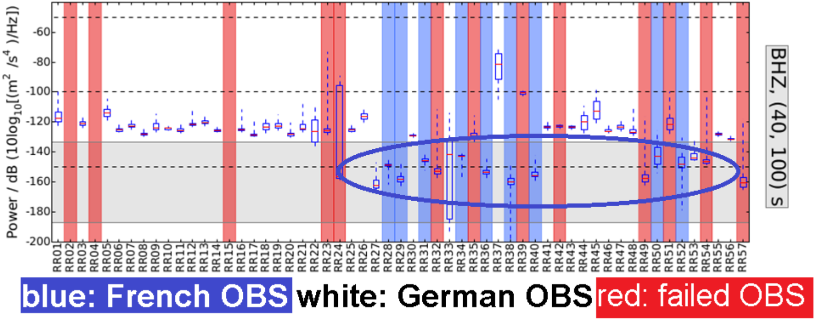


Figure 1: Overview of long periodic noise levels of German and French OBS

Study area Dars Sill

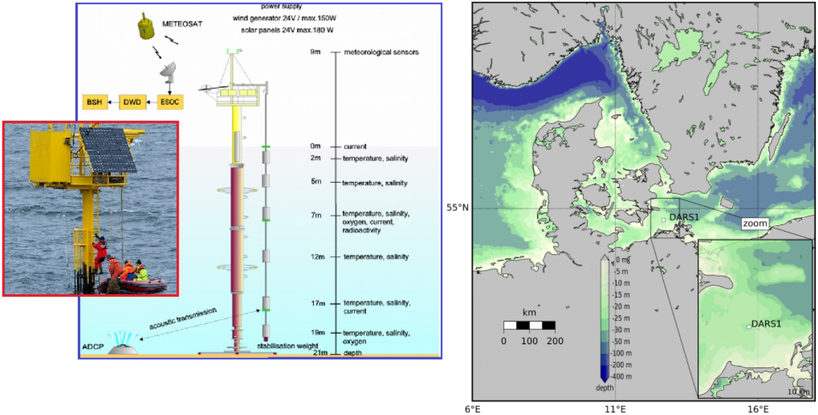


Figure 2: Darss Sill is located in the south-western Baltic sea.
An automated measuring station samples meteorologic and oceanographic parameters in close distance to the deployment. *source: BSH*

Investigating design and sensor

Figure 3: Two different OBS types. *source: K.U.M.*

- First deployment: Same design, but different seismometer
- Second deployment: Same seismometer, but different design

Part 1: instrument noise

High noise levels on OBS records

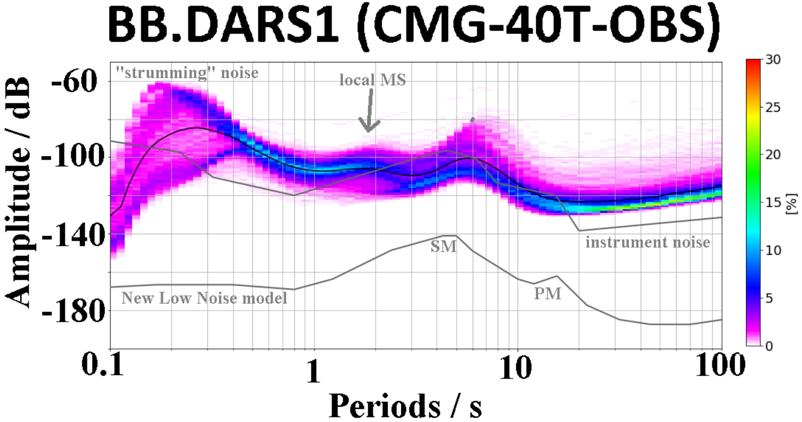


Figure 4: Probabilistic power spectral density plots for the vertical component of the two different seismometer sensors.

High noise levels on OBS records

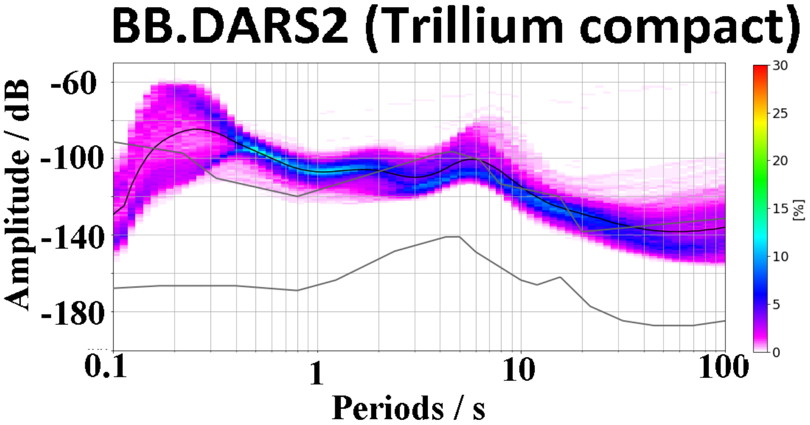


Figure 4: Probabilistic power spectral density plots for the vertical component of the two different seismometer sensors.

Self-noise curves

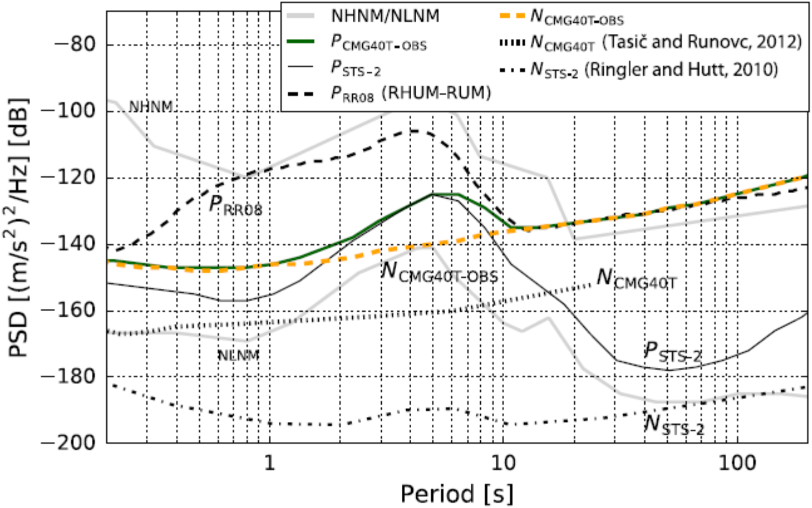


Figure 5: Self noise for STS-2, CMG-40T and CMG-40T-OBS

Noise level vs current velocity

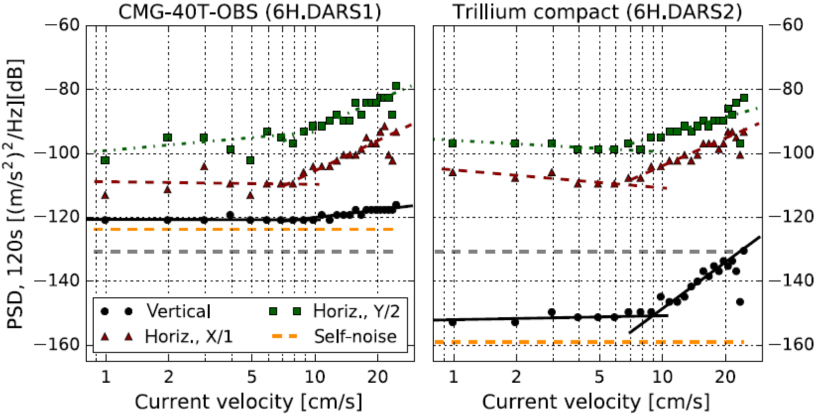


Figure 6: Long periodic (120s) noise levels in relation to prevailing current velocities for CMG-40T-OBS and a Trillium compact.

Part 2: harmonic noise

Karmán vortex shedding

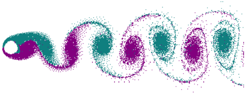
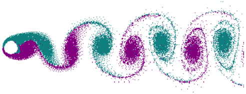


Figure 7: Vortex street created by a cylindrical object, source: wikipedia.org

Relation between Kármán vortex shedding and current velocity:

$$\boxed{f_{\mathrm{vort}} = \frac{St\,v}{d} = 10.5\,\mathrm{v}} \tag{1}$$

Karmán vortex shedding



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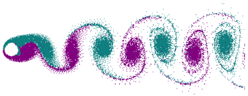
$$St = 0.198(1 - \frac{19.7}{Re}) \approx 0.20 \tag{2}$$

Karmán vortex shedding



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Relation between Kármán vortex shedding and current velocity:

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empirical formula for dimensionless Strouhal number:

$$St = 0.198(1 - \frac{19.7}{Re}) \approx 0.20 \quad (2)$$

dimensionless Reynolds number:

$$Re = \frac{v\, U}{\nu} \approx 1000 \quad (3)$$

v : flow velocity, U : characteristic length, ν : viscosity

Head-buoy cable strumming

lock-in: syncronicity between resonance and vortex shedding

fundamental frequency of cable:

$$f_{\mathrm{res},0} = \frac{(0+1)}{2\,\mathrm{L}} \sqrt{\frac{\mathrm{F_{buoy}}}{\lambda_\mathrm{m}}} \approx 0.48\,\mathrm{Hz}$$

linear density: $\lambda_\mathrm{m} = 0.145\,\mathrm{kg/m}$
length of cable: $L = 10\,\mathrm{m}$
buoyancy: $\mathrm{F_{buoy}} = 13.8\,\mathrm{N}$

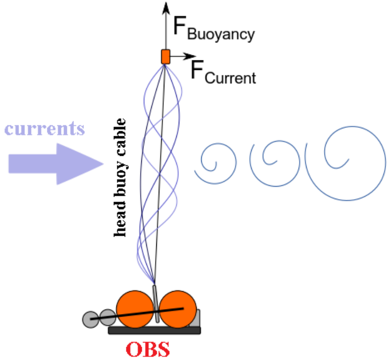

Figure 8: Sketch of strumming head-buoy cable, Stähler et al. 2018

VIVs - Harmonic signals

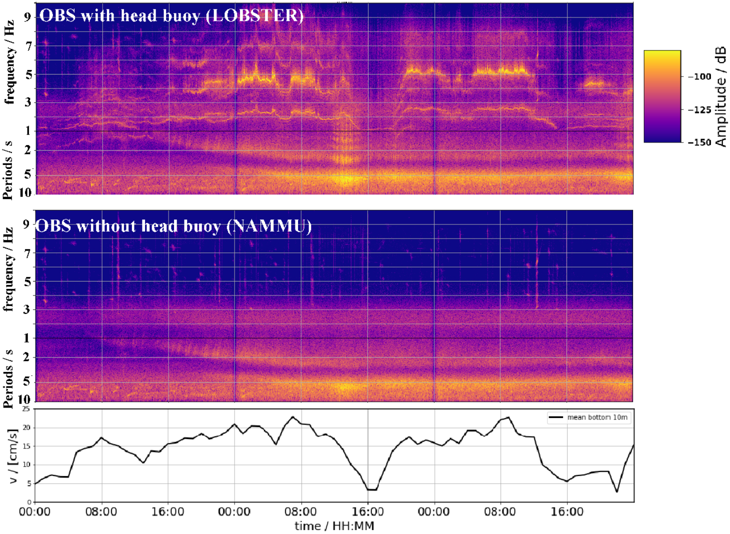

Figure 9: Three day spectrograms of the two different OBS types and measured and averaged bottom current velocities.

current velocity vs. harmonics

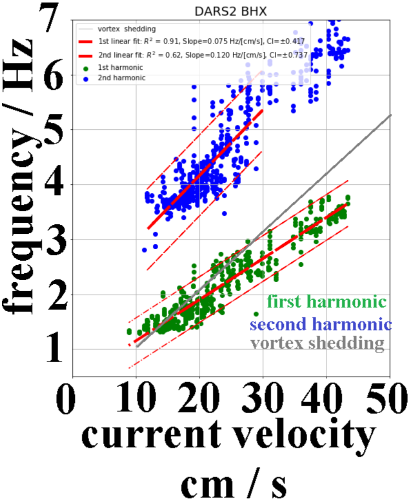

Figure 10: Picked first and second harmonics against the respective current velocity.

Outlook

Application to deep sea deployment (RHUM-RUM)

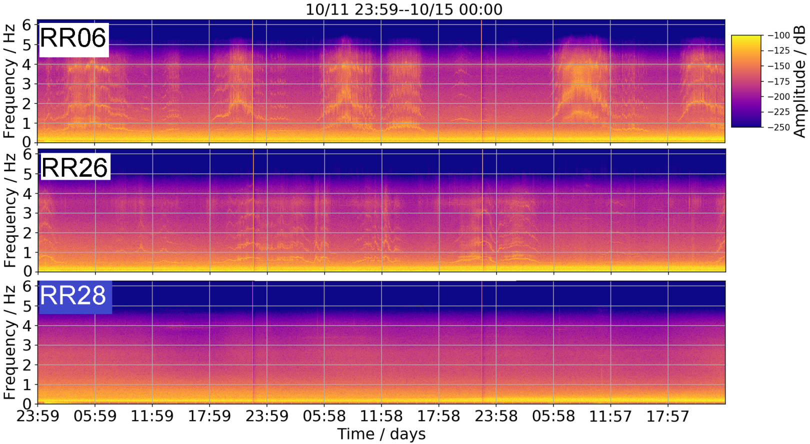

Figure 11: Three day spectrogram of RHUM-RUM stations showing harmonic signals for German OBS.

Application to deep sea deployment (RHUM-RUM)

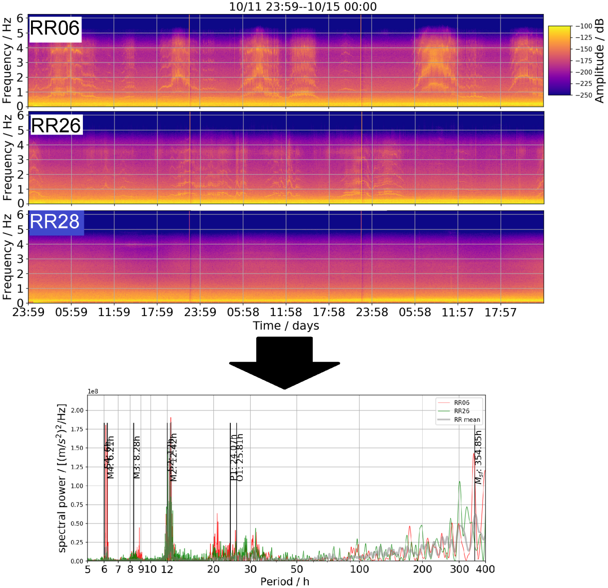

Figure 11: Extracting periodicity of harmonic signals.

Application to deep sea deployment (RHUM-RUM)

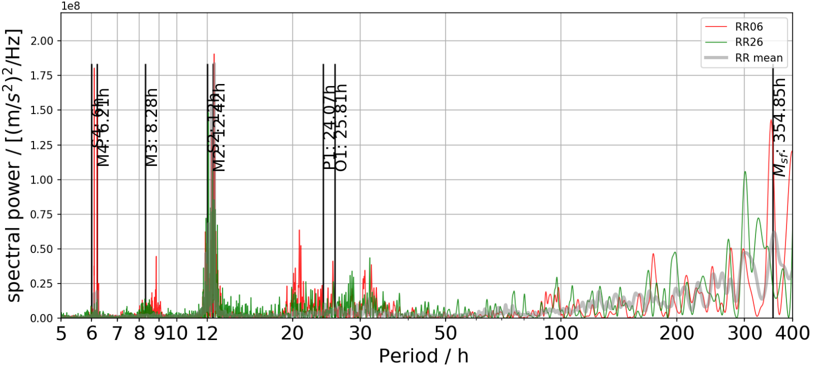

Figure 11: Power spectral density plot for different RHUM-RUM statios shows good agreement with tidal components.

Map of tidal peak ratio 6h/12h

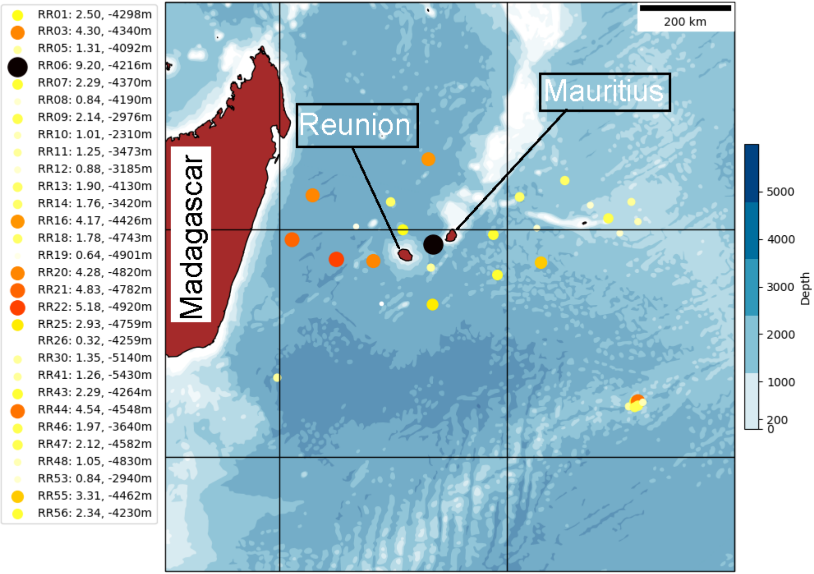

Figure 12: Distribution of tidal energy peaks.

Reference & Acknowledgements

[1] Stähler, Simon C and Schmidt-Aursch, Mechita C and Hein[1], Gerrit and Mars, Robert. "A Self-Noise Model for the German DEPAS OBS Pool." Seismological Society of America (2018)

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[1] Looking for a new PhD student? Would be happy to discuss potential possibilities :)