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Amphibian Seismological Studies in the Ross Sea, Antarctica

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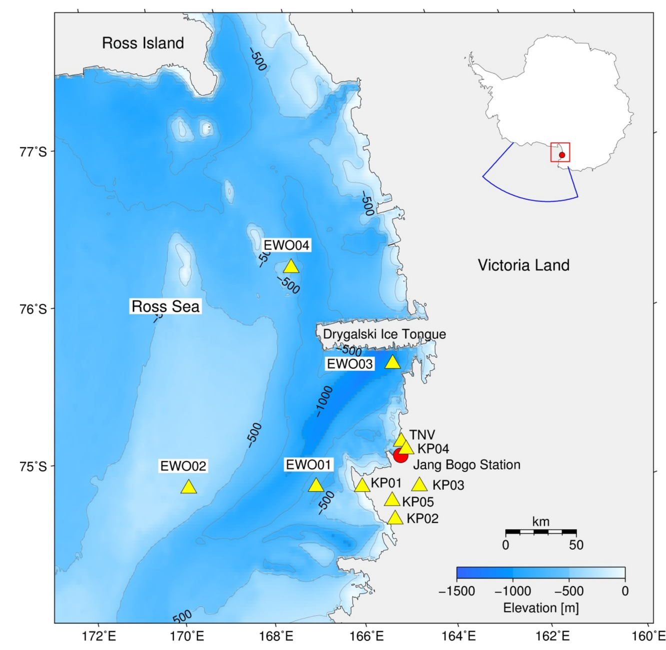
Introduction

The Antarctic Ross Sea is one of the key regions for polar research activities. Research stations from several countries located at the coast are the base for inland expeditions. Even in the austral summer, the Ross Sea is party covered with drifting ice fields; this requires an icebreaker for all marine explorations. Therefore, large geophysical surveys in the Ross Sea are difficult. But the area is of special interest for seismologists: The Terror Rift in the western Ross Sea is a prominent neotectonic structure of the West Antarctic Rift System (WARS). It is located near the coast in the Victoria Land Basin and extends parallel to the Transantarctic Mountains. The rifting processes and the accompanying active onshore volcanism lead to increased seismicity in the region. The annual waxing and waning of the sea-ice and the dynamics of the large Ross Ice Shelf and nearby glaciers generate additional seismic signals. Here we present studies on data from onshore and ocean-bottom broadband seismometers.



Bathymetric map (IBCSO; Arndt et al., 2013) with seismic station locations (yellow triangles). Blue line marks the offshore area used for the correlation of seismic noise and sea ice extent.

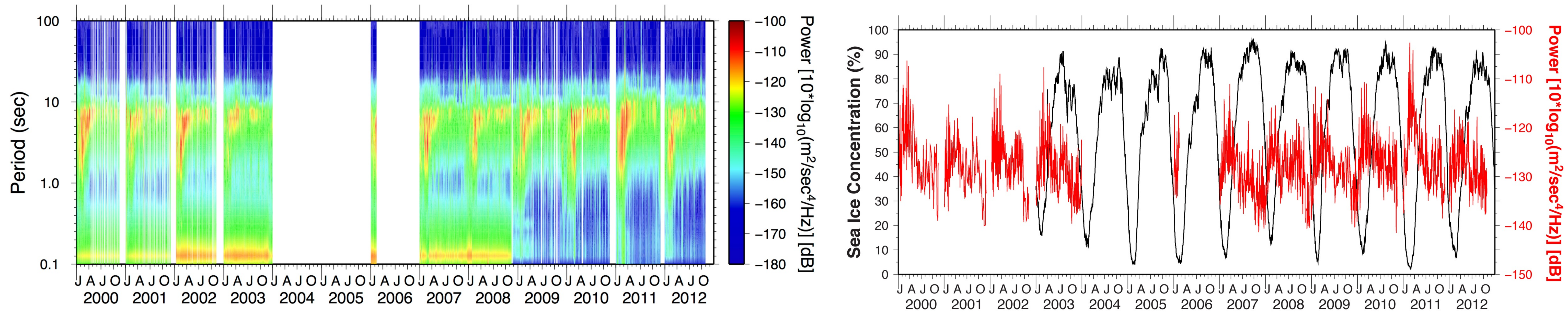
Data acquisition

The existing dense seismic network in Victoria Land around the Korean and Italian research stations was complemented by onshore and offshore temporary stations. Four broadband ocean-bottom seismometers (OBS) from the German DEPAS pool were deployed in January 2012 with the Korean research icebreaker RV Araon to study local seismicity, crust and mantle structure and oceanic noise. Three instruments could succesfully be recovered after 13 months, OBS EWO01 was not accessible due to local sea-ice coverage. It was retrieved one year late in January 2014. All stations were equipped with a Güralp CMG-40T seismometer (50 Hz- 60 s) and recorded data of good quality. EWO03 stopped after 8 months due to an recorder failure. OBS EWO01 recorded more than 17 months of data until the batteries became discharged. The seismometer of EWO03 malfunctioned and generated strong high-frequency noise peaks. These were suppressed with two notch filters (8.4-9.2 Hz and 16.8-18.4 Hz).

Noise studies

Onshore TNV station:

- Located near the Italian Mario Zucchelli station.
- Data used for analysis: years 2000-2012, large gaps in 2004-2006.
- Calculation of power spectral densities (PSDs, Petersen 1993; McNamara & Buland, 2004).
- PSDs show clear seasonal variations in the microseisms band (2-10 s).
- Strong microseisms amplitude during autral summer.
- Weak microseisms amplitude during other seasons.
- Negative correlation of micsroseisms energy and sea ice coverage.



Left: Temporal variation of ambient noise (vertical component) at the Italian Mario Zucchelli Station (TNV) in the years 2000-2012. Right: Microseisms (4-10 s) energy at the Italian TNV station and sea ice concentration .

OBS stations:

Particular events:

Levelling events (*LVE*):
- The seismometers are gimbal-mounted and perform automatic levelling every 30 days.
- These events are clearly visible in the PSDs, especially at low frequencies.

Teleseimic events (*TSE*):
- Teleseismic events are best visible at low frequencies, large events produce strong PSD signals.
- Example: 11. April 2012, two events off Sumatra, Mw 8.6 / 8.2 .

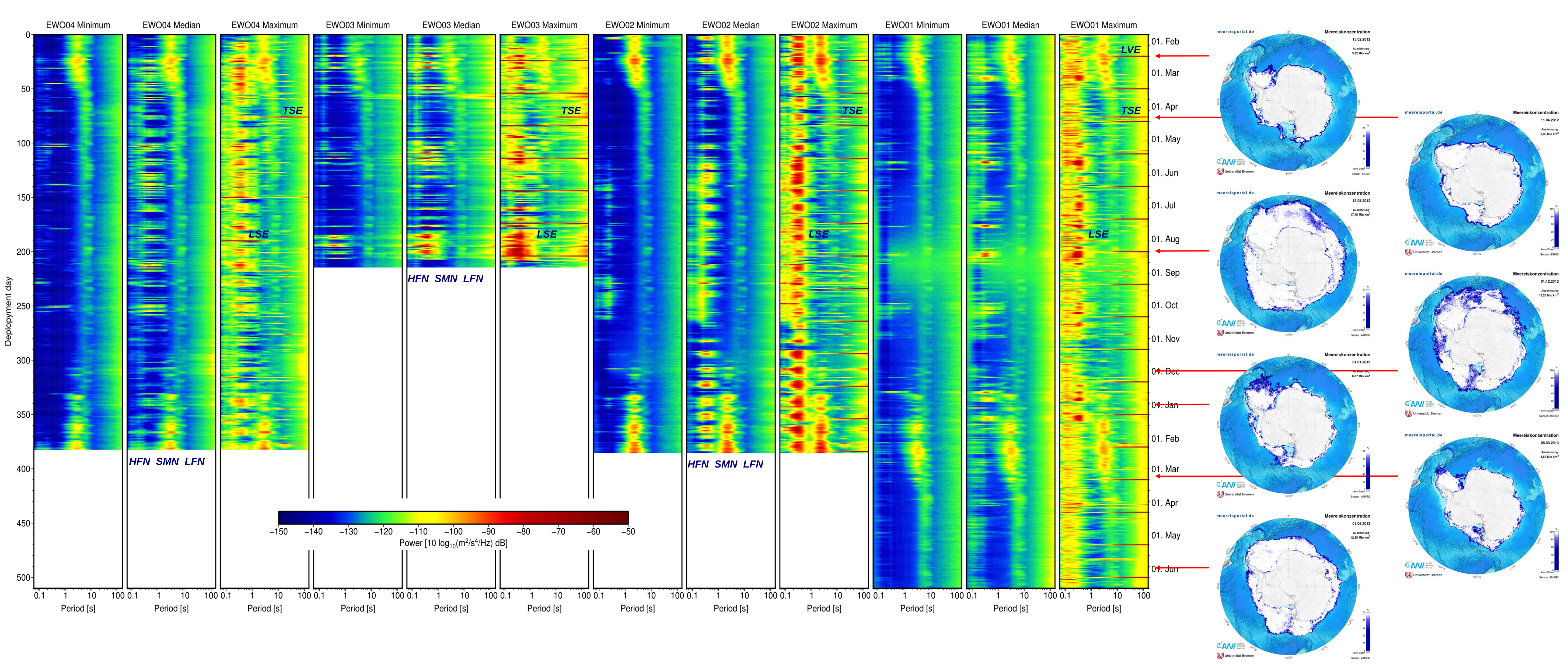
Local seismic events (*LSE*):
- Local seismic events are best visible at high frequencies, amplitudes are often similar to noise amplitudes.
- Example: local earthquake, 03. August 2012.

Noise characteristics:

High frequency noise (*HFN*, 0.06-1 s):
- Occasional correlation between stations.
- Two main contributors: short bursts and long-lasting tremors.
- No clear seasonal variations, independent from sea ice coverage.

Low frequency noise (*LFN*, 10-150 s):
No correlation between stations.
- No clear seasonal variations, independent from sea ice coverage.

Secondary microseismic noise (*SMN*, 1-10 s):
- Pronounced double-frequency peak (Bromirski et al., 2005).
- Weak perennial long-period (3-10 s) maximum.
- Strong short-period (1-5 s) maximum during austral summer.
- End of summer: decrease of frequency and amplitude.
- Long-period SMN largely independent from sea ice coverage.
- Short-period SMN strongly related to sea ice coverage.



Left: Power spectrograms (vertical component) of all OBS. Daily power spectral densities (PSDs, Petersen 1993; McNamara & Buland, 2004) were calculated for each station. Minimum, median and maximum of PSDs were extracted and plotted colour-coded. Right: Southern Ocean sea ice concentration for selected days.

Site effects:

Station EWO04:
- Located in 75 km distance to the coast and 40 km to the Drygalski Ice Tongue.
- Moderate sharp and variable high-frequency noise maximum.
- Moderate short-period secondary microseismic noise maximum.
- Moderate low-frequency noise.
- Moderate influence of coast and Drygalski Ice Tongue.

Station EWO03:
- Located in vicinity of the coast and the Drygalski Ice Tongue.
- Very broad and highly variable high-frequency noise maximum.
- Very weak short-period secondary microseismic noise maximum.
- Very broad and highly variable low-requency noise maximum.
- High influence of the Drygalski Ice Tongue.

Station EWO02:
- Located in approx. 110 km distance to the coast.
- Sharp and clear high-frequency noise maximum (0.3-0.5 s).
- Very pronounced short-period secondary microseismic noise maximum.
- Lowest low-frequency noise level of all stations.
- Only minor influence of the coast.

Station EWO01:
- Located in only 20 km distance to the coast.
- Broad and variable high-frequency noise maximum.
- Moderate short-period secondary microseismic noise maximum.
- High low-frequency noise level.
- High influence of the nearby coast (glaciers).
- Unexplained general amplitude increase in August 2012.

Acknowledgements:

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Figures were created with ObsPy (Bayreuther et al., 2010) and GMT (Wessel and Smith, 1998).

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TNV data were downloaded from panda.bo.ingv.it/download .
Photographs courtesy of Won Sang Lee