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6.2 Setup of an experimental infrasound deployment within the ARCES array

In mid-March 2008 NORSAR carried out an experimental installation of three micro-barometers at the stations ARA1, ARA2 and ARB2 of the ARCES seismic array near Karasjok, northern Norway. The purpose of this experiment was to compare the performance of microbarographs to that of the seismometers with regard to recording infrasonic signals. The full ARCES array has a diameter of about 3 km, whereas the distances between the three infrasound station is about 200 -300 m, as shown in Figure 6.2.1.

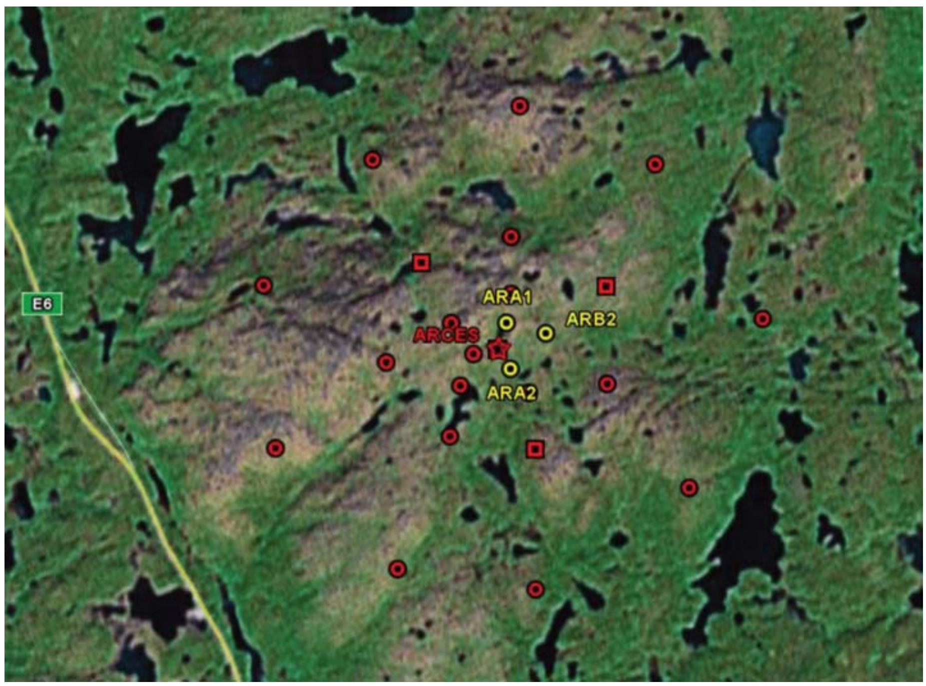

Figure 6.2.1. Map of the ARCES array with three infrasound sensors collocated with the seismic stations ARA1, ARA2, ARB2.

The microbarometers used in the experimental infrasound array are Martec MB2500 instruments with a bandwidth from 0.01 – 27 Hz and a sensitivity of 20 mV/Pa. Each barometer is about 35 cm high with a diameter of 15 cm and a weight of 7 kg (see Figure 6.2.2). The lower part of the instrument is the measurement chamber containing a barometric aneroid bellow, which is deformed by small variations of atmospheric pressure. The deformation of the bellow in turn is measured by a displacement transducer.

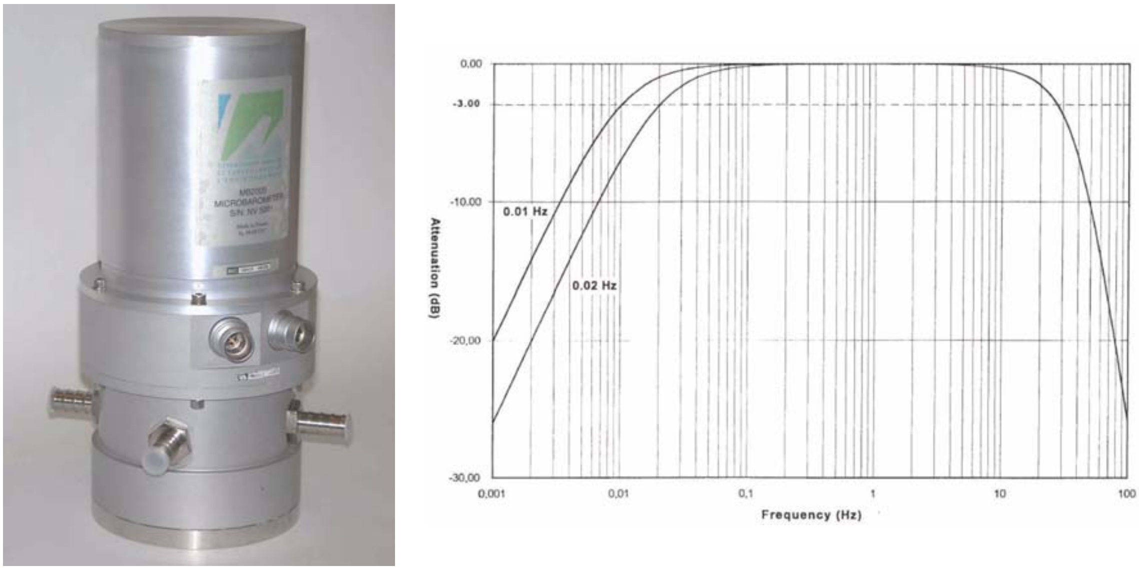

Figure 6.2.2. Martec MB2500 (left) and instrument response (right).

The microbarometers are installed in the very same pit as the seismometers (see Figure 6.2.3), and the analog signals are digitized in the pit at an 80 Hz rate using a Guralp DM24. The digital data (seismic and acoustic) are transmitted by an optical fiber cable to the central station at ARCES and from there by a VSAT satellite link to the NORSAR data processing center in real-time.

Figure 6.2.3. Pit containing a vertical seismometer with a Nanometrix digitizer and the microbarometer (middle) together with the Guralp digitizer (black box). A single inlet connects the barometer with the porous hoses arranged around the pit.

In order to suppress wind noise the decision was made to use porous hoses. At each pit four 12 m long porous hoses were installed in a cross-type layout (see Figure 6.2.4). The hoses are connected to a manifold outside of the pit, and therefore only one inlet penetrates the vault and connects to the barometer. For stations ARA1 and ARB2 we used only the porous hoses, for station ARA2 we additionally encased the hose by a plastic drainage pipe. At the time of the installation we still had a snow cover of up to 1.5 m depths. At all stations the hoses/pipes have been buried as deep into the snow as possible. The deployment is illustrated in Figures 6.2.5 and 6.2.6.

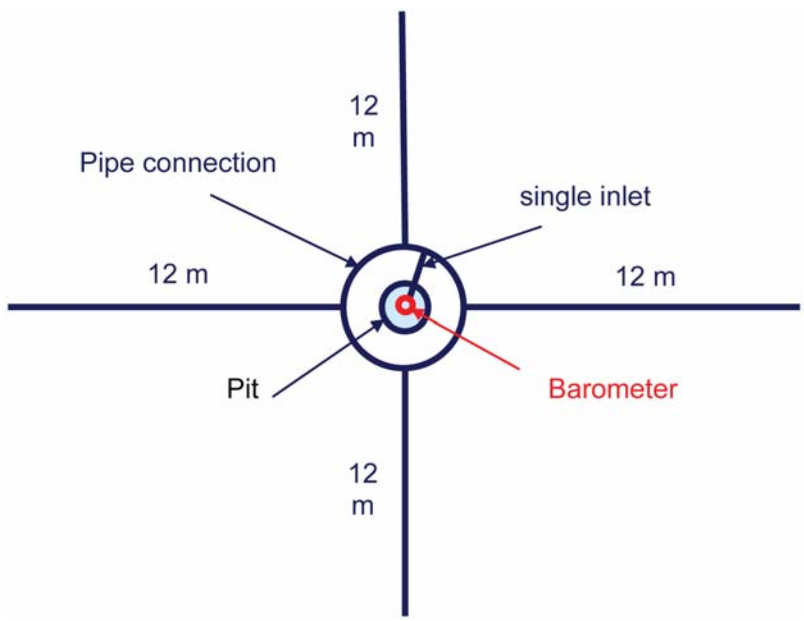

Figure 6.2.4. Sketch of the porous hose layout for wind noise reduction.

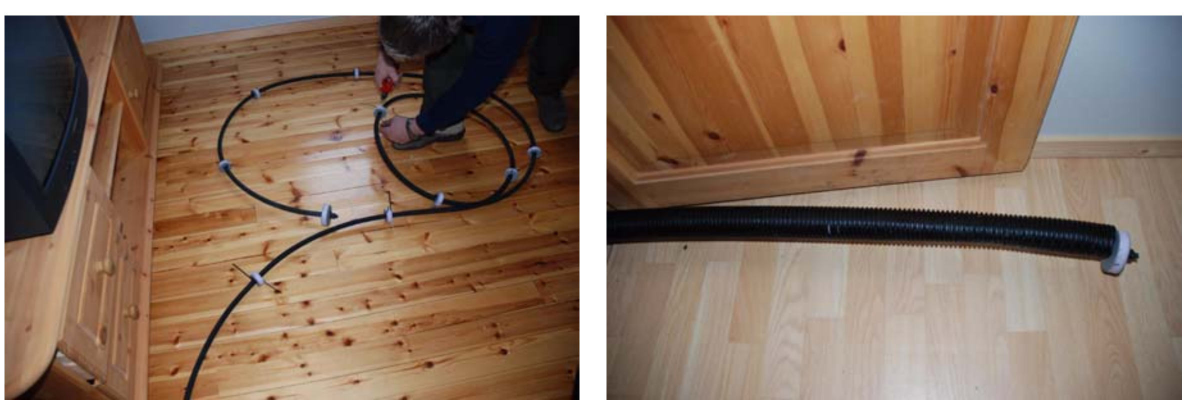

Figure 6.2.5. Porous hose (left) and porous hose in a drainage pipe (right) before deployment.

Figure 6.2.6. Burying the pipes.

Figure 6.2.7 shows the power spectral density of the three infrasound stations under calm conditions (May 1, 2008) and during a strong breeze (May 15, 2008) with average wind speed of 0.3 m/s and 8.8 m/s, respectively. During calm conditions the stations ARA1 and ARA2 have very similar spectra, whereas ARB2 has higher amplitudes (~ factor of 2) for frequencies below 2 Hz. All stations have a frequency peak around 2.3 Hz during quiet conditions. This peak is most probably an issue of the digitizers, and we will have to investigate the reasons more closely. During a strong breeze the noise level of stations ARA1 and ARA2 increase by about a factor of 10; for station ARB2 the effect is much more dramatic having an increase of about 3 orders of magnitude.

The reason for the blatant difference between the stations ARA1/ARA2 on one hand and ARB2 on the other hand, became obvious when we visited the ARCES in the beginning of June 2008. Once the snow had disappeared the hoses at ARB2 are lying on the bare rock directly exposed to the wind. In contrast, stations ARA1 and ARA2 are somewhat in the lee, and additionally, the hoses/pipes are protected from the wind by low brushes.

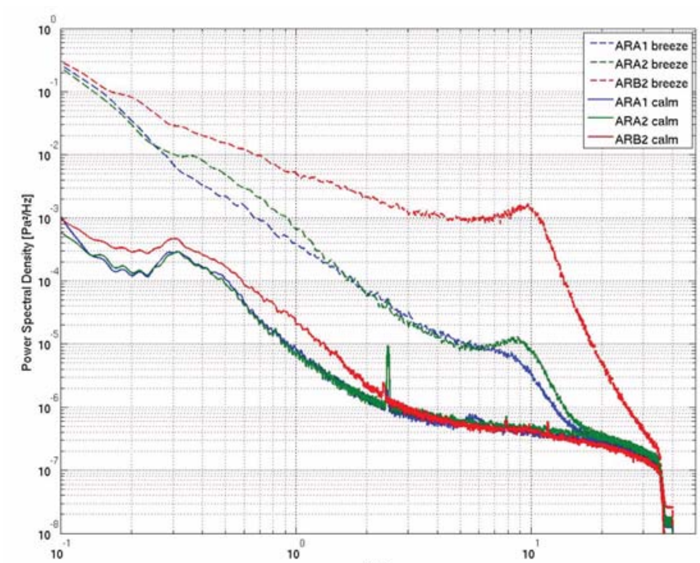

Figure 6.2.7. Power density spectra for the infrasound stations for calm conditions (continuous) and during a strong breeze (dashed). The spectra are computed for a 2-hour window.

Figure 6.2.8 (a-b) shows the infrasound records under calm conditions for two different time windows during May 15, 2008. The first plot (Fig 6.2.8a) highlights the ambient noise associated with shear-generated gravity waves with periods in the range of minutes. Fig 6.2.8b shows a 2-minute zoom of the first part of Fig. 6.2.8a, and shows microbaroms (generated by the interaction of sea waves with the atmosphere) with periods between 5-8 seconds together with a clear infrasound signal. Figure 6.2.9 shows results of slowness analysis of the infrasound signal which has an apparent velocity of 340 m/s and a backazimuth of 237 deg.

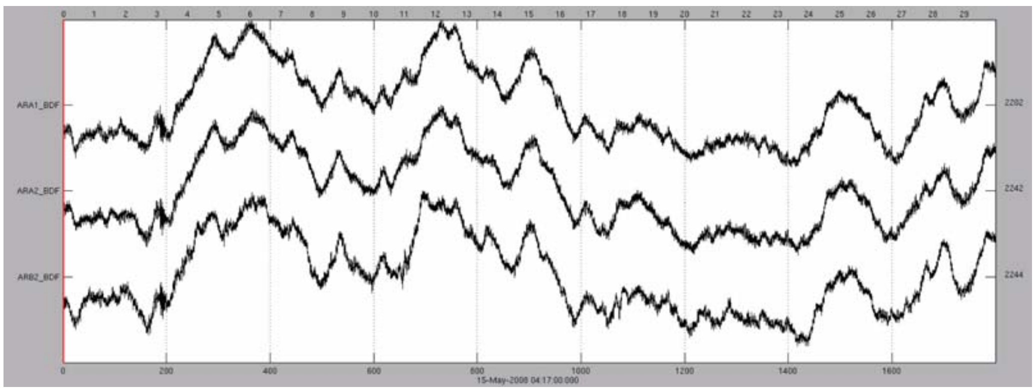

Figure 6.2.8a. A 30-minute time window.

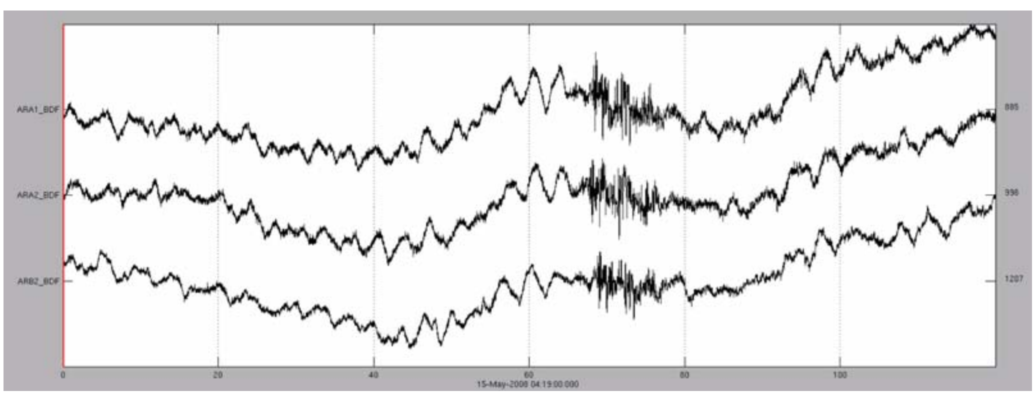

Figure 6.2.8b. A 2-minute time window taken from the first part of Fig 6.2.8a.

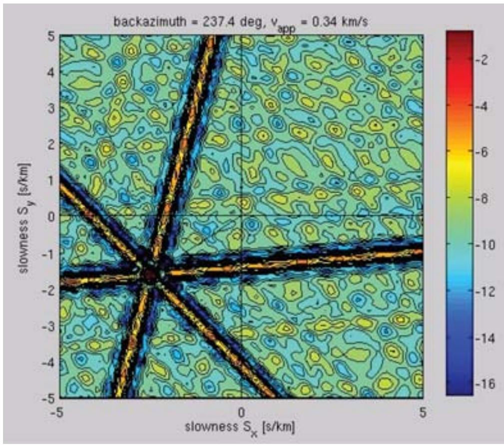

Figure 6.2.9. Slowness analysis of the infrasound event in Fig 6.2.8b.

Figures 6.2.10-6.2.12 illustrate some additional results for an event on May 22, 2008. This event is probably an explosion carried out by the Russian military with the purpose of destroying old, outdated ammunition. The infrasonic waves for this event were recorded both by the microbarographs (Figure 6.2.10) and the seismometers (Figure 6.2.11).

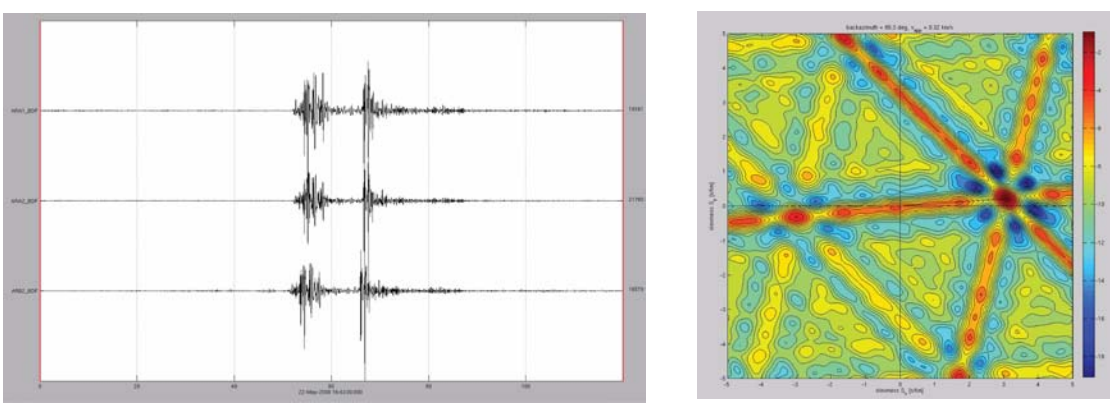

Figure 6.2.10. Barometer recordings (2-10 Hz), backazimuth 86.3 deg, apparent velocity 320 m/s..

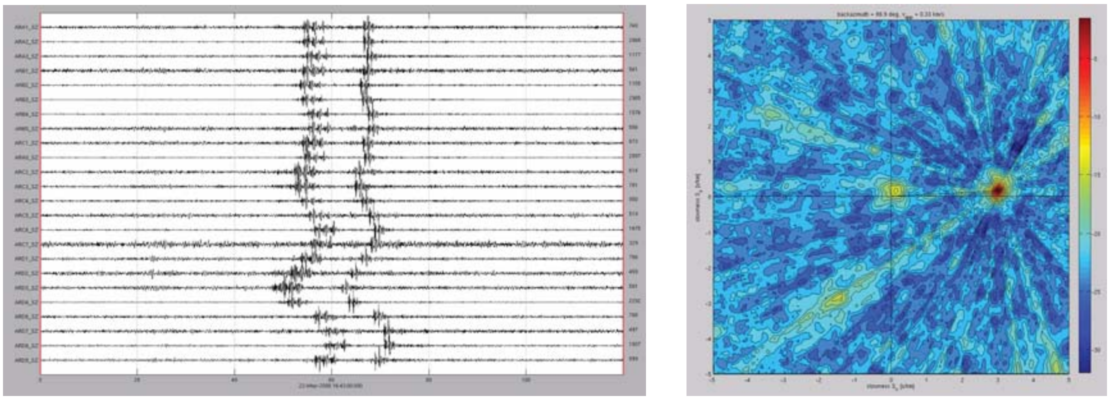

Figure 6.2.11. Seismometer recordings (2-10 Hz), backazimuth 86.9 deg, apparent velocity 330 m/s.

Figure 6.2.12 shows a pairwise comparison of the recordings by collocated microbarographs and seismometers. It is seen that the infrasonic signals are essentially identical on each pair of collocated instruments. We also note that the signal-to-noise ratio is significantly better on the microbarographs as compared to the seismometer recordings.

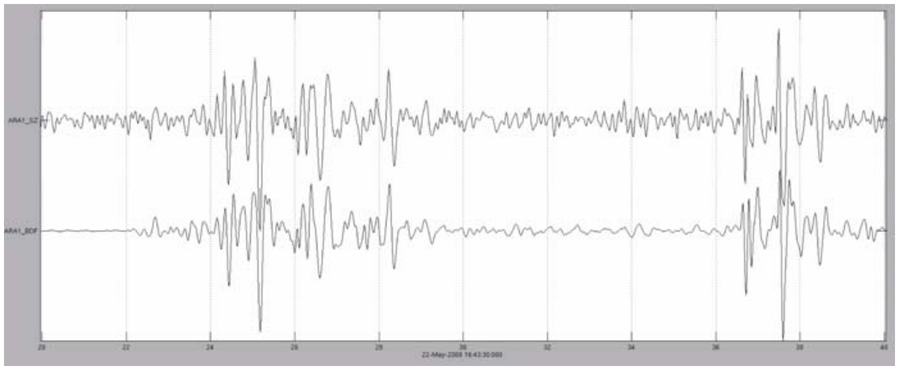

Figure 6.2.12a. Infrasound signal recorded with seismometer (top) and microbarometer (bottom) collocated in ARA1 (20 s time window, 2-10 Hz)

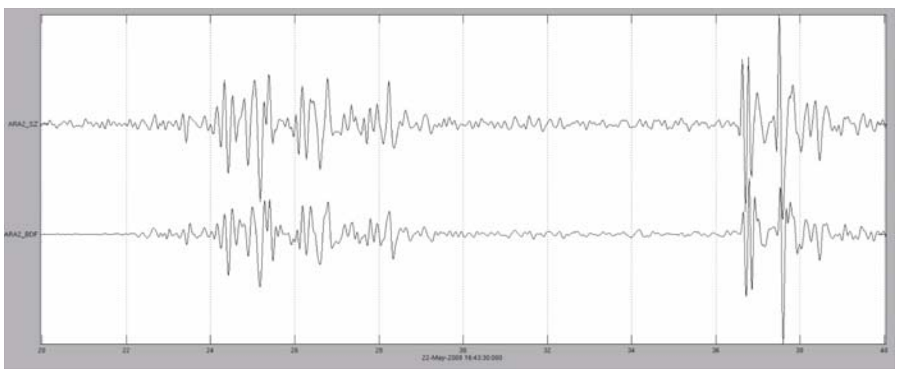

Figure 6.2.12b. Infrasound signal recorded with seismometer (top) and microbarometer (bottom) collocated in ARA2 (20 s time window, 2-10 Hz)

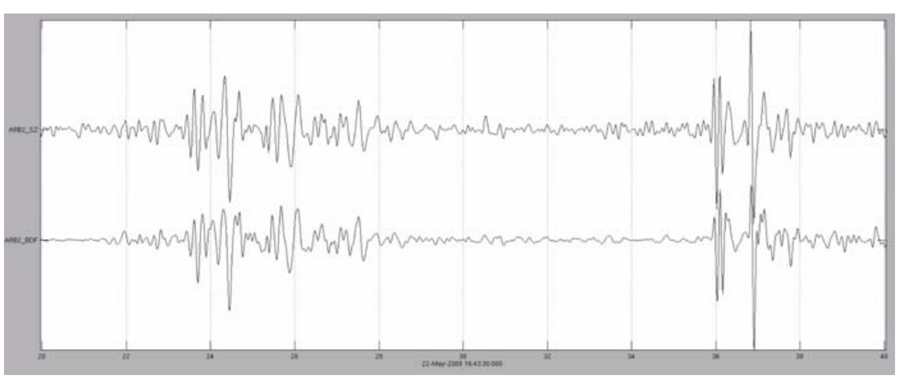

Figure 6.2.12c. Infrasound signal recorded with seismometer (top) and microbarometer (bottom) collocated in ARB2 (20 s time window, 2-10 Hz)

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