

Supplementary material for

The First Network of Ocean Bottom Seismometers around Jøtul Hydrothermal Vent Field, Knipovich Ridge

Yujie Quan^{1,2,*}, M.C. Schmidt-Aursch¹, Andreia Plaza-Faverola³, V. Schlindwein^{1,2}

¹Alfred Wegener Institute, Helmholtz Research Centre for Polar and Marine Research, Bremerhaven,
Germany

²Faculty of Geosciences, University of Bremen, Bremen, Germany

³UiT The Arctic University of Norway, Department of Geosciences, Tromsø, Norway

*Corresponding author: yujie.quan@awi.de

Contents

Table S1: Comparison between deployment and recovery positions of the OBSs

Figures S1-S15:

Figure S1: Deployment and recovery positions of the ocean bottom seismometers
(OBSs) at the sea surface.

Figure S2: Cross correlation functions (CCFs) between onshore stations and OBSs:
Example for JOT06.

Figure S3: Operation detail for non-linear time shift in time correction process: Example
for JOT06.

Figures S4-S6: Checking for time correction through cross correlation function between
OBS pairs: results for long-term OBSs (Fig. S4), results for long-term and short-terms
OBSs (Fig. S5), and results of short-term OBSs (Fig. S6).

24 **Figure S7:** Orientation correction results for OBSs by DLOPy.

25 **Figure S8:** The average CCF of all daily CCFs after time correction, example for JOT06-
26 JOT07 pair.

27 **Figures S9-S10:** Probabilistic power spectral density (PPSD) of seismometers and
28 hydrophones for OBSs for long-term stations (Fig. S8) and short-term stations (Fig. S9).

29 **Figures S11-S14:** Power spectrograms over time for all OBSs, vertical seismic and
30 hydrophone channels (Fig. S10), horizontal channels (Fig. S11) of long-term network;
31 Vertical seismic and hydrophone channels (Fig. S12), horizontal channels (Fig. S13) of
32 short-term network.

33 **Figure S15:** Example of active air-gun signals received by seismometers (Fig. S14).

34

35

36

37

38

39

40

41

Table S1. Comparison between deployment and recovery positions of the OBSs. Drift denotes direction and distance between deployment and recovery position at the sea surface.

Station code	OBSs deployment			OBSs recovery			Drift	
	Latitude (°)	Longitude (°)	Date	Latitude (°)	Longitude (°)	Date	Distance (km)	Angle (°)
JOT01	77.5502	7.5407	2023/07/28	77.5511	7.5456	2024/08/23	0.10	7.24
JOT02	77.5033	7.8506	2023/07/28	77.5084	7.8537	2024/08/23	0.57	7.43
JOT03	77.4300	8.0588	2023/07/28	77.4320	8.0649	2024/08/23	0.27	33.61
JOT04	77.3603	7.8408	2023/07/28	77.3643	7.8497	2024/08/24	0.49	25.91
JOT05	77.3875	7.5601	2023/07/28	77.3922	7.5611	2024/08/25	0.52	1.52
JOT06	77.4729	7.1696	2023/07/28	77.4715	7.1698	2024/08/25	0.16	177.69
JOT07	77.3836	6.9894	2023/07/28	77.3808	7.9897	2024/08/25	0.31	178.79
JOT08	77.2826	6.8816	2024/06/15	77.2802	6.8922	2024/08/25	0.37	135.77
JOT09	77.2490	7.9065	2024/06/15	77.2517	7.9152	2024/08/24	0.37	35.51
JOT10	77.5498	6.4185	2024/06/15	77.5510	6.4205	2024/08/25	0.14	20.06
JOT11	77.4578	7.6510	2024/06/15	77.4596	7.6632	2024/08/23	0.36	55.97
JOT12	77.3791	8.1219	2024/06/15	77.3831	8.1343	2024/08/24	0.54	34.25
JOT13	77.5066	8.1841	2024/06/15	77.5105	8.1972	2024/08/23	0.53	35.91
JOT14	77.6303	8.0433	2024/06/15	77.6372	8.0480	2024/08/23	0.77	8.29
JOT15	77.6667	7.5003	2024/06/15	77.6615	7.5145	2024/08/23	0.67	149.82

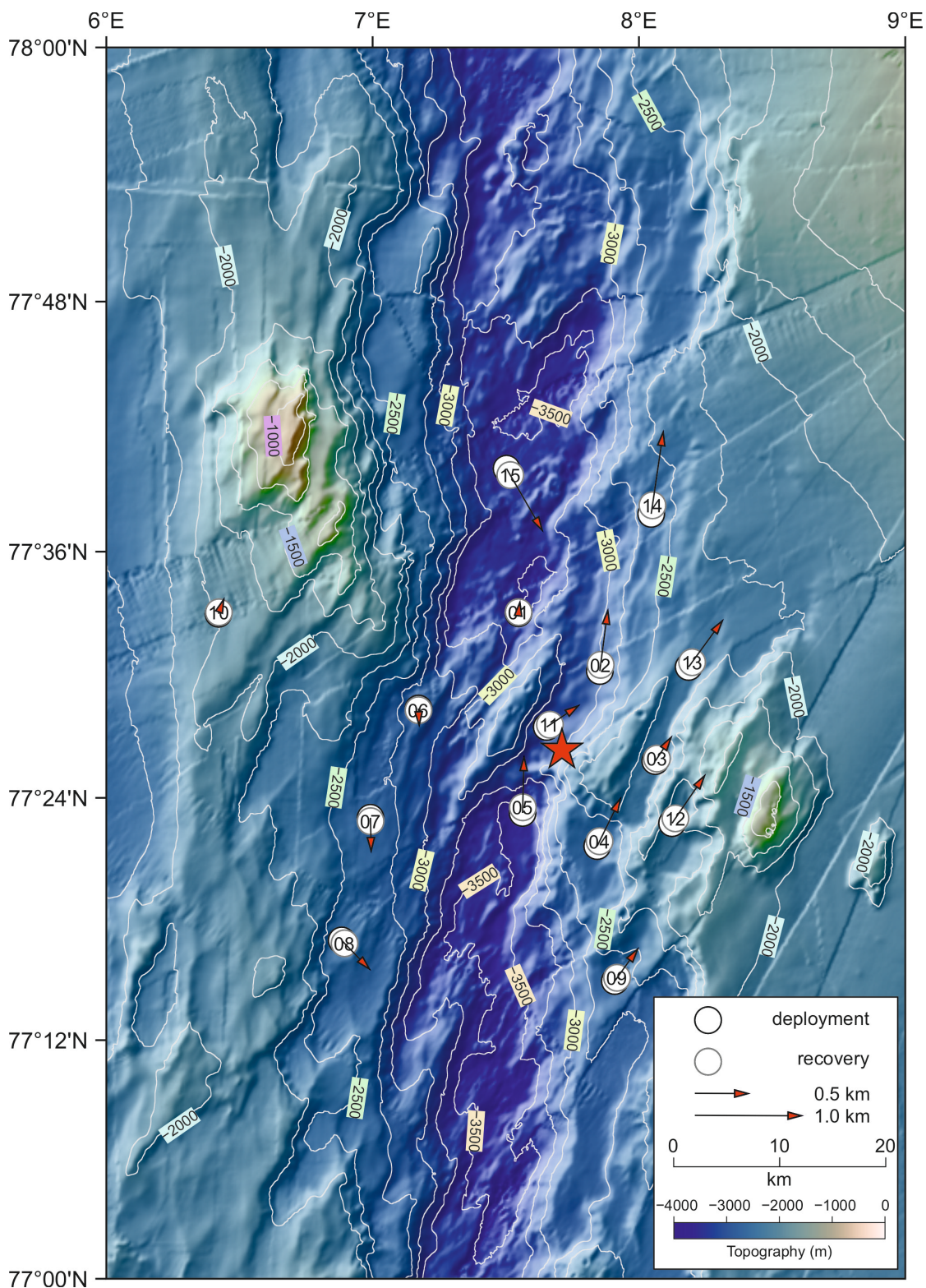
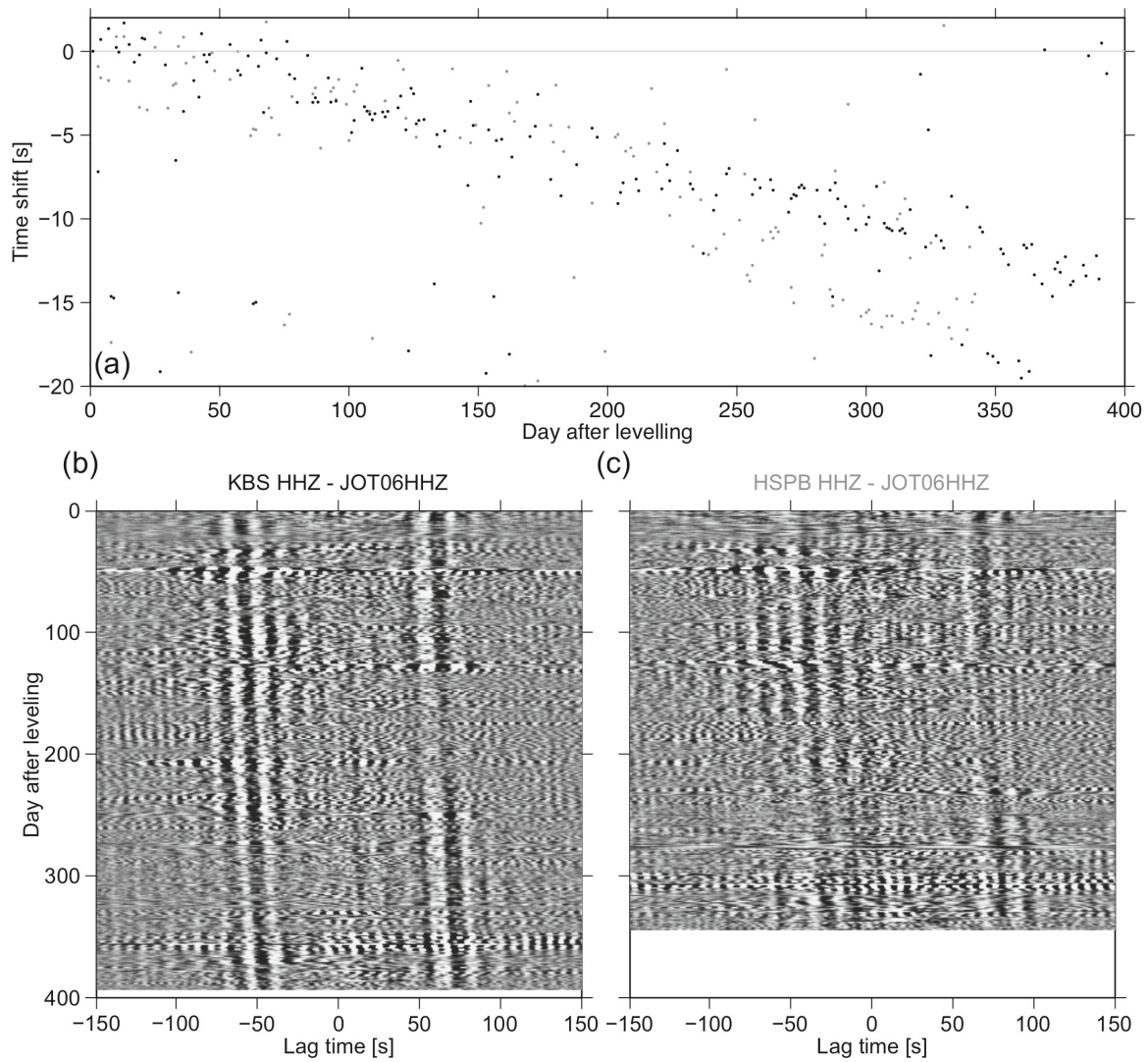
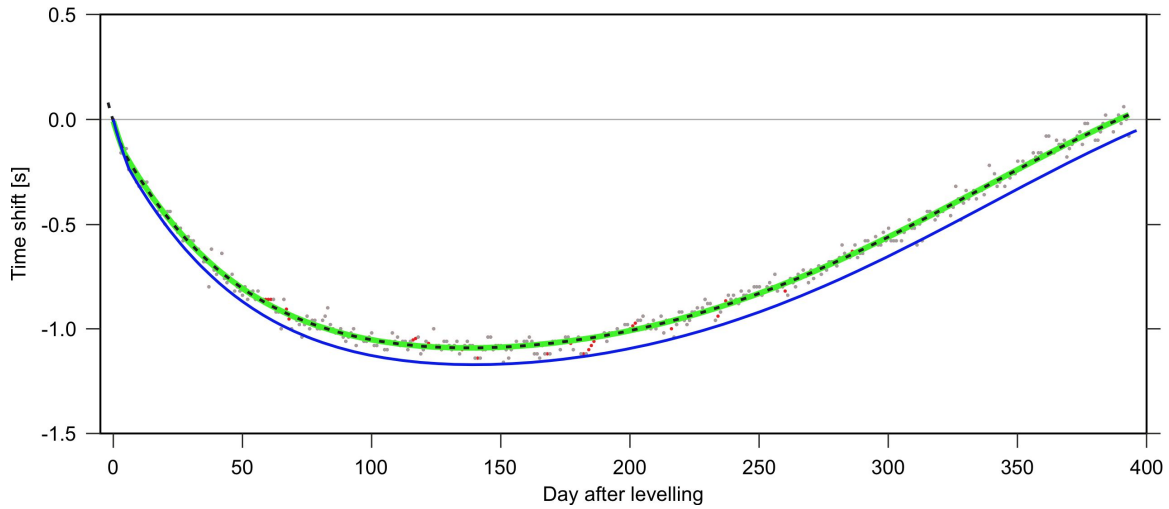


Figure S1. Map of OBSs deployment and recovery location around Jøtul hydrothermal vent field (red star). Deployment positions are plotted with white circle with black outline, while recovery locations are marked by circles with gray outline. Lines with red arrow indicate the direction and distance of the OBS drift between deployment and recovery position.



49

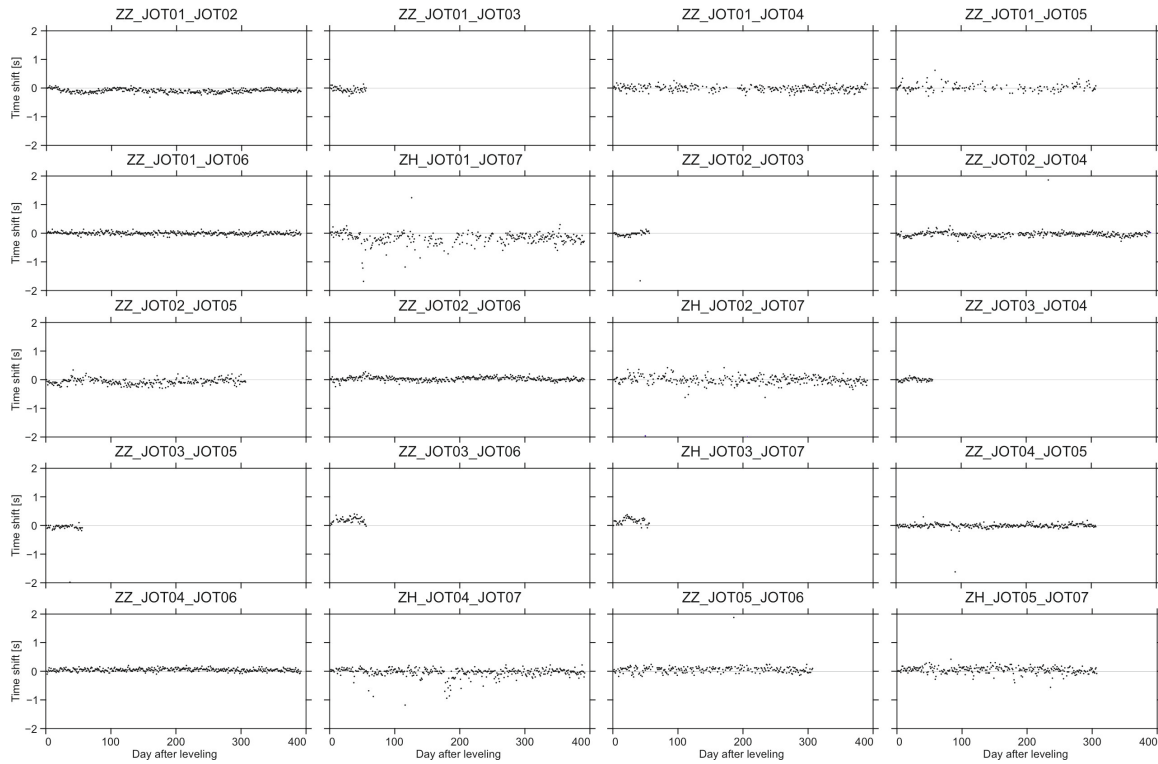
50 **Figure S2.** Cross-correlation functions (CCFs) between land-station and OBS before time correction.
 51 Time shift (a) of JOT06 is estimated from the CCFs (b, c) between KBS (black dots) and HSPB (gray
 52 dots). b) Example of CCFs between KBS and JOT06, and HSPB and JOT06 (c). Time CCFs are
 53 filtered between 10 and 100 s.



54

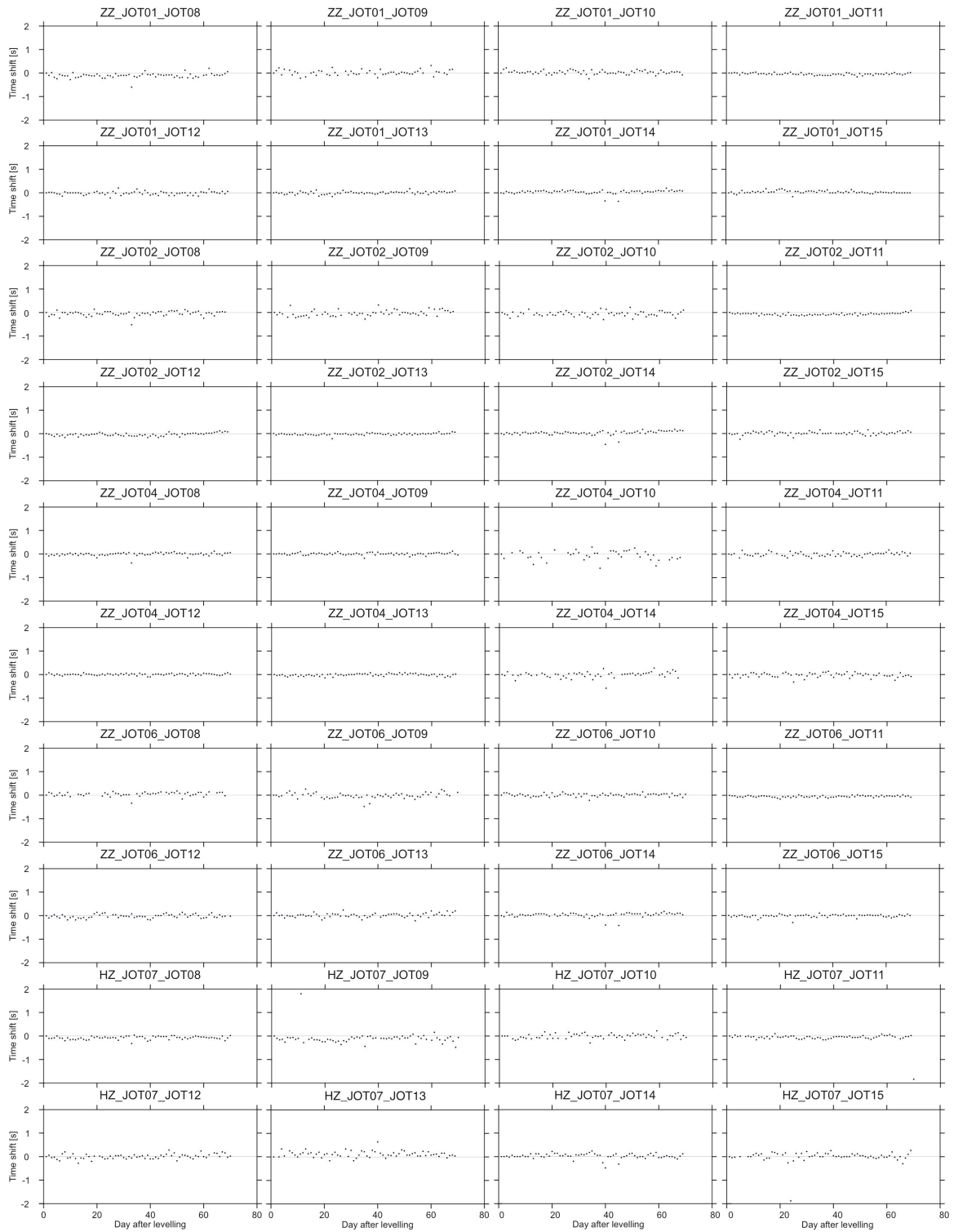
55 **Figure S3.** Procedure of non-linear time correction, example for JOT06. Gray dots indicate the time
 56 shift after linear time correction, and red dots are linear interpolation values between gray dots, for
 57 time periods of abnormal data. Green thick line is the polynomial approximation of gray and red dots.
 58 Black dotted line shows the linear extrapolation for 2 days prior to the levelling day and one day
 59 following recovery, from green line. Blue line is the non-linear time shift obtained from shifting the
 60 black dotted line to start at 0 s time lag at the time of clock synchronization.

61



62

63 **Figure S4.** Time shifts derived from noise cross-correlations between long-term station pairs after
 64 clock drift correction. The channel (H: hydrophone channel, Z: vertical seismometer channel) and
 65 station pairs used for calculation are indicated on top of each plot.



66

67 **Figure S5.** Time shifts derived from noise cross-correlations between long-term and short-term station
68 pairs after clock drift correction. Caption see Fig. S4.



Figure S6. Time shifts derived from noise cross-correlations between short-term station pairs after clock drift correction. Caption see Fig. S4.

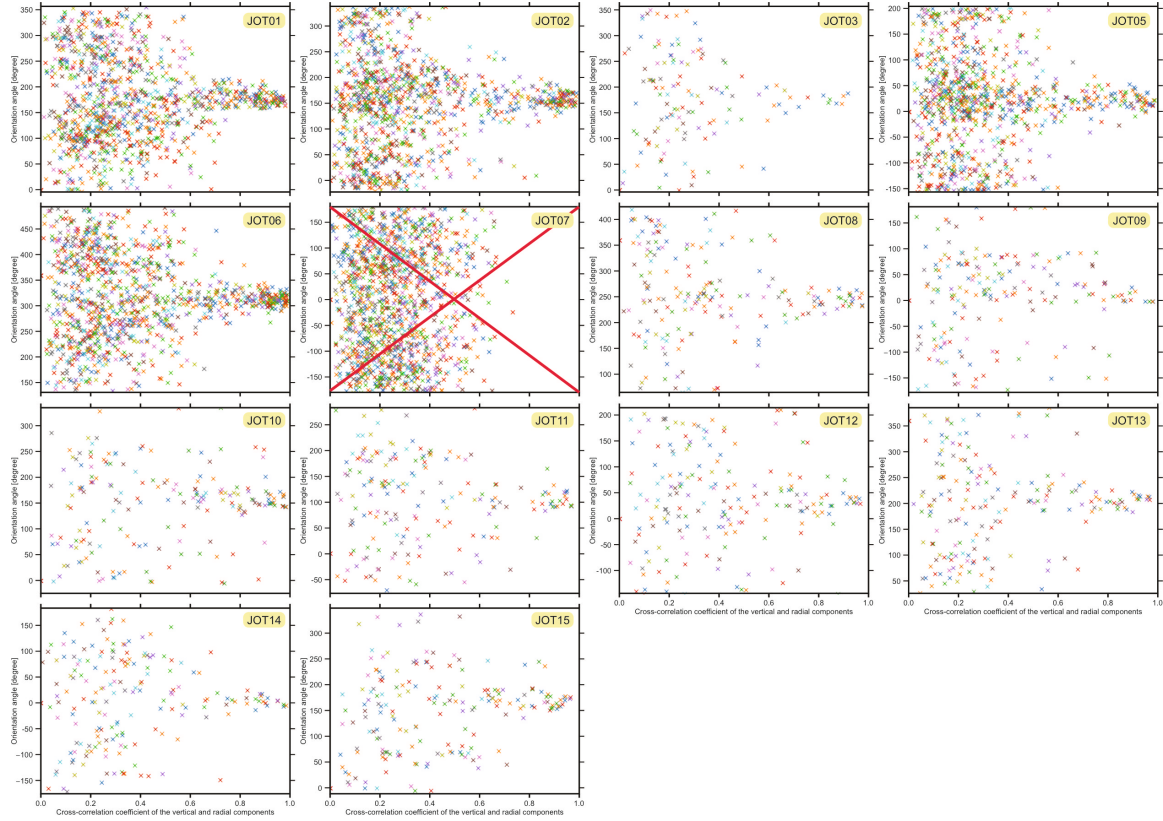


Figure S7. Plots of possible orientations and corresponding correlation value using DLOPy. The crosses are the calculated results of all used teleseismic events with different period filters, and plotted with random colour. Correction result of JOT07 didn't work, since no vertical channel data, and have been marked with red cross. Note that the vertical axis is different between plots.

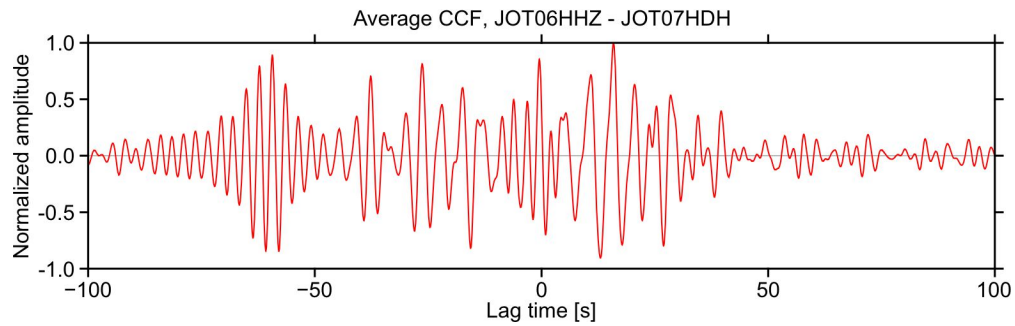
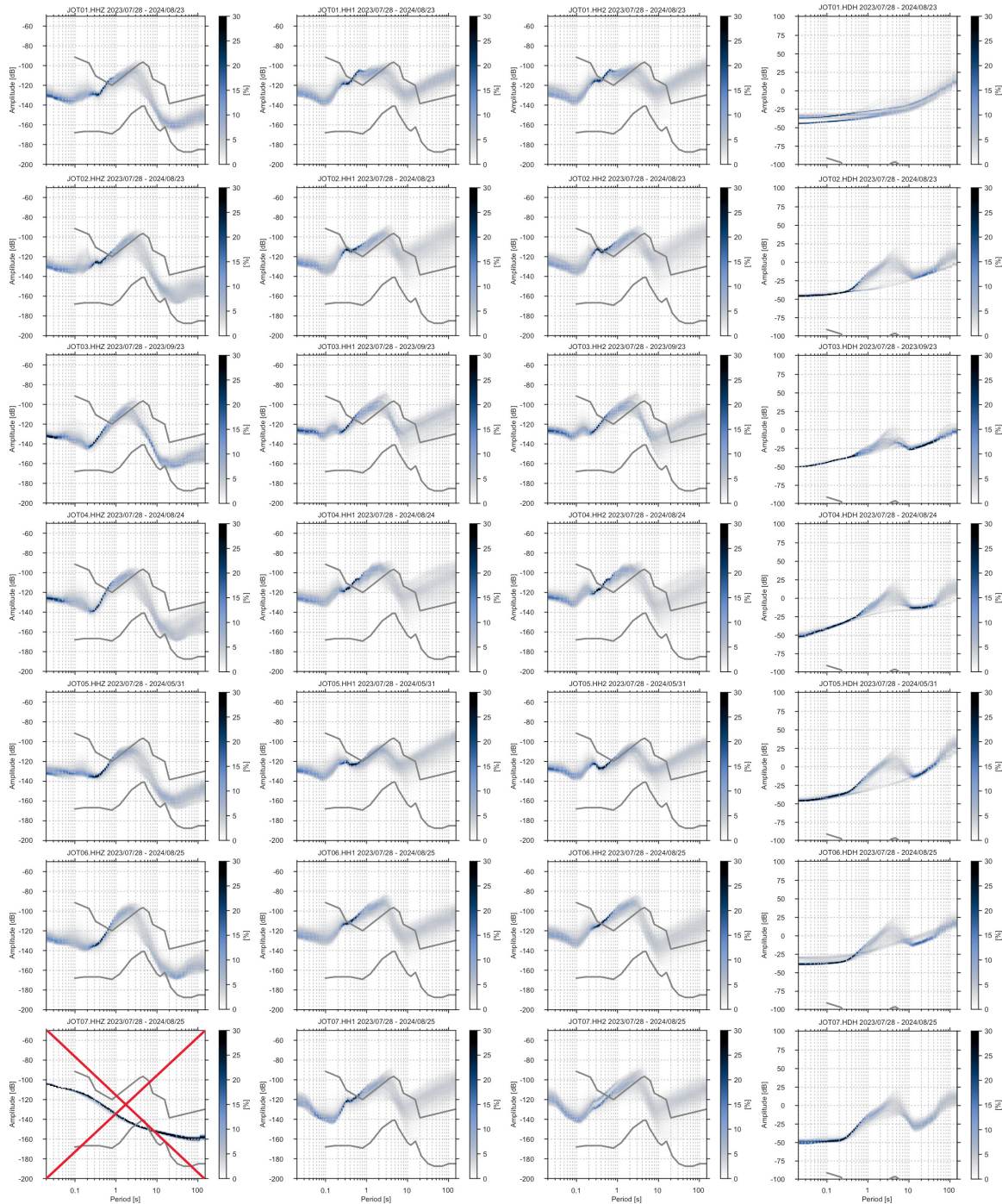


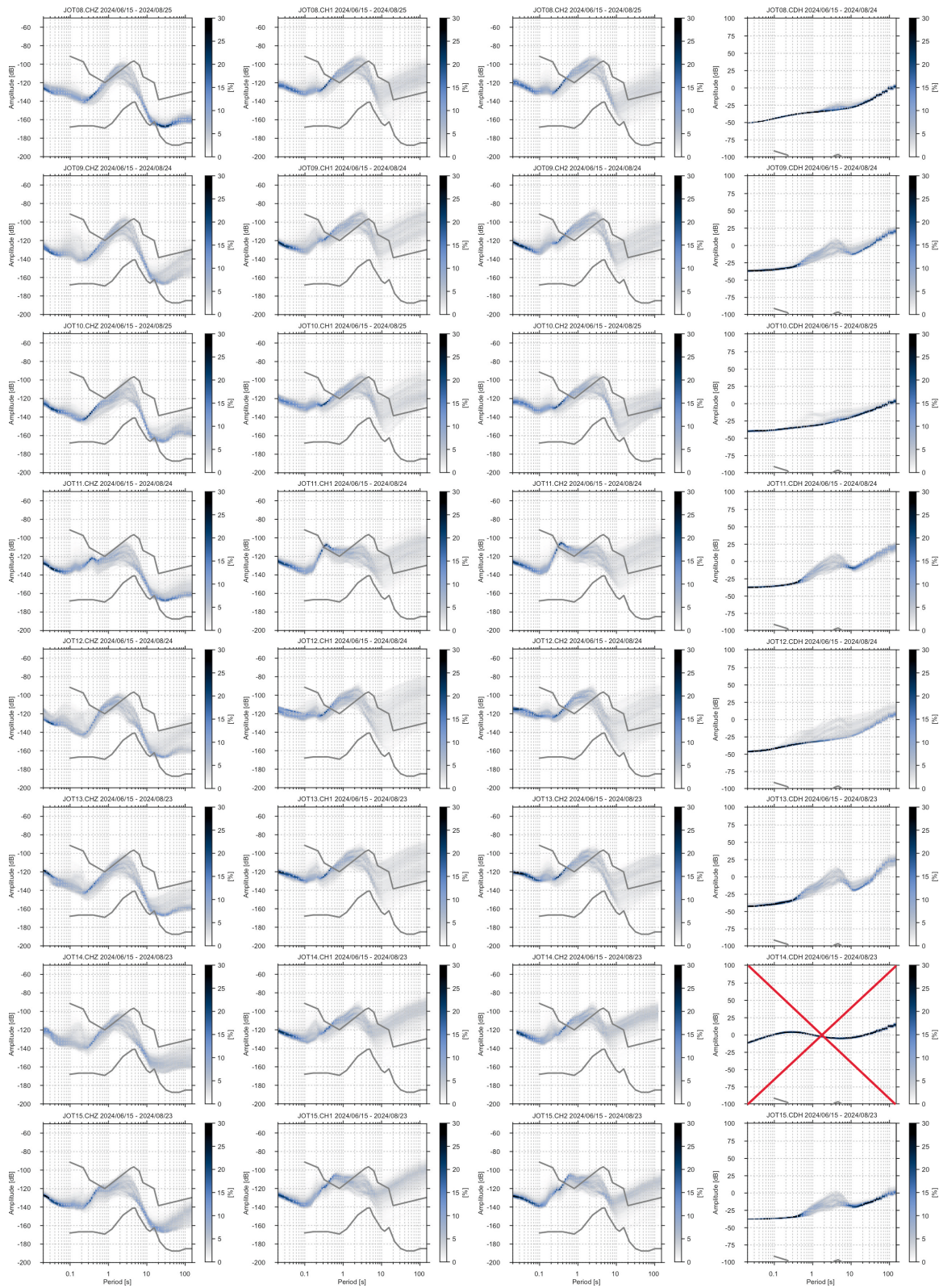
Figure S8. The average CCF from daily CCFs between the vertical channel of JOT06 (JOT06HHZ) and the hydrophone channel of JOT07 (JOT07HDH) after time correction. Daily CCFs are shown in Figure 3c.



74

75 **Figure S9.** Probabilistic power spectral density (PPSDs) plots of seismometers and hydrophones of
 76 long-term network. The time frame used for calculation is indicated on top of each PPSP plot. Color
 77 marks the frequency of occurrence of different noise amplitudes, where gray indicates relatively rare,
 78 and dark blue is relatively frequent. The two gray curves mark the upper and lower bounds of the new
 79 high noise model (NHNM) and low noise model (NLNM), respectively. Malfunctioning components
 80 are indicated by red crosses.

81



82

83

84

Figure S10. Probabilistic power spectral density (PPSDs) plots of seismometers and hydrophones of short-term network. Caption see Fig. S8.

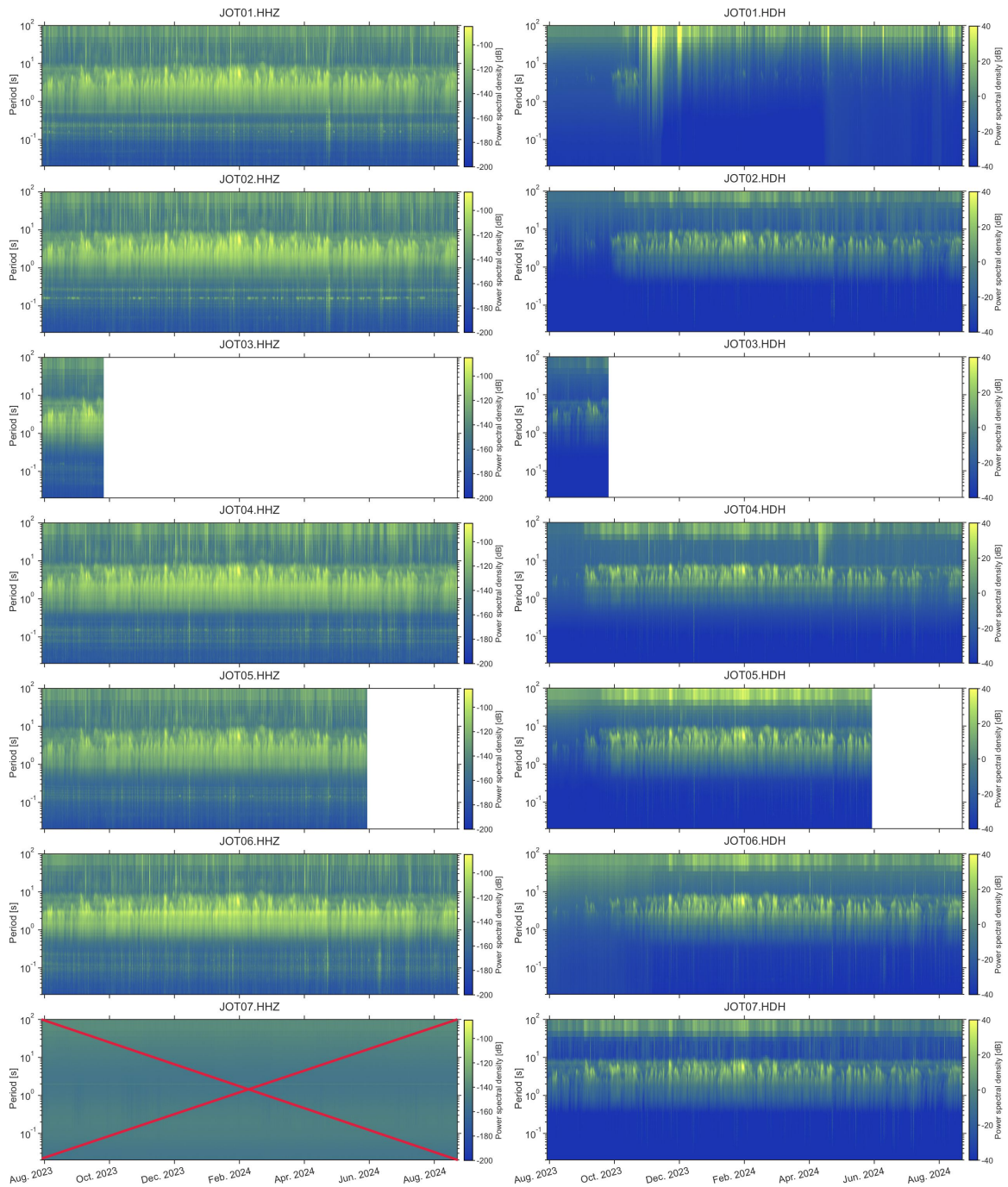


Figure S11. Power spectrograms from stations for vertical seismic and hydrophone channels of long-term network. The double-frequency microseism, a band of high spectral power between 0.5 and 10 s, is visible on all channels of all stations. Malfunctioning components are indicated by red crosses.

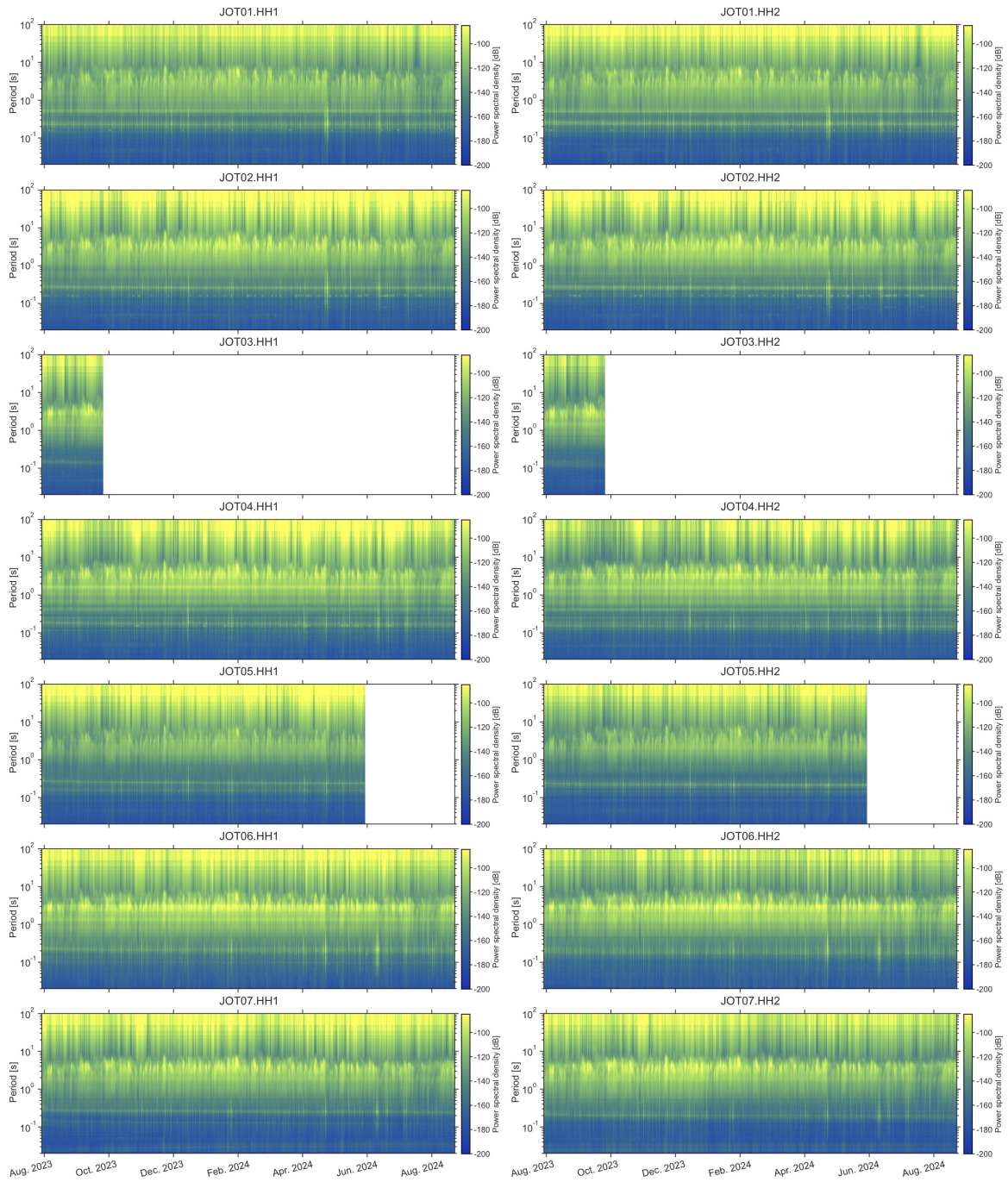
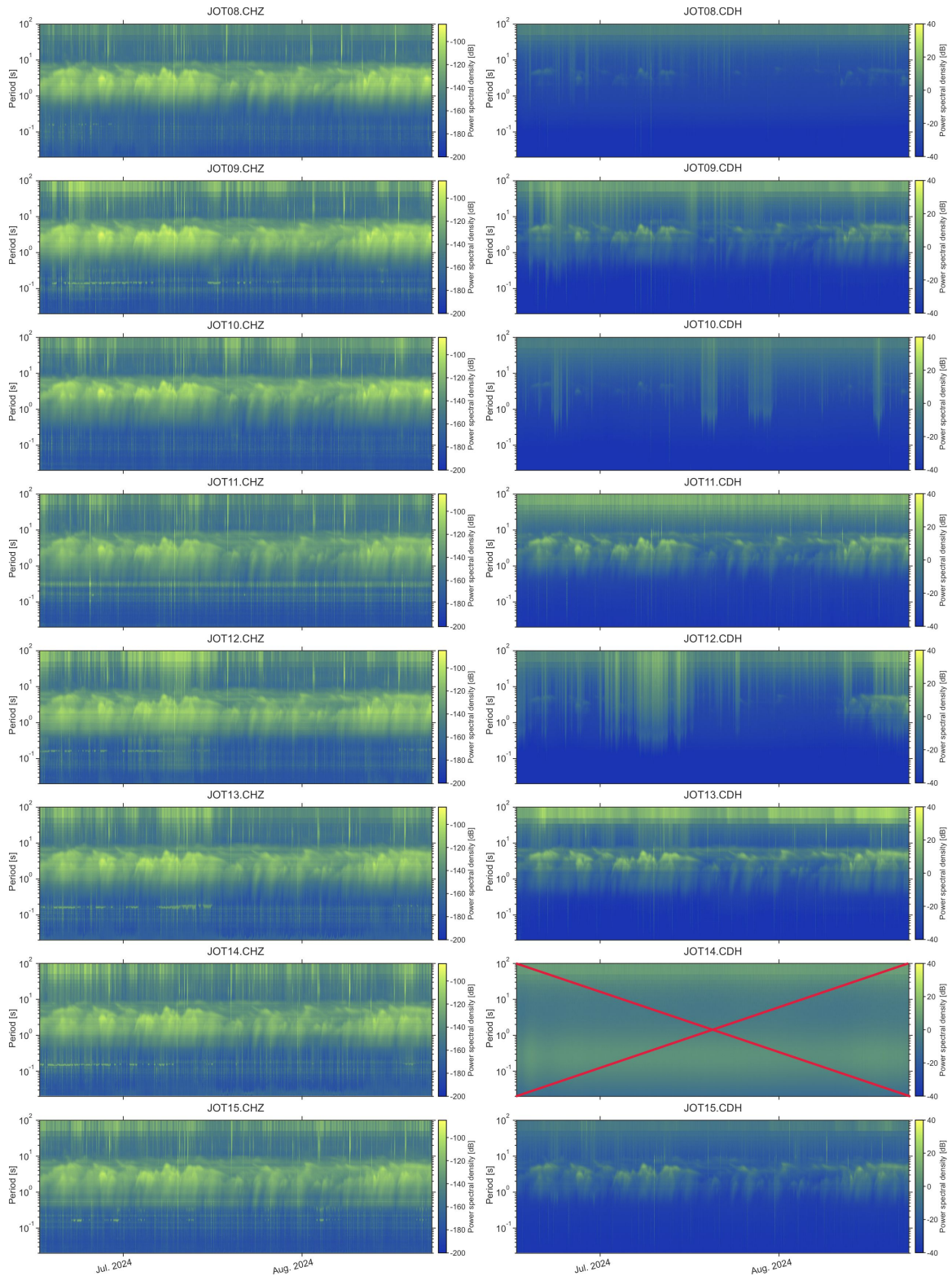


Figure S12. Power spectrograms from two horizontal seismic channels of long-term network. Caption see Fig. S10.

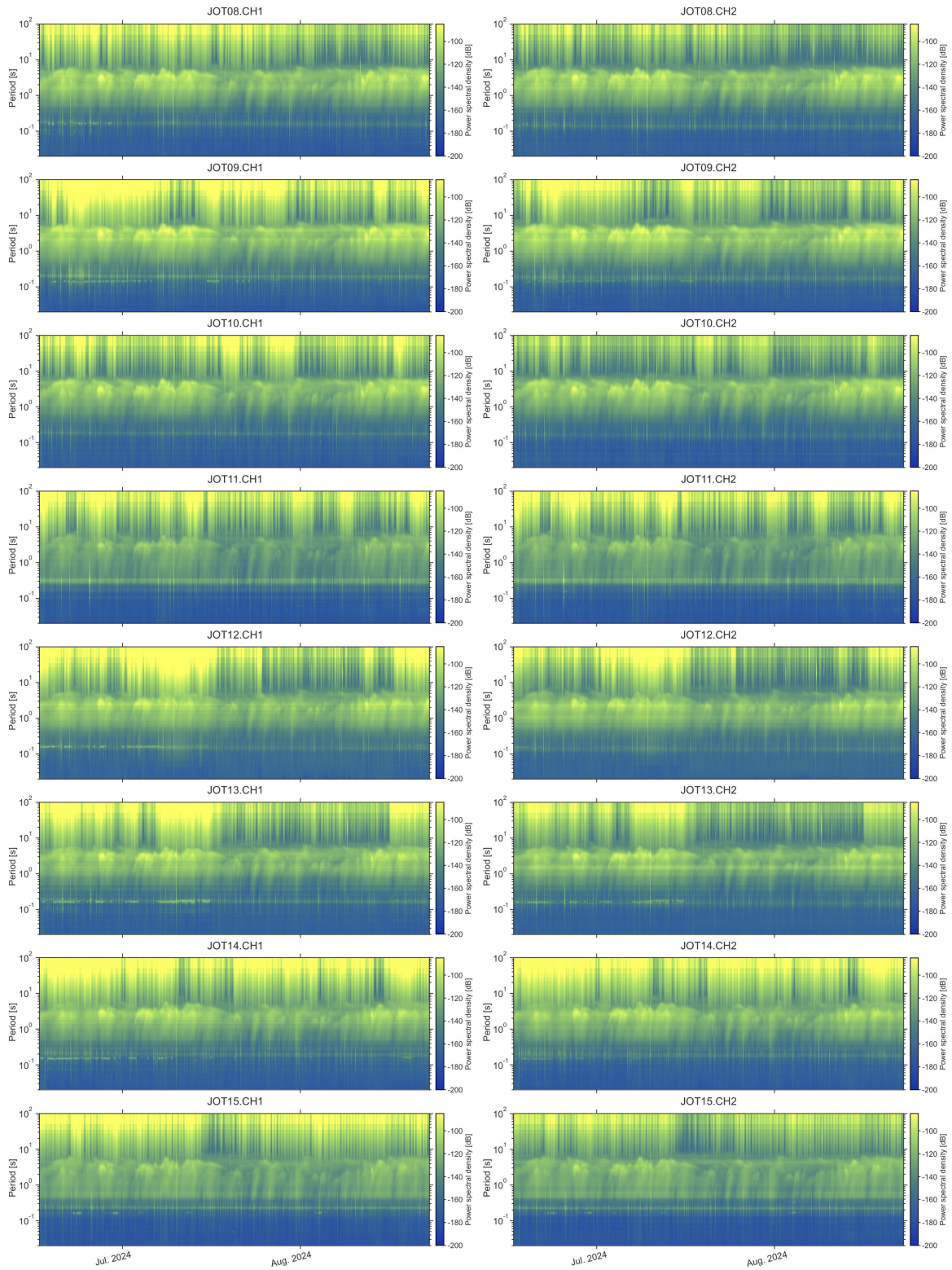


94

95

96

Figure S13. Power spectrograms from vertical seismic and hydrophone channels of short-term network. Caption see Fig. S10.



97

98

99

Figure S14. Power spectrograms from two horizontal seismic channels of short-term network.
Caption see Fig. S10.

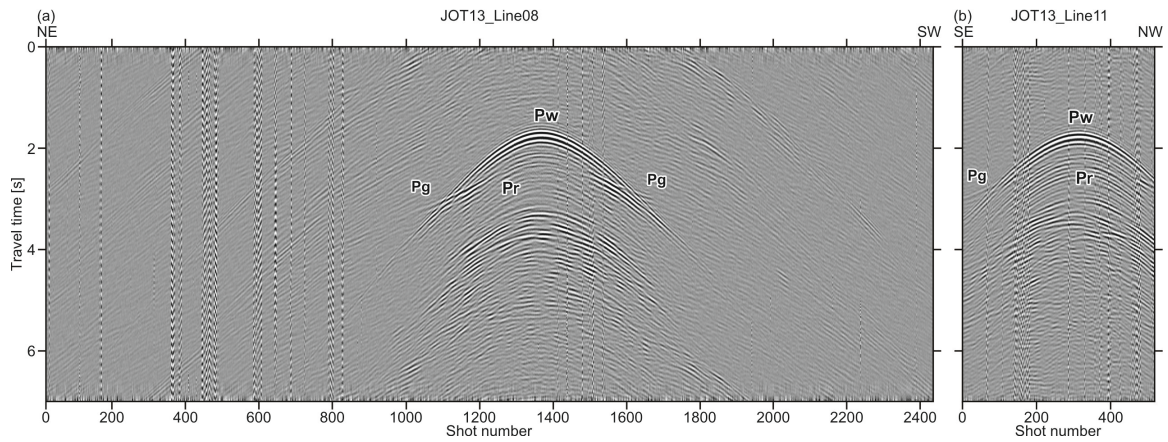


Figure S15. Air-gun signal seismic record sections of vertical channel of instrument JOT13. Record sections of seismic Line08 (a), and seismic Line 11 (b). Line location is shown Fig. 2. Pw is the direct water wave phase, Pg is the sedimentary layers or crustal refraction seismic phase, and Pr is the reflection phase from sediments or basement. The signal was filtered by a bandpass filter with corner frequencies $f = 1, 3, 16, 18$ Hz with Seismic Unix (Cohen & Stockwell, 2008).

Reference

Cohen, J. K., & Stockwell, J. J. W. (2008). *CWP/SU: Seismic Unix Release No. 43: an open source software package for seismic research and processing* Center for Wave Phenomena, Colorado School of Mines.