Contents of the supplemental material:

- Supplementary figures 1 to 9
- List of all earthquakes used in this study as an Excel file
- A Jupyter notebook of all the codes and parameters

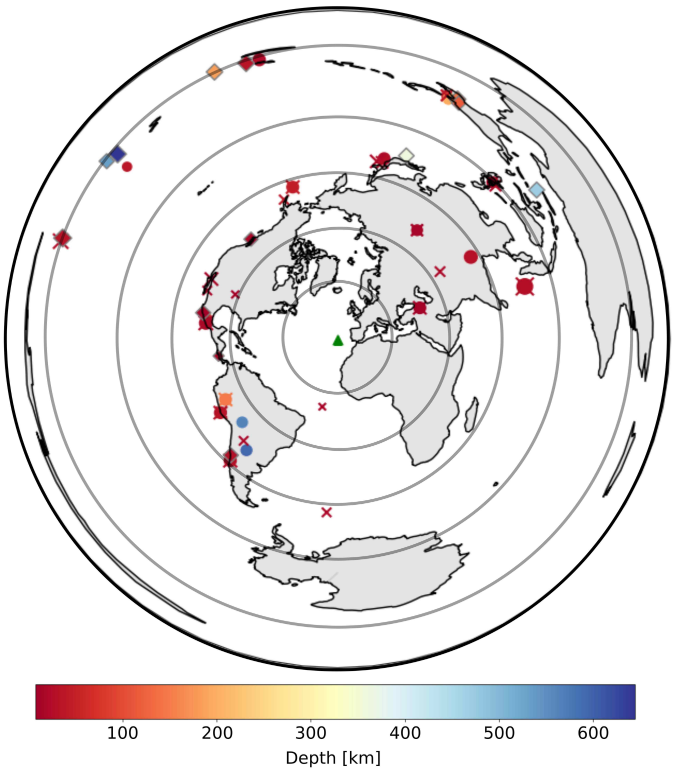

Fig. S1. Location map of the events used in this study. The 46 events are colorized according to their magnitude Mw. Events used for the Receiver Function analysis (20 events) are marked by colorized circles and events used for the Surface-wave analysis (24 events) are marked with colorized crosses. Other events are marked by colorized diamonds. The D10 station (green triangle) is located in the center and the grey circles indicate the epicentral distances (30-160°) from the D10 station. The D10 station is one of in total 12 stations of the DOCTAR array around the Gloria fault in the North Atlantic.

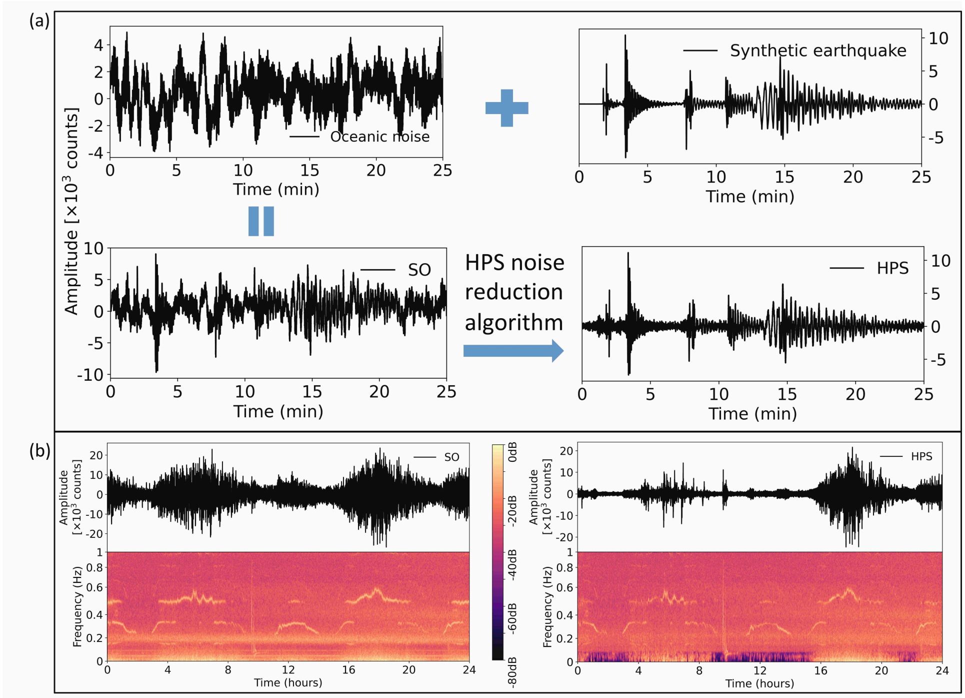

Fig. S2. The process of synthetic signal generation with an example of the method application on synthetic data. (a) Shows a synthetic earthquake signal, which is summed with a real world oceanic noise waveform and resulted in the synthetic SO signal. The SNR of SO is 1 in this example. After applying the HPS noise reduction algorithm the HPS noise reduced signal is generated. (b) Shows one day synthetic signal (SO) and HPS noise reduced signal (HPS) along with their spectrograms.

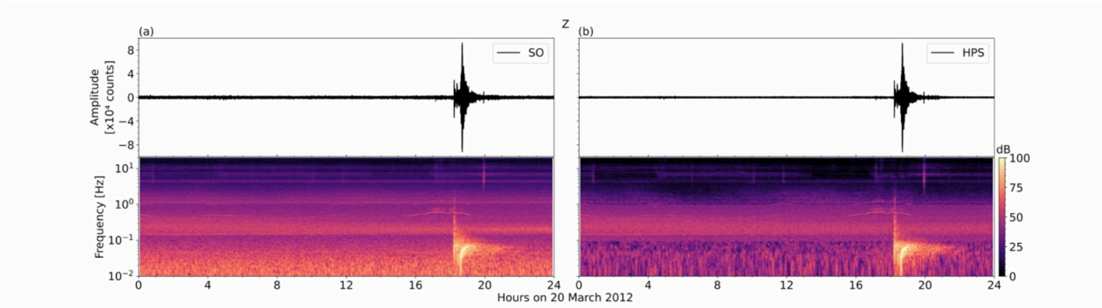

Fig. S3. Comparison of the seismograms and spectrograms of the original signal SO (a) and the HPS noise reduced signal (b) on the Z component for real data. The upper panels show the seismograms and the lower panels show the spectrogram. The sampling rate of the data was 100 Hz and the spectrogram was calculated with a window length of $\mathbf{2^{16}}$ samples. The spectrogram clearly shows the reduced noise level on the HPS signal.

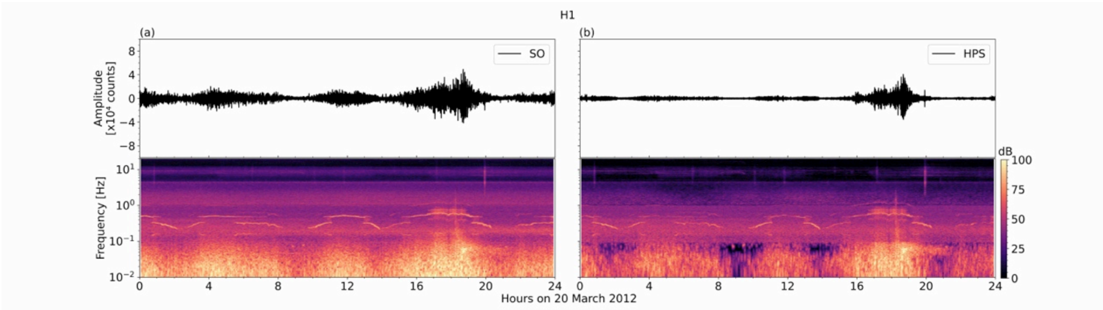

Fig. S4. Comparison of the seismograms and spectrograms of the original signal SO (a) and the HPS noise reduced signal (b) on the H1 component for real data. The upper panels show the seismograms and the lower panels show the spectrogram. The sampling rate of the data was 100 Hz and the spectrogram was calculated with a window length of $\mathbf{2^{16}}$ samples. The spectrogram clearly shows the reduced noise level on the HPS signal.

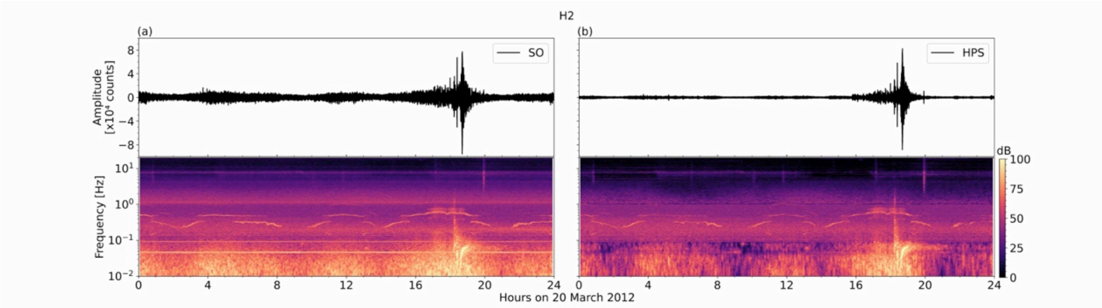

Fig. S5. Comparison of the seismograms and spectrograms of the original signal SO (a) and the HPS noise reduced signal (b) on the H2 component for real data. The upper panels show the seismograms and the lower panels show the spectrogram. The sampling rate of the data was 100 Hz and the spectrogram was calculated with a window length of $\mathbf{2^{16}}$ samples. The spectrogram clearly shows the reduced noise level on the HPS signal.

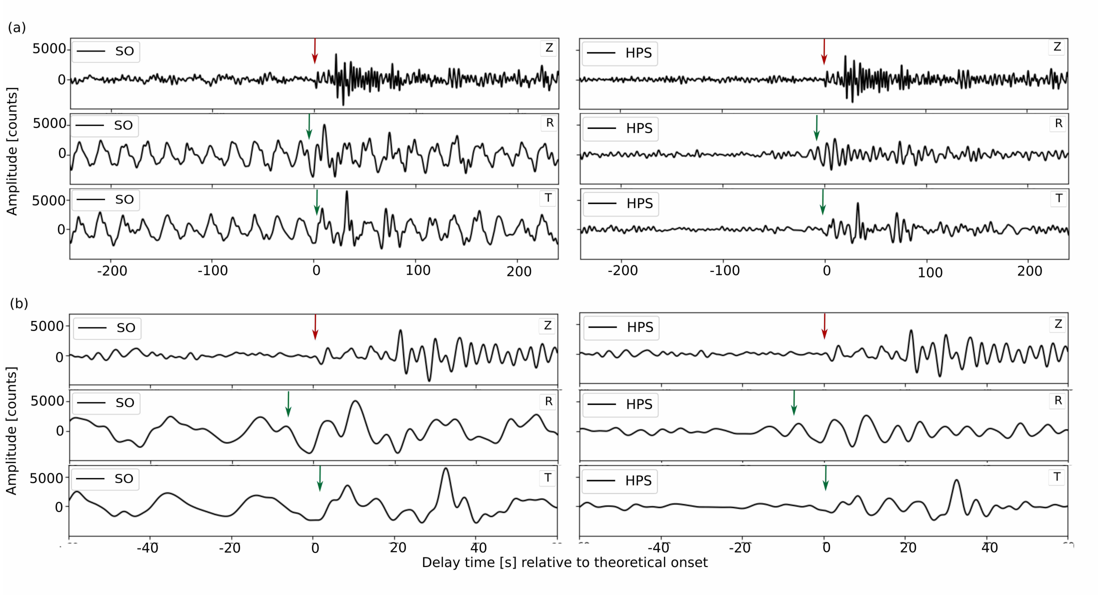

Fig. S6. Comparison of the real data ZRT traces of the input SO and the resulted HPS noise reduced signal. The traces are zerophase bandpass filtered between 0.025-0.25 for S waveform (R- and T-component) and 0.025-0.5 for P waveform (Z-component). (a) Seismogram of SO and HPS noise reduced +/- 4 minutes from the theoretical P-onset. (b) Detailed view of the P- and S- arrivals (red and green arrows, respectively). It shows unchanged waveforms of the P- and S- phases on Z, R and T, respectively. The traces are plotted +/- 1 min from the theoretical P- and S- arrival on Z, R and T, respectively.

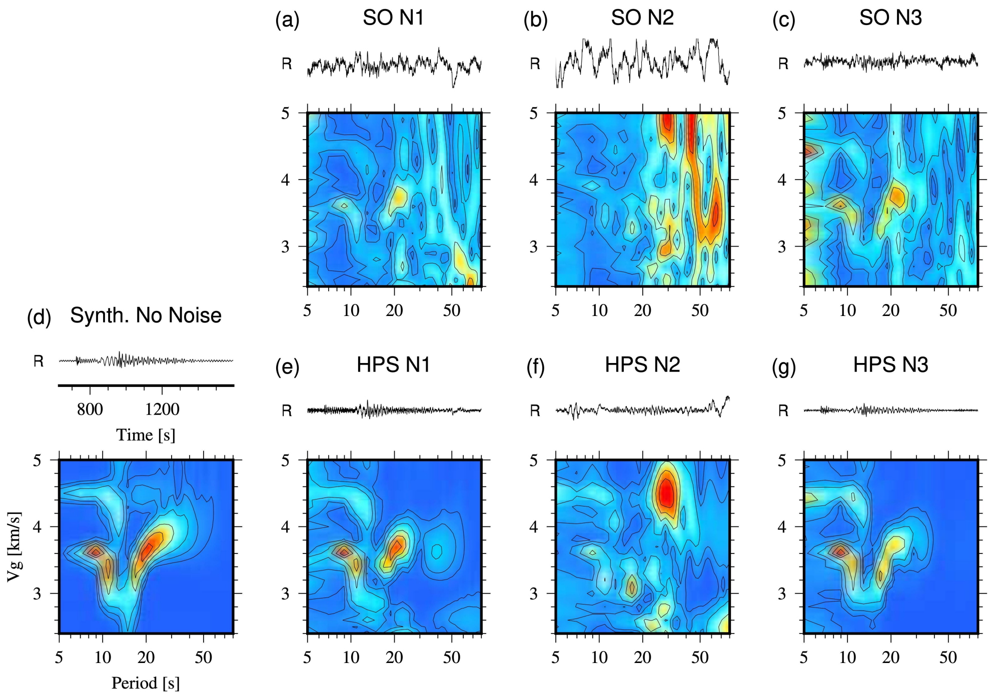

Fig. S7. Rayleigh wave group velocity analysis for unfiltered and HPS processed synthetic Rayleigh wavetrains contaminated with three real world OBS noise signals (noise signals N1-N3, station D10, DOCTAR experiment, see section 2 for more details). (a)-(c): Lower panels: Unfiltered synthetic signal (SO) MFT analysis results. Top panels: seismogram time windows corresponding to the range of group velocities shown on the y-axis. (d) Noise free synthetic case. (e)-(g): HPS processed input traces for noise situations N1-N3 (lower panel: MFT analysis result, top panel: HPS processed seismogram).

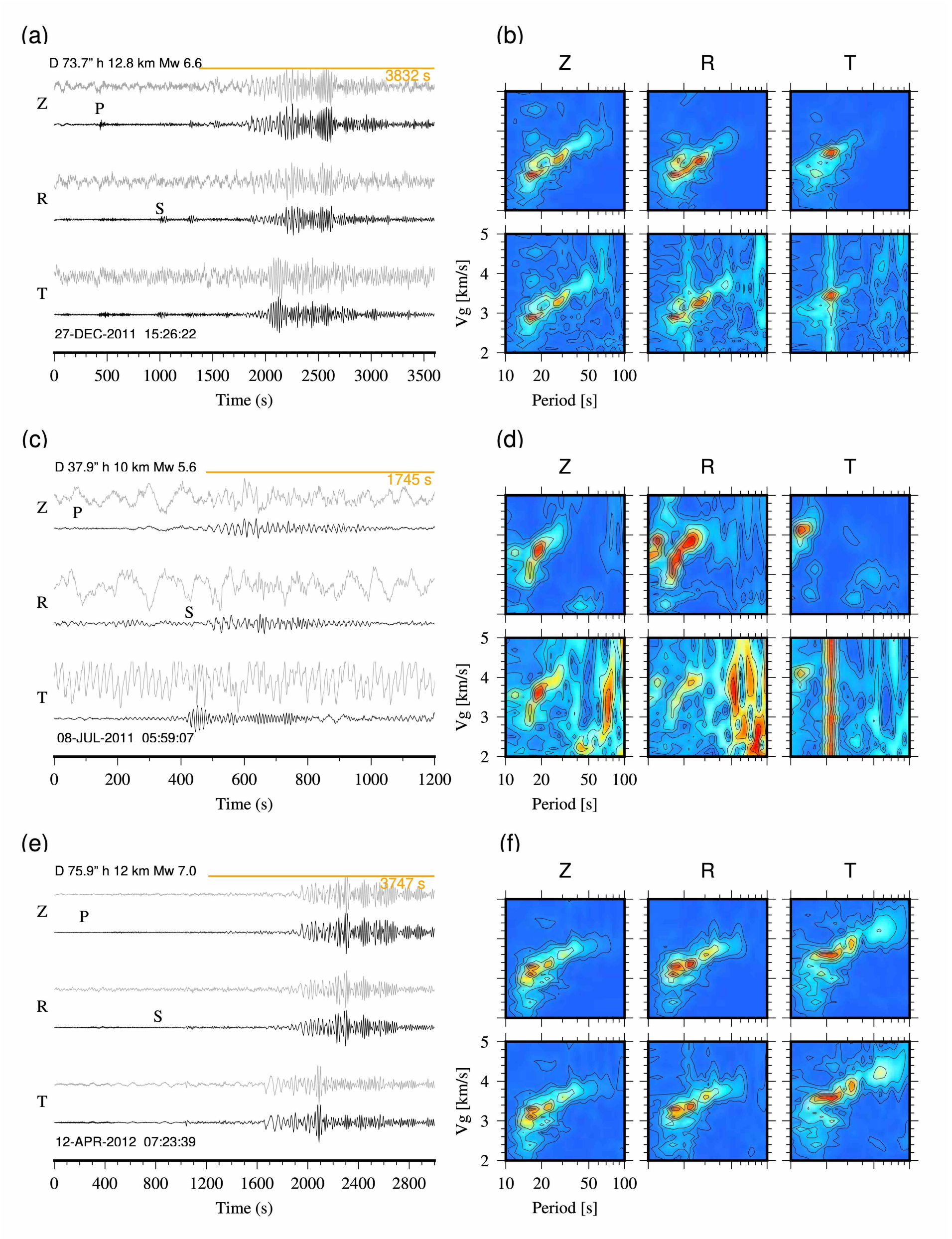

Fig. S8. Seismogram and MFT analysis examples (similar to the software mft96 (Herrmann, 2013)) for real data. Panels (a), (c), (e) on the left show ZRT seismograms for three events (see table S1 for the event parameters). Traces were restituted to true ground velocity up to 100 s period and subsequently low pass filtered with a 3rd order Butterworth filter at 10 s. Unprocessed traces are shown in grey, HPS-processed traces are shown in black. The start time of the seismogram is marked on the lower left of each panel, event parameters are marked on the top left of each panel. An orange bar marks the time window encompassing the group velocity range used in the MFT analysis (the end time of the analysis window is given as number in orange). Panels (b), (d), and (f) on the right show the corresponding MFT results normalized to the maximum amplitude. In (b), (d), and (f) the panels in the upper row correspond to unprocessed and the panels in the lower row correspond to HPS-processed traces.

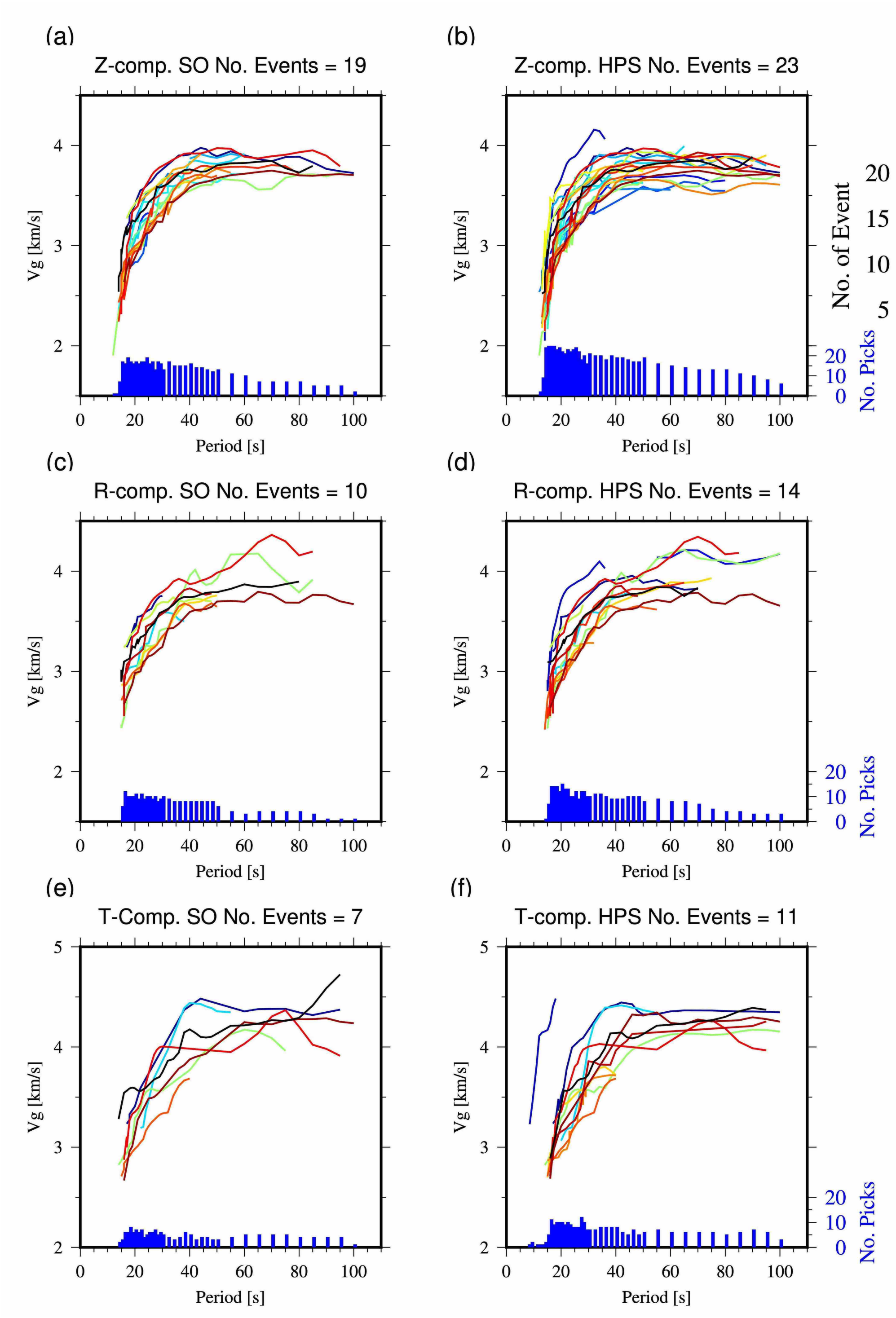

Fig. S9. Picked group velocity curves for the events in Figure S1 (real data). The event number is color coded according to Table S1. (a) and (b) show results for unprocessed and HPS processed vertical component input traces, respectively. The histogram on the lower end of the panels displays the overall number of picks for a specific wave period. (c) and (d) are same for radial component. (e) and (f) are same for transversal component.