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Stability of HVSR spectra obtained from ocean bottom seismometers (OBS) near the Japan Trench

○Atikul Haque Farazi, Yoshihiro Ito

Ocean bottom seismometers (OBS) are widely in use since recent past to monitor seismicity of slow earthquakes as well as that of ordinary earthquakes. Seismic velocity structures, especially of S-waves, are essential to estimate hypocenters of them with accuracy. The horizontal to vertical spectral ratio (HVSR) method, originally proposed by Nogoshi and Igarashi (1971) and familiarized by Nakamura (1989), is a good technique to get S-wave velocity structure by inversion of the HVSR curve. Both microtremor and ambient noise could be utilized using this method. However, we aim to use the ambient noise HVSR method utilizing OBS data. From this perspective, here we focus on spatial and temporal stability of HVSR spectra of ambient noise calculated from OBS data as the first step toward future application of this method to estimate S-wave velocity structure deploying OBS stations. We aim to use the Nakamura's method (1989) for obtaining HVSR spectra using a 3-component (H1, H2, and V) OBS array in the Japan Trench to characterize deep structure above the plate interface near the trench. However, a total of 21 OBS, 3 broadband and 18 short-period, stations have been used in this study. To retrieve the spectra, preprocessing to the waveform data is applied, the first step of which include removal of instrumental response, and downsampling of the trace to 20Hz, removal of mean and trend from the record, and tapering. Then, Fourier amplitude spectra of each 3 components are calibrated applying fast Fourier transformation (FFT). After that, we applied smoothing to the amplitude spectra following Konno and Ohmachi (1998) method. Next, the 2 horizontal amplitude spectra (H1 and H2) are merged together by taking their quadratic mean (H). Finally, HVSR spectra is achieved for the selected time window by dividing the mean of the horizontal components (H) by the vertical component (V). Prior to preprocessing, each 24-hours record was split into 1-hour window, and we selected time windows which are quiet or devoid of any earthquake arrivals so that use of the ambient noise part of the record is ensured. The quiet hours or time windows are selected manually making dayplots (or hourly plots) for each components of a station, from their spectrogram for checking the frequency content, and also from power spectral density (PSD).

The hourly HVSR spectra of every station is also examined to see if their shape indicates similarity or good stability. The hourly spectra are then stacked together and averaged in a single window to get each day spectra. These day spectra are also compared for understanding the temporal stability of the HVSR spectra from individual OBS station. Later again, these daily spectra are also stacked and averaged to get the final HVSR curve of a single station. The final spectra of a single station is then exploited to make station to station comparison to discern the spatial stability of the HVSR curve from the OBS stations in use. Stability of HVSR spectra of ambient noise from OBS data is promising for conducting our future work for deeper observation using the ambient noise HVSR method.

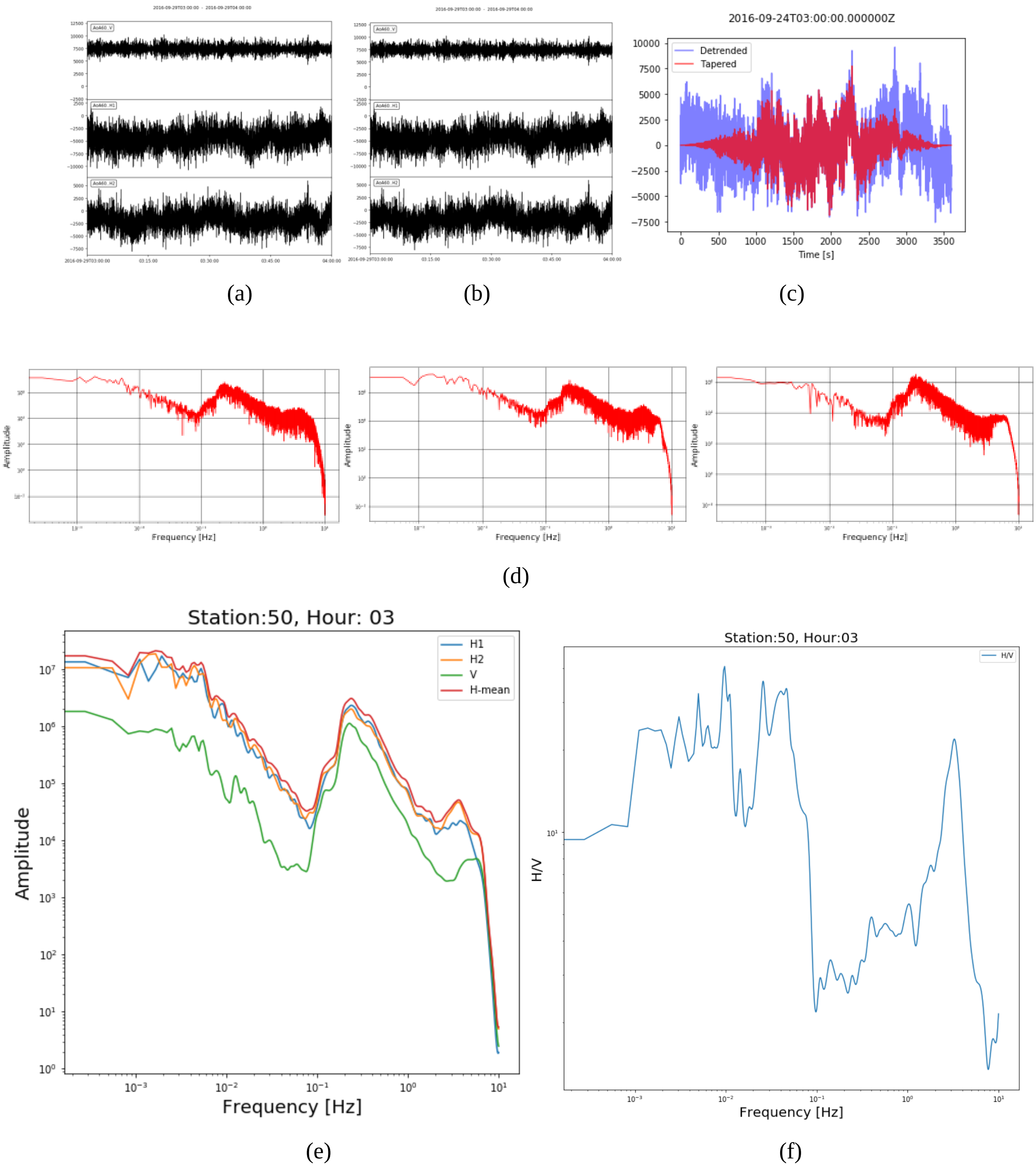

Figure 1: Some basic steps of the ambient noise HVSR method has been exhibited from a broadband OBS by (a) illustrates the selected 1-hour waveform, (b) waveform after downsampling to 20 Hz, (c) mean and trend removal from the waveform, and tapering, (d) Fourier amplitude spectra of each component (H1, H2, and V from left to right), (e) Fourier amplitude spectra after smoothing as well as mean of the two horizontal spectra, and (f) shows the HVSR curve from the 1-hour window.