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Session SM1.3 Ambient noise seismology: Topics, targets, tools & techniques

Stability of ambient noise H/V spectra obtained from OBS near the Japan Trench

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Introduction

Ocean bottom seismometers (OBS) are widely in use since recent past for monitoring 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 (H/V) method, originally proposed by Nogoshi and Igarashi (1971) and familiarized by Nakamura (1989), is a commonly used technique to get S-wave velocity structure by inversion of the H/V curve. However, we look forward to obtain S-wave structure from H/V spectra of ambient noise utilizing OBS data near the Japan Trench. From this perspective, here we focus on the stability of H/V spectra of ambient noise from OBS as the first step toward such future application. We followed the Nakamura's (1989) method for having the H/V spectra and then compared their peak frequency, peak amplitude and shapes by visual inspection for spatial and temporal stability analysis. Besides, available ambient seismic noise in the study area was also determined following the procedure of McNamara and Buland (2004).

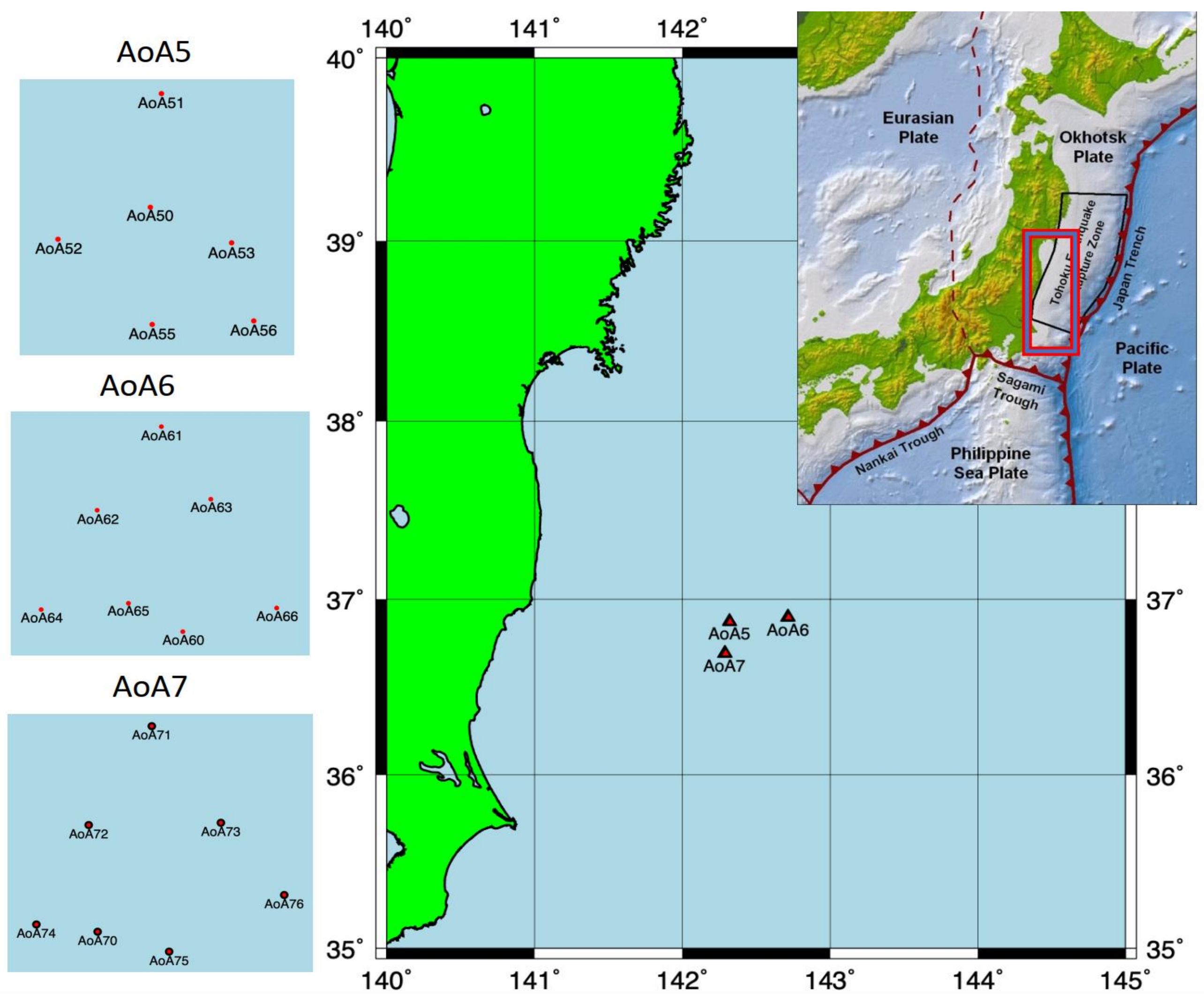

Figure 1: The above study area map shows the locations of the OBS arrays along with station distribution at each array on the left panels. The panel on the top right exhibits tectonic setup of the study area (after Grossi and Apel, 2012).

Data

3 broadband (360s natural frequency) and 16 short-period (1s natural frequency) stations were used in this research. They were deployed as array with the pattern of 1 broadband station at the center and 6 short period stations on the periphery in equal distance, forming a circle of about 1 Km radius around the broadband station. Recording lengths of all of them are 24 hours and sampling rate is 200Hz. Data available in the period of 2016 Sep 24 to 2016 Sep 30 has been exploited here.

No.	Station Name	Lattitude	Longitude	Elevation	Seismometer type
1	AoA50	36.87473	142.31894	-2855	Broadband
2	AoA60	36.89619	142.71511	-4226	Broadband
3	AoA70	36.69105	142.28529	-2548	Broadband
4	AoA51	36.87833	142.31939	-2857	Shortperiod
5	AoA52	36.87368	142.31545	-2854	Shortperiod
6	AoA53	36.87355	142.32205	-2854	Shortperiod
7	AoA55	36.87097	142.31902	-2852	Shortperiod
8	AoA56	36.87109	142.3229	-2853	Shortperiod
9	AoA62	36.90051	142.71146	-4227	Shortperiod
10	AoA63	36.90093	142.71631	-4226	Shortperiod
11	AoA64	36.89697	142.70905	-4225	Shortperiod
12	AoA65	36.89722	142.71276	-4226	Shortperiod
13	AoA66	36.89704	142.71913	-4222	Shortperiod
14	AoA71	36.69802	142.28747	-2529	Shortperiod
15	AoA72	36.69467	142.28493	-2542	Shortperiod
16	AoA73	36.69474	142.29025	-2545	Shortperiod
17	AoA74	36.6913	142.28282	-2543	Shortperiod
18	AoA75	36.69038	142.28817	-2551	Shortperiod
19	AoA76	36.6923	142.2928	-2550	Shortperiod

Methodology

Seismic background noise was estimated following the method described by McNamara and Buland (2004) and using Obspy PPSD (probabilistic power spectral density) routine.
Instrumental response was removed from the data. Then H/V spectra was retrieved using geopsy software. The 24 hour record was split into 500s time windows with 75% overlap. Antitriggering option was selected to remove earthquake response and lowpass filtering of 2 Hz was applied. Konno and Ohmachi (1998) method with constant of 40 was chosen for smoothing of the fast Fourier transformed (FFT) spectra of the components. Finally, the H/V spectra of ambient noise was achieved by the following formula, where squared average of the horizontal components are taken:

$$\frac{H}{V} = \frac{\sqrt{|H_1|^2 + |H_2|^2}}{|V|}$$

Here, H_1 and H_2 denote the Fourier amplitude spectrum for the two horizontal components, and V denotes that for the vertical component. H denotes the mean of the two horizontal components.
For examining day to day and station to station stability of the spectra, besides peak amplitude and peak frequency their shapes were also visually evaluated and compared. The daily spectra is the average of all of the time windows of that day. The daily spectra of each station, again, was averaged for inspecting spatial variation among the stations.

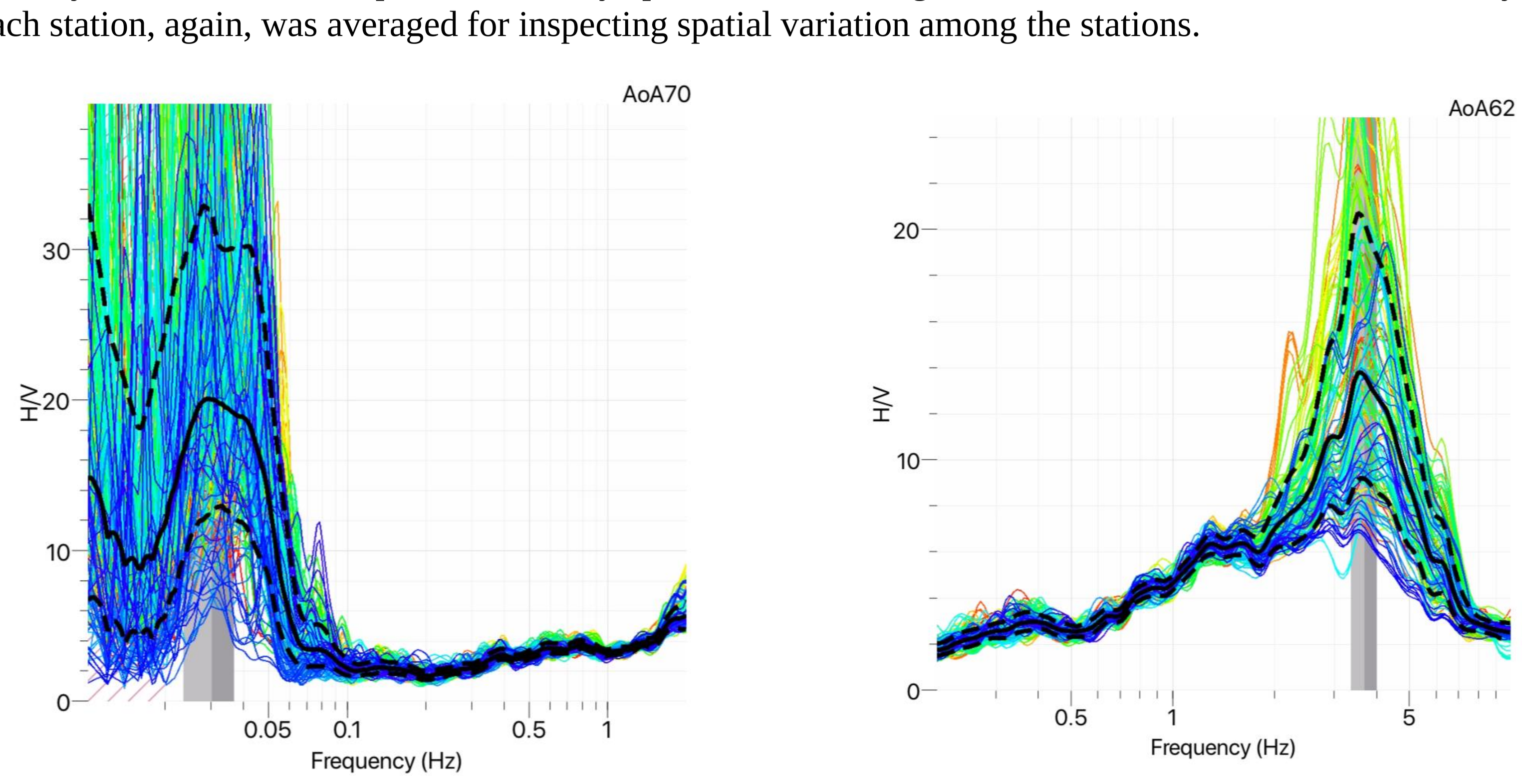

Figure 2: H/V spectra example of 24 hour record from a broadband (left) and a shortperiod (right) seismometer.

Results

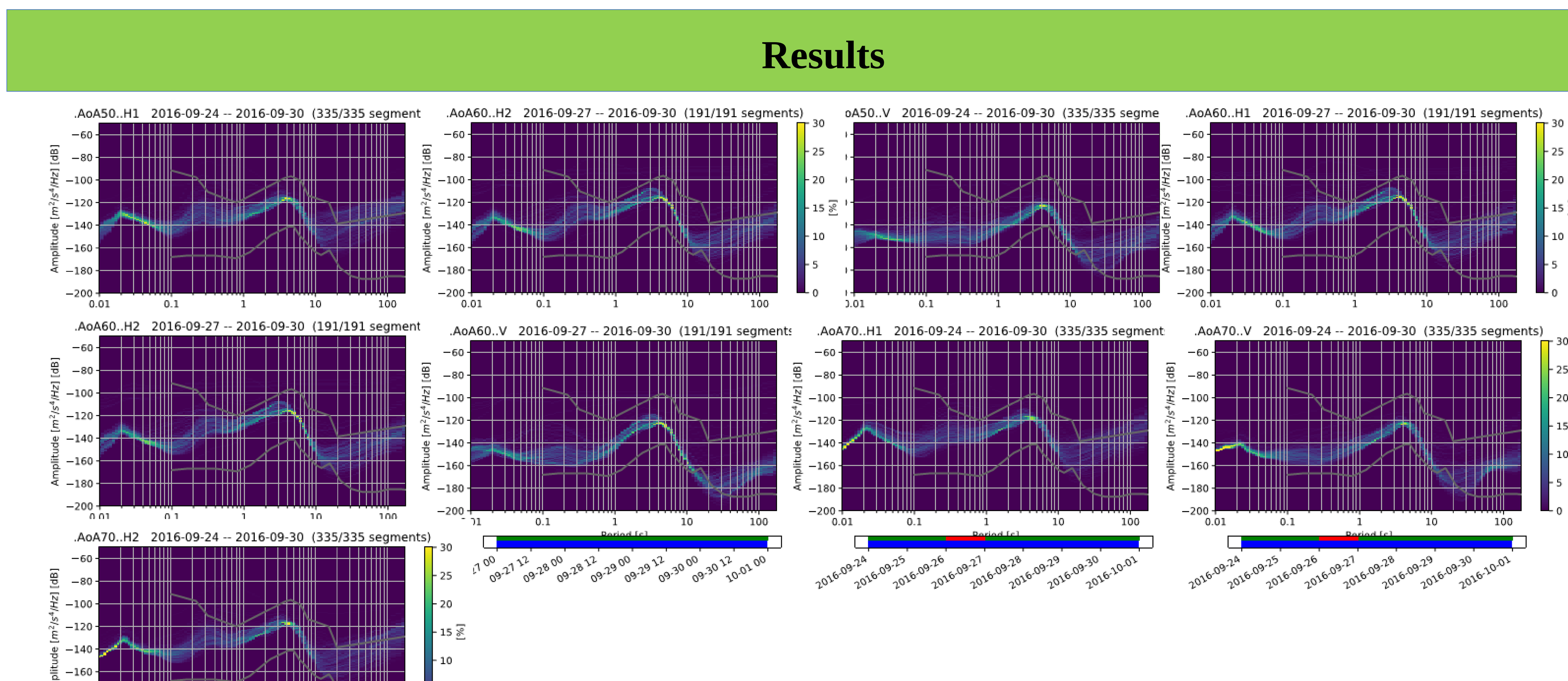
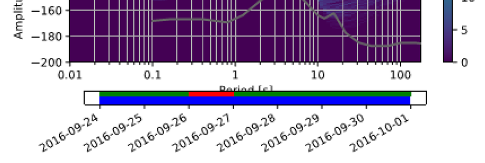

Figure 3: Background seismic noise model as amplitude vs. period for all 3 components of all the 3 broadband OBS stations.

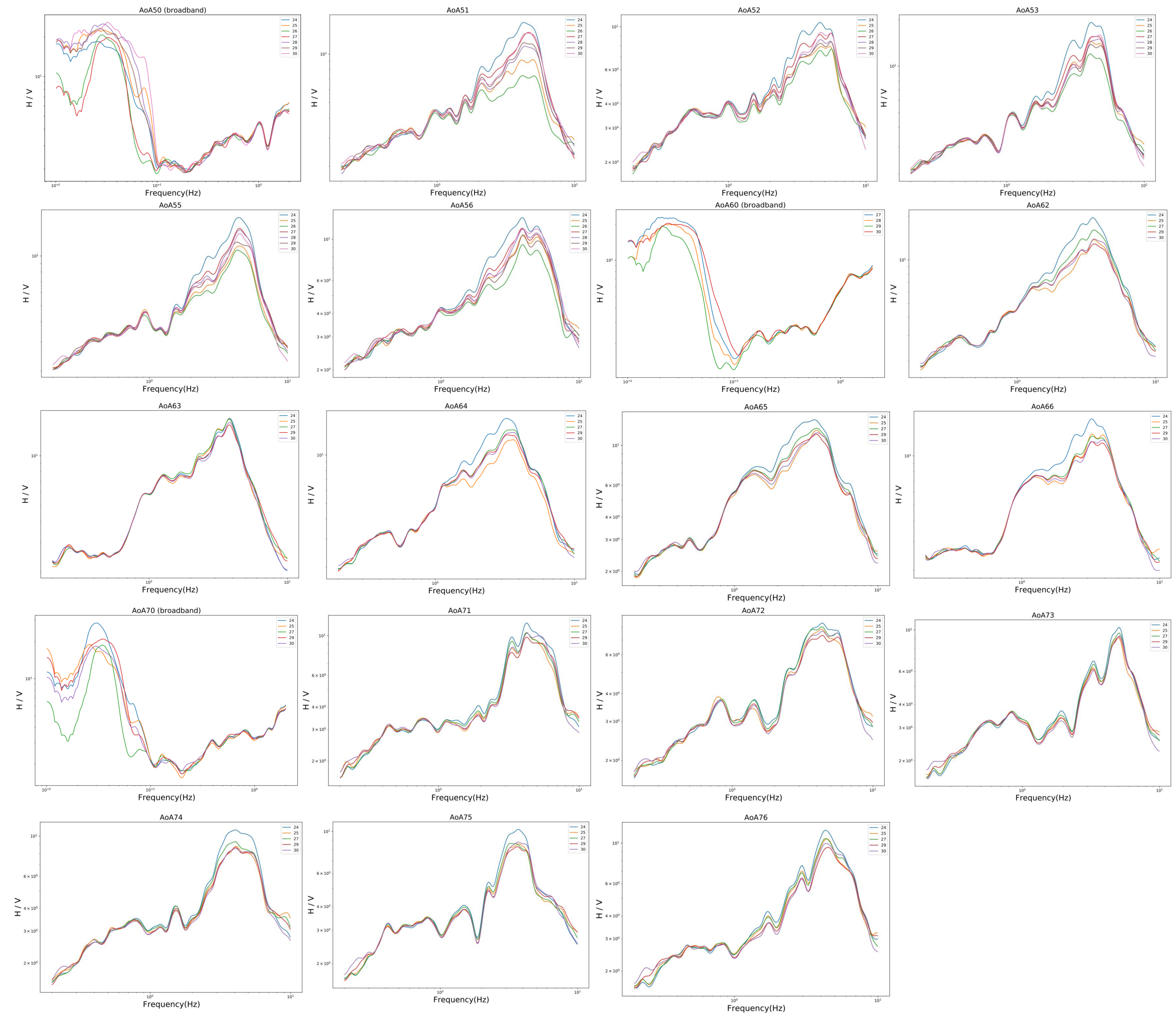

Figure 4: Stack of daily spectra of each station for temporal stability inspection of a station. A daily spectra is calculated after averaging the time windows of each dates.

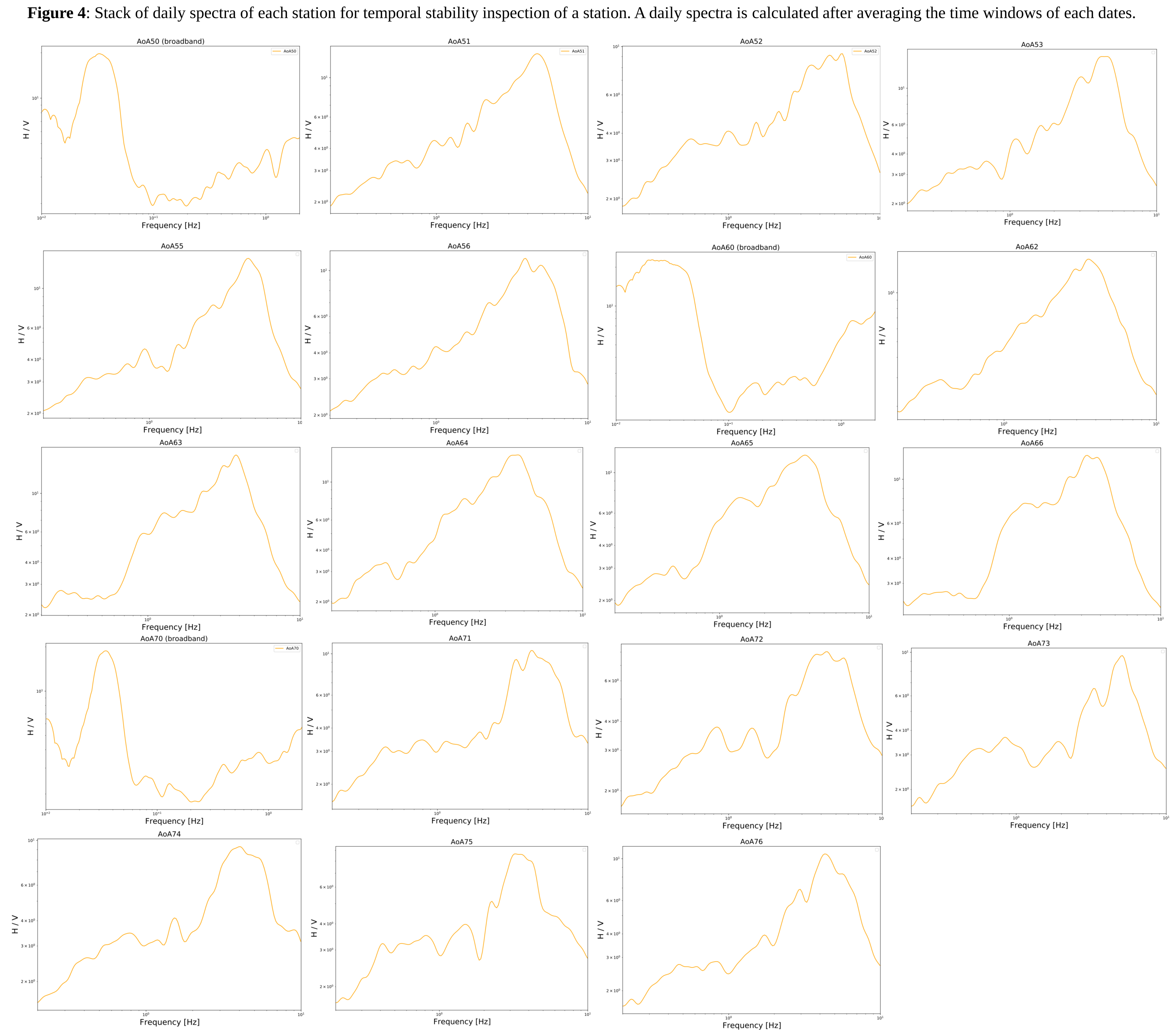

Figure 5: Average of daily H/V spectra of every station for spatial stability assessment by station to station comparison.

Discussions

We get the following insights after analyzing the outcomes of this study:

- Ambient noise is available in the study area at least up to period as long as 100 s that could be used for deriving H/V spectra of ambient noise.
- Satisfactory temporal stability of the H/V curves of each station is discerned after day to day comparison among them: curve shapes are mostly similar, amplitude and frequency of the fundamental peaks are almost equal for each day curve.
- Good spatial stability is visible among stations as curve shape, fundamental peak amplitude and peak frequency are closely similar at almost all the stations.
- The longer period peak, at the broadband stations, between 0.10 to 0.01 Hz is probably associated with deeper structure in the area—most probably the plate interface at 5 to 6 km depth that come into existence because of subduction of the oceanic Pacific Plate beneath the continental Okhotsk Plate. In this regard, it might be worthwhile to note that the seismometers are placed on the sediments of the overriding plate. On the other hand, the shorter period (0.1 to 1 Hz) peak at the shortperiod stations perhaps accounts for shallower structure there. Additionally, peaks' shapes might be related to the shape of the structure beneath the stations.
- S-wave velocity structure of the subsurface of the area could be derived by extending this research toward inversion of the H/V curves.

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