Importancy of Noise Level at CTBTO Facilities

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Abstract

The seismometers can detect not only the seismic events but also other natural vibrations such as cultural activities, wind and ocean waves which referred to seismic noise. Seismic noise exists everywhere on the Earth surface so it can mask seismic signals completely. In this study, we analyzed seismic background noise of BRTR array (PS-43) which is one of International Monitoring System(IMS) primary seismic station under Belbasi Nuclear Monitoring Center for the verification of compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT) since February 2000. PS-43 is composed of two sub arrays and they deliver data online to the International Data Center(IDC) in Vienna. The most essential advantage of a seismic array is to provide high quality data for earthquake-monitoring and detection purposes but noise levels affect the quality of data , thus it is needed to know the seismic noise levels of a seismic station or an array.

The background noise levels of BRTR array for the period of 2005 -2011 have been analyzed and the results indicate a little change in noise conditions in terms of time and location. Noise level changes were observed at 3-5 Hz in diurnal variations at Keskin array and there is a 5-7 dB difference in day and night time in cultural noise band (1-10 Hz). On the other hand, noise levels of medium period array are high in 1-2 Hz frequency range. In general, high noise levels were observed in daily working times when we compared to night-time in cultural noise band. The seasonal background noise variation at both sites also shows very similar properties to each other.

Introduction

Bogazici University and Kandilli Observatory and Earthquake Research Institute (KOERI) act as the Turkish National Data Center and is operating IMS Primary Seismic Station (PS-43) under Belbasi Nuclear Tests Monitoring Center for the verification of compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT) since February 2000. The NDC is responsible for operating two arrays which are part of the International Monitoring System (IMS), as well as for transmitting data from these stations to the International Data Centre (IDC) in Vienna.

PS-43 is composed of two sub-arrays (Ankara and Keskin). The medium-period array with about 38 km diameter located in Ankara and the short-period array with about 3 km diameter located in Keskin. Each array has a broadband element located at the middle of the circular geometry. Short period instruments are installed at depth 30 meters from the surface while medium and broadband instruments are installed at depth 60 meters from surface.

Figure 1. Location of Ankara and Keskin array.

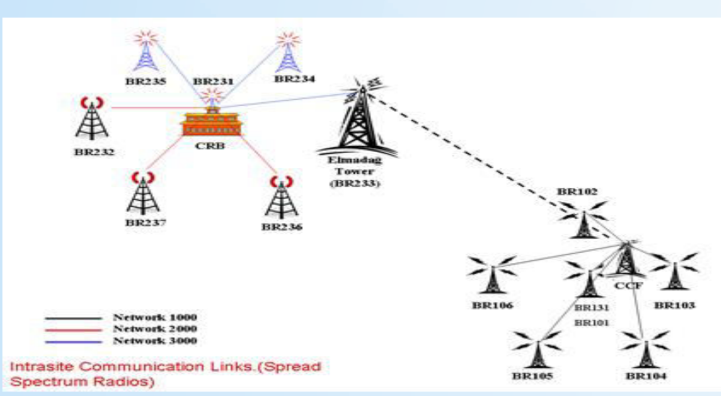


Figure 2. Structure scheme of BRTR array.

Background Noise Analysis

Data Analysis

We have analyzed 6-year seismic data for different timings of year,seasonal,diurnal and Summer-Winter for the noise analysis. We have compared Keskin Short Period array with Ankara Medium Period array in order to evaluate changes of the noise. The noise effects on short period array and medium period array data were analyzed with following methods;

-Power Spectrum Density (PSD) and Probability Density Functions (PDF) calculation.

Power Spectrum Density

Hour-long, continuous, and over-lapping (50%) time series data are processed. There is no removal of earthquakes, system transients and/or data glitches. The instrument transfer function is removed from each segment, yielding ground acceleration for easy comparison to the NLNM/NHNM by Peterson. Additional data preparation includes;

-Removing the mean;

-Removing the long period trend;

-Tapering using a 10% sine function; and

-Transforming using an FFT algorithm (Bendat and Piersol, 1971).

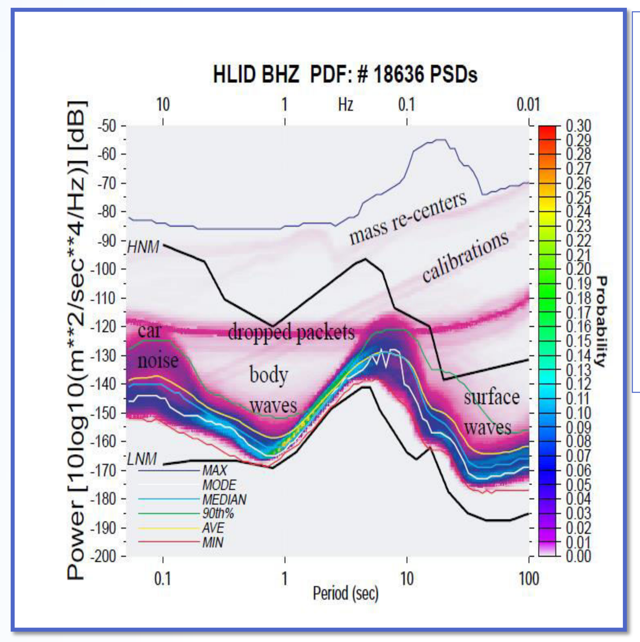


Figure 3. Example of a PDF figure. Colour bar on the right shows the probability values. HNM and LNM are reference high and low noise models by Peterson(1993). We can easily see culturel, microseismic noises and the system artifacts (calibrations, gaps vs.) System artifacts are low probability occurences (purple colour).

Probability Density Functions

We have used the algorithm developed by *McNamara and Buland,* in order to estimate the true variation of the background noise at a given site. In most noise studies, body and surface waves from earthquakes, or system transients and instrumental glitches such as data gaps, clipping, spikes, mass re-centers or calibration pulses are removed. These signals are included in our processing because they are generally low probability occurrences that do not contaminate high probability ambient seismic noise observed in the Probability Density Functions (PDF). In fact, examination of artifacts related to station operation and episodic cultural noise allows us to estimate both the overall station quality and a baseline level of earth noise at each site.

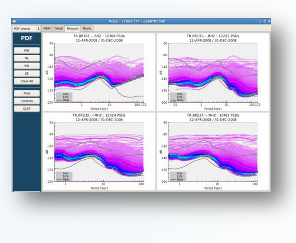
For each channel, raw frequency distributions are constructed by gathering individual PSDs in the following manner:

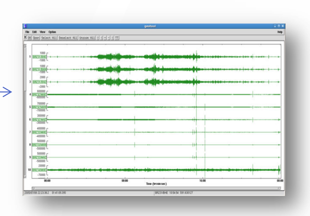
1) binning periods in 1/8 octave intervals; and
2) binning power in 1 dB intervals.

Each raw frequency distribution bin is then normalized by the total number of PSDs to construct a Probability Density Function (PDF). The probability of occurrence of a given power at a particular period is plotted for direct comparison to the Peterson high and low noise models (NHNM, NLNM). *(McNamara and Buland, 2004)*

Flow of the process

WFDISC
↓
GEOTOOL
↓
SAC
↓
PQLX
↓
PSD
↓
PDF median
↓
GMT
↙ ↘
DIURNAL SEASONAL





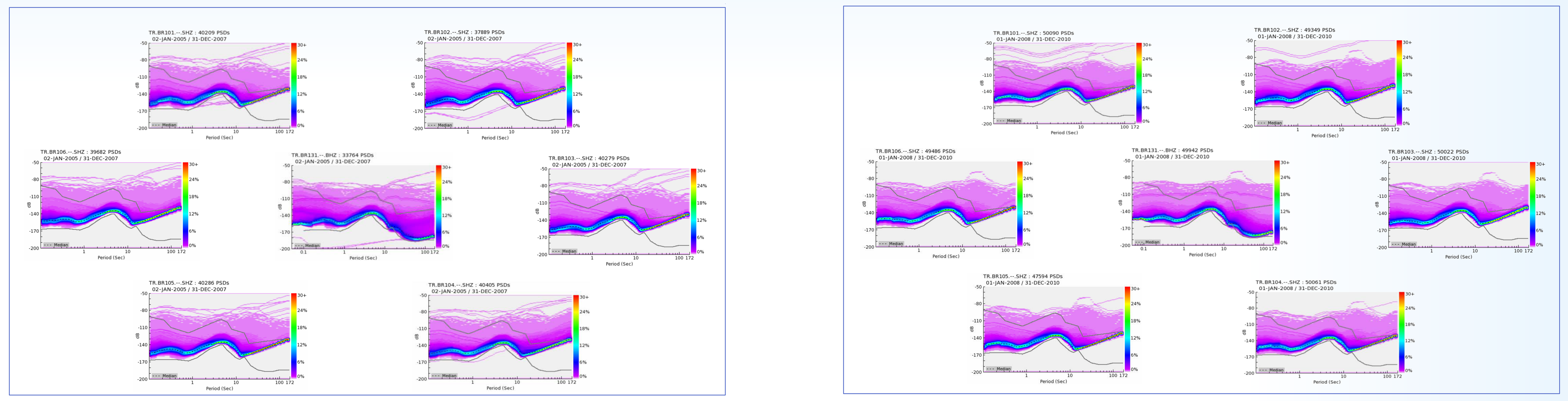


Figure 4. PDF plots of Keskin array from 2005 to 2008 and 2008 to 2011. Scale bars reperesent probability of occurences.

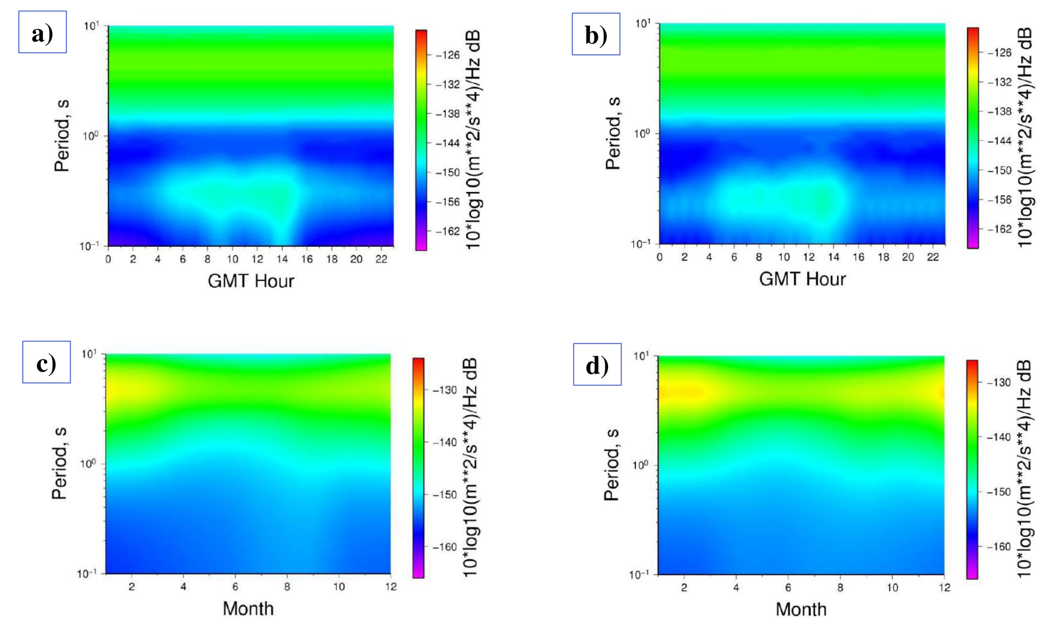


Figure 5. a and b indicate diurnal variations plots of BR101 from 2005 to 2008, and from 2008 to 2011, respectively. c and d show seasonal variations plots of BR101 from 2005 to 2008, and from 2008 to 2011, respectively.

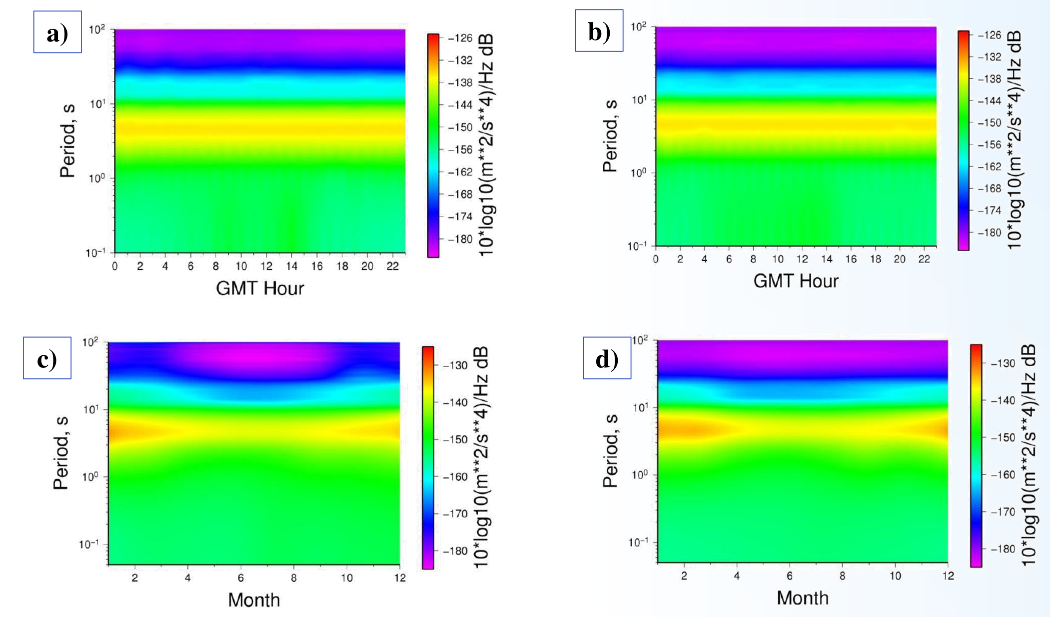


Figure 6. a and b indicate diurnal variations plots of BR131 from 2005 to 2008, and from 2008 to 2011, respectively. c and d show seasonal variations plots of BR131 from 2005 to 2008, and from 2008 to 2011, respectively.

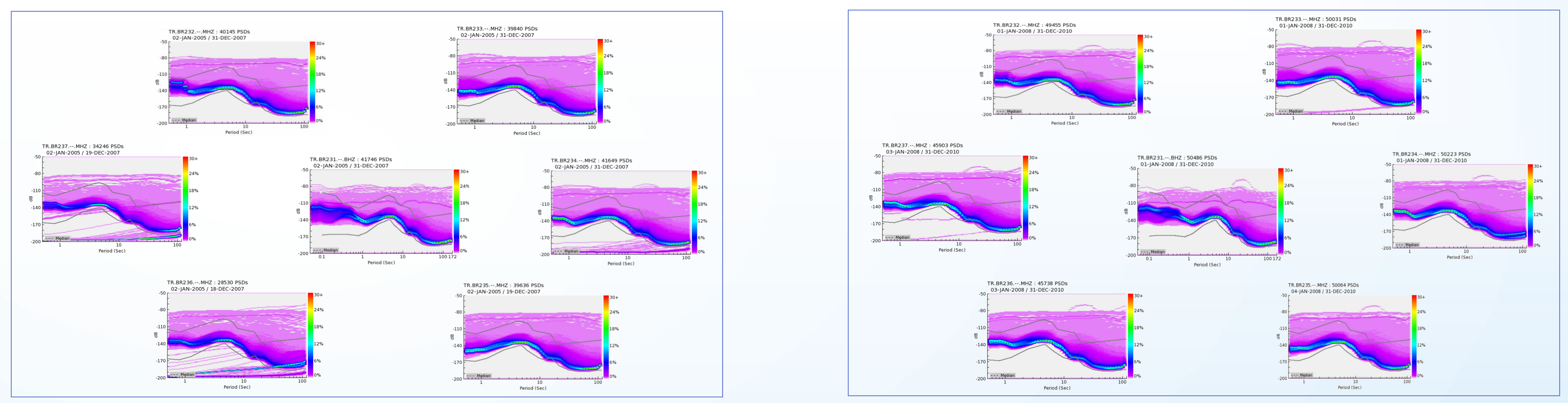


Figure 7. PDF plots of Ankara array from 2005 to 2008 and 2008 to 2011. Scale bars reperesent probability of occurences.

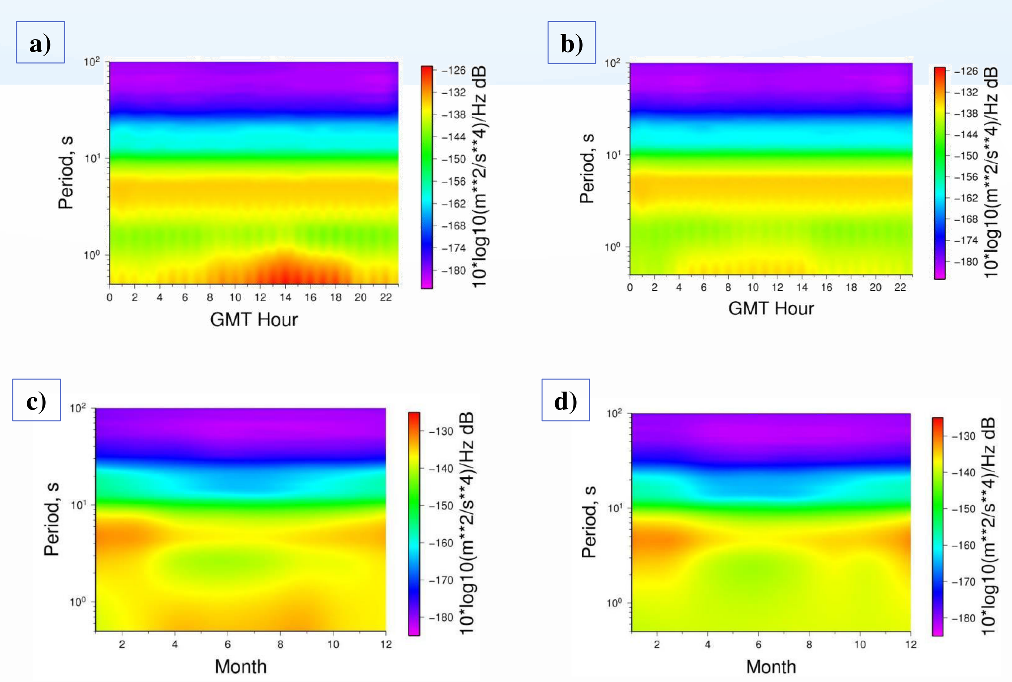


Figure 8. a and b indicate diurnal variations plots of BR232 from 2005 to 2008, and from 2008 to 2011, respectively. c and d show seasonal variations plots of BR232 from 2005 to 2008, and from 2008 to 2011, respectively.

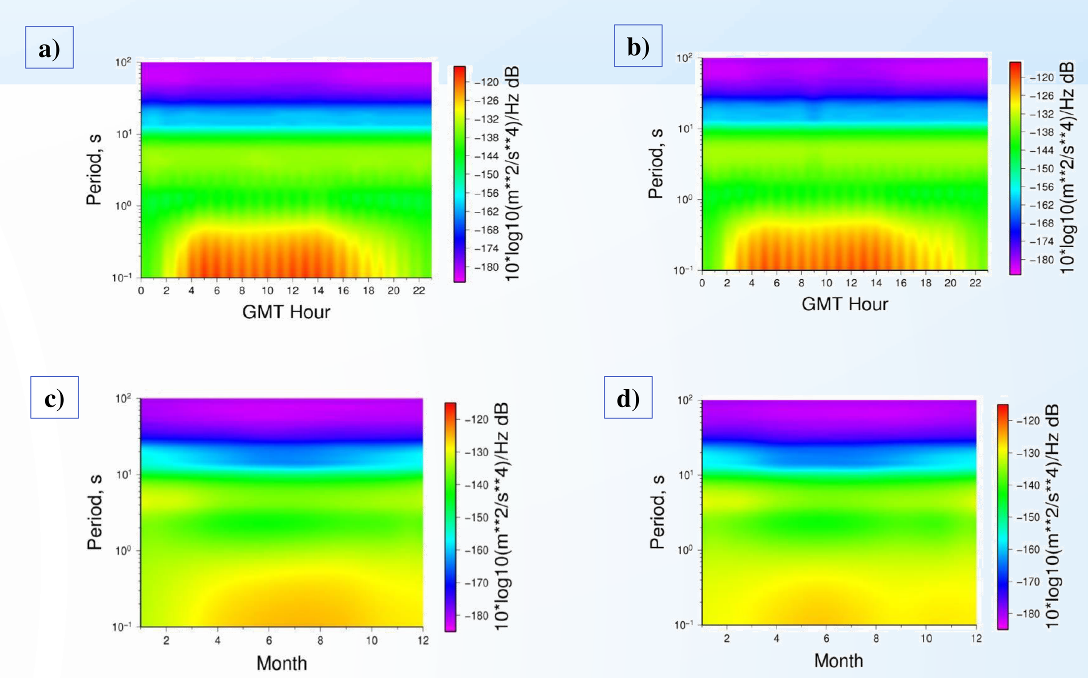


Figure 9. a and b indicate diurnal variations plots of BR231 from 2005 to 2008, and from 2008 to 2011, respectively. c and d show seasonal variations plots of BR231 from 2005 to 2008, and from 2008 to 2011, respectively.

Conclusion

We have analyzed the background noise levels of BRTR array for the period of 2005 - 2011. The results show us a little change in noise conditions in terms of time and location. We have compared diurnal background noise levels and seasonal background noise levels at Keskin short period array and Ankara medium period array from 2005 to 2007 and from 2008 to 2011. In Keskin array, the figures show us the diurnal and seasonal variations at both sites are almost the same. There is a 5 db difference in day and night time (lower noise) in cultural noise band (1-10 Hz). As we understood that high noise levels were observed in daily working times when we comparedto night time in cultural noise band. The seasonal background noise variation at both sites also shows very similar properties. Since these stations are borehole instruments and away from the coasts, we see a small change in noise levels caused by microseism. During winter months, Cultural noise levels lowers while microseism noise (5-8 s) gets higher compared to summer time. From 2005 to 2007 winter time there was a water leak in the borehole of site BR131.BHZwhich caused a very high noise levels as can be seen from the seasonal graph in the long period band. In Ankara medium period array, the figures illustrate us the diurnal variations and seasonal variations of stations have small noise changes . In 1-2 Hz frequency band, BR232 are noisier than other stations. Due to the quarry activities around array, BR232.MHZ and BR234.MHZ indicate high noise levels compare to other stations in medium period array. Daily working times are noisier than night time among stations. Due to closer to settlement area, BR231.BHZ shows high noise levels in both diurnal variations and seasonal variations. Noise levels of Keskin short period array are low when it is compared to Ankara medium period array. In conclusion, medium period array are noisier than short period array due to closer to settlement area and quarry activities around array.

References

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