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A Deployment of Broadband Temporary Seismic Station around Tangkuban Parahu Volcano Complex: Preliminary Results

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Abstract. Tangkuban Parahu volcano is one of the active volcanoes in Indonesia, which is in West Bandung and Subang Regency, West Java Province. In this study, we deployed eight broadband temporary seismic stations around Tangkuban Parahu volcano to investigate the subsurface structure of Tangkuban Parahu and its surroundings. We used a Trillium Compact Nanometric broadband sensor and LPR-200 ANU data recorder with a duration of the recording is approximately one month (between May to June 2021). The ambient seismic noise tomography method was performed on the vertical component of the recorded data. At the first stage of data processing, we conduct the data preparation for each station, including downsampling, mean and trend removal, bandpass filtering, RMA time-domain normalization, and spectral whitening to reduce the earthquake signal recorded by instruments. The next step is the cross-correlation for daily data time series and stacked the results to obtain Rayleigh wave green's functions between pairs of stations. This processing produced 56 empirical green functions with distances between pairs of stations in the range of 4 – 17 km.

Keywords: *broadband seismometer, Tangkuban Parahu, Ambient noise tomography, green's function, volcanoes*

1 Introduction

Indonesia has 127 active volcanoes, the most in the world and ranks first with the highest number of fatalities [1]. Based on historical records of eruptions, this active volcano is divided into three types, 1) Type A Volcano, which has a historical record of eruptions since 1600, 2) Type B Volcano, has a historical record of eruptions before 1600, 3) Type C Volcano, has no record eruption history but still shows traces of volcanic activity. Tangkuban Parahu is one of the active volcanoes in Indonesia which is included in the type A volcano. This volcano is located in West Bandung Regency and Subang Regency, West Java Province. Tangkuban Parahu has grown as the youngest phase of the Sunda volcano, which was formed by the collapse of the summit of the larger and older Sunda volcanoes [2]. The main crater consists of Ratu Crater, Upas Crater, and Baru Crater, while the parasite crater is in the eastern part outside the main crater consisting of Domas Crater, Badak Crater, Jarian Crater, Jurig Crater, and Orok Crater. The structure that develops in the peak area is a normal fault with a direction of N 340^{o} E where the eastern block is relative to the west [3]. In the southwestern part of the Ratu Crater area there is also the Sukatinggi Fault which forms a straight line in the southwest-northeast direction. While in the northeastern part of Ratu Crater there is the Ciater Fault, which forms a straight line in almost the same direction [4].

In order to gain a deep understanding of the seismic characteristic and subsurface structure from Tangkuban Parahu volcano, seismic activity recording data is needed. The data was obtained by installing a network of seismic stations that surround the Tangkuban Parahu complex. Previous studies [5] using inversion tomography in seismicity studies have shown the presence of low Vp, high Vs, and low Vp/Vs associated with product accumulation and zones of young volcanic eruption material. To increase observations around Tangkuban Parahu, we must increase the number of monitoring stations [5].

In this study, we deployed eight broadband temporary seismic station around Tangkuban Parahu. We used a Trillium compact nanometric broadband sensor and LPR-200 ANU data recorder with duration of the recording is approximately one month (between May to June 2021). The recorded data does not show any earthquake events originating from the volcanic activity of Mount Tangkuban Parahu. Therefore, we applied the Ambient Seismic Noise Tomography (ANT) method to extract subsurface information from seismic recording data. Some of the previous studies using the same methods have successfully applied in several places in Indonesia. There are in the Java Island: Bandung Basin [6], Western Part of Java [7,8], Central Java [9], Eastern part of Java [10], volcanic region of Toba Lake [11] and Agung – Batur volcanoes [12]. In this paper, we will focus on the Tangkuban Parahu Volcanic Complex.

2 Data and Methods

2.1 Data

In this study, we deployed eight broadband temporary seismic stations around Tangkuban Parahu to investigate subsurface of velocity structure. The distribution of the temporary seismic station temporer can be seen in Figure 1. The inverted red triangle shows the location of installed stations. Tangkuban Parahu is in the middle of the station spread. The basemap used is ESRI satellite and plotted using Quantum GIS (QGIS).

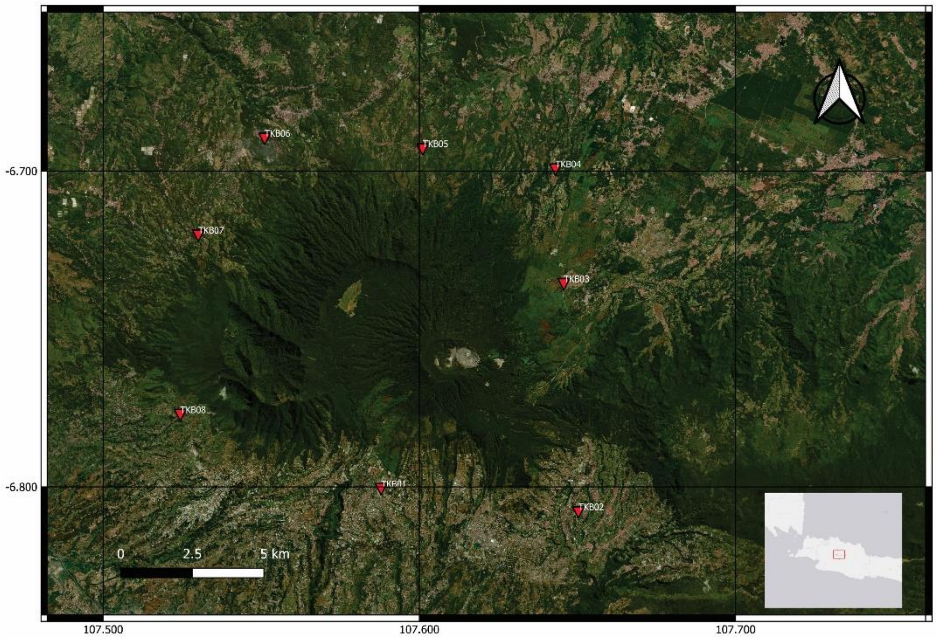

Figure 1. Distribution of location portable stations (red inverted triangles) overlays with ESRI satellite plotted using QGIS.

We used a Trillium compact nanometric broadband sensor and LPR-200 ANU data recorder, abd synchronized the time with GPS. Recorded data is stored on an external memory card in the form of a miniseed file. This form can be directly used for further data processing. The recording duration is one month (between May to June 2021). Most of these temporary stations are located is government building such as village offices and schools. Consideration of the selection of this place is the safety factor. Some documentation of the deployment of the temporary stations can be seen in Figure 2.

Figure 2. Documentation of the deployment of the temporary stations

The installation of temporary stations is carried out during the Community Activities Restrictions Enforcement (CARE) or in Bahasa is PPKM period so that this activity applies strict health protocols. Before and after the activity, a swab test is carried out. Use of masks during activities as you can see in Figure 2.

2.2 Methods

The vertical of the continuous waveform was used in ths study. The waveform was preprocessed following the data processing flow proposed by Bensen et al [13]. First, records of the single station continuous waveform were divided into one-day segments (24 hours) then did we did the data preparation for each station, including downsampling to 20 Hz, mean and trend removal, bandpass filtering, RMA time-domain normalization, and spectral whitening to reduce the earthquake signal recorded by instruments.

After the single-data preparation, we calculated the cross-correlation for daily data time series and stacked the results to obtain Rayleigh wave green’s functions between pairs of stations. Green’s function extracted from interstation pairs gives information about the surface wave travel time and dispersion curve between the stations. Data preparation and cross-correlation step we used ObsPy and NoisePy [14] module in Python.

3 Results and Discussion

The recording time for all stations is one month. The average data duration is 28 days, there also stations that record less than average because the battery used has been exhausted. The recording time duration of each station is shown in Figure 3. The horizontal axis represents the length of data in days, meanwhile, the vertical axis represents a station name.

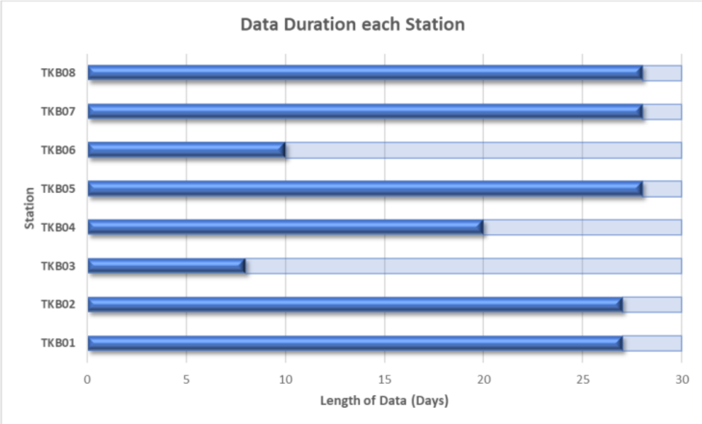

Figure 3. Data duration each station.

One of the earthquake event recorded by the installed temporary station network can be seen in Figure 4. The figure shows a vertical component (Z) seismogram display for all installed temporary stations. Based on information from PVMBG, the probable event at that date and time was an earthquake that occurred in the South of Blitar Regency, East Java Province (inset on Figure 4). From the results of seismicity analysis, there were no event originating from the volcanic activity of Mount Tangkuban Parahu. There are two possibilities that cause this, firstly there is no or the volcanic activity is decreasing, secondly there is activity but is very weak so it is covered by ambient noise. Howefer, because this study used ambient noise data, it doesn’t matter if there are no recorded volcanic or tectonic events. This is an advantage of the ANT method which data can be used without having to wait for an event.

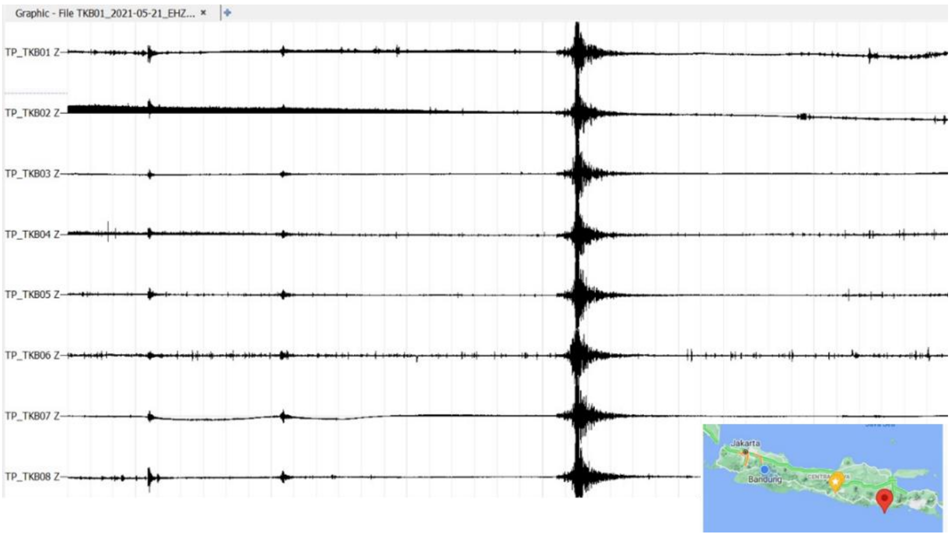

Figure 4. Vertical component (Z) seismogram display for all installed temporary stations shows event on May 21st, 2021. Inset on Figure show location of hypocenter from event.

In the process of processing cross-correlation data between pairs of stations, 56 empirical green's function are produced. In addition to the empirical green's function, other information generated from this data processing is the distance between pairs of stations. The distance information is useful for next stage of data procesing, namely determining the travel time of surface waves between stations. The relationship between the distances between stations and their number is represented by a histogram shown in Figure 5. In the histogram, it can be seen that the distance between pairs of temporary station instaleed is in the range of 4 – 17 km.

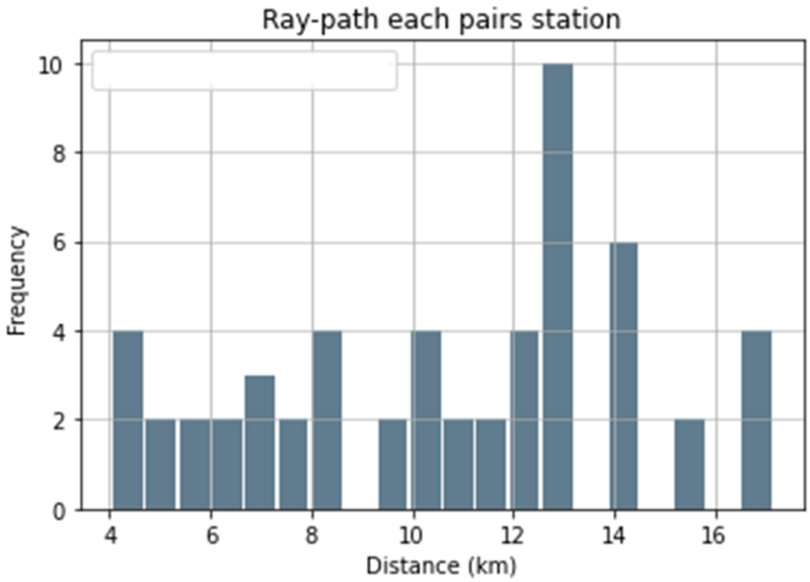

Figure 5. Histogram of the distance between pairs of stations.

The preliminary result produced in this study are the empirical Green's function obtained in the cross-correlation process. An example of the results of cross-correlation between pairs of stations can be seen in Figure 6. Where station TKB01 is used as a virtual source and other stations are considered as receivers. In additional, the ray-path from the cross-correlation is shown by the blue line in Figure 6. Empirical green's function appears around the 0 – 15 s period, this is reasonable because the distance between stations that are not so far away (range 4 – 17 km). The same thing is shown by another pair of stations, where in each cross-correlation result green's function appears in the same band period.

From the result obtained, optimistic data processing is carried out to the next stage, namely the extraction of dispersion curves and tomography. It's just that at the cross-correlation stage, optimization of the parameters used, such as the selection of time lag is needed so that the green's function can be seen more clearly.

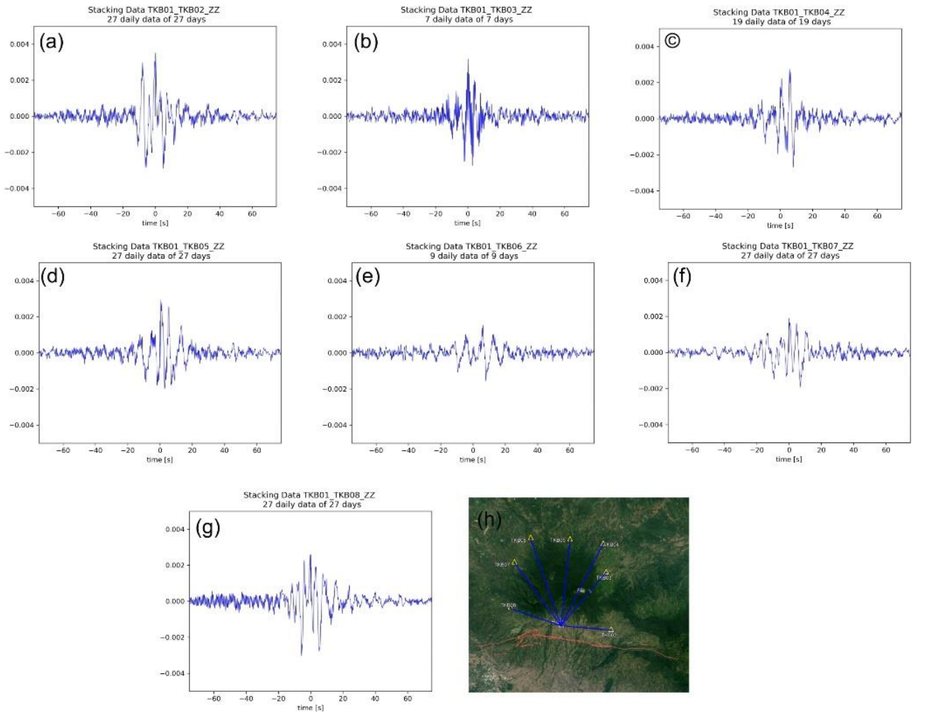

Figure 6. Empirical green's function result from cross-correlation. Station TKB01 is used as a virtual source and other stations are considered as receivers. The ray-path from the cross-correlation is shown by the blue line.

4 Conclusion

In this study, we deployed eight temporary seismic broadband seismometer stations around the Tangkuban Parahu Complex with a recording duration of one month. From the recorded data, no volcanic activities events were found in that period. The results of cross-correlation processing produce 56 empirical green's functions that can be used at a next stage in the ambient seismic noise tomography to investigate the Tangkuban Parahu seismic structure.

For the ongoing research and future research plans, we will install more temporary seismic stations covering the Tangkuban Parahu Volcanic Complex area.

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