Detecting and locating changes of volcanic tremor source using seismic correlation and covariance matrix analysis

*Theodorus Permana[1], Takeshi Nishimura[1], Hisashi Nakahara[1], Nikolai Shapiro[2]

1. Department of Geophysics, Graduate School of Science, Tohoku University, Sendai, Japan, 2. Institut des Sciences de la Terre (ISTerre), Université Grenoble Alpes, Grenoble, France

Volcanic tremors are a type of seismic event associated with the movement of magma and other volcanic fluids inside the volcanic edifice. Some of the observed volcanic tremors are closely related to eruption activity so that the determination of their source location is important to understand the eruption mechanism of a volcano. We perform detection and location determination of volcanic tremors using six months of continuous seismic records of Sakurajima volcano in Japan. The volcano is considered to be one of the most active volcanoes in Japan, and volcanic tremors with duration ranging from several minutes to hours are sometimes observed. To systematically examine the volcanic tremor activity, we perform detection and location analyses for every 10 minutes of seismic data. Firstly, we compare two detection methods. The first method is the inter-component correlation coefficient analysis, which can be applied using a single station. The second method is based on the covariance matrix analysis from a network of six seismic stations. Both methods measure the coherency of seismic signals to distinguish the coherent signal from tremors (and other volcanic events) generated by a localized source from noise signals that are less coherent across the stations. Then, we use the combination of seismic interferometry-based technique to obtain the stacked cross-correlations and grid search in three-dimensional space. By assuming an S-wave velocity structure, we determine the most likely source location for each 10-minute data. The measures of signal coherency obtained by the detection methods are used to evaluate the reliability of the source location.

We perform the analyses in 1-4 Hz, which is the predominant frequency of volcanic tremors. The detected tremors during the period of April to September 2017 are consistent with the reported time for seismic activities by the Japan Meteorological Agency, and interestingly, are related to the reported eruption activity at Sakurajima volcano. Also, a seismically quiet period is observed before the eruptions. The source locations are distributed down to 7 km depth, and sometimes show upward migration from deeper parts and intense shallow activity during eruptions. We also observe downward migration of the tremor source between eruption episodes. These changes in the location may represent volcanic fluid injection, eruption, and magma retreat beneath the volcano. By using a small seismic network and almost no *a priori* information, our study shows the possibility of high temporal resolution monitoring of volcanic tremor.

Keywords: Volcanic tremor, volcano monitoring, volcano seismology, seismic correlation, tremor detection

