Detection of long-period volcanic earthquakes using continuous wavefield processing system

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Long-period earthquakes and low-frequency earthquakes observed around active volcanoes are considered to be generated by the movement of volcanic fluid in the shallow hydrothermal system, and the elucidation of these signals are thought to be one of the critical keys to understand the thermal state of hydrothermal system and to evaluate volcanic activities. So far, the observation of long-period signals has been conducted using broadband seismometers close to the focal area around active craters and fumaroles, and it is rather difficult to detect them comprehensively at volcanoes where the observation networks is not sufficient. For example, at Hakkoda volcano, where long-period (10 s) events frequently occurred between 2013 and 2015, the detail of their activity had been unclear until the installation of a broadband seismometer close to the focal area. To systematically detect long-period earthquakes around active volcanoes using the data observed at permanent stations like NIED Hi-net, we have been developing a continuous wavefield processing system as a part of MEXT ‘Integrated Program for Next Generation Volcano Research and Human Resource Development’. In this presentation, we report the result of an evaluation test of back projection analysis of the long-period events at Zao volcano.

Our continuous wavefield processing system is being developed to analyze continuous seismic wavefield using seismic interferometry, back projection, and spectral analyses. The back projection analysis in the system is based on the slant stack of wavefield assuming predefined virtual sources, and it is almost similar to the Source-Scanning Algorithm by Kao and Shan (2004). Because the dominant period of long-period events occurring at shallow depth is around 10 s and the observed wavefield at far stations is dominated by surface waves, we stack the observed wavefield assuming the propagation of Rayleigh wave from the virtual source. To obtain the travel times of Rayleigh wave propagating between the focal area and far stations, we use the ambient noise seismic interferometry between the station in the vicinity of postulated source location and far stations.
In this study, to verify the detectability of long-period earthquakes and the robustness of the method, we apply this processing to the analysis of long-period events at Zao volcano. In the analysis, we use the vertical component data at stations operated by Tohoku Univ., JMA, and NIED, and apply the method for several frequency bands. As the result, we find that the method successfully detects almost all the events which are detected by manual inspection, and the estimated source energy well correlates with the amplitude of long-period events observed at nearby stations.

We are now operating the continuous back projection analysis at three volcanoes (Zao, Azuma, and Asama) as a trial, and we expect further optimization of the processing will contribute the monitoring of volcanic activities as well as the systematical detection of long-period events.

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