Automated seismic event detection and localization: An application to long-period seismicity at Aso Volcano influenced by large earthquake

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The interplay between earthquakes and volcanic activity that may lead to eruptions has been well-established. Dynamic stress from a remote large earthquake brought by propagating of body and surface waves triggers gas exsolution at a magma reservoir. The exsolution of gasses could further lead to a bubble nucleation and pressurize the magma chamber. If the pressure continues to increase and exceeds a critical value, then magmatic fluids could breach impermeable layers overlying the magma chamber. Hot magmatic fluids heat up water filling hydrothermal system or continue to rise until surface resulting in an eruption. The interaction between the ascent of magmatic fluids with water at shallow triggers long-period (LP) seismicity. LP events reflect the resonance of fluid-filled cracks due to changes in fracture pressure. Because this process usually occurs near the surface, then LP seismicity could be used as a possible precursor to volcanic eruptions. Many studies have been conducted to analyse LP seismicity at Aso volcano. The origin of this seismic activity was a pressurization at the hydrothermal system at depth of about 1 km from the surface. However, the relationships between LP seismicity and earthquakes have not been studied. Moreover, LP signals show no clear onset of wave arrivals causing difficulties in performing classical seismic event localization that relies on manual travel-time picking. In this study, we present the source location of LP (with period of 15 s) seismicity at Aso volcano recorded by F-net and V-net seismic networks, between January 2015 and December 2016, a period that includes the Mw 7.0 Kumamoto earthquake of April 2016 and volcanic eruptions of October 2016. The initial LP events were identified by applying STA/LTA method using window lengths of 10 s and 100 s. To avoid false positive detection, waveform cross-correlation was applied to all pairs of the initial events resulting in a reliable three-component template waveform. In order to obtain robust LP events from 2-year continuous seismograms, a template matched filter was employed. We developed a differential-time back-projection method to locate LP events. Then, a coherency measure (semblance) was computed from the cross-correlograms of waveforms instead of the seismograms. In order to increase the focusing of the coherency image, we applied weighted-semblance by making use of a phase-stacking function. The seismic event locations with uncertainties were estimated from the probability density function of the coherency image. The performance of the developed method was remarkable since we have successfully revealed two distinct clusters of LP seismicity beneath the Nakadake crater. The spatio-temporal variation of LP events could be related to the large earthquake and volcanic eruption.

Keywords: differential-time, back projection technique, template matched filter, coherency, long-period seismicity