Monitoring volcanic long period tremors from Aso volcano in 2014-2015

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Introduction

Aso volcano is one of the most active volcanoes in Japan and has erupted repeatedly more than a thousand years since the dawn of history. It has been proposed that long period tremors (LPTs) are caused beneath Aso volcano by the elastic interaction between the volcanic gasses or ash passing the crack-like vent, and the wall of the vent. This LPTs have a dominant period of about 15 s. By monitoring the LPTs from Aso volcano for two years from 2014 to 2015, we revealed the relationship between LPTs and eruptive activities.

The monitoring of LPTs

We used three-component broadband seismograms from seven F-net broadband seismograph network stations operated by National Research Institute for Earth Science and Disaster Prevention around Aso volcano. First, we investigated the changes in daily power spectrum for each component and each station. The continuous signal with a dominant period of 8-12 s was observed at time periods from October 2014 to April 2015, and from September to October 2015. These periods well agree with Strombolian eruptions and occurrence of volcanic tremors reported by Japan Meteorological Agency. Furthermore, this signal was not observed in the same season in the previous year. Therefore, it is interpreted as LPT signal rather than seasonal changes of microseisms. The signal amplitude was dominated in the radial and vertical component measured from Aso volcano, and this suggests that it was Rayleigh waves of the LPT.

Then, we detected LPTs by applying the matched filter technique. We first selected a LPT event with high signal-to-noise ratio as a template event, and prepared three-component waveforms at the seven stations. We then calculated the cross-correlation coefficient between the template and continuous waveforms, with sliding the time window through the continuous waveforms for two years, to compute the sum of 21 cross-correlation coefficients as a function of time. When the sum of the coefficients exceeded a threshold set based on the median absolute deviation, we detected an event as a LPT. The amplitude ratio between the template and detected events were also estimated by a waveform fitting method. We also applied the same analysis to records from six stations because a record of one station was unavailable for a period in 2015.

As a result, we detected LPTs with wider dynamic range in amplitudes, including amplitudes smaller than 100 nm/s, which previous study (Sandanbata et al., 2015) excluded from their analysis. In addition, we observed that the amplitude of LPTs dropped sharply only from the end of December 2014 to January 2015 during the continuous eruption from November 25th, 2014 to May 21st, 2015.

Changes in frequency-amplitude distribution

We divided the analysis period into 21 stages based on the trend of the time-series of LPT amplitude and calculated frequency-amplitude distribution for each stage. Previous study (Sandanbata et al., 2015) showed that the distribution follows the power-law distribution rather than the exponential distribution just after the Strombolian eruption in November 2014 and interpreted that the characteristic amplitude scale was lost by the Strombolian eruption. We obtained the similar result during this period. We note that the all stages in 2015 activities show that they follow exponential distribution, and this suggests the peculiarity of the Strombolian eruption in November 2014. On the other hand, smaller LPTs dominated from the end of December 2014 to January 2015 compared to other stages. Japan Meteorological Agency reported that grayish white fumes were observed from November to December 2014 and from March to May 2015, whereas white fumes were observed from January to February 2015. Our result and the reported phenomena indicate that the change in the main component of the fumes from water vapor to volcanic ash had some effect on the amplitude of LPTs.

Keywords: Mount Aso, Volcanic tremor, Long period tremor, Frequency-amplitude distribution, Rayleigh wave