Tilt Chages Preceding Repeating Very Long Period Events Beneath Zao Volcano, Northeastern Japan

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Volcanic earthquakes and tremors have been occurring beneath Zao volcano located in northern Honshu, Japan since 2013, following the increase in the number of deep low frequency earthquakes from around 2012. On account of a burst of volcanic earthquakes initiated in April 2015, the Japan Meteorological Agency announced a warning of eruption, however, the number of events gradually decreased for the next two months and the warning was canceled in June 2015. In the same time period, minor expansive deformation was observed by GNSS. Small-scale volcanic earthquakes are still continuously occurring, and long-period earthquakes (LPE) occur sometimes accompanied by static tilt changes. In this study, we try to extract the sub-millimeter displacements from the LPE waveforms observed by broadband seismometers (BBS) and utilize them for geodetic inversion to monitor volcanic activities.

Thun et al. (2015, 2016) devised an efficient method using a running median filter (RMF) to estimate and remove long-period noises, which contaminate displacement waveforms obtained by integrating velocity LPE waveforms. They demonstrated the reproducibility of displacement waveforms derived by a BBS corresponding to the experimentally given sub-millimeter displacements in the laboratory. They also apply the method to the field LPE data obtained from several volcanoes to show static displacements. The processing procedure is outlined as follows: (1) Unfiltered removal of the instrument response (retrieving ground velocity), (2) Long period noise estimate by Low-pass filter with a corner frequency of 5/M and the RMF with a time window of M seconds, which should be at least three times the length of the rise time. (3) Subtract the noise estimated from step (2), and (4) Integrate to obtain displacement waveforms.

We apply the method to the vertical BBS waveform at a distance of about 1.5 km ESE from the summit crater of Zao Volcano associated with a LPE that occurred on April 1, 2017. Assuming the time window M as 300 seconds, we successfully obtained the displacement history as follows: taking the rise time of about 2 minutes, the site was gradually uplifted with the amount of about 50-60 μm and then subsided together with high-frequency displacements in the next 2 minutes resulting about 20-30 μm static upheaval. Comparing the waveforms obtained by the RMF and the conventional methods, the onset of the upheaval is delayed a little in the former one, while the latter one is consistent with the inclination change observed by the tiltmeter installed at the same site. It may be caused by the characteristics of the RMF and attention should be paid to detailed discussions of the source time histories.

From above, the original recording (A / D count), BBS characteristic corrected velocity waveform (m / sec), RMF method (time window M 300 seconds) by displacement waveform (m) and displacement waveform according to a conventional method (Tohoku University, 2017). Suggesting Looking displacement waveforms by RMF method, LPE not long period component is seen in the displacement before and after the rise of the LPE is clearly, tends to become said observed, that it is necessary to optimize the parameters. In the LPE, about settle over about two minutes accompanied by high frequency fluctuation after raised approximately 50-60ﾎｼm in 2 minutes, resulting in it can be seen that the static raised about 20-30ﾎｼm occurs. In the lecture, we will also report geodetic inversion using displacements and inclination data obtained by RMF method including cases other than this.

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