Characteristics of seismic velocity changes on volcanoes using noise correlation method: Analyses of JMA seismic data

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Temporal changes of seismic velocity have been detected associated with the occurrence of large earthquakes and volcanic activities. The velocity changes are estimated to be about 0.1 ~ a few %. At active volcanoes, such seismic velocity changes are interpreted to be caused by the magma intrusion. To estimate seismic velocity changes preceding eruptions, it is important to examine the characteristic of seismic velocity changes during time periods having no volcanic activities. Therefore, we systematically investigate the characteristic of seismic velocity changes by applying seismic interferometry to ambient noise recorded at active volcanoes in Japan.
We estimate seismic velocity changes using continuous records of short period seismometers by Japan Meteorological Agency (JMA). We analyze 12 volcanoes which are observed by more than two seismometers and more than three GNSS stations: Hokkaido-Koma, Meakandake, Tokachidake, Tarumaesan, Adatarayama, Nasudake, Kusatsu-Shirane, Izuoshima, Miyakejima, Unzendake, Bandaisan, and Sakurajima. We use data from 2012 to 2013. Distances between stations are within about 5 km, and the number of station pairs ranges from 1 to 45 at each volcano. The seismic data are first filtered at 0.5-1Hz, 1-2Hz, and 2-4Hz, and cross correlation functions (CCF) of ambient seismic noise are then calculated. Daily seismic velocity changes are estimated by comparing each 1-day stacked CCF with a whole period stacked CCF as a reference based on MWCS method (Poupinet et al., 1984).
We recognize annual or a few monthly seismic velocity changes with amplitudes of about 1 ~ 3 %. The seismic velocity change largely even when there is no volcanic activity or earthquake. Correlation coefficients of velocity changes between each station pair at Izuoshima and Miyakejima and Tarumasan are high in the 1-2 Hz, however coefficients of other volcanoes are less than 0.5. The result implies that there would be localized velocity changes within the limits of a few kilometers in many volcanoes. We also compare seismic velocity changes between the three frequency bands for the same station pair. At a few volcanoes, the amplitudes of seismic velocity change are different between frequency bands while time series of velocity changes are well correlated. At the other volcanoes, trends or phases of seismic velocity changes are different. These results suggest changes of seismic velocity with depth or complex wave properties of ambient noise.
We investigate the relationship between seismic velocity changes and strain changes at each volcano because some studies reported velocity changes associated with stress changes. We estimate areal strain changes using three GNSS stations operated by JMA. We analyze the data with areal strain amplitudes of more than 2×10^{-6} and those of less than -2×10^{-6} considering measurement errors. We calculate the correlation coefficient between seismic velocity changes and areal strain changes using only time periods when the areal strain exceed the maximum shear strain. The high correlation coefficient between areal strain and seismic velocity changes are estimated at Izuoshima and Tarumaesan. However, it doesn't appear that seismic velocity changes correlate with areal strain changes in Tokachidake where irregular patterns are recognized in seismic velocity changes at three frequency bands and at different station pairs.
Seismic velocity changes are estimated to be about 1 ~ 3 % at volcanoes during no eruptive periods. Some stations show the high correlation coefficient between areal strain and seismic velocity changes. We suggest that areal strain changes may affect seismic velocity changes.

Keywords: Seismic velocity changes, Seismic interferometry, Volcano deformation

