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Temporal changes of seismic velocity at Miyakejima associated with 2000 activity based on ambient seismic noise analyses

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Miyakejima Island is located about 170 km south of Tokyo, Japan. From the end of June, 2000, Miyakejima volcano experienced small submarine eruption that accompanied earthquake swarms, and formation of a caldera with diameter of about 1.6 km from July to August 2000. The volcanic gasses were continuously effused for more than four years. To study the volcano structure behavior associated with these volcanic activities, we apply cross-correlation analyses to the ambient seismic noise continuously recorded from July 1999 to December 2002 at four NIED seismic stations. The seismic data of short period (1 s) vertical components recorded with sampling frequency of 100 Hz and A/D conversion of 16-bit are filtered by three-order Butterworth filter at frequency bands 0.4-0.8 Hz and 0.8-1.6 Hz. We calculate cross-correlation function (CCF) with 60 s window length for every possible station pair, and then stack them every day (we call this stacked CCF as one day CCF). We also define a reference cross-correlation function (RCCF) for every station pair by stacking the CCFs from March to December 2002. This period is selected because significant eruptive activities were observed and no major instrumental errors were found for any of the four seismic stations considered. We further calculate the cross-correlation coefficient between the RCCF and the one day CCF, and then select good CCFs that have cross-correlation coefficient larger than 0.7 and lag time smaller than +/- 0.5 s. We pick travel times of the maximum amplitude of the wave packets at positive and negative lag times, which correspond to the travel time of Rayleigh waves between two stations, from the RCCF and the one day CCF. Calculating the average travel time difference for periods July 1999 - May 2000 and March - December 2002, we estimate temporal changes of the seismic velocity in the medium. At frequency band 0.4-0.8 Hz, we observe that station pairs surrounding the caldera show seismic velocity increase up to 1.8 +/- 2.6 %. Station pairs crossing or close to the caldera show seismic velocity decrease up to 2.2 +/- 11.6 %. At frequency band 0.8-1.6 Hz, we observe similar results except that the CCFs are not constructed well at station pairs crossing or close to the caldera. Spherical deflation sources determined by GPS data (Nishimura et al., 2002) can explain the seismic velocity increase observed at the volcano flank. By assuming a bulk modulus of $5x10^{10}$Pa, we estimate that the stress sensitivities of velocity changes are ranging from $1.4x10^{-3}$to $1.5x10^{-2}$/MPa. However, the observed seismic velocity decrease at station pairs crossing or close to the caldera cannot be explained by the deflation sources. This inconsistency may be explained by considering unknown pressure sources, seismic wave propagation across the newly formed caldera, or volcanic gas permeation into volcanic rocks.

Keywords: Miyakejima, Ambient seismic noise, Monitoring