Shallow crustal velocity structures obtained from ambient seismic noise study in the Aso caldera

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The Aso volcano is situated approximately in the central of Kyushu and is one of the most active volcanoes in Japan. There were four gigantic eruptions occurred and present caldera was formed about 89 ka known as Aso-4 eruption, with around 18 km in E-W and 25 km in N-S direction. Recently, the major volcanic activities focus on the post-caldera central cones, especially the first crater of the Mt. Nakadake. The conceptual volcanism and magma plumbing system of the Aso volcano were investigated with various geophysical and geodesic observations. The magma chamber is approximately spherical, located 3–4 km southwest of Mt. Nakadake (around Mt. Eboshidake) at depths of 6-10 km. Fumaroles and surface geothermal activities also expose in the southwest flanks of Mt. Eboshidake.

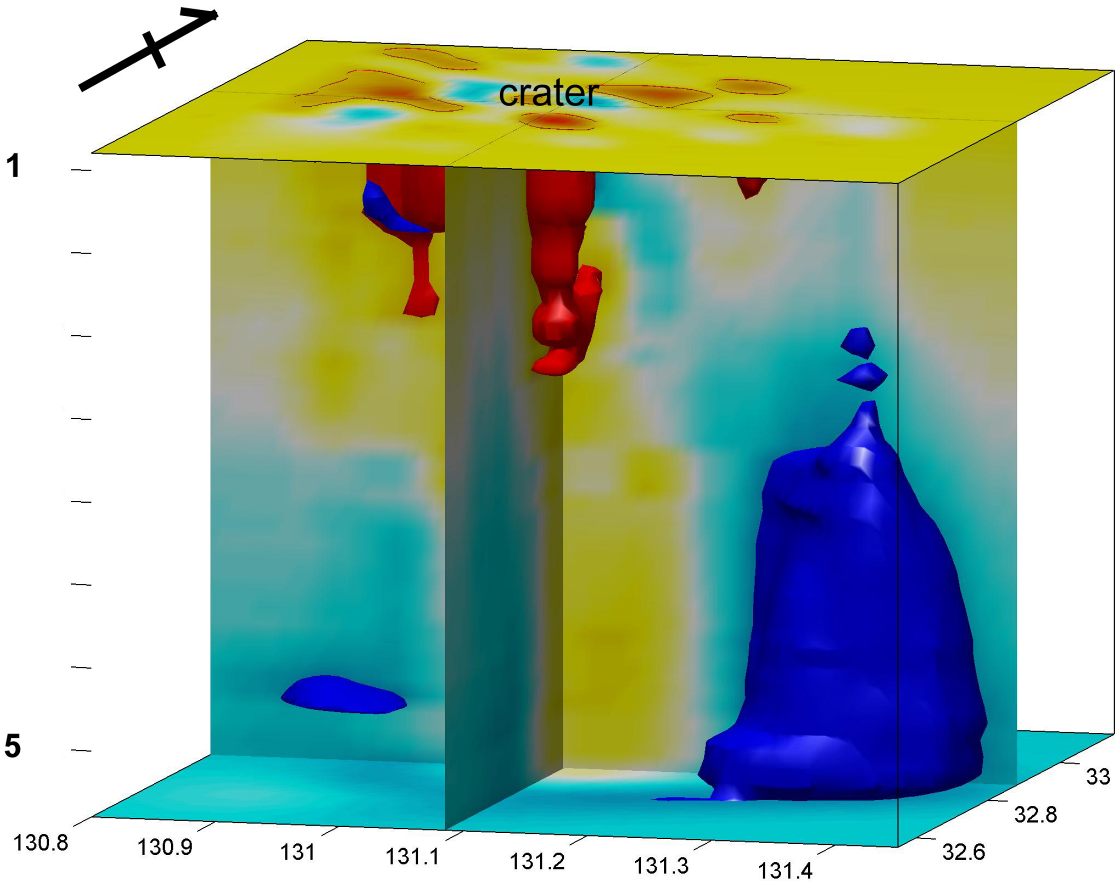
Analyzing ambient seismic noise signals has been routinely used to investigate the subsurface shear-wave velocity structure around the world in the past decade. Some studies also demonstrated it is possible to monitor the magma and hydrothermal fluid movement, or seismic velocity variations beneath active volcanos from the temporary changes of cross-correlation functions (CCFs). The seismic activities of Aso volcano have been monitored with around 20 broadband and short-period seismometers operated by Aso Volcanological Laboratory (AVL). The seismic dataset also included five permanent broadband stations operated by Japan Meteorological Agency (JMA) or National Research Institute for Earth Science and Disaster (NIED), which are located inside and surrounding the Aso caldera.

The interstation distances are much shorter (1-2 km) near craters on the Mt. Nakadake comparing with station-pairs surround the Aso caldera (10-20 km). Seismic data is daily vertical component between November 2009 and September 2013, i.e., before recent eruptions started on 25 November, 2014. Raw data were firstly transferred from WIN to SAC format and downsampled to 20 Hz. After primarily checking data quality, the daily CCFs were obtained in the 1-10 s period band for broadband station-pairs and 0.2-5 s for short-period station-pairs. Daily CCFs were stacked monthly, and then monthly CCFs were stacked again to further obtain Rayleigh wave phase velocity dispersion curves. The 2D and 3D phase velocity maps were mainly constructed in the 1-5 s period band and to determine the predominant velocity distributions.

Generally speaking, Rayleigh waves are sensitive at depths approximating one-third of wavelengths and vary with periods. Therefore, the sensitive depths of S-wave velocity structures ranged from approximately 0.7-5 km in this research. At most of periods, low velocities are dominant underneath the post-caldera central cones and the western portions of the Aso caldera, which might be corresponding to magma conduits and geothermal activities. High velocities are observed in the east of Mt. Nakadake and also the regions surround the Aso caldera, which might be related with much earlier volcanic activities that stopped recently.

The obtained velocity structures in this study can be as a reference, which were obtained with seismic data before latest eruptions. More recent seismic data should be easier to observe temporary variations of daily CCFs, which might be related to the movement of magma or hydrothermal fluid that cause temporary velocity structural variations in the shallow crust. More dense seismic stations might be required to image more detail 3D velocity structures and temporary variations.

Keywords: ambient seismic noise tomography, Aso caldera, shallow crust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