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Temporal changes of auto-correlation functions accompanied by crustal deformation for the eastern off-Izu seismic swarms

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In December 2009, a seismic swarm occurred off the east coast of Izu Peninsula, central Japan. The largest earthquakes during the swarm were two events with MJMA ˜ 5.0. For the whole period of the swarm, tilt record changes were observed at stations in the area. Such seismic swarms, accompanied by crustal deformation, occurred often in the region and are likely caused by magma intrusion from depth into the seismogenic crust [e.g., Okada et al., 2000]. NIED has started to record continuous seismic waveforms since 1990s. Recently, temporal changes of auto- and cross-correlation functions were reported before and after seismic and volcanic events in Japan [e.g., Wegler et al., 2009; Maeda et al., 2010] with continuous waveform data. Here we analyzed continuous auto-correlation functions (ACFs) to infer temporal changes of the velocity structure in the eastern off-Izu Peninsula region, before and after seismic swarms accompanied by crustal deformations. We then compare the velocity changes with tilt records, GPS measurements, and seismicity.

We used Hi-net stations to monitor ACFs of continuous seismic records. We divided the continuous waveform data of 100 Hz sampling into segments of 5 minutes length, removed the mean and trend, and applied 1-3 Hz band-pass filtering and one-bit normalization. The ACFs were calculated for each of the 5 minute segments and stacked for time intervals of one week to obtain stable records. The temporal changes of the ACFs versus time are analyzed by considering a reference ACF, which is the mean of the ACFs for a time period without major seismic swarms. The temporal changes of the ACFs were used to calculate the relative fluctuations of the velocity structure (dv/v) following a similar approach with Wegler et al. [2009]. The tilt records were obtained using high sensitivity acceleration seismographs, having the same locations as the Hi-net stations. The records were corrected for the tidal components using the BAYTAP-G software (Tamura et al., 1991). GPS data for this area were provided by GEONET of the Geospatial Information Authority of Japan.

By using the continuous waveform data, we have obtained ACFs since 2002. The record section of ACFs shows that there is a stable phase around 10 s in lag time. The dv/v estimations show a clear decrease associated with significant earthquake swarm activity. The decrease of the dv/v appears to have gradually recovered in several years. Because the noise level did not have specific changes associated with swarm activities except for a short period of several weeks after large events, the systematic velocity fluctuations for a long period detected using ACFs were not caused by changes in the noise characteristics. Crustal deformations detected with tilt record and GPS-measurement also appeared during the earthquake swarms and they correlate with the seismic activity. The processes of the decreases of the dv/v and its recoveries associated with seismic swarms and crustal deformations appeared in the 2006 and the 2009 eastern off-Izu seismic swarms. We interpret the velocity degrease as being caused by magmatic intrusions that are consistent with the crustal deformation measurements. The recovery process after the velocity decrease seems to have a longer time-span compared to the gradual return to the background level of seismicity and crustal deformations. The longer period of velocity recovery might be related to magma cooling processes.

Keywords: Auto-correlation function, temporal change, Izu Peninsula, seismic swarms, crustal deformation