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Temporal Changes of the Waveform Auto-correlation Properties Associated with the 2009 Izu Earthquake Swarm

Bogdan Enescu[1*], Kazushige Obara[1], Shiro Ohmi[2], Tetsuya Takeda[1], Youichi Asano[1], Tatsuhiko Saito[1], Tomotake Ueno[1], Katsuhiko Shiomi[1]

[1]NIED, [2]Disast. Prev. Res. Inst., Kyoto Univ.

Seismic noise interferometry (Sens-Schonfelder and Wegler, 2006) is one of the most promising seismological methods to detect possible temporal changes in the underground velocity associated with the occurrence of significant earthquake activity (e.g., Ohmi et al., 2008; Wegler et al., 2009; Maeda et al., 2009). The basic principle of the method is that the Green's function between two seismometers can be retrieved by cross-correlation of a random isotropic wave field sensed at both instruments (Sanchez-Sesma and Campillo, 2006). The auto-correlation function (ACF) of seismic noise recorded at a single station retrieves the source-receiver collocated Green's function.

Seismic swarm activity started in the eastern Izu Peninsula region, central Japan, from 17 December 2009. It was high in the first few days of the swarm, with two moderate events of M5.0 and M5.1, and had a relatively fast decay afterwards. We have analyzed the ACF properties of continuous waveforms recorded by four Hi-net seismic stations located relatively close to the epicentral region of the Izu swarm, from September 2009 to 27 January 2010. The waveform processing consists in: removing the mean and trend, band-pass filtering (1 to 3 Hz), cutting the continuous data at the length of one-hour, applying time-domain waveform normalization (Bensen et al., 2007) to reduce the effect of auto-correlating sources other than noise, computing auto-correlations and finally stacking the hour-long correlations for each day in the studied period. The stacked ACFs show a rather stable pattern until approximately the beginning of the seismic swarm, followed by a coherent time-shift of the ACFs that gradually recovers with time to the pre-swarm pattern. The ACFs temporal changes are particularly clear at ITOH station, which is closest to the epicentral area of the swarm, especially on the vertical component.

Since the time-shifts are delays of various ACF phases, we can interpret them as velocity decrease associated with the swarm activity. While the ACFs changes in the first few days of the swarm could be "contaminated" by the intense earthquake activity, it is likely that the gradual, rather smooth recovery that follows reflects changes of the underground velocity since the earthquake activity is much decreased for the later times. The observed changes are clearer for auto-correlation lag times from 6s to 8s. If we assume observing changes in the S-wave velocity, the velocity decrease takes place in a circular shell with a radius of about 10-15 km. The swarm activity migrated from the deeper (about 8 km depth) to shallower part (Asano, 2010) and suggests magma migration as a possible triggering. This is consistent with observed tiltmeter changes that indicate deformation at depth. Thus, our observations could be a consequence of velocity changes due to magma migration. The relatively fast recovery might reflect the end of magma supply and its fast solidification. To assess the robustness of such changes we are analyzing continuous waveforms for longer time periods.

Keywords: seismic noise interferometry, earthquake swarm, temporal changes of seismic velocity, magma migration