Temporal variations of seismic velocity and azimuthal anisotropy in near-surface rock and soil at KiK-net downhole array sites

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Measuring stress and damage induced seismic velocity and anisotropy in crustal structure and their temporal behaviors provide insights into the underlying mechanisms of healing processes and its evolution, which would lead to a better understanding of earthquake cycle. We analyze three-component surface and borehole seismic data collected by KiK-net (Kiban-Kyoshin Net) to explore temporal variations in P- and S-wave velocity and S-wave azimuthal anisotropy (strength of anisotropy and polarization direction of the fast S wave) through coda wave interferometry. Our preliminary focus is on Hokkaido sites that experienced ground motion from the 2003 magnitude (M) 8.3 Tokachi-Oki and the 2018 M 6.0 Hokkaido Eastern Iburi earthquakes. Following Chen et al. (2017, EPSL), we analyzed all available KiK-net seismic waveforms in a frequency band of 1-15 Hz from 1997 through 2018 (more than 700 events) and evaluated seismic velocity and azimuthal anisotropy between surface and borehole sensors at 22 KiK-net sites. Median P- and S-wave velocity stacked by all measurements at each site are good agreement with them obtained from borehole logging data provided by NIED (National Research Institute for Earth Science and Disaster Resilience). We find that a number of KiK-net sites recording peak ground acceleration (PGA) higher than ~500 cm/s^2 (at surface sensor) exhibit clear S-wave velocity reductions following the 2018 Hokkaido Eastern Iburi mainshock. Station IBUH03 (located at Atuma town) also shows a sudden decrease of S-wave velocity following the 2003 Tokachi-Oki earthquake (PGA = ~350 cm cm/s^2 at station IBUH03). Reductions of S-wave velocity were about 6.5% for both mainshocks. However, there are a number of differences between two earthquakes. Our preliminary analysis suggests that the polarization direction of fast S-wave was systematically changed from 50 degrees to 10 degrees (measured clockwise from the north) following the 2018 earthquake and no notable change of P-wave velocity was observed. On the other hand, for the Hokkaido earthquake case, station IBUH03 appears to have a large variability in the polarization direction and displays a P-wave velocity reduction of about 4.5%. Our observation suggests a temporally increase of randomly oriented fractures following the 2003 Tokachi-Oki earthquake and also may suggest that the stress changes from the 2018 Hokkaido Eastern Iburi earthquake created water-saturated cracks oriented at ~10 degrees from north.

