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New insight into the postseismic deformation of the Mw 9.0, 2011 Tohoku-oki earthquake from seismic noise-based monitoring

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Studying the mechanical response of the crust to large earthquakes provides unique insight into the processes of deformation in preparation for future earthquakes. Noise-based seismic velocity monitoring can directly probe the mechanical state of the crust at depth continuously in time. In this work, we study the deformation of the crust concerning the Mw 9.0, 2011 Tohoku-oki earthquake. In addition to the Hi-net short period sensors, we employ here for the first time for the noise-based monitoring the particular dense network of Hi-net tiltmeters as long period (8 – 50 s) seismometers to sample the crust below 5 km depth. Spatial distribution of strong velocity decreases at short periods can be limited to strong ground shaking induced by the 2011 Tohoku-oki earthquake, while the long period velocity changes correlate well with modeled static strain induced by viscoelastic relaxation and afterslip at depth. This observation indicates that the variations at depth are not a spurious effect of changes in the shallow layers. The amplitudes of coseismic velocity changes diminish with increasing depth. The temporal evolution of velocity changes at different depth shows that the maximum drops of velocity at greater depth are delayed in time with respect the date of the earthquake. This delay could find its origin in both the visco-elastic response of the crust to substantial strain changes or a complex response of crustal seismic velocities to transient deformation.