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Temporal variation of crustal structure around the 2008 Iwate-Miyagi Nairiku earthquake by cross-coerrelation analysis

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Seismic interferometory can reproduce the Green's function between two receivers by calculating cross-correlation of ambient noise and/or coda measured at their locations. For example. we obtained spatial variation of shallow seismic velocity structure in and around the focal region of the 2008 Iwate-Miyagi Nairiku earthquake (Takagi et al., SSJ Meeting, 2009). Interferometory of ambient noise also can make it possible to monitor subsurface structure. For examples, Weglar et al. (2009) shows coseismic drop at 2004 Mid-Niigata earthquake. In this study, we analyzed continuous data observed at dense network to detect temporal change of seismic velocity at the occurrence of the 2008 Iwate-Miyagi Nairiku earthquake.
Data were vertical components of ambient noise at 34 routinely-oparated seismic stations (Hi-net, JMA, Tohoku Univ.) in the central Tohoku. Period of data that we analyzed is 16 days before and after the earthquake. 207 pairs of two stations are made to calculating cross-correlation functions (CCFs). Daily CCF for each pair is computed by stacking cross-correlation functions of ambient noise over 1 day. Spectral whitening are applied to raw data before calculating cross-correlation functions.
We estimated temporal change of seismic velocity from running average of daily CCFs using the stretching method. The relative change of velocity, dv/v, is estimated from grid search by calculating correlation coefficient between a CCF whose time axis is stretched or compressed and the reference CCF. The frequency ranges that we use are 0.5-1.0 Hz, and 0.25-0.5 Hz. In the two ranges, most CCFs of station pairs show sudden drop of seismic velocity at the time of the present earthquake and the amplitude of velocity decrease are up to -0.7 %. Note that some pairs show sudden increase of seismic velocity.
We also estimated the distribution of coseismic change of relative velocity by the same method as above from 16-day stacked CCFs before and after the Iwate-Miyagi Nairiku earthquake. The decreases are up to -0.7 % in the two frequency ranges for most of station pairs. The increases are up to +0.3 % for some of station pairs. The absolute amplitude range of the coseismic changes obtained in this study is consistent to the result of Weglar et al. (2009). Generally, coseismic velocity change is estimated in the focal region. In details, large decreases are detected near the fault zone and a few increases are estimated around the fault zone.
Possible interpretations of the velocity decrease in and near the fault zone are follows: (1) damage of fault zone, (2) migrated water after the main shock, and (3) nonlinear response at shallow layer. (1) Damage of fault zone due to new creation of fractures can explain the decrease of seismic velocity. (2) Migration of overpressured fluid after the main shock might decrease seismic velocity in and around the fault zone (Sibson, 1992). Low velocity zone is detected by tomography at a deep portion of the fault (Okada et al, 2009), which might be an evidence of existence of fluid. (3) Strong ground motion cause non-linear behavior of subsurface structure especially in shallow sedimentary layer. Decreases of velocity are anticipated by these models.
Another factor which changes the seismic velocity is static stress change by the earthquake. Static stress change by the fault motion can explain not only decrease but also increase of seismic

velocity. However, the spatial comparison between the spatial pattern of static stress change by the fault motion and that of velocity changes do not show correspondence. Therefore, static stress change is difficult to explain the major part of observed velocity changes.
As conclusions, time-dependent analysis of ambient noise show coseismic changes of velocity at the 2008 Iwate-Miyagi Nairiku earthquake. The coseismic change of velocity of about -0.7 to +0.3 % are observed. Several different factors contributed the changes of seismic velocity.