Temporal Variation in Seismic Velocity Accompanied by 2011 Tohoku-Oki Earthquake and the Slow Slip Event, on Seismic Interferometry of Ambient Noise

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Seismic interferometry is one of the most effective techniques to detect temporal variations in seismic velocity before or after a large earthquake. Some previous studies have been reported on seismic velocity reductions due to the occurrences of large earthquakes (e.g., Wegler et al., 2009; Yamada et al., 2010) and preceding them (e.g., Lockner et al., 1977; Yoshimitsu et al., 2009). However, only a few studies accompanying slow slip events have been conducted.
Between the end of January and the occurrence of the largest foreshock on March 9 that preceded the 2011 Tohoku-Oki earthquake, slow slip events and low-frequency tremors were detected off Miyagi (Ito et al., 2013, 2015; Katakami et al., 2016). We apply seismic interferometry using ambient noise to data from 17 OBSs that were installed above the focal region before the 2011 Tohoku-Oki earthquake. All OBSs with three components are short-period seismometers with an eigenfrequency of 4.5 Hz that were deployed off Miyagi between November 2010 and April 2011. Before the analysis, we estimated the original deployment orientation with two horizontal components for 13 OBSs, by using particle orbits of some direct P waves from natural earthquakes, to analyze one vertical and two horizontal components. The method is as follows. First, we applied a band-pass filter of 0.25-2.0Hz in the frequency domain, and compared this with a one-bit technique in the time domain to the ambient noise signal. Second, we calculated Auto-Correlation Coefficients using a 5-s time window with lag time from -30 s to 30 s at intervals of 0.1 s, using seven continuous days of waveforms to make a daily ACF. Third, we stacked up all daily ACFs for the entire time period, to make a reference ACF. Finally, we calculated the Correlation Coefficients between the one-day ACF or the 16-day ACF and the reference ACF.
The results are follows. At all OBSs, the 16 days' CC declined after the SSE initiated and then it recovered in the latter half of the SSE duration. In the region of SSE occurrence, the difference between the absolute and incremental reduction in the 16 days' CC is small. However, in the area of the largest foreshock, the difference is significant. The former 16 days' CC values are suddenly decreasing before the SSE, and the latter 16 days' CC values are gradually decreasing starting around November, or around four months before the largest foreshock. The small difference could be related to the occurrence of SSE, while the large difference could be related to critical conditions preceding the largest foreshock.

Keywords: seismic interferometry, ambient noise

