Spatio-temporal variations in coda attenuation associated with the 2011 Off the Pacific Coast of Tohoku, Japan (Mw 9) Earthquake

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The spatial and temporal variations in coda attenuation (Q_C^{-1}) were studied in the source region of the 2011 Off the Pacific Coast of Tohoku, Japan (Mw 9) earthquake. The Q_C^{-1} values were determined from the amplitude decay rate of the S-wave coda window of 35 sec starting at 1.2 times S-wave arrival ($1.2t_S$) in five frequency bands from 1.5 to 24 Hz based on single isotropic scattering model (Sato, 1977). We analyzed about 1000 vertical component seismograms of more than 300 earthquakes (M_{JMA} 3~6.5) in the region recorded by the Japanese strong motion network K-NET in a period from January 2005 to June 2011 including pre- and post-seismic period. The change in Q_C^{-1} is stable with a small change of 10-15% during the pre-seismic period, while it increases significantly (~10-25%) after the 2011 Tohoku event in *f*=1.5-24 Hz. This change may be attributed to increased crack density, such as due to increase in stress induced by the earthquake. A model of heterogeneity with dominant scale length of *a*=0.3-1.5 km in *f*=1.5-6 Hz enhanced by increased stress change of 0.01 MPa due to the 2011 event possibly controls the increased Q_C^{-1} near the source rupture region. The average $Q_C^{-1}(f) = (0.014 \pm 0.002) f^{-(1.0 \pm 0.01)}$, in comparison with other parts of northeastern Japan, typically exhibit high values Q_C^{-1} at 1 Hz and a strong dependence on frequency. The Q_C^{-1} value determined from a seismogram depends on the position and length of coda window, which can be attributed to the effect of multiple scattering and/or focal depth. We showed that the effects of position and length of coda window are minimum in observed variation of Q_C^{-1}. The variation in Q_C^{-1} is small among the stations on northern and southern parts of the source rupture area and is not correlated with the station locations and can therefore not be ascribed to the change in the site effect at each station. The observed variation in Q_C^{-1} among them is attributed to the different sampling regions of coda waves during their propagation, indicating that there may exist lateral variations in the attenuation properties of the lithosphere in the studied region. Further Q_C^{-1} analysis outside the source rupture area, using seismic waves that propagate through both the focal region and the surrounding region, is necessary to examine its spatial variation induced by the 2011 event, which is planned in our ongoing study. Because temporal differences are observed by stations at different azimuths and are highly correlated across all frequency bands, we believe that our results are valid estimates of the relative Q_C^{-1} values as a function of time and space in the source area of the 2011 Tohoku-Oki main shock. Finally, monitoring of Q_C^{-1} can be considered a reliable indicator of a stress change in the crust.