D-region periodic oscillations observed in LF transmitter signals after the 2011 off the Pacific coast of Tohoku Earthquake

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So far, a lot of studies for the F-region ionosphere associated with post-earthquake phenomena have been reported, although few studies for the D-region ionosphere have reported. It is difficult to observe the D-region electron density by MF/HF radio sounding method such as ionosondes, because the MF radio waves are highly attenuated in daytime D-region, and HF radio waves penetrate into the D-region in both night and day. In this study, we investigate the D-region disturbances associated with the 2011 off the Pacific coast of Tohoku Earthquake using intensity and phase of LF transmitter signals. The phase was converted to the reflection height of the waves based on Earth-ionosphere waveguide mode theory. The reflection height corresponds to electron density in the D-region. The propagation paths are Saga -Rikubetsu (RKB) over Japan and BPC (China)-RKB (Japan). Clear oscillations of the intensity over both propagation paths were simultaneously observed about 372 seconds after the earthquake onset. Both the intensity and reflection height show oscillations with a period of about 100 s. The one-to-one correspondence between the intensity and reflection height was not seen clearly. The changes of the intensity and reflection height for the oscillations were about 0.1 dB and 50 - 65 m, respectively. The time difference between the earthquake onset and the 100 s-oscillations was consistent with the propagation time of the Rayleigh waves (seismic waves) propagating from the epicenter to the LF propagation paths along the Earth surface, plus the propagation time of acoustic waves propagating from the ground to 68 km altitude vertically. Thus, the LF oscillations of the 100 s may be caused by the acoustic waves excited by the Rayleigh waves. In addition to the oscillations of the 100 s, the periods of a few tens to 1000 s were identified based on Wavelet analysis in both the intensity and phase of the two LF transmitter signals. In vertical velocity of seismic waves observed in HID (Hidaka, Hokkaido) station of NIED F-NET Broadband Seismograph Network, the similar periods of 10 – 1000 s were seen in the Wavelet spectra. In the presentation, we will also show the squared coherence of the LF transmitter signals and the seismic waves.