D-region ionospheric signatures observed in LF standard radio waves 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 around 70 km altitude by MF/HF radio sounding method such as ionosondes, because both MF and HF radio waves penetrate at 70 km altitude in both night and day. In this study, we investigate the D-region signatures associated with the 2011 off the Pacific coast of Tohoku Earthquake using intensity and phase of LF standard frequency and time signals (SFTSs). The propagation paths are JJY Saga (60 kHz, SAG) -Rikubetsu (RKB) and BPC (68.5 kHz, China)-RKB (Japan). Both transmissions mainly propagate over the Japan Sea. Clear oscillations of the intensity over the SAG-RKB propagation path were observed about 372 seconds after the earthquake onset. The period of the oscillations was about 100 s. The oscillations in the phase were not seen clearly. The amplitude of the oscillations were about 0.1 dB. On the other hand, small oscillations of the intensity with the similar periods were found in BPC-RKB signal. The time difference between the earthquake onset and the SAG-RKB 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 about 70 km altitude vertically. The occurrence time of the observed 100-s oscillations was agreement with a numerical simulation of acoustic wave propagation. By considering the propagation delay of the Rayleigh waves at individual radio wave reflection points, observation of the LF signals was shown to be consistent with the simulation using the wav-hop radio propagation theory. Thus, we conclude that the origin of the LF oscillations of the 100 s was the Rayleigh waves. In the presentation, we will discuss the amount of change of the D-region electron density during the LF oscillations.