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D-region ionospheric oscillations measured by LF transmitter observations 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 earthquakes 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 techniques 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 (Magnitude: 9.0) using intensity and phase variations of LF transmitter signals. The reflection height of the signals estimated from the phase variations corresponds to the electron density in the D-region. The propagation paths are Saga -Rikubetsu (RKB) over Japan and BPC (China)-RKB (Japan). As a result, two kinds of oscillations were detected over both propagation paths after the mainshock: one was clear oscillations of the intensity with a period of about 100 s observed about 6 minutes after the mainshock, and the other was 30-90 s oscillations of the intensity and phase about 17 minutes after the mainshock. 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 vertical propagation time of acoustic waves propagating from the ground to a 68-km altitude, which is estimated based on neutral atmosphere simulation. Thus, the LF oscillations may be caused by the acoustic waves excited by the Rayleigh waves. In the presentation, we will discuss the cause of the LF oscillations in more detail.