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D-region Ionospheric Oscillations Measured by LF Transmitter Signals after the 2011 Off the Pacific Coast of Tohoku Earthquake

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1. Introduction

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.

2. Observations

The Tohoku Earthquake occurred off the coast of Japan (38.10◦N, 142.86◦E) at 05:46:18 UT on 11 March, 2011. Two propagation paths of LF transmitter signals were JJY (Saga, 60.0 kHz) -Rikubetsu (RKB) and BPC (China, 68.5 kHz)-RKB (Japan). The minimum distances of the propagation paths from the epicenter were 430 km and 562 km, respectively. In addition, the vertical velocity components of seismic waves of the NIED F-net data were used for the comparison to the LF transmitter signals.

3. Results

Two kinds of the LF oscillations were detected over both propagation paths after the mainshock: one was clear oscillations of the intensity and phase 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 phase (the 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 100-s oscillations may be caused by the acoustic waves excited by the Rayleigh waves. In the session, we will discuss the cause of the 30-90 s oscillations.

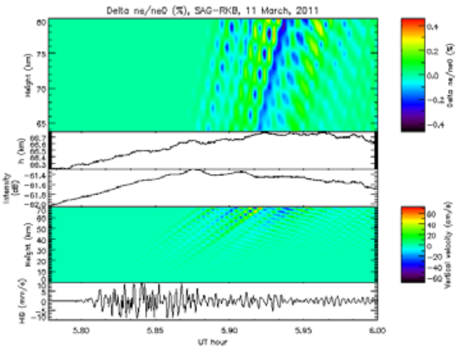

Figure 1. From the upper panel, *delta ne/ne0* (%) by the simulation, the height, *h* (km) and intensity (dB) of SAG-RKB path, the vertical velocity (cm/s) of the neutral atmosphere by the simulation, and the vertical velocity (mm/s) of the seismic waves at HID station close to the LF receiver.