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Automated estimation of electron density profile in the lower ionosphere by the radio wave propagation characteristics

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SRP-5 sounding rocket was launched from Poker Flat Research Range, Fairbanks, Alaska at 14:17 LT on January 10, 2009. The primary science objective of SRP-5 Project is to measure the plasma density profile of the polar D region ionosphere above Poker Flat Research Range, which was carried out with using a plasma probe, radio receivers, and other sensors. The objective of TPU (Toyama Prefectural University) radio receiver is to investigate the electron density profile in the polar D region at daytime. The electron density profile in the lower ionospheric region is estimated from the absorption of three radio waves observed by SRP-5 sounding rocket.

We observed three different radio waves, CHENA (257 kHz), KFAR (660 kHz) and KCBF (820kHz), transmitted from navigation and broadcast stations near Fairbanks, Alaska. They were successfully observed from the altitude 0 to 98 km during the ascent flight. The receiver observed magnetic field intensities and waveforms down converted to about 100 Hz. During the rocket ascent, up to about 150 seconds, the intensities of these radio waves attenuate gradually with increasing time, until they reach the system noise level of the receiver at about 110 seconds. These attenuations are due to collisions between the electrons and the neutral molecules in the lower ionosphere. On the other hand, the spectra of three radio waves are obtained by FFT (Fast Fourier Transform) from the waveforms. These spectra branch into two after launch, since the frequencies of the polarized waves are affected by the rocket spin.

The approximate electron density profile can be estimated from the comparison between these observation results and propagation characteristics calculated with Full wave method. The estimated electron density profile suddenly increase then decrease at the altitudes between about 80 and 90 km. The magnetic intensity, calculated with Full wave method from this electron density profile, are almost the same as the experimental results. In addition, we are going to distinguish the right- and left-hand polarized waves from the spectra of observed three radio waves, and estimate more detailed electron density profile in the lower ionosphere below 65 km.

This estimation process has some problems. At first, we have no clear standard for comparing observation results and propagation characteristics calculated with Full wave method. In addition, we have to iterate many times correcting the electron density profile by handwork, calculating propagation characteristics with Full wave method and comparing observation results and calculated propagation characteristics. This iteration takes too long to estimate appropriate electron density profile. To reduce these problems, we are going to develop a application to realize automated estimation of electron density profile by the radio wave propagation characteristics analysis.

Keywords: radio wave propagation characteristic, electron density profile, ionosphere, sounding rocket measurement