Analysis of propagation characteristic of MF band radio waves observed by S-310-40 sounding rocket

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Receiving AM radio broadcast in the ground, we can receive a distant broadcast at night that cannot receive it in the daytime. This is because D layer disappears at night, MF band radio waves which have been absorbed by D layer are reflected by E layer and MF band wave propagates in the distance.
We observed radio wave of NHK Kumamoto 2nd broadcasting (873 kHz) which can be received ordinarily in the night at Uchinoura Space Center during the period from November 24 to November 28, and also we measured the radio wave from after sunset to before sunrise. As a result, we found time that radio wave intensity has been decreased sharply during from 2 to 4 hour after sunset, and we confirmed that 873 kHz radio waves cannot be received at that time. As one of the reason, we guessed that a region of high electron density occurred on lower ionosphere at night. Therefore, we launched S-310-40 sounding rocket at Uchinoura Space Center on 19 December 23:48 (JST), in order to investigate an abnormal radio wave propagation at night. The rocket was equipped with LF/MF band radio receiver (LMR). The LMR received 4 radio waves of 873 kHz, 666 kHz, 405 kHz, and 60 kHz. Moreover, this rocket carried the Fast Langmuir Probe (FLP), the impedance probe (NEI) too. In this study, we investigate the propagation characteristics of radio waves and estimate the electron density profile by the intensities of 873 kHz and 60 kHz radio waves. In addition, we compare the electron density estimated from LMR and the electron density observed by FLP and NEI. In the propagation characteristics of radio wave, we calculate the propagation vector of radio waves by using a Doppler shift frequency calculated from characteristic wave components obtained by frequency analysis. Radio waves received by the sounding rocket are influenced by polarization, the magnetic field of the Earth, and Doppler effect. Therefore, it is possible to obtain characteristic wave components by the frequency analysis, and then we can calculate the Doppler shift frequency. Next, we solve the Booker quartic equation by using Doppler shift calculation, and estimate electron density profile. Consequently, we can obtain the propagation characteristic of radio wave when radio waves propagated unusually, and we can estimate electron density in ionosphere. Additionally, we confirm validity of the estimation result of electron density by change in roots of the quartic equation to electron density. We investigate the cause of abnormal propagation of MF band radio waves by the estimation result of electron density.