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Study of the ionospheric plasma density structure observed by topside sounder on board the EXOS-D (Akebono) satellite

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The electron number density, electron and ion temperature of the ionospheric trough in the polar ionosphere has been investigated based on the analysis of data obtained by Plasma Wave detectors and Sounder (PWS) system onboard the EXOS-D (Akebono) satellite.

Stimulated Plasma Wave experiments (SPW), one of the subsystems of PWS, enables us to conduct topside sounding of the ionosphere and to measure the excitation of plasma resonances in the surrounding plasma [Oya et al., 1990]. In operation of SPW in H-band normal sweep mode, RF pulse is transmitted with a swept frequency ranging from 0.3 MHz to 11.4 MHz within 32 sec. We measure the frequency and delay time of each echo found in the ionograms. We then divide the topside ionosphere into multiple plasma layers, and determine group velocities in them, which are to be consistent with measured frequency and delay. Finally, we can obtain the plasma density distribution of the topside ionosphere.

First, we analyze ionograms obtained by SPW in the region nearby European Incoherent Scatter (EISCAT) radar at (69.58 N, 19.23 E) (Tromso, Norway). We identified two events of ionospheric trough, in which the plasma density is depleted. One is found at (65 N, 15 E) on Feb. 28, 1995 (hereafter called ”Event 1”), and the other is found at (70 N, 35 E) on Mar. 1, 1995 (hereafter called ”Event 2”). We also analyze simultaneous EISCAT UHF radar data with EXOS-D observations and find no density depletion in the radar data.

Next, we derive the vertical profile of the scale height inside and outside the inospheric trough from the vertical profile of the electron number density. The derived scale height at 500 km altitude inside the ionospheric trough of these 2 events is 20 % less than that outside the ionospheric trough. Assuming that the distribution of electrons and ions can be explained by the diffusive equilibrium of the bipolar diffusion, we estimate the sum of electron and ion temperature from the scale height. The estimated temperatures are 3730 K inside the trough and 5070 K outside the trough found in Event 1, and 3290 K outside the trough and 2940 K inside the trough in Event 2. These results indicate that the plasma temperature in the identified plasma depletion region is lower than that in the surrounding region. Based on the explanation that the frictional heating increase the plasma temperature, and cause the plasma density depletion by the enhanced dissociative recombination, the plasma temperature in the trough have to be higher than that outside the trough. The results do not agree with the expectation. However, in Event 1, the estimated plasma temperature in the trough is higher than the plasma temperature (about 3000 K) obtained from IRI-2012 model at the observed local time. So we can consider also that the plasma temperatures both inside and outside the trough was higher than normal background ionospheric temperature. We also discuss the dependence of the temperature inside the trough on other control factor such as composition of ionospheric plasma, and unsteady control factor such as the geomagnetic activities.

Keywords: ionosphere, topside sounder, trough