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Electron densities in nighttime D-region ionosphere at the low-mid latitudes during severe magnetic storms by tweek atmospherics

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Nighttime electron density variations in D-region ionosphere at the low-middle latitudes during magnetic storms have not been known in detail, because it is difficult to measure them regularly below 100 km height. The D-region height is too low for satellite measurements. Ionosondes and incoherent scatter radars using HF-VHF frequency range cannot receive echoes from the D-region ionosphere with lower electron densities less than 1000 el./cm^3.

We propose to use tweek atmospherics for the measurement of nighttime electron densities in the D-region ionosphere. Tweek atmospherics are characteristic signals caused by that ELF/VLF electromagnetic waves originated from lightning discharges propagate in the Earth-ionosphere waveguide mode over long distance. Usually, 150-200 tweeks per one minute are received in nighttime in low-mid latitudes. On the extraordinary mode propagation of tweeks, reflection altitudes of tweeks represent equal electron densities (20-30 el./cm^3). The purpose of this study is to investigate electron density variations in the D-region ionosphere during magnetic storms by the use of tweeks, LF (40 kHz) radio waves and MF radars. The intensity and the relative phase data of LF radio waves propagating over Japan, and electron density data by the MF radars are used for evaluation of the tweek method.

The received points of tweeks are Moshiri (geographic coordinate, 44.37N, 142.27E) and Kagoshima (31.48N, 130.72E) in Japan. The transmitter of 40 kHz radio waves is located at Fukushima (37.37N, 140.85E) and the received point is Kagoshima. The path length is 1170 km and the middle point is (34.43N, 135.79E). The sky and ground waves have nearly same amplitude in such case, and cause a typical interference pattern with maxima and minima of the recorded total field strength. The MF radars are located at Wakkanai (45.36N, 141.81E) and Yamagawa(31.20N, 130.62E).

On the analysis of the tweek signals, we fit the signals to the dynamic spectrum by the least-mean-square method and then determine three parameters; the cut-off frequency of the first order mode, the propagation distance and the propagation time. The apparent reflection height is calculated from the cut-off frequency, assuming that incident angle of a tweek to the reflection surface is nearly zero on the first-order mode cut-off frequency. Source positions of tweeks are determined by crossing of two propagation distances from Moshiri and Kagoshima by a spherical triangulation method, which are confirmed by the Lightning Imaging Sensor (LIS) data by TRMM satellite and cloud distribution data by GMS satellite.

The events analyzed are in the periods of October 2-12, 2000, April 11-15, 2001 and November 24-27, 2001. Dst-index minimum of these periods were around -200 nT. The reflection heights of tweeks of usually 85-91 km altitudes in quiet days changed to 79-84 km altitudes in the main phase for two severe magnetic storms (October 2-3, 2000 and November 24, 2001).

Simultaneously the intensity and the relative phase of 40 kHz radio waves were disturbed. These results indicate that the tweek mothod is useful for detection of global disturbances in D-region ionosphere.

Tweek reflection heights and electron densities at the reflection heights are reasonable agreement with MF radar results. We will present more detail comparison tweek reflection heights with MF radar data in the session.