Global investigation of low-latitude D-region disturbances by MF/LF/VLF/ELF waves observations

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Tweek atmospherics are VLF/ELF electromagnetic waves that are originated from lightning discharges and propagate in the Earth-ionosphere waveguide over long distance. The aim of almost tweek studies was the clarification of their propagation mechanism. However, we used tweeks for the estimation of nighttime electron density in the D-region at mid-low latitudes, based on the theoretical consideration that the electron density at the reflection point is estimated from extraordinary mode (Shvets and Hayakawa, 1998). The advantage of tweek observations is that electron density at the bottom of the D-region ionosphere can be measured in wide sea area surrounding the Japan Island. Here we estimate of the electron density and thus reflection height in the D-region ionosphere at mid-low latitudes during magnetic storms.

Tweeks are observed at Moshiri Observatory (Geographic coordinate, 44.37N, 142.27E) and Kagoshima Observatory (31.48N, 130.72E) which is belonged to Solar-Terrestrial Environmental Laboratory in Nagoya University, Japan.Tweeks are recorded at magnetic tape in the time-period of 2 minutes every hour. The 2-minute data are regarded as the representative during one hour. The Earth-ionosphere waveguide model over the flat surface is adopted for analyzing tweeks. Dynamic spectrum of tweeks is fitted to the theoretical frequency-time curve by the least square method and we estimate the reflection height and the propagation distance of tweeks in the first order mode. Locations of lightning discharges are obtained by a triangulation of the propagation distance from the two observatories and are confirmed from Lightning Imaging Sensor data, Optical Transient Detector data and the cloud distribution by the Meteorological satellite HIMAWARI.We assume that tweeks of the first order mode reflect at the middle point of the propagation path, and obtain average reflection height every 10 degrees mesh in geographic latitude and longitude. Applying our data to the electron density-the cut off frequency equation and calculating the electron density, it is estimated that the electron density at this reflection height is 20-30 electrons/cm3.This electron density is in agreement with the one at the bottom of the D-region ionosphere according to the IRI-95 model. All reflection points of tweeks are regarded as an equal electron density surface because they are in range of the electron density 20-30 electrons/cm3. Further, we assume that when the electron density increases (decreases) in the D-region, the bottom height of the D-region ionosphere falls down (rises up), keeping the shape of the electron density profile of IRI-95 model. That is, the electron density profile of IRI-95 model is referred because the profile cannot be obtained from the reflection of tweeks that corresponds to the equal electron density.

We analyzed the variations of nighttime D-region electron density during three magnetic storms: (1) April 11-17, 2001, (2) November 5-9, 2001 and (3) November 24-27, 2001 (in UT). The maximum of Dst index was (1)-251 nT (April 12, 2001), (2)-257 nT (November 6, 2001) and (3)-225 nT (November 24, 2001), respectively. As a result, the reflection height could be estimated in the range of 60-110 km altitude. Moreover, the region of the lower reflection height could be decided. In particular, the reflection height (65-70 km) was lower than usual one around Japan Island at 14:50-52 on November 24,2001(UT). At the same time, the intensity and the phase of 40 kHz radio waves (the propagation path; Fukushima-Kagoshima) were disturbed. It is considered that the electron density increased in D region around Japan Island in a wide area.The detailed analysis results will report in this session. The comparison of the tweek observations with the electron density measurements by MF radar will be presented in this session.