Variations in the reflection height of tweek atmospherics in the D/E-region ionosphere during the solar cycle 21

Hiroyo Ohya[1]; Kazuo Shiokawa[2]; Yoshizumi Miyoshi[3]
[1] Graduate School of Eng.,Chiba Univ; [2] STELAB, Nagoya Univ.; [3] STEL, Nagoya Univ.

The aim of this study is to investigate variations in reflection height of tweek atmospherics during the solar cycle 21 (1976-1986). Tweeks are VLF/ELF signals (1.5 - 10 kHz) that originate from lightning discharges and propagate in the Earth-ionosphere waveguide over several thousands of kilometers (the average distance is about 5000 km). The frequency of tweeks falls from 10 kHz to 2 kHz during about 50 ms. Horizontal (E-W) magnetic field component of wideband VLF/ELF signals has been received with loop antennas at Moshiri and Kagoshima, Japan, by the Solar Terrestrial Environment Laboratory, Nagoya University, over 33 years since April 1976. Tweek are usually received only at night, when attenuation by the ionosphere is negligible. On average, about 100 tweeks are received per minute at night. The equivalent electron densities at the reflection heights are theoretically 20-28 cm^{-3}. The reflection heights are calculated from the cut-off frequency for the first-order mode. We consider that the descent (rise) of the reflection heights corresponds to the increase (decrease) in the electron densities.

So far, there were no sufficient data to investigate solar cycle variations of the nighttime sub-ionosphere below 100 km heights, although daytime electron density profiles are known by rocket experiments. Here we present variations in the reflection heights of tweeks obtained at Kagoshima (31.48N, 130.72E) on April, both in 1976 and 1979. The solar minimum and maximum were March 1976 and December 1979, respectively.

We automatically estimated the reflection heights (h) and the propagation distance (d) of tweeks by fitting a theoretical curve to the tweek dynamic spectrum obtained by the maximum entropy method. Figure 1 shows an example of the automatic estimation for the tweek data obtained at 20:51 JST on April 17, 1979. Dots and the curve indicate automatically estimated frequencies on the tweek and the fitting curve, respectively. It appears that the automatic procedure can detect the frequencies of the tweek well. The estimated h and d were 93.8 km and 7769.5 km, respectively. In this presentation, we will show the results of the tweeks for both April 1976 and 1979 during geomagnetically quiet nights to avoid the effects of seasonal variations and the geomagnetic activities. 2834 tweeks obtained from 1950 JST to 0450 JST were automatically analyzed. The estimation errors of the h and d were +1.7 % and +5.3 % when the noise level is zero, respectively. Using these data, we will discuss the variations in the reflection heights during the solar cycle 21.