Automated detection of mid-latitude sporadic E using GPS-TEC ROTI data

*Masahiro Takahi[1], Keisuke Hosokawa[1], Jun Sakai[2], Susumu Saito[3]

1. Department of Communication Engineering and Informatics, University of Electro-Communications, 2. Center for Space Science and Radio Engineering, University of Electro-communications, 3. Electronic Navigation Research Institute, National Institute of Maritime, Port, and Aviation Technology

The sporadic E (Es) layer is a thin layer having dense electron density that appears at altitudes around 100 km. Es mainly appears at mid-latitudes during summer months. When the Es layer appears, radio waves in HF and VHF frequencies, sometimes above 100 MHz, propagate for a long distance through reflection by the Es layer. Because of such an abnormal reflection, the Es layer leads to anomalous propagation of radio waves and then causes interference on radio systems such as FM broadcast and aeronautical navigation systems. Therefore, the Es layer have been studied by using a number of observational techniques for a long time.
Recently, Global Positioning System Total Electron Content (GPS-TEC) mapping has been used to observe the Es layer. Recent studies of the Es layer using GPS-TEC maps demonstrated that Es has a frontal structure extending roughly along the east-west direction in daytime. More recently, GPS-TEC Rate Of TEC Index (ROTI) mapping was proposed to detect fluctuations of TEC associated with the Es layer. This method also indicated that the Es layer has a frontal structure roughly elongating in the east-west direction. As mentioned above, it is possible to identify the appearance of the Es layer visually by using either GPS-TEC or GPS-TEC ROTI data. However, it is still difficult to extract such Es layer events automatically from a large amount of data in real time. To solve these problems, it is necessary to establish a method for automated detection of Es.
Recently, it has been demonstrated that applying the Hough transform, which can extract lines from images to ROTI maps is effective to detect the Es layer with a frontal structure. In this paper, we propose a method to detect automatically the spatial structure of the Es layer as a segment by applying the Hough transform. We also tried to estimate the length and motion of the frontal structure of the Es layer. We applied the Hough transform to GPS-TEC ROTI maps obtained during an Es layer event in daytime on May 30, 2020 (01:00-02:55 UT) and succeeded in extracting the frontal structure of the Es layer automatically. On the other hand, if the Es layer does not have a linear frontal structure, the extracted lines did not represent the location or the scale of the Es layer correctly. Furthermore, we calculated the moving velocity of the Es structure from horizontal displacement of lines in consecutive ROTI maps. As a result, it was found that the speed ranged from 40 to 100 m/s, the average being 83m/s, and the structure moved northward. These characteristics are roughly consistent with those of previous researches confirming the feasibility of the current method for extracting the dynamical characteristics of the Es layer.

Keywords: Sporadic E, GPS, TEC, ROTI

