中緯度電離圏TECへのIMF-By効果とそのメカニズム

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IMF-By effect on the mid-latitude ionospheric total electron content and its mechanism

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The primary factor that controls ionospheric total electron content (TEC) is solar UV/EUV radiations through the ionization of the thermospheric neutral particles and also through changes in the thermospheric parameters such as the temperature, the composition of the neutral particles, and the atmospheric circulation. Thus, the relationship between the solar spectral irradiance and ionospheric TEC is highly complex. To model solar irradiance effects on TEC, we applied an artificial neural network (ANN) technique that has a great capability of function approximation of complex systems. Three solar proxies, $F_{10.7}$, $SOHO\_SEM_{26-34}$ EUV flux, and MgIIc-w-r were chosen as input parameters specifying the solar spectral irradiance in the ANN-TEC model (T. Maruyama, JGR, 2010). Another important effect on TEC is ionospheric storms caused by geomagnetic disturbances. The am index was used to model the storm effect. The ANN was trained on the target of daily TEC variation maps as a function of local time and latitude over Japan's area for the period from 1997 to 2014, i.e., one and a half solar cycles. The trained ANN model worked fairly well to predict the TEC long-term variability with the 11-year solar activity cycle and the solar rotational period. There remain, however, errors that may not be related to the above input parameters.

To improve further the ANN-TEC model, the time series of the residual error in the TEC prediction was analyzed by using a wavelet transformation, which revealed an increase in error with approximately 27-day periodicity during the summer. Examining several possible origins of the error, we found that the 27-day periodic error disappeared when the IMF-By component and a solar wind-magnetosphere coupling function were added in the input space of the ANN. Detailed comparison of the time series showed that TEC tends to be high (low) when the IMF-By is negative (positive) for all local times.

It is known that the magnetospheric convection pattern changes depending on the polarity of the IMF-By component. The thermospheric circulation is also affected by the IMF-By polarity through the ion-neutral drag force, resulting in the change in transport of the neutral atmosphere with enhanced molecular composition in the polar region to mid-latitudes (L. Goncharenko et al., JGR, 2006). Previous satellite measurement showed that the molecular ratio to the atomic oxygen at mid-latitudes increased when the IMF-By is positive (T. J. Immel et al., JGR, 2006). Most probably, the IMF-By effect on TEC is due to the change in the thermospheric composition and/or the circulation pattern.

The ionospheric peak height (hmF2) is sensitive to the change in the meridional neutral wind. We have modeled and analyzed the prediction error in hmF2 over Kokubunji by the similar technique used for the TEC modeling. A general IMF-By effect was found in hmF2 such that hmF2 tends to be high (low) when IMF-By is negative (positive) during the day. This tendency was reversed during the night. In other words, the thermospheric wind is more equatorward during the night and more poleward during the day when IMF-By is positive. The equatorward wind during the night is thought to convey the molecular-rich atmosphere toward mid-latitudes when IMF-By is positive, being consistent with the previous works. This atmosphere mass rotates into the dayside and causes the negative TEC disturbance conjointly with the enhanced poleward wind that depresses the ionospheric height.