Abstract

Low latitudes' ionosphere most often shows the occurrence of large plasma density fluctuations with a broad range of scale sizes and amplitudes. In Southeast Asia, a number of phenomena that could significantly disrupt radio communication and GPS navigation systems such as ionosphere disturbances and plasma bubble frequently occur. The GPS positioning/navigation system is increasingly used for critical missions like the air-traffic navigation in Japan and all around the world. To avoid an unexpected scenario, understanding the generation and evolution of the ionospheric irregularities over the South-East Asia is important to nowcast/ forecast of the space weather. This dissertation focuses on development of the data processing technique for analysis of ground-based TEC observations, and on investigating the development and dynamics of Equatorial Ionization Anomaly (EIA), Plasma BubBle (PBB), and mesoscale and/ or sub-mesoscale ionospheric structures.

The new bias estimation technique for the total electron content (TEC) from the dual-band beacon network has been intensively researched. An experiment of dual-band beacon over Southeast Asia was started in March 2012 in order to capture and analyze ionospheric irregularities including the plasma bubble, the wave-like structures, and the EIA in the equatorial region. Five GNU Radio Beacon Receivers (GRBRs) were aligned along 100° geographic longitude. The distances between the stations reach more than 500 km. The field of view of this observational network covers ± 20° geomagnetic latitude including the geomagnetic equator. In Southeast Asia, the observational network is too sparse to attain a benefit of the classic two-station method, a so-called Leitinger method, in order to estimate TEC offsets of dual-band beacon experiment. Moreover, the least-squares approach used in the two-station method failed mainly due to it overly adjusted the small scales of the TEC distribution which are the local minima. We thus proposed a new technique to estimate the TEC offsets with the supporting data from absolute GPS-TEC from local GPS receivers and the ionospheric height from local ionosondes. The key of the proposed technique is to utilize the brute-force technique with weighting function to

find the TEC offset set that yields a global minimum of RMSE in the whole parameter space. The weight is not necessary when the TEC distribution is smooth, while it significantly improves the TEC estimation during the Equatorial Spread *F* (ESF) events. To validate an effectiveness of latitudinal TEC estimation, the comparisons between the beacon TEC and TEC reconstructed by using ionosondes and the in-situ density data from Communications/Navigation Outage Forecasting System (C/NOFS) satellite were made. Both TECs are very consistent as the beacon TEC well match with the reconstructed TEC. As a result, the latitudinal TEC shows double-hump distribution because of the EIA. The EIA formation was revealed. The small-scale fluctuations during an ESF appearance are captured at nighttime in equinox seasons considered as the structures of plasma bubbles. It is a significant step, which can make the beacon data a dependable tool to study the low-latitude features.

A temporal change of the EIA asymmetry was monitored by a multipoint satellite-ground beacon experiment along the meridional plane of the Thailand-Indonesia sector. This is the first EIA asymmetry study with high spatial resolution using the GRBR observations in Southeast Asia. GRBR–TECs from 98 polar-orbit satellite passes in March 2012 revealed the rapid evolution of the EIA asymmetry especially during the geomagnetic disturbances. The meridional wind is found to be the main source of the EIA asymmetry. Besides, the geomagnetic activity possibly played an important role on the rapid evolution of the EIA asymmetry during the daytime. The physical mechanism that controls the temporal change of the EIA asymmetry during the daytime and the nighttime is possibly different. Also the EIA asymmetry had a quasi 3-day variation at 21 LT, which suggests the forcing from the lower atmosphere. Precise capturing of the crests' locations and the asymmetry evolution enhances an understanding of the temporal change of the EIA asymmetry in local scale. It contributes to a local modeling of the ionosphere in Southeast Asia.

Deep plasma depletion during substorm at predawn was captured by GRBR network and was confirmed by sparse GPS networks in Southeast Asia. The observed depletion showed a large TEC gradient that can trouble in the aeronautical augmentation system in terms of positioning error. In addition to the depletion, the GPS-TEC revealed the collocating Medium-Scale-Ionospheric-Disturbance-like

(MSTID-like) structures. Because the sparseness of the observation points has restricted the resolution of the observations, several assumptions are necessary to interpret the data, such as the neglect of the temporal variations of their structures. As a result, a deep plasma depletion event was understood as having fossil plasma bubbles and sub-mesoscale MSTID-like structures collocating. The wavefront of the plasma bubbles and the MSTID-like structures are found to be the same. Even though we have successfully interpreted this event, we should be careful to interpret the data from such a sparse network. This event improves the predawn ionospheric information over Southeast Asia and is significant for being the prior-knowledge for the ionospheric modeling in Southeast Asia.

The Neural Network (NN) model is an artificial intelligent network, which learns from the prior knowledge, and applicable with the non-linear data, such as the TEC. We did a long-term study of the GPS-TEC variation at the magnetic equator and proposed the NN modeling technique for the prediction of the GPS-TEC over the magnetic equator. The studied period is based on the available data during the low-solar-activity period from 2005 to 2009. To obtain the optimum NN, the root-mean-square error (RMSE) is taken into account. In order to measure the effectiveness of the NN, the normalized RMSE of the NN TEC computed from the difference between the NN TEC and the GPS-TEC is investigated. Even with a constraint of a limited amount of available data, the results show that the proposed NN can predict the GPS-TEC quite well over the dip equator.

To improve the database of the NN model, solar activity and latitude dependence of plasma bubble occurrence in Southeast Asia was statistically studied from GPS-TEC. The study period starts from 2008 to 2011 when is the rising period of the solar cycle 24. The plasma bubble Height On the Dip Equator (HODE) was studied to clarify the altitudinal structure of the plasma bubble, and its solar activity dependence. The occurrence rate of the plasma bubble at latitudes apart from the dip equator is found to correlates to the solar activity significantly. This study improves the ionospheric database in Southeast Asia region.