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Comparison of equatorial plasma bubble zonal drifts and neutral winds velocity over Southeast Asia

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Abstract. The purpose of the presented study is to investigate the zonal drifts of Equatorial Plasma Bubbles (EPB) which applied two different ground-based instruments. Malaysia Real–Time Kinematics GNSS Network (MyRTKnet), consists more than 78 GPS receivers was used to observe EPB along 96° East to 120° East longitudes. Subsequently, zonal drift of EPBs derived from GPS-ROTI is compared with neutral winds velocity from Fabry-Perot interferometer (FPI). On 10 April 2013, we founded the maximum drift is about 194.4 m/s at 1430 UT to 1500 UT whereas the minimum drift is 111.1 m/s at 1330 UT to 1400 UT. The results illustrate that temporal variations of EPB zonal drift velocities are consistent with the neutral winds.

1. Introduction

The equatorial plasma bubbles (EPB) is defined as depletion of total electron content (TEC) in the ionosphere. The investigations of EPB have been done before by using ground based data such as imaging technique and radar measurement. The first observation of EPB over Southeast Asia using GPS data was carried out by Buhari et al. [1]. One of the characteristics of EPB which have been commonly reported in the past years using various techniques was including zonal drift velocity. The study of this characteristic is a vital in maintaining a stable communication between satellite and ground. Most of the previous study observed velocities of EPB using ground based instruments such as imaging techniques [2]. They reported that the velocity of EPB were decreased with time. Apart from that, the past studied believed that the zonal drift velocity were related to the zonal neutral winds. There are numbers of discussion regarding the relation between the zonal drifts of EPB with the neutral winds. For instance, a study from Chapagain et al. [3,4] obtained a positive correlation in the variations of zonal neutral winds and the EPB zonal drift velocity. The present study focuses on the EPB zonal drift velocity estimated from high density of GPS receivers over Southeast Asia (SEA) on night-time of 10 April 2013 and compared with neutral winds velocity from Fabry-Perot interferometer (FPI).

2. Method and analysis

2.1. GPS-ROTI MEASUREMENT
The EPB zonal drifts were calculated using rate of TEC change index, ROTI obtained by high density GPS in the Southeast Asia sector [1,5]. Department of Survey and Mapping Malaysia, JUPEM was installed more than 78 receiver stations called as Malaysia Real-Time Kinematics GNSS Networks, MyRTKnet. These GPS data is in the format of Receiver Independent Exchange, RINEX were provided by JUPEM for this study.

In order to present the variations in terms of longitudes with times, the structure of EPB was extended in north-south directions. The east to west cross section of ROTI at five degree north in each five minutes was considered to plot keogram. Based on keogram, after 1200 UT about thousands kilometre scale of irregularities can be shown. According to past studies, the first EPBs structure are found to be initiate at 104°E longitude at 1230 UT and it developed faster against times [1,6]. The EPB are believed to moving in eastward direction [7,8]. In this keogram, we can showed that every EPB moves in eastward direction and disappeared almost after 1800 UT.

We only considered 1-day of ROTI-keogram that generated from MyRTKnet to determine EPB in Malaysia sites. The occurrence of EPB was clarified with ROTI values is higher than 0.1 TECU/min on the keogram. Thus, the zonal drifts of EPB can be estimated from the change of longitude with time [5]. Zonal drifts was calculated due to the initial largest ROTI value to the last largest ROTI value as can be shown on the keogram. In this case, we estimate zonal drifts of one EPB selected with range times from 1230 UT to 1530 UT.

2.2. Fabry-Perot Interferometer
The FPI was used to measure the neutral winds motions through 630-nm airglow emission lines observations of the Doppler shift with two interference fringes: inner and outer by 15 min of the time resolution [8]. FP03 code shows that this FPI is in operation at Kototabang, Indonesia. The code for each FPI will be different due to the location of their operation. This instrument was a part of the Optical Mesosphere Thermosphere Imagers (OMTIs) [9] and operated by the Space-Earth Environmental Research (ISEE), Nagoya University.

3. Results and discussions
In previous section, the method to estimate the zonal velocity drift on the night of 10 April 2013 have been discussed. By approaching the GPS-ROTI data that covered SEA, the temporal and dimensional (spatial) variations of EPB can be observed.

Figure 1 depict the keogram formed from 2-D map of ROTI with the variations of longitude. This plot gives a clear feature of EPB characteristics, where it is a cross section of ROTI that have been chosen the horizontal profiles of the ROTI at 5 degree north latitude. The white gap in Figure 1 shows the missing data during certain period. We further select one single EPB from the keogram to investigate the zonal drifts denoted by red arrow in Figure 1. This EPB are chosen based on the feature that we can fully observed from the ROTI keogram.

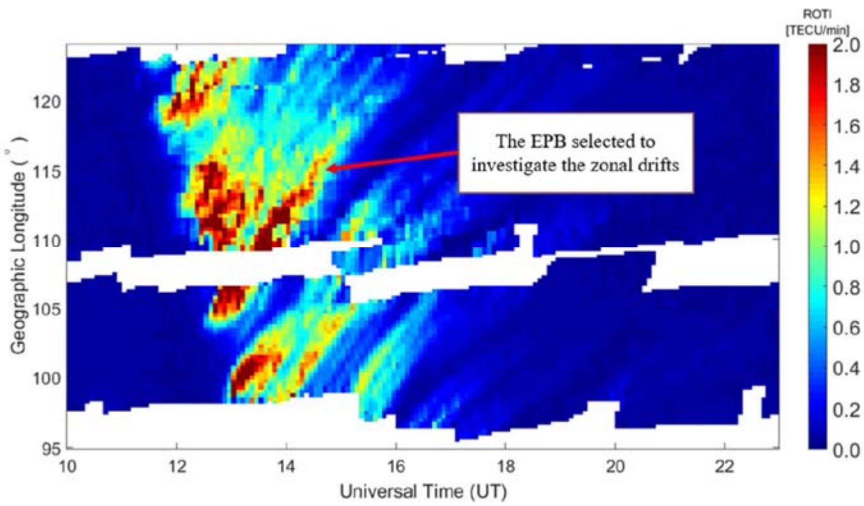

Figure 1. ROTI keogram at five degree north latitude acquired from GPS networks in SEA from 1000 UT to 2230 UT on night of 10 April 2013. The red arrow represent the EPB selected to be investigate.

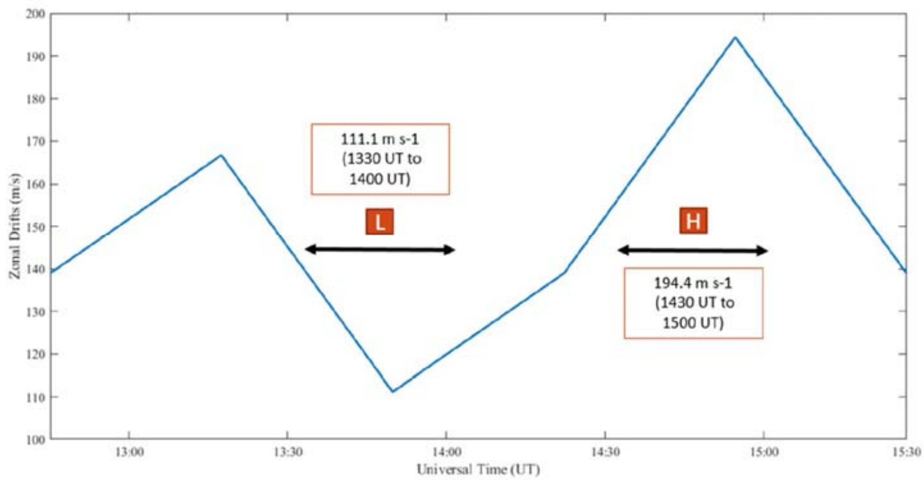

Figure 2. The zonal drifts of EPB calculated for red arrow shown in Figure 1.

Figure 2 shows plots of EPB zonal drifts obtained from GPS ROTI keogram. We can see the trend were decreased from 1230 UT to 1530 UT. Our results correlated with several past studies by [4,5,6,7] where drift velocity of EPB gently decreasing against time. The zonal drifts of the EPB shows a significant different during period of 1300 UT to 1500 UT. The maximum drifts (H) is found as 194.4 m/s at 1430 UT to 1500 UT whereas the minimum drifts (L) is 111.1 m/s at 1330 UT to 1400 UT.

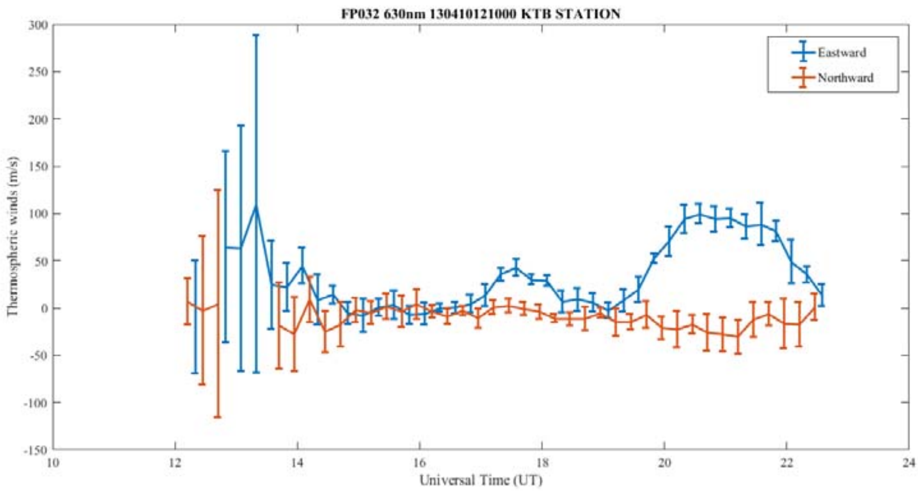

Figure 3. Temporal variation of thermospheric neutral winds observed by FPI at KTB station.

In Figure 3, we observed the thermospheric winds using FPI at KTB station. The positive values of neutral winds represent eastward velocity while negative values show winds to be northward. On this night, the estimated neutral winds peak at ~100 m/s in eastward and ~ -40 m/s in northward. The eastward winds show higher value than that of northward winds. This explained that the eastward winds play an important role as an indicator in drifting of the EPB which is moving in eastward direction. Apart of that, we can see from both Figure 2 and Figure 3, the zonal drift velocity variations of EPB and eastward winds have similar variations. At the beginning (1230 to 1300 UT), the zonal drift velocity is increased, but after 1300 UT they gradually decreased until reached at a certain time the zonal drift velocity were formed a peak and suddenly dropped.

4. Conclusion

In this paper we have exposed zonal drift of EPB from high density GPS receivers over SEA on 10th April 2013 and compared with neutral winds velocity from Fabry-Perot interferometer (FPI). The results illustrate that temporal variations of EPB zonal drift velocities are consistent with the neutral winds.

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