Temporal and spatial variation of TEC around the northern crest of EIA along 95°E

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Abstract:
The total electron content measured simultaneously at three locations, Dibrugarh (27.4^{0}N, 94.9^{0}E), Kohima (25.6^{0}N, 94.1^{0}E) and Aizawl (23.7^{0}N, 92.8^{0}E) for the year 2015 is used to study the seasonal and spatial variations of ionosphere around the northern crest of equatorial ionization anomaly along 95^{0}E for the first time using GNSS receivers. The EIA crest appears around Aizawl and gradually decreases towards northern stations Kohima and Dibrugarh. Spring autumn asymmetry exists for this year over all three stations. Winter anomaly is not observed for this year.

Key words:
Ionosphere, GNSS, STEC, TEC, EIA.

Introduction:
The equatorial and low latitude ionosphere is very dynamic and significantly different from middle and high latitude ionosphere and exhibits many unique features in density and temperature such as the equatorial electrojet (EEJ), equatorial spread F (ESF), equatorial ionization anomaly (EIA) etc. [1]. The plasma fountain produced by the E × B drift over the magnetic equator is known to be the primary causative mechanism behind the formation of the EIA [2], [4]. In addition, field aligned plasma transport produced by neutral winds and neutral composition effects are also known to affect the EIA structure. The EIA produces the greatest level of ionization in the globe at the anomaly crests and the occurrence of the anomaly crest and its strength are found to have a daily, monthly, seasonal, solar activity [6], [3] and geomagnetic activity variations [8]. Apart from these general features, the characteristics of the ionosphere differ considerably in various longitude sectors for the same local time, season or latitude. It is also established that a longitudinal wave like structure with 90° in phase and varying amplitudes exists along the crest of the equatorial ionization anomaly (EIA) with strongest enhancements in the noontime hours at 100°E and weakest at 10°E (Wave Number four, WN4). Therefore, an attempt has been made to study the dynamics of the EIA in this longitude sector using a chain of GNSS receivers.

Data and Methodology:
TEC data are collected from 3 GNSS NovAtel GPSTATION-6 receivers situated at 3 different locations along 95^{0}E, Dibrugarh (27.4^{0}N, 94.9^{0}E), Kohima (25.6^{0}N, 94.1^{0}E) and Aizawl (23.7^{0}N, 92.8^{0}E). The locations have been selected on the basis of their respective coordinates with respect to the geomagnetic equator along the 95°E meridian and located at a latitude interval of 2° for continuous monitoring of the development and decay of the EIA in

local time, season or solar cycle. So this work include investigation of EIA structure along a chain of 3 stations (along 95°E) using GNSS receiver for the first time.
The slant TEC has converted to vertical TEC (VTEC) by using standard expression mentioned in [4]. In this study the TEC data for elevation greater than 50° has been taken in order minimize multipath reflection.

Results and discussion:

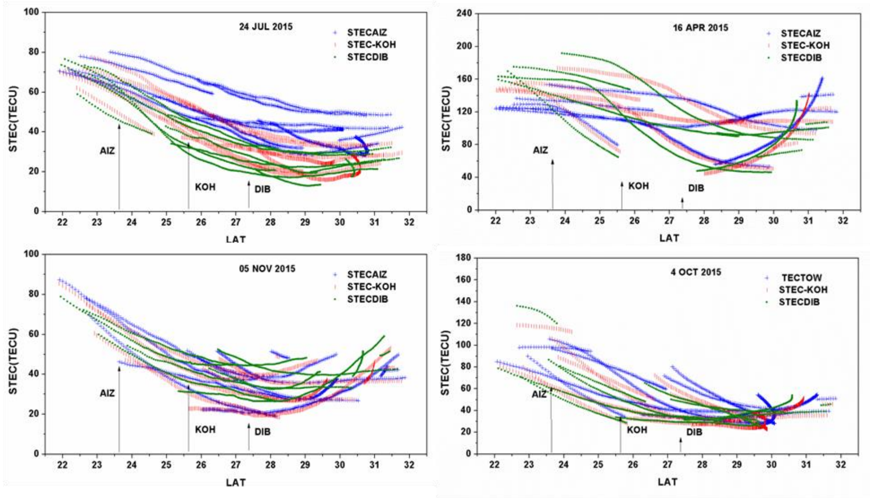

Figure 1. Latitudinal distribution of STEC on selected days of each season in the year 2015.

To study the spatial distribution of TEC over northern crest of EIA, daytime (10:00-14:00LT) slant TEC (STEC) from each station for different PRN for selected days of each season has been plotted against latitudes in figure 1. From this figure, it is clear that development of EIA is strongest over the station Aizawl which is at the crest of EIA and gradually decreases towards northern stations Kohima and Dibrugarh respectively.
To examine the seasonal variation of TEC over 95°E , the year 2015 is graded into four seasons which are Summer, Winter, Spring and Autumn. Figure 2. shows seasonal average of GNSS derived TEC observed for four seasons of the year 2015 depending on the availability of the data. Seasonal mean TEC show pre-sunrise minimum between 0400-0600LT and daytime maximum 1400-1500LT. Daytime maximum TEC for the summer seasons are obtained as 49.56 TECU, 47.13 TECU and 43.23 TECU at 14:00LT for Aizawl, Kohima and Dibrugarh respectively. Daytime maximum TEC during the spring equinox (March-April) of 2015 obtained at 1500LT as 83.48 TECU and 78.86 TECU for Kohima and Dibrugarh respectively. Similarly during autumn equinox (September-October) highest daytime peak TEC was found over Aizawl (52.02 TECU at 15:00LT) followed by Kohima (44.28 TECU at 15:00LT) and Dibrugarh (37.75 TECU at 14:00LT). During the winter daytime peak TEC over all three stations are obtained as 45.69 TECU at 14:00LT, 38.02 TECU at15:00LT and 33.98 TECU at 14:00LT for Aizawl, Kohima and Dibrugarh respectively. Thus from the figure 2., it can be inferred that TEC is higher in equinoxes than the other seasons. Among equinoxes, the TEC in the spring equinox is found to be higher than the autumn equinox. This equinoctial asymmetry might be due to higher ExB drift and thermospheric O/N_2 densities during the spring equinox [7], [4]. The winter anomaly is not observed during this year. Winter anomaly is only evident in peak solar activity year as reported by [4].

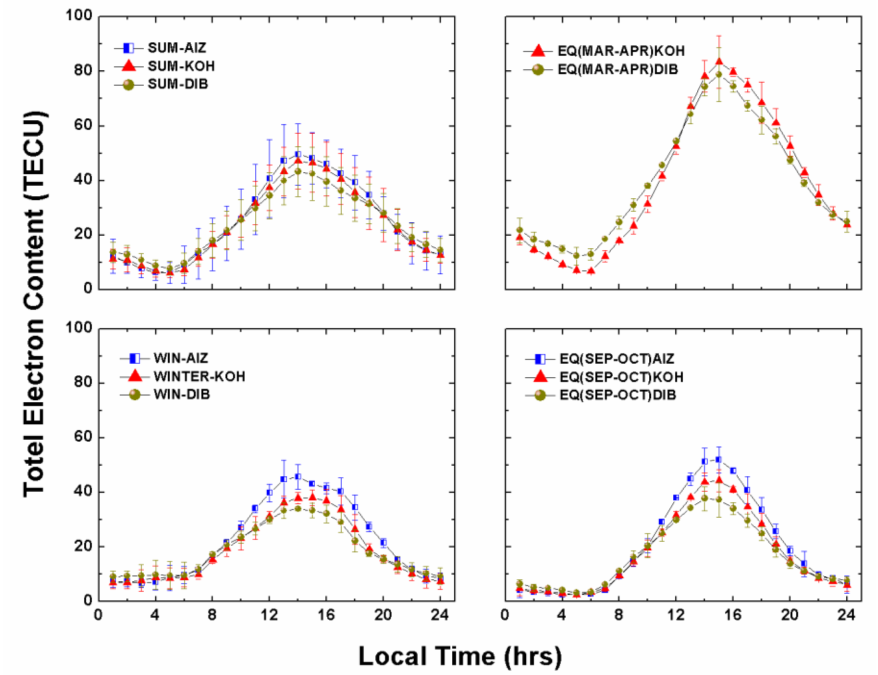

Figure 2. Seasonal variation of TEC plotted at hourly intervals over the three different stations viz. Dibrugarh (27.4^{0}N, 94.9^{0}E), Kohima (25.6^{0}N, 94.1^{0}E) and Aizawl (23.7^{0}N, 92.8^{0}E) around 95°E for the year 2015.

References:

[1] Appleton, E.V., (1946). Two anomalies in the ionosphere, Nature 157, 691.
[2] Anderson, D., (1973). A theoretical study of the ionospheric F region equatorial anomaly – II. Results in the American and Asian sectors. Planet. Space Sci. 21, 421–442.
[3] Bhuyan, P. K., Bhuyan, K., (2008). The equatorial ionization anomaly at the topside F region of the ionosphere along 75^{o}E, Advances in Space Research, doi:10.1016/j.asr.2008.09.027.
[4] Bhuyan, P.K., Hazarika, R., (2013). GPS TEC near the crest of the EIA at 95°E during the ascending half of solar cycle 24 and comparison with IRI simulations, Adv. Space Res. 52, 1247–1260.
[5] Hanson, W.B., Moffett, R.J., (1966). Ionization transport effects in the equatorial F region, J. Geophys. Res. 71, 5559–5572.
[6] Huang, Y.N., Cheng, K., Chen, S.W., (1989). On the equatorial anomaly of the ionospheric total electron content near the northern anomaly crest region, J. Geophys. Res. 94, 13515–13525.
[7] Ren, Z., Wan, W., Xiong, J., Liu, L., (2010). Simulated wave number 4 structure in equatorial F region vertical plasma drifts, J. Geophys. Res. 115, A05301. http://dx.doi.org/10.1029/2009JA014746.
[8] Su, Y.Z., Oyama, K.I., Bailey, G.J., Takahashi, T., Hirao, K., (1995). Comparison of the satellite electron density and temperature measurements with plasmasphere ionosphere model, J. Geophys. Res. 100, 14591–14603.

Acknowledgements:
The author acknowledges DST-SERB, India for providing the financial support.