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STUDY OF TEC, EQUIVALENT SLAB-THICKNESS AND NEUTRAL TEMPERATURE OF THE IONOSPHERE IN THE INDIAN LOW LATITUDE SECTOR

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Abstract. The ionospheric slab-thickness is an important parameter which measures the skewness of the electron density profile of the ionosphere. In this paper, the diurnal, seasonal, day-to-day and latitudinal variations of ionospheric parameters (TEC, NmF2, slab-thickness and neutral temperature) have been presented. The simultaneous observations of GPS TEC and ionosonde measurements (NmF2) from Trivandrum $(8.47^0 N, 76.91^o E)$, Waltair $(17.7^0 N, 83.3^o E)$ and Delhi $(28.58^0 N, 77.21^o E)$ are used to compute the slab-thickness $(\tau = TEC/NmF2)$ during the low sunspot period 2004 to 2005. The daytime TEC values at Waltair are greater than those at Trivandrum, while at Delhi the day time TEC values are much lower compared to those at Trivandrum and Waltair. The trends of variation in the monthly mean diurnal variation of TEC and NmF2 are similar at Delhi, which was different at Trivandrum and Waltair during the day time. In general, the slabthickness has shown a pre sunrise peak around 05:00hrs LT at all the three stations, except during the summer months at Delhi. A consistent secondary peak in slab-thickness around noon hours has also been observed at Trivandrum and Waltair. During equinox and winter a large night time enhancement in the slab-thickness (comparable to the early morning peak in slab-thickness) is observed at Delhi. The latitudinal variation of slabthickness has shown a decrease from the equatorial station, Trivandrum to the low-mid latitude station, Delhi. Further, the neutral temperatures (Tn) have been computed from the slab-thickness (τ) using Titheridge (1973) method for the three different stations and the results of which are found to show similar nature of variation as those of the electron and ion temperatures measured by the SROSS C2 satellite (Niranjan et.al., 2003).

1 INTRODUCTION

The ionospheric slab-thickness (τ) which is the ratio of TEC and F2-layer peak electron density (NmF2) ($\tau = TEC/NmF2$) provides a measure of the skewness of the vertical ionization distribution of the ionosphere. It represents the equivalent thickness of the ionosphere having a constant uniform density equal to that of F2-layer peak. It is capable of addressing many ionospheric phenomena and has been studied extensively over the last five decades by several researchers (Bhonsle et.al., 1965; Davies and Liu, 1991; Gulyaeva, 1997). Slab-thickness contains all the new information obtainable from TEC measurements which is not readily available in foF2 (Titheridge, 1973). The diurnal, day to day, seasonal and geomagnetic variations of ionospheric slab-thickness in the Indian low and mid latitude regions have been investigated by several researchers (Das Gupta et.al., 1975; Bhuyan et.al., 1986; Prasad et.al., 1987). Since both TEC and NmF2 exhibit a marked latitudinal dependence over the equatorial region, it is of interest to examine the latitudinal variation of the slab-thickness parameter over the equatorial and low latitude region.

Slab-thickness is also an important parameter since it contains the information regarding the neutral temperatures of the ionosphere. It is known that the slab-thickness depends on the scale height of the ionizable constituents and the scale height of loss processes both of which are dependent on neutral temperature. Therefore, neutral temperature can be represented by the slab thickness (Titheridge 1973). The relationship between slab-thickness and electron temperatures has also been reported by Mahajan et. al., (1968) and Pande et.al., (1984). The present paper reports GPS derived TEC for an equatorial, low and low-mid latitude stations namely Trivandrum, Waltair and Delhi respectively in the Indian sector. Diurnal, seasonal, day-to-day and latitudinal variation of slab-thickness has also been studied. Further, the neutral temperatures computed using Titheridge (1973) relation has been presented.

2 DATA AND ANALYSIS

The total electron content (TEC) data derived from the dual frequency GPS receivers from three typical stations namely Trivandrum $8.47^0N, 76.91^oE$, an equatorial station, Waltair $(17.70^0N, 83.30^oE)$, a station located at the inner-edge of the Equatorial Ionization Anomaly and Delhi $(28.58^0N, 77.21^oE)$, located at the outer edge of the Equatorial Ionozation Anomaly for the period from March 2004 to February 2005 are considered for the study of equivalent slab-thickness (τ). Simultaneous NmF2 data derived from three identical ionosonde located at the above three stations, namely Trivandrum, Waltair and Delhi are used for deriving the slab-thickness (τ) using the relation

$$\tau = TEC/NmF2(Km) \tag{1}$$

The diurnal variation of the slab-thickness is obtained using the monthly mean diurnal variation plots of TEC and NmF2 from the three different locations. The values of the slab-thickness thus derived are used to calculate the neutral temperature of the ionosphere with the help of the relation given by Titheridge(1973)

$$Tn = (\tau - 15)/0.225(^oK) \tag{2}$$

The results obtained both from slab-thickness as well as the neutral temperature are discussed on a month to month as well as on seasonal basis and presented in the following section.

3 RESULTS AND DISCUSSION

1) Variation of TEC and NmF2

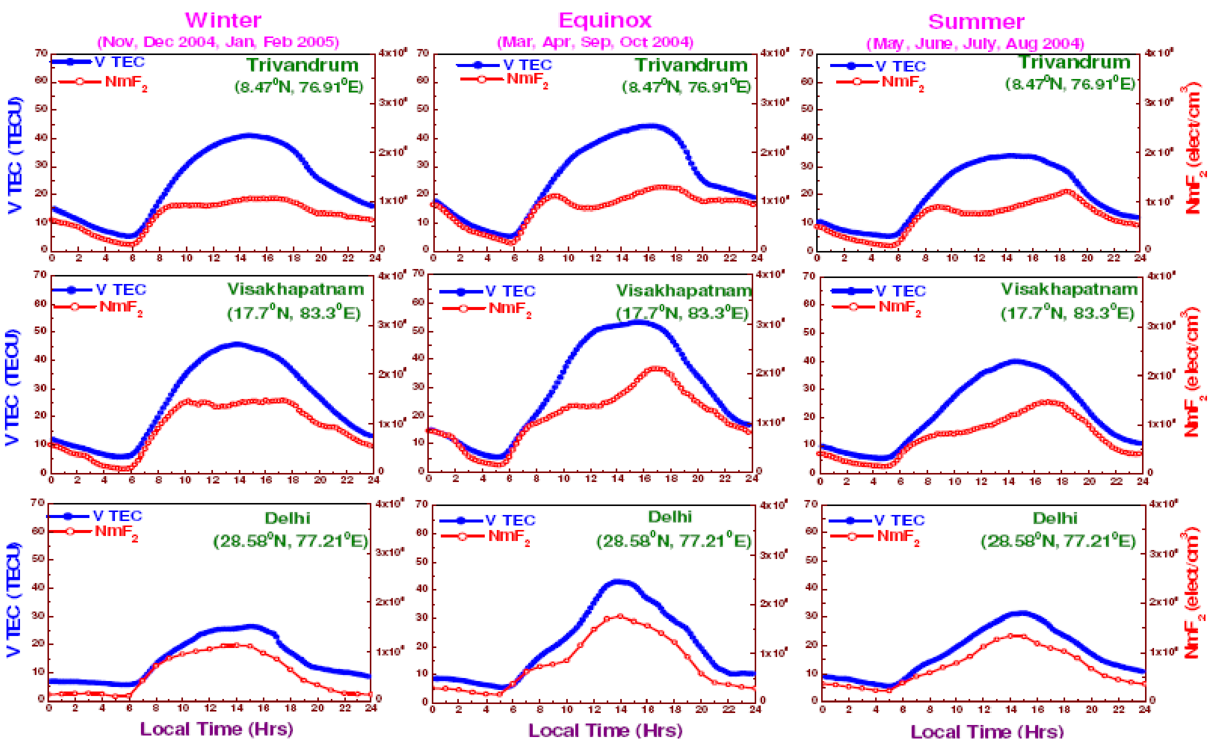

Figure 1: The average diurnal variation of the TEC and NmF_2 for the three different seasons

The average diurnal variation of the Total Electron Content (derived from GPS) and the maximum electron density of the ionosphere (derived from the ionosonde data) for the three different seasons winter, equinox and summer from the three different latitudinal sectors namely Trivandrum, Waltair and Delhi are presented in Fig.1. It may be readily seen from these plots that the TEC shows a sharp day minimum around 0500 hrs LT and a broad day maximum during all the three different seasons at the equatorial and low latitude stations Trivandrum and Waltair. However, at Delhi, a station situated at the outer edge of the equatorial ionization anomaly, the TEC values are in general lower compared to those at Trivandrum and Waltair in all the three different seasons. Also, the night time values at Delhi are mostly at the minimum level during the three different seasons contrary to Trivandrum and Waltair. The diurnal variation of TEC at Delhi shows nearly similar variation as that of a mid latitude station.

The maximum electron density (NmF_2) at all the three different stations shows more or less similar variation with much lower values during most of the daytime compared to those of TEC. One interesting feature noticeable in the diurnal variation of NmF_2 at Trivandrum and Waltair is the presence of noon time bite out during the three different seasons which is absent at Delhi.

2) Variation of equivalent Slab-thickness (τ)

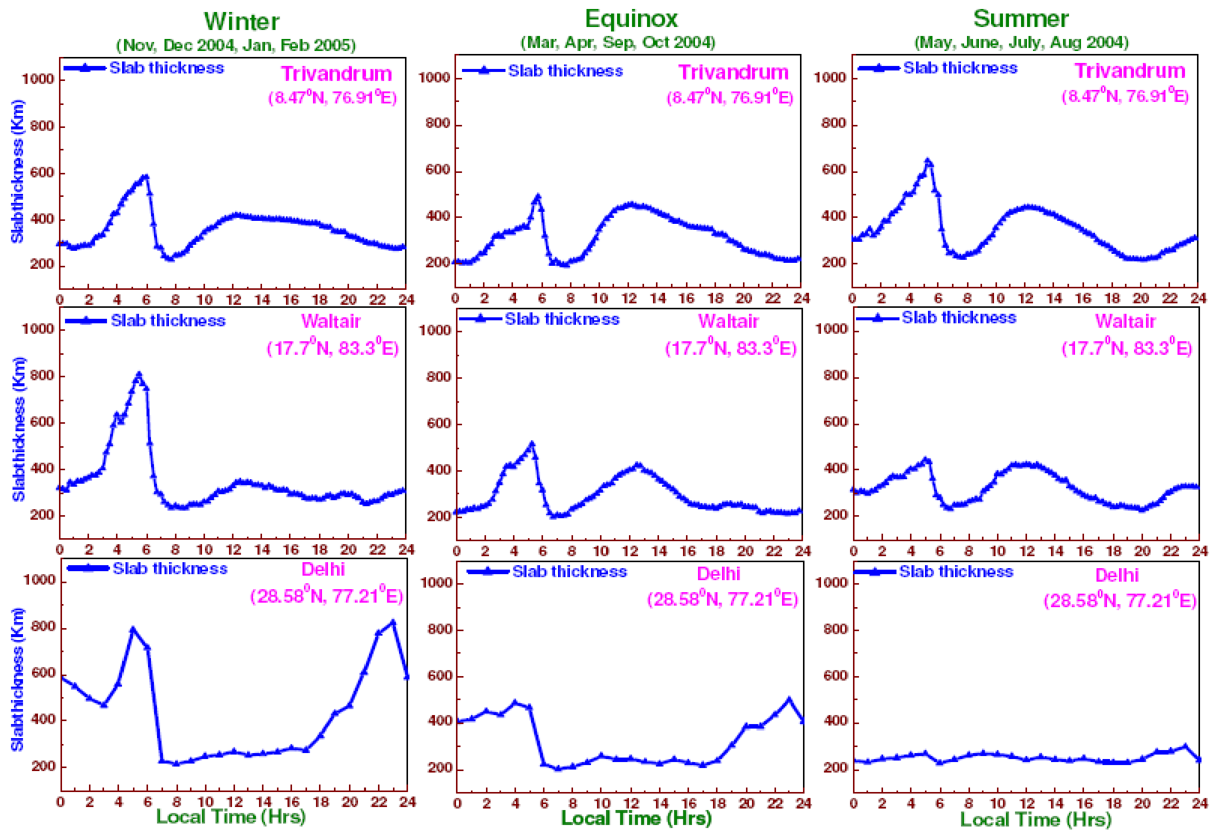

Figure 2: The average diurnal variation of the slab-thickness τ for the three different seasons

In Fig.2, the diurnal variation of the equivalent slab-thickness($\tau = TEC/NmF2$) at the three different stations obtained are presented. It may be seen from this figure that the slab thickness shows nearly similar features at Trivandrum and Waltair during the three different seasons whereas at Delhi the features in the diurnal variation are different.

At Trivandrum and Waltair a significant early morning increase in slabthickness around 0500 hrs LT (except during summer in Waltair) with minimum values varying from 200 Km to a maximum value of around 800 Km is observed. However at Delhi, during the summer month, the slab- thickness remains nearly constant around 250 Km throughout the day, whereas during winter months the night time (1900 to 0600 hrs LT) values are significantly high at Delhi varying from around 400 to 800Km, while the daytime values remain at 200 to 250 Km. The diurnal variation of slab-thickness in equinox at Delhi shows considerably higher values varying between 200 to 500 Km during night time (1900 0600 hrs LT), while the daytime values being same as those in the other two seasons.

3) Neutral Temperature

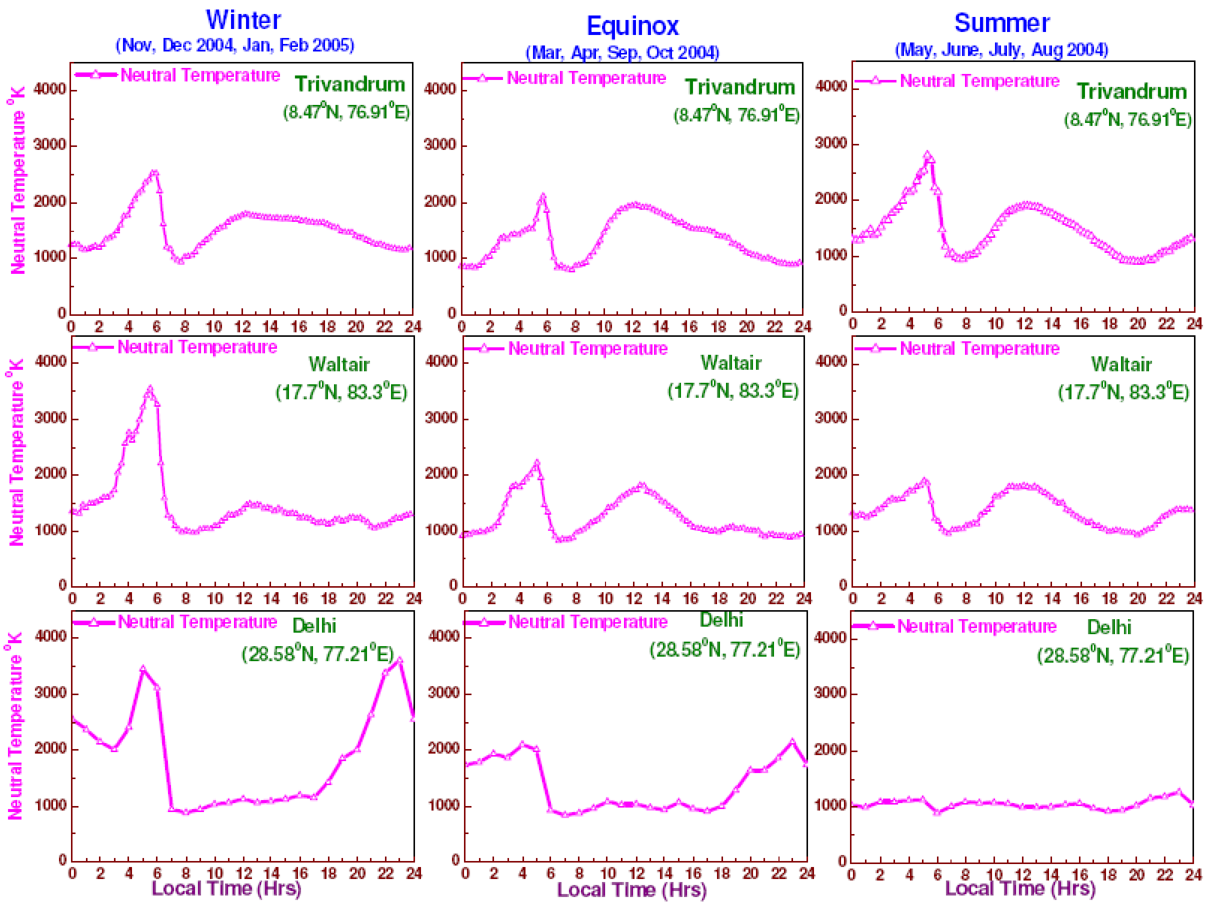

Figure 3: The average diurnal variation of the neutral temperature (Tn) for the three different seasons

Using the values of the slab-thickness, the neutral temperature of the upper atmosphere has been computed (Titheridge 1973) and presented in Fig.3. Typically the diurnal variation of the neutral temperature of the three different stations during the three different seasons shows similar nature of variations as that of the equivalent slab-thickness. At the equatorial and low latitude stations the neutral temperature shows sharp increase around 0500 hrs LT with the temperature values varying from 2000 to 3500 ^oK. The highest value of neutral temperature (3500^oK) is observed at Waltair during winter. During the rest of the day and night time hours the neutral temperature varies from a minimum of 1000 to a maximum of 2000^oK. However, at Delhi a double peaking is observed in the neutral temperature variation during winter and equinox, reaching peak values of 3500^oK around 0500 hrs LT and 2300 hrs LT. Whereas, at Delhi during summer months, the neutral temperature remains constant around 1000^oK during all the 24 hours similar to those of the day time values in winter and equinox at Delhi. When these neutral temperature variations are compared with the electron and ion temperature variations derived from the SROSS C2 measurements (Niranjan et.al.,2003), more or less show similar nature of variations with the typical early morning peak around 0500 hrs LT. The maximum values of the SROSS C2 measured electron temperatures are also around 3000^oK. However, the minimum values are slightly lower (750^oK) compared to those (1000^oK) derived from the present study.

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