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ON THE VARIABILITIES OF THE TOTAL ELECTRON CONTENT IN THE INDIAN LOW LATITUDE SECTOR

P.V.S. Rama Rao, K. Venkatesh, D.S.V.V.D. Prasad, K. Niranjan and J. Vara Prasad

Space Physics Laboratories
Department of Physics, Andhra University
Visakhapatnam 530 00, India

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Abstract. The day to day and latitudinal variability in the GPS measured Total Electron Content (TEC) in the Indian low latitude sector during the low sunspot activity year of 2004 are presented in this paper. Day to day variability is found to be minimum at the equatorial station Trivandrum ($8.47^0N, 76.91^oE$) and increases as a function of latitude up to the crest of Equatorial Ionization Anomaly (EIA) and decreases beyond the crest. The percentage of deviation from the average diurnal value inTEC is found to be higher during night times compared to the daytime hours, with maximum variation during the equinoctial month of September 2004 at the crest region, Raipur ($21.18^0N, 81.74^oE$). Similar variations are also seen in the NmF2 variations derived from the ionosonde data. The strength and location of the EIA in TEC shows a significant correspondence with the strength of the EEJ. The measured values of the GPS TEC is found to be closer to the TEC derived from the reconstructed IRI profiles using the ground based and ROCSAT e data.

1 INTRODUCTION

The Total Electron Content (TEC) in the upper atmosphere plays a vital role in the accurate determination of the range delays introduced by the electromagnetic signals travelling through the ionosphere. In the recent past, the need for the accurate determination and prediction of the TEC has gained significant importance in the satellite based navigation and communication systems. It is known that the ionospheric electron density at the equatorial and low latitudes varies significantly from hour to hour, day to day, season to season as well as with latitude, owing primarily to the changes in the incoming solar radiations and the equatorial electro dynamics such as the Equatorial Ionization Anomaly (EIA) and meridional winds. Of the various factors, the day to day variability in the strength of the equatorial electrojet, E X B drifts contributes more for the observed day to day and latitudinal variations. Added to these typical dynamical conditions at the low latitudes, the determination of the absolute TEC poses yet another problem owing to the errors involved in the determination of TEC such as the transmitter and receiver errors and the errors in the use of the mapping function while converting the slant TEC to vertical TEC and vice versa particularly in the EIA region. The various problems associated with the variabilities and the accuracies in the measurement of the TEC using the GPS signals in the Indian low latitude sector are discussed in this paper.

2 DATA AND ANALYSIS

The TEC data derived from the GPS network of receiving stations (18) deployed under the GAGAN project in the Indian sub continent are used for the purpose of this study. The TEC data of the low sunspot activity period 2004 from four typical stations namely the equatorial station Trivandrum $8.47^0N, 76.91^oE$, a low latitude station Waltair ($17.70^0N, 83.30^oE$), a station located around the crest of the EIA, Raipur ($21.18^0N, 81.74^oE$) and a station at the outer edge of the EIA, Delhi ($28.58^0N, 77.21^oE$) are chosen for a detailed study. The simultaneous ionosonde data from the three stations, Trivandrum, Waltair and Delhi has also been considered in this study. The day to day variations in TEC for one representative month in each of the seasons from the three different stations is plotted and the percentage of deviations from hour to hour during a day are separately plotted and studied. Simultaneously the day to day variability in the strength of Equatorial Electrojet (EEJ) as a function of local time has also been presented.
Using the data from 8 stations located all the way from equator to 35^ON latitude along the common longitude of 77^OE, the movement of the crest of the EIA as a function of EEJ strength has also been presented. Further, the GPS measured TEC data is evaluated using TEC derived from the IRI profiles reconstructed embedding the measured values of bottom side NmF2 from the ionosonde data and the topside electron density data derived from the ROCSAT satellite data.

3 RESULTS

The day to day variability in the diurnal variation for three representative months of the seasons winter (December 2004), Equinox (September 2004) and summer (May 2004) for the four representative stations Trivandrum (Equatorial station), Waltair (at the inner edge of the EIA), Raipur (around the crest of the EIA) and Delhi (on the outer edge of the EIA) along with the corresponding diurnal variations of the EEJ strengths from Trivandrum are presented in Fig. 1. It may be seen from this figure that the day to day variability is lowest at the equatorial station and is maximum around the crest of the EIA. Further, the TEC values are relatively higher in the equinoctial month of September 2004, where EEJ strength is also maximum. The diurnal variation in the percentage of deviation from the monthly average TEC values is presented in Fig. 2.

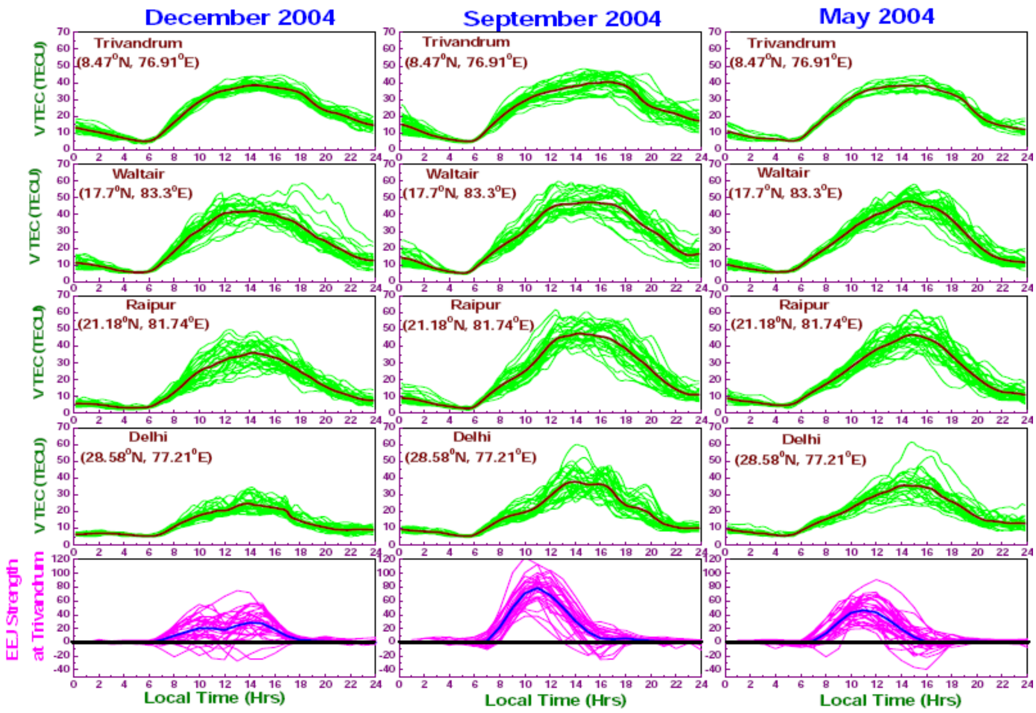

Figure 1: Mass plots of diurnal variation of TEC for three typical months for the four different stations along with Equatorial Electrojet Strength.

It may be seen from Fig.2 that the percentage deviations, on the average, vary from a minimum of 5% (during December 2004 at Delhi) to a maximum of 35% (during September 2004 at Raipur). Strikingly at the three stations Trivandrum, Waltair and Raipur, the night time percentage deviations are higher than those during the daytime. Whereas at Delhi, a station on the northern side of EIA, shows a mixed trend during the three different seasons. Similar nature of variations in the day to day variability as well as the percentage deviations are observed in the maximum electron density measured from the ionosonde data. From a study on the monthly variation of the EIA along the 8 stations described above, it is seen that there is a strong association of EEJ strength with the location and magnitude of the EIA.

Our maiden attempts made to evaluate the GPS measured TEC with that of the IRI measured TEC is presented in Fig. 3 and Fig. 4. Fig. 3 represents the IRI profiles at Trivandrum and Fig. 4 represents the IRI profiles at Waltair. The red colour represents the uncorrected IRI profile, while the blue and the brown represents the reconstructed profiles using the ionosonde and ROCSAT data. It may be seen from a comparison of the computed TEC values presented in each frame, the TEC values derived from the reconstructed profiles are much closer to the GPS measured TEC values. Added to these aspects some problems associated with the measurement of absolute TEC are also

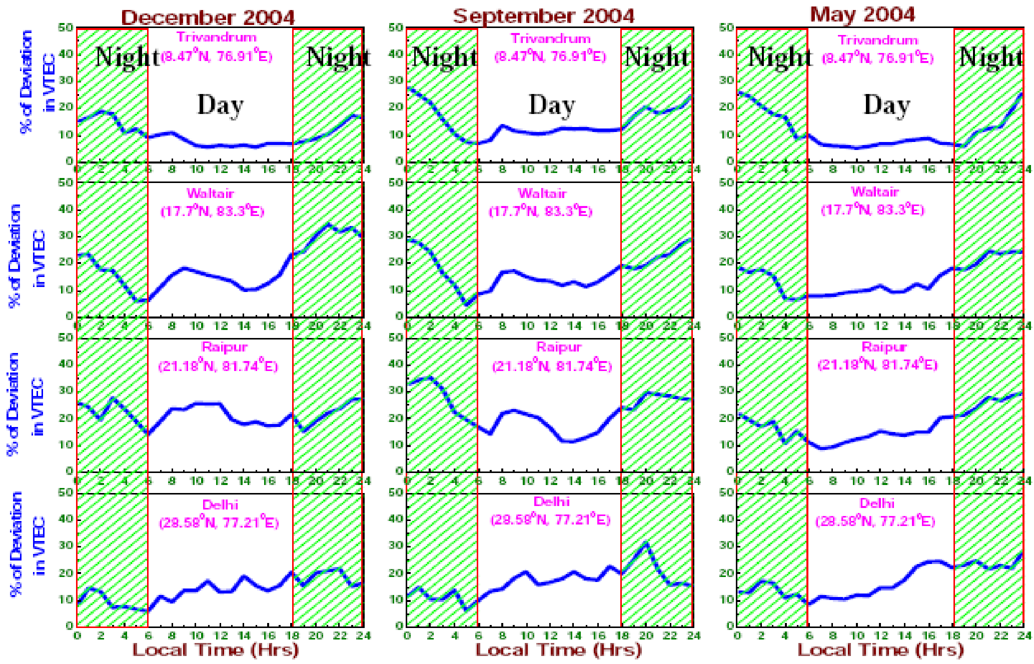

Figure 2: Diurnal variation of % of deviation in VTEC for the three typical months for four different stations

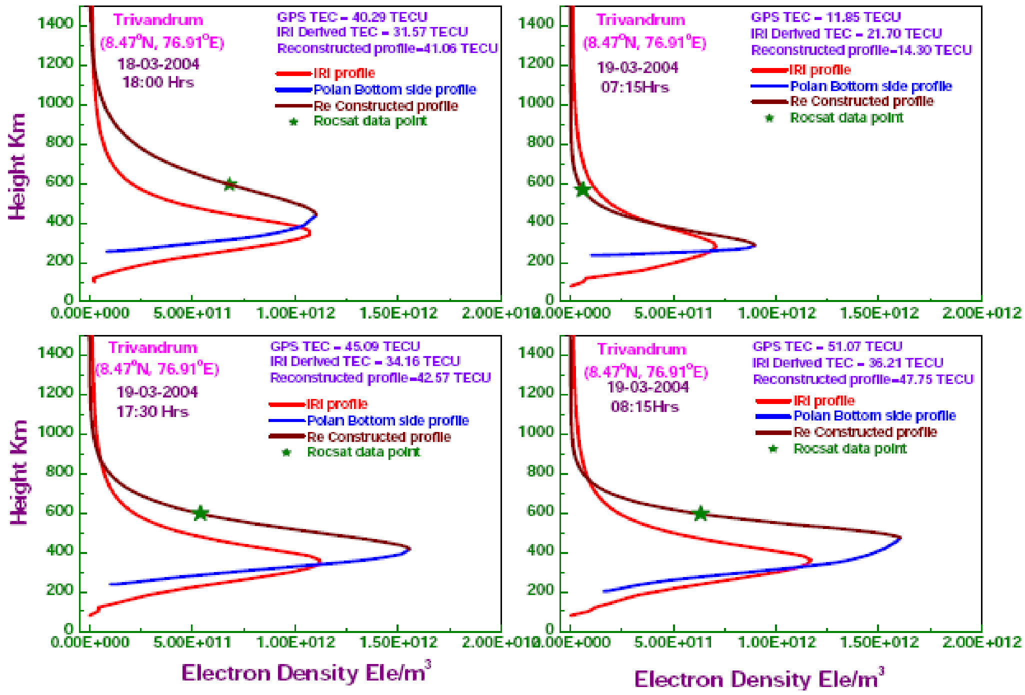

Figure 3: Vertical Electron density profiles(IRI) over Trivandrum $(8.47^o N, 76.91^o E)$

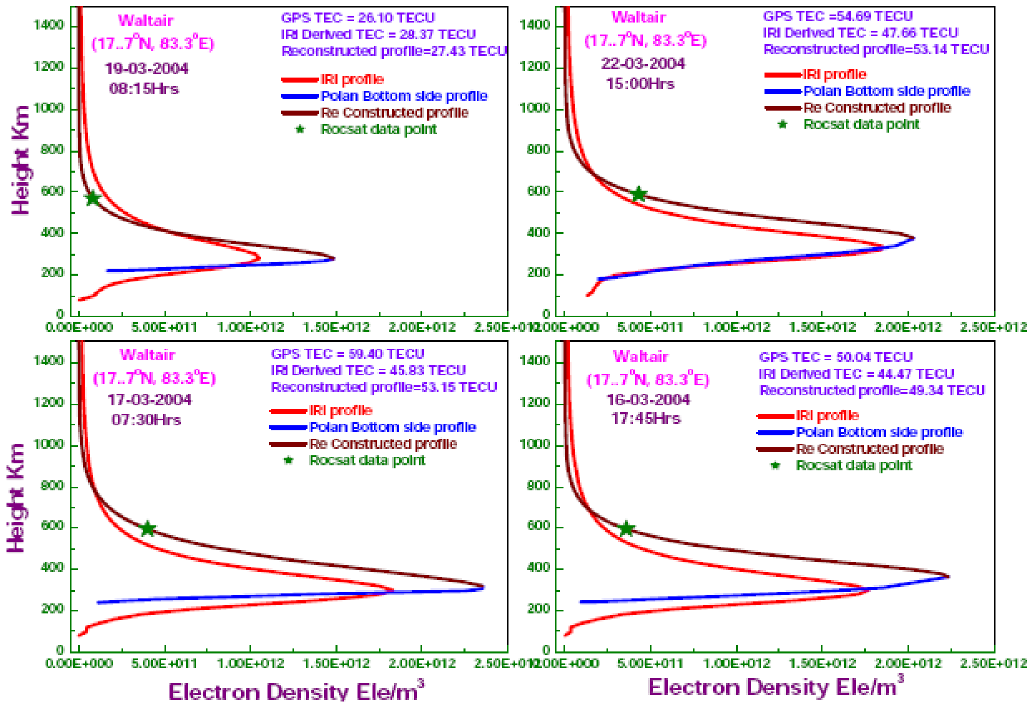

Figure 4: Vertical Electron density profiles(IRI) over Waltair $(17.7^oN, 83.3^oE)$

discussed.