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BEHAVIOR OF TOTAL ELECTRON CONTENT OVER AURORAL REGION AT MAITRI, ANTARCTICA

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Abstract— *The dual frequency Global Positioning System (GPS) receiver provides an opportunity to determine Total electron content widely used to study the dynamics of the ionosphere. For this purpose a dual frequency GSV 4004A GPS receiver is installed at sub auroral region over Indian base polar station Maitri (71.45 S Lat,11.45 E Long), Antarctica. In this paper to discuss the behavior of TEC has been studied using GPS data. The diurnal and seasonal variation of VTEC is studied for different seasons. GPS derived TEC is than compared with International Reference Ionosphere (IRI) 2007 model. From the analysis we observed that TEC achieves its highest value during the summer as minimum in winter. Also observed maximum TEC value of Polar Day month (December) because during these months the polar cap receives the solar radiation round the clock as compared to Polar Night month (June).* We use only those GPS satellite data whose elevation angle is greater than 300 for TEC during at low solar activity period December 2009 to December 2010.

Index Terms— Auroral region, ionosphere, Total Electron content,

1 Introduction :

Solar ionizing radiations are responsible for ionospheric theory. The ionosphere region is a dispersive medium, plays an important and active role in Earth-space radio communication. Molecules of the atmosphere, ranging in between 50 km to 500 km, are ionized by the Solar radiation thus forming ionosphere. The ionosphere varies with the solar cycle, magnetic activity, seasons, and local time. This phenomenon is more prominent over auroral region. The structure of the high latitude ionosphere is very complicated and varied. Also, the auroral region ionosphere is characterized by large diurnal and seasonal variations hence there is a necessity to thoroughly understand the effect of this variations. In this region irregularities at a different scale are common, which causes fluctuations in the Total electron content. TEC values is one important parameter to retrieve the integrated electron density measured between satellite to receiver [10] and can provide an overall specification of ionosphere. Total Electron Content index are by product of GPS data which can also be used to study the long term behavior, variability and to survey the ionosphere.

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A radio wave crossing the upper and lower atmosphere of the Earth atmosphere suffers a distortion. the physical process controlling in high latitude ionospheric plasma density like generation mechanism and transport of ionospheric irregularities, soft particle precipitations with energies ~100 eV, penetration of magnetospheric electric fields and auroral current systems[1],[7]. In the auroral regions, under perturbed condition caused by solar wind magnetosphere coupling, the ionosphere may become highly turbulent and the probability of irregularities formation, these irregularities on a different scale cause fluctuations in the total electron content (TEC fluctuations). Many researecher introduced TEC fluctuation as [2];[4]; [5]; and [11}. Large-scale fluctuations are caused by ionospheric irregularities whose scale is larger than 100-350 km. and occur as deep spatial variations of TEC. Irregularities of about ten kilometers cause scintillation effects. The intensive phase fluctuations observed along GPS satellite passes are caused by dramatic changes in total electron content (TEC) and demonstrate a strong horizontal gradient of TEC. Fluctuation effects and TEC gradients can have a different impact on GPS measurements and data processing for high-precision GPS positioning. They affect phase ambiguity resolution, increase the number of undetected and uncorrected cycle slips and loss of signal lock [8]; [12]. The development of TEC fluctuations over Antarctic regions of the Earth has been studied with distinct satellite transmissions. Several researchers [1]; [3]; [8] also used GPS permanent observations to study irregularities in the auroral region. [9] have utilized the GPS data at 30 s intervals to study ionospheric irregularities of electron density by computing the time rate of the change of the differential carrier phase. Sometime the Earth magnetic field gets disturbed due to events on the Sun, density of free electron increases and decreases. For the improvement of

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radio communication links, it is necessary to know the actual behavior of ionosphere characteristics with high temporal and spatial resolution with the best possible accuracy.

This paper presents an attempt to study the diurnal and seasonal behavior of Total electron content during low solar activity and starting of 24 solar cycles (2009-2010) and compared with IRI-TEC with GPS-derived TEC data for different seasonal condition observed over high latitude Indian base station Maitri, Antarctica.

2 DATA AND METHODOLOGY:

Irregularities in the ionosphere due to space weather events caused by solar flares and coronal mass ejection can scatter trans-ionospheric radio signals producing fluctuations in both amplitude and phase and GPS cycle slips disrupting satellite communications and navigation. We concern our study sub auroral region during starting of 24 solar cycles. For this purpose a dual frequency GSV 4004A GPS receiver is installed at sub auroral region "MAITRI", Antarctica (70.45 S Lat, 11.45 E Long.) during 29th Indian scientific expedition to Antarctica.

The slant Total Electron Content (STEC) is the measure of the total number of free electron in a column of the unit cross section along the path of the electromagnetic wave between the satellite and the receiver. The total number of free electron is proportional to the ionospheric differential delay between L1 (1575.42 MHz) and L2 (1227.60 MHz) signal.

$STEC=\int_{receiver}^{Satellite} N ds$

Where N is the electron density (1 TEC Unit= 1016 Electron /m2)

Integration is with limits from observer to satellite.

For our purpose, we use Slant total electron content measured by the receiver at every 30 second and converted in to vertical total electron content (VTEC)

3 RESULT AND DISCUSSION

Diurnal and seasonal Variation

Global navigation satellite systems such as GPS offer a unique opportunity to monitor the total electron content (TEC) of the ionosphere on global scale. Diurnal variation of TEC shows interesting features of auroral region like TEC minimum at pre-down and gradual increase with the time of the day attaining maximum in the afternoon and gradual decrease after sunset. The day to day variability of TEC is contributed by various parameters like EUV Flux, solar activity, geomagnetic activity, and latitudinal dependence, Dabas et al.,(1984), and local ionospheric condition in the thermosphere.

The 24-hourly mass plots of TEC diurnal variation for the month of December 2009 to December 2010, It is observed that the maximum value of TEC reached to 24 TECU on Dec 2009 at 11:30 UTC and minimum in the month of June 4 TECU at around 21:00 UTC. Fig.(1) Clearly shows peak shift toward right side from December to June and again reverse from July to November 2010.This type of behavior of TEC shifting caused by solar Zenith angle in the auroral region. These curves show appreciable day to day variability. Figure shows the month to month variation is not smooth, it is clear that maximum peak in December and gradually decrease and minimum TEC observed in June. The daily peak occurs around 11:30 to 21:00. Figure (2) Shows value is separately shown for day and night (Polar Day month And Polar Night month). The maximum value of Day time TEC is in the month of December and minimum in June. It is known that TEC shown marked variation with the geographic locations.

Seasonal variations in the total electron content have been studied by many researchers for solar minimum condition. Figure (3) clearly show the result During 29th ISE 2009 to 2010 at Antarctica, summer have the maximum variation in TEC, Equinox gives the moderate and winter have the minimum variation of TEC. During the summer when the Antarctica has continually day for few months cause ionization at a constant rate in the upper atmosphere due to solar radiation and excessive heat. The gradual decrease in the slope of the region with decrease in solar activity indicates that the rate of production of ionization is positively co-related with solar activity. More solar radiation reaches the surface of the equivalent period to predict the changes in the trend in the past. This cold continent is ideal for such type of analysis.

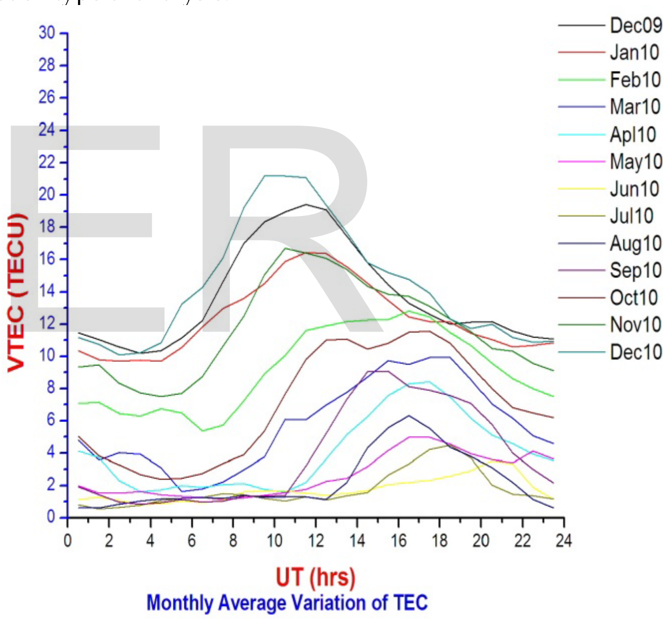

Figure -1

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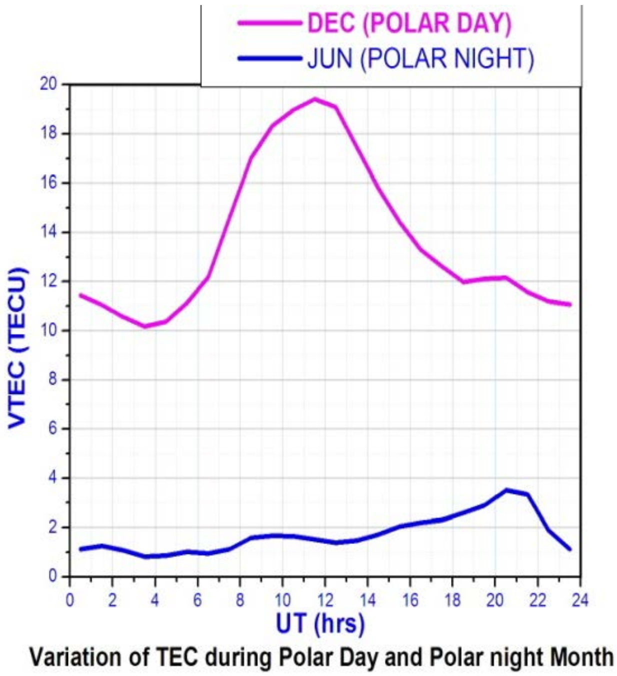

Figure-2

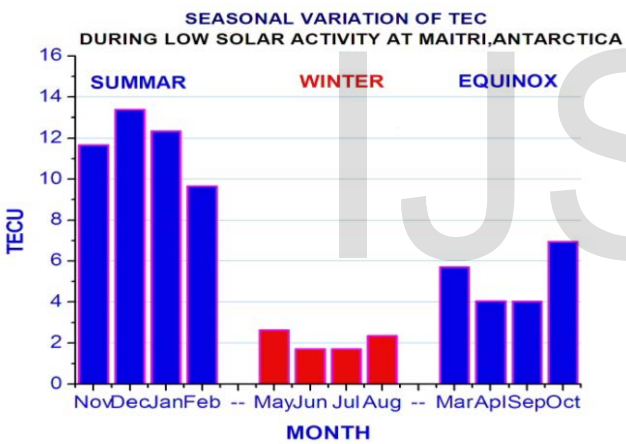

Figure -3

Comparing IRI TEC and GPS TEC:-

The objective of this paper is to compare the International Reference Model (IRI) 2007 TEC prediction with GPS TEC maitri, Antarctica (70.450S and 11.450 E).

Figure shows the comparison of the monthly average value of GPS TEC and IRI TEC (in TECU of 1016m-2= TEC) at Maitri, representing summer, winter and equinox respectively, which was a period of starting of 24 solar cycle. Preliminary study of the seasonal variation and annual variation of GPS TEC and IRI TEC is not direct co-relates, therefore IRI 2007 modal is not satisfied in auroral region.

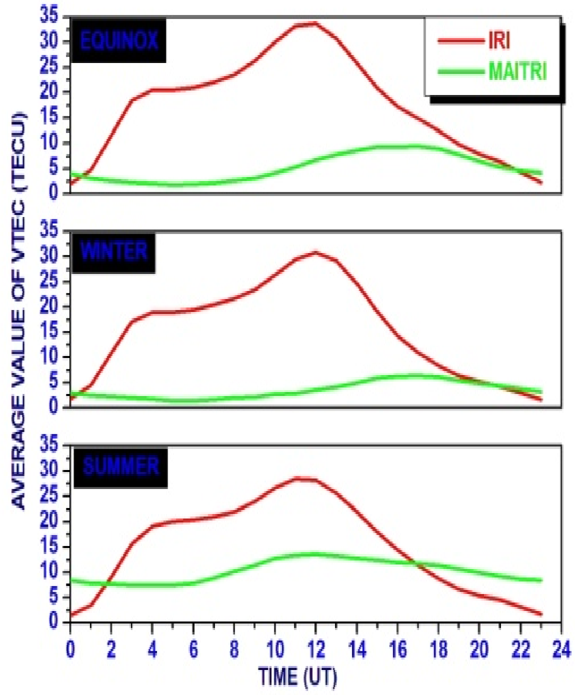

Figure-4

4 Conclusion

The conclusions are drowning from the analysis as follows. Summers have the maximum variation in TEC, Equinox gives the moderate and winter has the minimum variation of TEC. Preliminary study of the seasonal variation and annual variation of GPS TEC and IRI TEC is not direct co-relates, so we can say the IRI modal not satisfied in auroral region. Peak shift toward right side from December to June and again reverse from July to November 2010.This type of behavior of TEC shifting caused by solar Zenith angle in the auroral region. Preliminary study GPS TEC and IRI TEC is not direct co-relates in auroral region, therefore IRI 2007 modal is not satisfied.

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