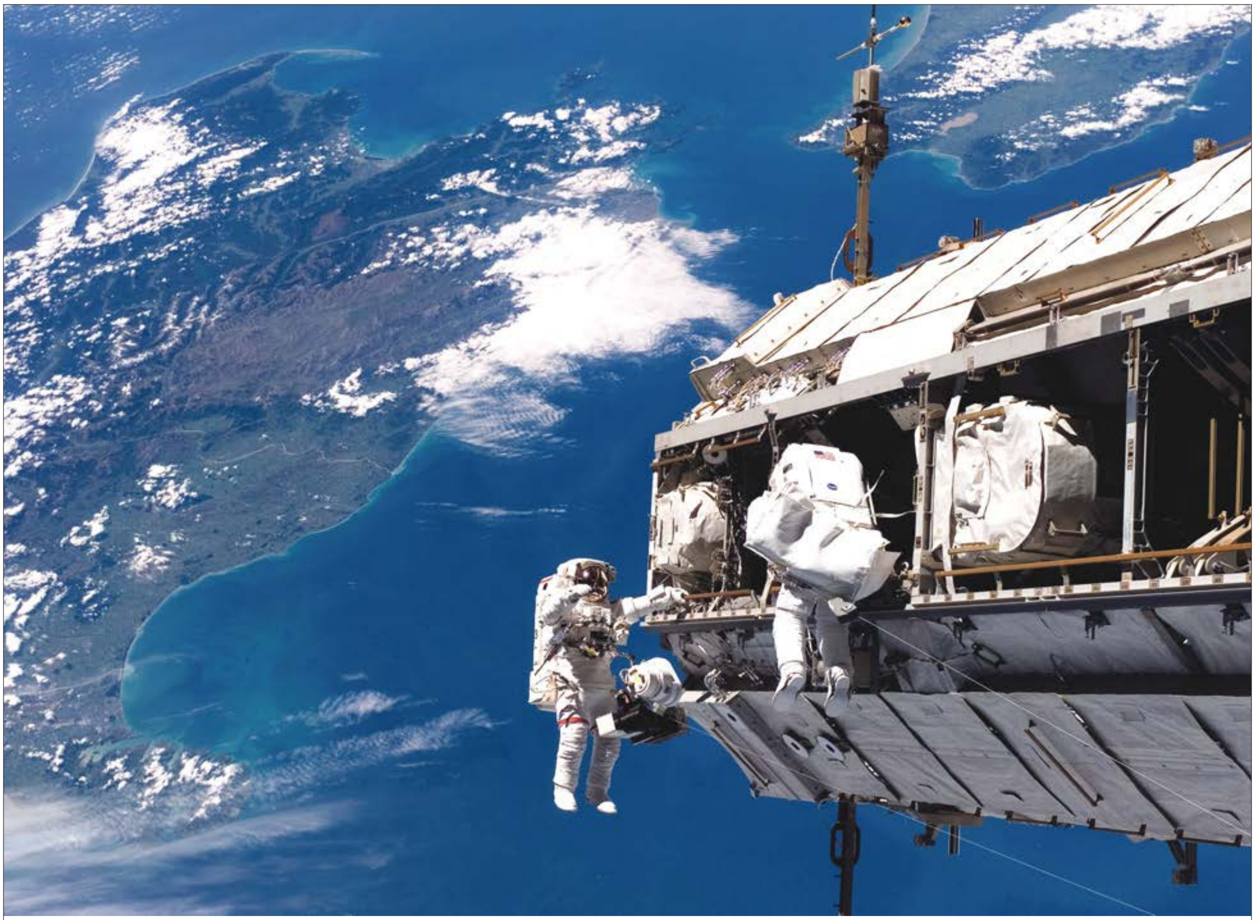

Current Research in

Space Science

ISSN 2154-3097

Academic
Journals Inc.

www.academicjournals.com

Current Research in Space Science 1 (1): 1-6, 2013
ISSN 2154-3097 / DOI: 10.3923/crssaj.2013.1.6

Preliminary Results of GPS Derived Total Electron Content Variations Over Indian Antarctica Station, Maitri as Part of International Polar Year

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ABSTRACT

This study investigated the behavior of high latitude ionosphere and space weather effects on it, in term of Total Electron Content (TEC), from installed Global Positioning System (GPS) over the Indian base Station Maitri (70.65^0 N Lat, 11.45^0 E Long) at Antarctica during the low solar activity period 2008. The study is divided into three parts namely monthly, seasonal and mid polar day and mid polar night variations. We observed that TEC values are highest during the months of January and December as compare to June month, because during January and December months, there is 24 h sun light present (Polar days) whereas in the month of June there is no sun light (Polar night). During the study of seasonal variations, in southern winter season i.e., May, June, July and August 2008. TEC values were lowest because ionization processes are very low due to absence of sunlight and in the southern summer season TEC values reach its highest due to presence of 24 h sunlight and maximum solar radiation present at this duration. During equinoxes the study shows that in the autumnal equinox period TEC disparity is low as compare to vernal equinox period. During autumnal equinox period sun goes towards the sunset point and hence solar ionization radiations decrease day by day, whereas in the vernal equinox period it is reverse i.e., sun goes towards sunrise and it is visible for maximum duration which causes increase in ionization process and TEC value again increases.

Key words: Polar region, ionosphere, total electron content, GPS

INTRODUCTION

The polar region offers exclusive vantage point and proceed as open natural laboratories for ionospheric research. Ionospheric studies at polar regions are of interest to users of satellite transmissions and those who are studying Aeronomy (Warnant and Pottiaux, 2000; Abdullah *et al*., 2009). Ionospheric total electron content data are recorded every 30 sec. throughout the year 2008. High latitudes are directly affected by the energy of charged solar particles and energy thus the ionosphere becomes highly fluctuating. The TEC fluctuations over polar region depend on various factors and ionization process in high latitude region is one of them, ionization process depends on suns activities and zenith angle of the sun. Total electron content is largely variable with time and season. In particular several studies demonstrated that TEC strongly depends on solar activities (Da Rosa *et al*., 1973; Soicher, 1988; Feichter and Leitinger, 1997; Krankowski and Shagimuratov, 2006). Many studies reported that the 11 year solar activity cycle (23rd) will reach its maximum phase in 2000 or 2001, during the high solar activity period, the ionosphere will have a strong influence on GPS and the end of solar activity cycle will reach in 2008 or 2009, during this period of negligible solar activity we observed that the ionosphere will have weak influence on GPS (Tiwari *et al.*, 2008; Li *et al.*, 2010; Prikryl *et al.*, 2010; Purohit *et al.*, 2010; Nandy *et al.*, 2011).

Now a days GPS measurements are commonly used to investigate the structure and dynamics of ionosphere (Krankowski and Shagimuratov, 2006; Bhawre *et al.*, 2011). Here we present data on the ionospheric Total Electron Content (TEC) response during the year 2008.

The present study stresses on the response of ionospheric TEC during the end of 23 solar cycle period over Maitri, Antarctica where established GPS station was used for analysis of Monthly, Seasonal and Polar day and polar night TEC behavior of ionosphere during the year 2008.

MATERIALS AND METHODS

The measurement systems for this work are based on the NovAtel GPS, which was stationed at Indian Base Station Maitri, Antarctica. The system was installed on January 2008 during the 27th Indian Antarctica Scientific Expedition. It consist of a 24-channel, high precision, dual-frequency GPS receiver, GPS antenna model 702 or 701 for Low-Noise Amplifier (LNA) which boosts the power of the incoming signal to compensate for the line loss between the antenna and the receiver, RF Antenna Cable, 12V Power Adapter Cable, Null Modem Data Cable, Data Communications Equipment.

The GPS receiver was set to track GPS signals at 1 sec sampling rate and cut off elevation angles was set to 40^0 to eliminate the multipath effect of GPS data. A standard of 30 sec data sampling was executed in order to reduce processing time.

The GPS observables are biased by the instrumental delay therefore it is necessary to remove these biases for accurate estimation of TEC. The absolute Total Electron Content (VTEC) determination has the capability to remove the instrumental biases both from the receiver and the satellite. The instrument time delay potential errors are corrected using the code biases obtainable from Indian base station, Maitri, Antarctica and all data was analyzed in Space Science Laboratory, Department of Physics, Barkatullah University, Bhopal.

RESULT AND DISCUSSION

One year of GPS-TEC data have been processed for Indian base station Maitri, Antarctica during the year of 2008. The study was divided into three parts.

Monthly behavior of total electron content: The observation for monthly variation of TEC is based on 12 months GPS data. During the month of January TEC fluctuated between the ranges of 10 to 22 TECU. In the February month 7 to 22 TECU, in March month TEC fluctuated between 6 to 20 TECU. In the April month minimum TEC observed 6 TECU and maximum 15 TECU observed. In the starting of polar night month May, minimum TEC was 7 TECU and maximum 15 TECU was observed, in the Dark month of June minimum TEC was 4 TECU and maximum 15 TECU was observed, in the month of July minimum TEC goes to 3 TECU and maximum TEC of 16 TECU was observed, in the starting of suns activity month August minimum TEC observed was 3 TECU and maximum 19 TECU, in the spring months of Antarctica September and October minimum TEC noted 3 and 7 TECU and maximum 22 and 22 TECU, again in the summer months November and December TEC variation observed between the range of minimum 6 and 8 TECU and maximum 27 and 26 TECU. This type of behavior of TEC in polar region depends on solar zenith angles. Figure 1 clearly shows 12 month TEC behavior and we noted in every month the TEC peak shift pattern. Between the month of January to May TEC peak shifted to right side,

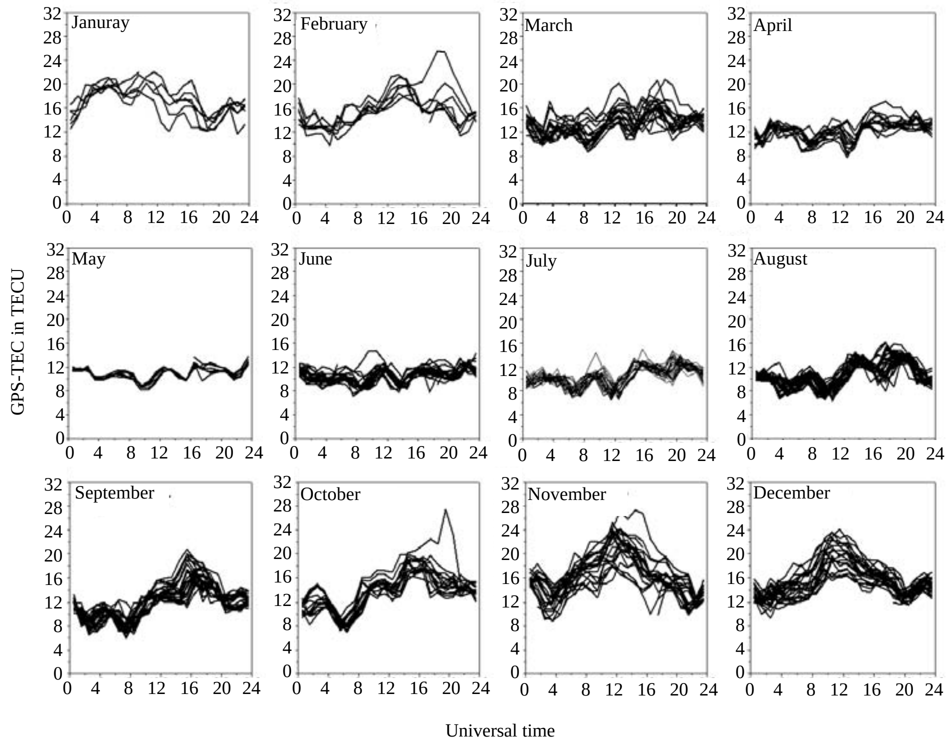

Fig. 1: Monthly total electron content variations over Maitri, Antarctica

between the month of June and July TEC peak almost observed overlapped but again in sun rising month August to peak summer month December TEC peak noted was towards left side. This type of peak shifting pattern depends on the solar zenith angle.

Seasonal variation of TEC: The observation for seasonal variation of ionospheric TEC over Antarctica is divided into three seasons: first is summer season (November, December, January and February) Second is winter season (May, June, July and August) and third is equinox season divided into two equinoxes seasons according to solar activities first Autumnal equinox (March and April) and other Vernal equinox seasons (September and October). In the summer period TEC monthly median value fluctuate in the range of 11 to 20 TECU, this type of performance of TEC in summer period was due to presence of 24 h solar activity in polar region. In the period of winter TEC monthly median value drops and fluctuates between the ranges of 8 to 14 TECU. During the winter period solar activities are negligible as compared to summer period. The study of equinox period is divided into two parts first is Autumnal equinox from March to April and second is Vernal equinox from September to October 2008. In the autumn equinox TEC monthly median value vary between the ranges of 8 to 16 TECU; it is because of partial decrease of solar activities. In other vernal equinox period TEC fluctuates between 8 to 18 TECU during the period of partial increase in solar activities. Figure 2 shows seasonal variation of TEC over Maitri, Antarctica.

Mid polar day and mid polar night observation: June is a totally dark night month and 21 June is a mid night of polar night months over Antarctica. During this night we observed that

TEC variation was very less because total solar activities are closed due to absence of sun light. December is a total sunny day month and 21 December is a mid day of polar day months over

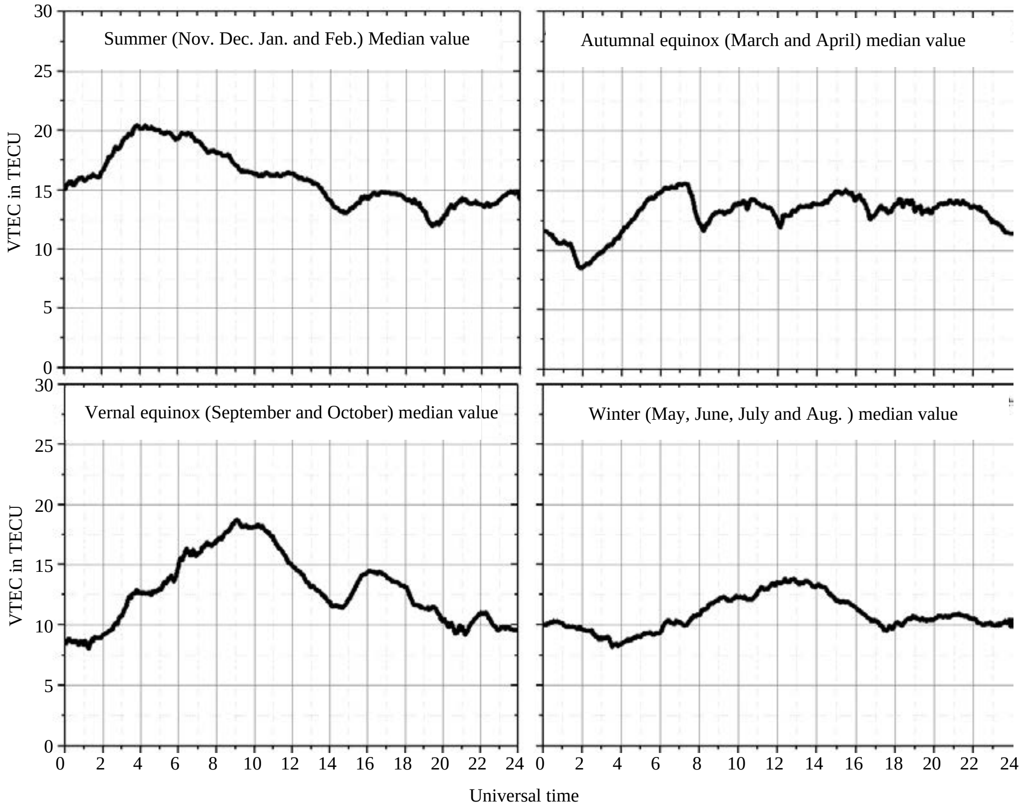

Fig. 2: Seasonal variations of total electron content at Maitri, Antarctica

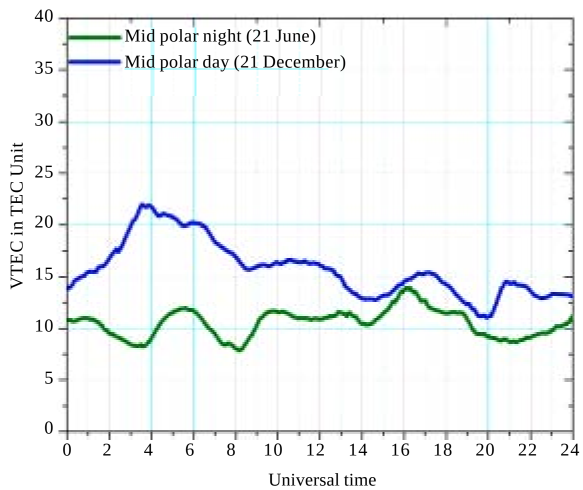

Fig. 3: Mid polar day and mid polar night variation of total electron content at the Maitri Antarctica

Antarctica. In this month complete full sunny days and high solar activities was present and TEC fluctuating maximum as compared to polar night. Figure 3 shows mid polar day and mid polar night variations.

CONCLUSION

Present study shows the presence of strong relationship between GPS-TEC and its dependence on solar activities. During the monthly observation, the first January month TEC value goes to high as compared to June month and again TEC value goes to high in December month. In January and December months solar activities are very high as compared to June month. In seasonal study during the winter season total solar activities are discontinued, ionization processes are stumpy during this season so TEC value goes to minimum. The study of summer season is just opposite of winter season, the total solar activities are present which is due to presence of 24 h sun light then TEC value goes to maximum. And the equinox season which is divided in two parts: in the first equinox period (March and April) solar activities are low due to raise of solar zenith angle and in the second equinox period (September and October) solar zenith angle goes toward maximum to minimum and solar activities are again started and ionization process progresses and during this period TEC variation are high as compared to March and April months. During the study of mid polar night 21 June the TEC variation is very low due to maximum zenith angle of the sun and absence of solar radiations and we observed just opposite conditions during mid polar day 21 December.

Ionospheric Total Electron Content (TEC) variation depends on solar activities and solar zenith angle. TEC variations are lofty in presence of solar activities and minimum solar zenith angle and TEC variations lower down in absence of solar activities and maximum solar zenith angle.

ACKNOWLEDGMENTS

This study is supported by the National Center for Antarctica and Ocean Research, Goa, under the Ministry of Earth Sciences, Govt. of India and all 27 IAE members of Maitri, Antarctica for their scientific and logistic supports. One of the author (Purushottam Bhawre) acknowledges National Physical Laboratory, New Delhi for providing an opportunity at Maitri, Antarctica during 27th Winter Expedition and Council of Scientific and Industrial Research (CSIR) for awarding Senior Research Fellowship.

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