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OBSERVATIONS OF IONOSPHERIC ELECTRON CONTENT AT MAITRI ANTARCTICA

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Abstract

Obeservations of Total Eectron Content (TEC) of the ionosphere were carried out at the Indian station MAITRI, Antarctica from Jan. 12, 1998 to Feb. 6, 1998 during the 17th Indian Scientific Expedition to Antarctica. For this Purpose signals from Global Positioning System (GPS) satellites were monitored. Diurnal range in variation of TEC is found to be much less than that at low latitudes. Signatures of large scale disturbances are seen superposed on the Diurnal variation of TEC

Introduction

Global Positioning System satellites are the available satellites of opportunity which can be made use of to monitor Total Electron Content (TEC) of the Ionosphere. The 24 US Navigational satellites orbit the earth at a height of 20000 km with a 12 hour period. At any instant four or more satellites are visible any where on the globe. They transmit at two harmonically related frequencies at 1575.42 MHz. (called L1) and 1227.60 MHz. (called L2). These frequencies are modulated by Pseudo Random Noise (PRN) codes which enable the receiver to measure the arrival time of each bit of code. As the transmitted signal also contains information about the clock and the time of transmission of the signal, the receiver can measure the time taken by the signal to travel the distance between the satellite and receiver and hence the pseudo range. This is given the name pseudo range because time of travel is biased by the delay introduced by the medium through which the signal travels, the satellite transmitter and receiver clock offsets, and satellite transmitter and receiver bias. Differenital group delay and carrier phase advance at the two frequencies is made use of to derive the total electron content f the Ionosphere.

As the satellites are orbiting, at any instant the receiver measures the slant TEC in different directions depending upon the position of the satillites visible. However, we need IEC in the vertical direction at the observation point to get the diurnal variation.

Lanyi and Roth (1988) and Coco et al (1991) removed the biases and determined vertical TEC (VTEC) by representing the vertical TEC by a polynomial. Wilson et al (1995) used data from a global network of stations to model vertical TEC by spherical harmonics. Sardon et al (1994) employed the Kalman filter technique.

Data and Method of Analysis

Global Positioning System satellite observations were recorded at the Indian station MAITRI, in Antarctica from Jan. 12, 1998 to Feb. 6, 1998 during the 17th Indian Scientific Expedition to Antarctica. A method similar to that used by Sardon et al. (1994) has been developed to derive the total electron conten. A GPS receiver measures P code pseudo range and carrier phase from signals transmitted by the satellites at both the frequencies L1 and L2. The observations are modeled as (Blewitt 1989)

$$p^i_{kj}. = p^i. + dion^i_{kj} + dt^i_k + dr_{kj}.$$

$$L^i_{kj} = P^i_j + dion^i_{kj} + \lambda_k N^i_{kj} + \lambda_k dtt^i_k + \lambda_k drr_{kj}$$

P^i_{kj} L^i_{kj} represent P code range and carrier phase range respectively in cycles between satellite i and receiver j for frequency k.

p^i_j is the pseudo range consisting of geometrical range and the biases introduced by the troposphere and transmitter and receiver clock biases.

$dion^i_{kj}$. is ionospheric delay

dt^i_k , dr_{kj} are satellite transmitter and receiver instrumental group delay biases at, frequency represented by index k having wavelength λ_k

dtt^i_k , drr_{kj} are satellite transmitter and receiver instrumental phase delay biases at frequency represented by index k having wavelength λ_k

N^i_k. is the number of complete phase cycles (undergone by the wave during its travel between satellite i and receiver j).

Carrier Phase ambiguity is removed using Blewit (1989) approach. Then using P code pseudo range data

$$Igps = (P^i_{2j} - P^i_{1j}. + dt^i_2 - dt^i_2 + dr_{1j}. - dr_{2j}) *f_1^2*f_2^2/ (40.3(f_1^2-f_2^2))$$

Using carrier phase data

$$Igps = (\lambda_1\varphi_1 - \lambda_1\varphi_1 + dtt^i_2 -dtt^i_2 + drr_{1j} - drr_{2j}) * f_1^2 * f_2^2/ (40.3 (f_1^2 - f_2^2))$$

In both cases Igps be written as

$$Igps = Islant + bias$$

P code pseudo range is used to adjust the carrier phase ambiguity. Then the Igps obtained from the carrier phase data is utilised for further analysis.

Islant is related to vertical TEC (VTEC) as (Wilson et al 1995)

$$I_{slant} = VTEC * M(E) \quad \text{where} \quad M(E) = (1-(\cos E/(1.+h/R))^2)^{-1/2}$$

Where E is satellite elevation, R the Earth radius and h the sub ionospheric height usually taken as 400 km. VTEC was modeled either as polynomial in latitude and longitude (Lanyi and Roth 1988, Sardon et al 1994).

Results

A sample of the diurnal variation of Total Electron Content at Maitri (70.65°S,11.75°E) Antarctica is shown in Fig.1. Also shown in the figure is the diurnal variation of TEC at Bangalore (12.97°N, 77.57°E). It is seen that diurnal range observed at Maitri is much less than that at Bangalore. This is due to the much less variation of Solar Zenith angle at Maitri as compared to Bangalore (Fig.2). The TEC Diurnal varation at Maitri is superposed by short period small amplitude variations. This is attributed to the stronger coupling of the high latitude ionosphere with the magnetosphere as compared to low latitudes. Figure 3 shows the average diurnal variation of TEC for the normal days. The number of days used is 23. A comparison of the behaviour of TEC during a quiet day (15-1-98) and a disturbed day (30-1-98) is shown in figure 4. Signatures of a large disturbance on the disturbed day is clearly seen.

Acknowledgements

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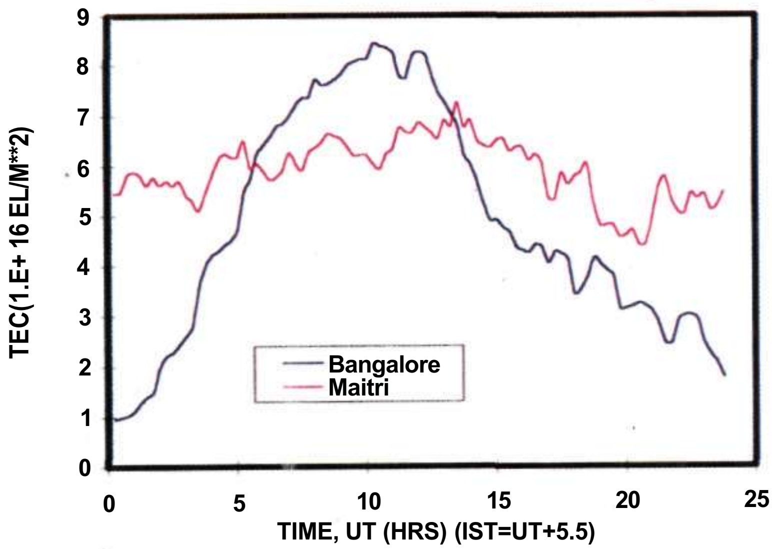

Fig.1. Diurnal variation of TEC at Bangalore and Maitri on 20-1-98

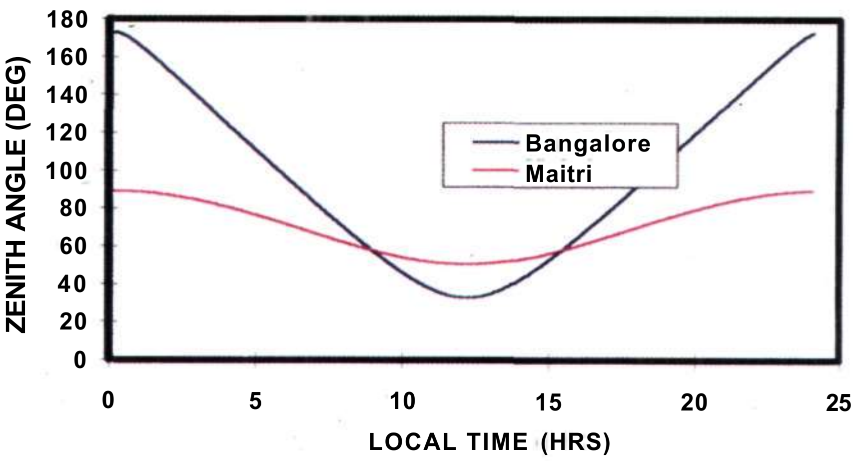

Fig.2. Diurnal variation of Solar Zenith Angle at Bangalore and Maitri on 20-1-98

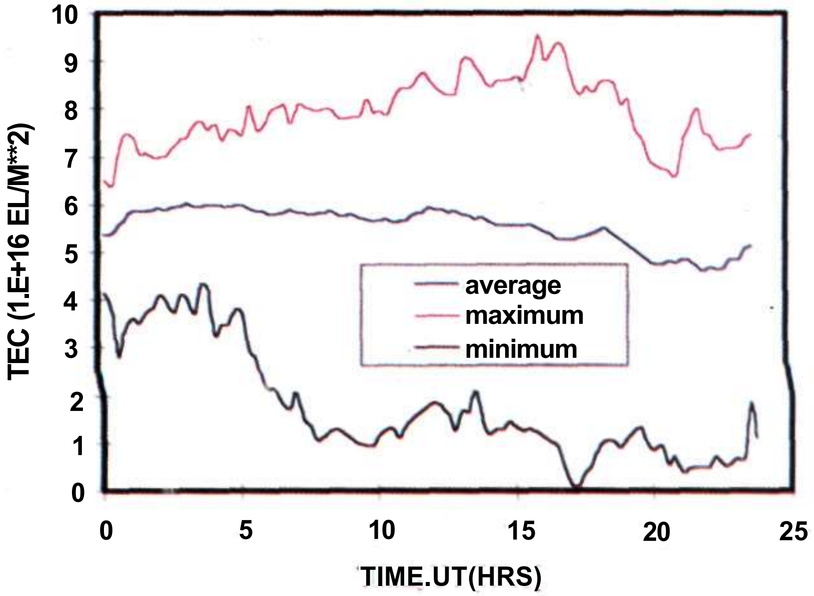

Fig.3. Average Diurnal variation of TEC at Maitri

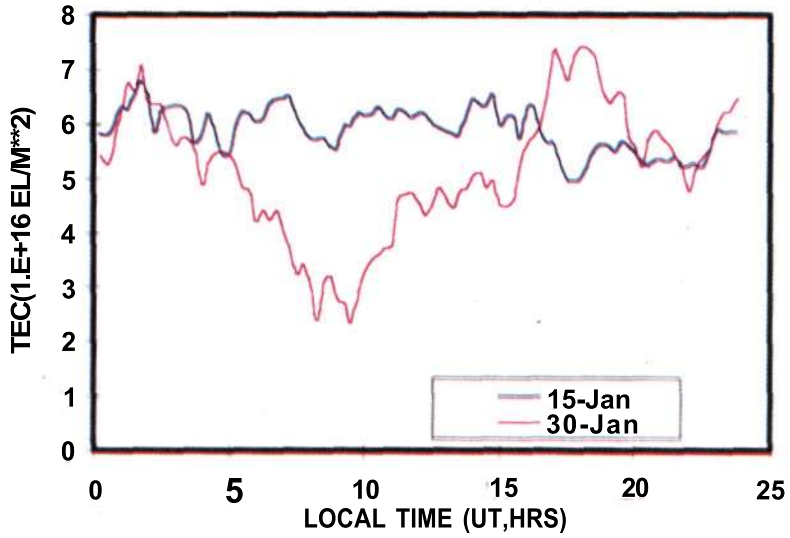

Fig.4. Diurnal variation of TEC on a quiet (15 Jan.) and disturbed (30 Jan) day