Observations of TEC and Dst values using wavelet transform in F2 layer near the equatorial region in August 2011

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Abstract

Observations of terrestrial ionosphere using Wavelet Transforms on data from GPS receivers with dual frequency ionospheric held in Manaus. Were also included in the study, the indices Kp and Dst for comparison purposes. The results showed that when solar flares occur, the Wavelet Transform can better characterize the phenomenon, allowing better visible frequency, duration and intensity, and there is also a direct influence on the data collected by GPS.

Introduction

This study analyzes data from total electronic content (TEC), during the period of geomagnetic storms recorded by the Kyoto WDC (World Data Center for geomagnetism, Kyoto - Dst index), GFZ - POTZDAM (Deutsches Zentrum Geo Forschungs - Kp index) and Manaus station (TEC) (Figure 1), being part of the sensor network of low latitude ionospheric - Lutheran University Center of Manaus (CEULM - ULBRA) and the University of Vale do Paraíba (UNIVAP) that the LISN (Low-Latitude Ionospheric Sensor Network) ionospheric monitoring. In the study by Lima (2009) on the equatorial ionosphere in Central Amazonia, shows that it is of great relevance these observations because of this mosaic in South America, is the region of the globe increased formation of Rayleigh-Taylor instability ("gradient drift" Plasma or bubbles) and strong variations in the TEC (temporal-spatial), compared to other regions of the Earth.

It is also used in the technique of wavelet transform in Dst values, which proved ideal tool for the analysis of no stationary signals due to its ability to compress or expand depending on the scale of analysis (Farge 1992; Daubechies 1992; Bolzan and Vieira 2006).

Figure 1: Location of ionospheric station on the campus of CEULM / ULBRA in Manaus (2.9 0 S, 60.0 0 W, dip latitude 6.4 N).

The sensor network ionospheric low latitude LISN, of which UNIVAP and CEULM-ULBRA part, possesses 70 GPS receivers and 5 ionosondes capable of measuring the TEC in F layer and 5 magnetometers that are positioned along the same meridian magnetic extending from the crest north to the southern crest of the equatorial anomaly, described by Cardoso et al. 2010 and Pillat 2006.

Method

The TEC is defined by the integral (Eq. 1) of the electron density along the path of the signal between the satellite S and the receiver R, in cylindrical column with cross-section area of 1m ² (Monico 2000; Kaplan and Hegarty 2006).

$$\mathrm{TEC} = \int_{r}^{s} n_e ds \qquad (1)$$

The parameter of ionospheric total electron content is presented in TEC units (TECU), where a 1 TECU corresponds to 10^{16} electrons / m². The main reason the TEC parameter is intensively studied is the fact that interfere directly in the calculation of positioning via GPS. There is great interest in studying the TEC in the equatorial region of the globe and for this we used the vertical TEC (VTEC) (Kaplan and Hegarty 2006).

There are two types of wavelet functions, the wavelet continuous and discrete wavelet. Among the best known are discrete wavelet: the Haar, Daubechies, Meyer, among others. The continuous wavelet best known is the Morlet (that will be used here), which is complex also allows the analysis of step and module signal (Bolzan 2006).
The function of Morlet wavelet is a complex, which provides lots of information about the signal is not stationary, especially atmospheric (Farge 1992; Weng and Lau 1994, Lau and Weng 1995).
Torrence and Compo in the definition of Morlet wavelet function is described as (Eq. 2):

$$\Psi(t) = e^{iKt}.e^{-t^2/2} \qquad (2)$$

$\Psi(t)$ = Mother wavelet; K = 5; i = number of desired interactions; t = time.

Geomagnetic Kp index, introduced by J. Bartels (1940), which also was signed by S. Chapman, a statistical method is perfect for a geophysical model called "planetarische Kennziffer" (planetary index). Getting eliminate the irregularities of the earth's magnetic field, Bartels showed that the impact of the solar wind with the magnetosphere could be turned into a musical diagram in semi-logarithmic scale for a sweep of 3 hours, reflecting the state average magnetic activity on the globe. The numerical values of K varies from 0 to 9, with the intermediate fractions 1/3 (GFZ 2005; Kirchhoff 1990; Lima 2009).

Dst Index (Disturbance Storm Time), time index that measures the geomagnetic activity through magnetometers near the equator. This index was introduced in 1964 by Sugiura for observation of geomagnetic activity. When there is an increase in velocity and concentration of solar wind hit Earth, occur sudden ionospheric disturbances (DIS), which constitute true ionospheric storms or magnetic storms (Lima 2009).

Results

Figure 2 shows data obtained TEC in Manaus station, on 05 and 06 August 2011. It can be seen (Fig. 2) that after 17:00 LT ("Local Time") of day 06, the values of TEC suffer a deterioration of your symmetry, driven by a magnetic storm arising from a Solar Flare (CME - coronal mass ejection) took place the day before that can be seen in Figures 3 (Kp index), 4 (Dst index) and 5 (Wavelet Transform). This delay, since the times of the axes of abscissas (time) which occurs in the record of ionospheric GPS data (Fig. 2) is derived the transport time of coronal mass up your connection in terrestrial magnetosphere causing the appearance of auroras (northern and southern). For a better understanding, we can compare the day 05 with day 06 (Fig. 2), when the difference can be observed from the storm occurred.

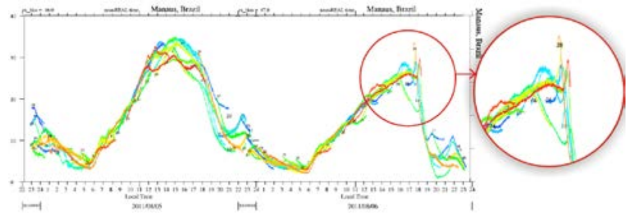

Figure 2 - Values of TEC obtained on August 6, 2010 by the office of Manaus.

Conclusions

Through this study we can see that the magnetic storm occurred on August 5, 2011 had a direct influence on the data collected by GPS Ionospheric. According to Figure 5 in the range from 4 to 0.5 and the time scale between the 5th and 7th of August, the wavelet power spectrum of the magnetic storm is observed with strong intensity. It is planned to conduct future studies in a period of maximum solar cycle # 24, due to the greater number of solar storms.

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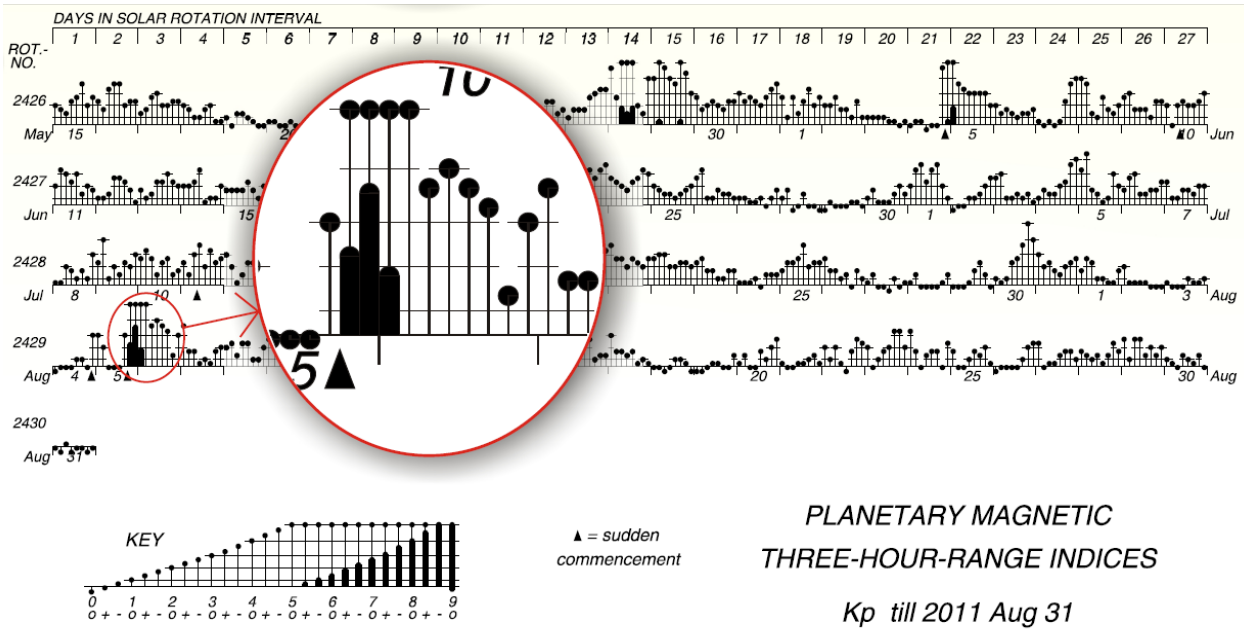

Figure 3 - Kp index of the year 2011 generated by GFZ - POTZDAM.

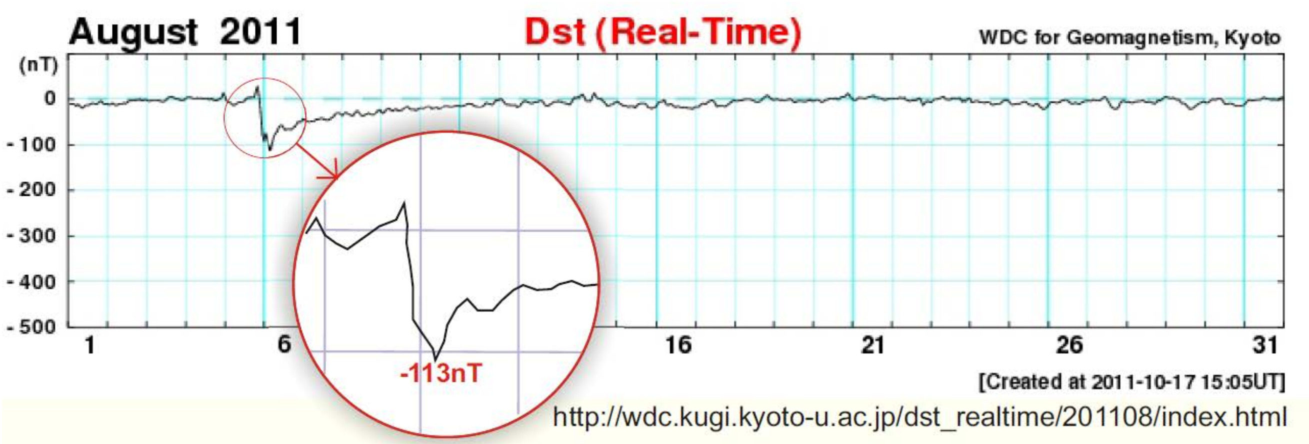

Figure 4 - Dst index for the month of August 2011 generated by WDC - Kyoto.

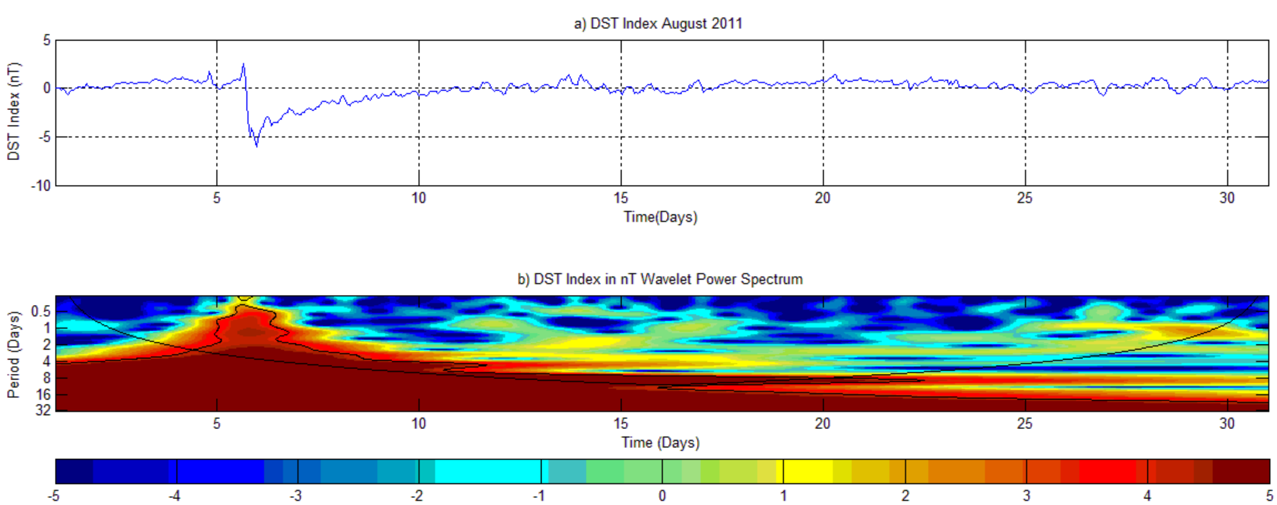

Figure 5 - wavelet transform in the Dst index for the month of August 2011

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