Periodicities on GPS TEC data over South American stations

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Abstract

GPS TEC data is analyzed to look for periodicities due to processes such as planetary waves, gravity waves, lunar tides etc.

Introduction

The Ionosphere varies hourly, daily, seasonally, yearly. For prediction purpose it is important to identify regular features and if possible the physical mechanisms. Much of the variation is due to solar radiation (solar zenith angle, day and night, inclination of earth rotation axis, solar cycle) and geomagnetic activity (geomagnetic storm). But ~20% at daytime and ~33% at nighttime of the F region ionospheric electron density does not come from these mechanisms (Rishbeth and Mendillo, 2001, Forbes et al., 2000, Mendillo et al.,2002). For example, meteorological processes such as planetary wave, gravity wave, tides etc. can directly or indirectly have impact on the ionosphere electron density (Rishbeth,2006).

Vertical coupling processes involving planetary waves (PW) are believed to play a significant role in the day-to-day variability widely observed in important parameters of the equatorial and low latitude ionosphere. Planetary waves of quasi 2-day and 3- to 5-day periodicities in equatorial mesospheric winds were reported and in mesospheric airglow intensity. Planetary wave scale oscillations of different periods have also been identified in the equatorial electrojet current (EEJ) strength and, more recently, in mesopause temperature and EEJ strength, equatorial ionization anomaly and equatorial F layer height and vertical plasma drift (Abdu and Brum,2009).

Also Earth external driving forces like lunar tides should possibly drive 16 days period variation on TEC data.

Looking for those influences GPS TEC data was spectrally analyzed.

Data

The RINEX observation and navigation files were obtained from the International GNSS Service (IGS), < ftp://garner.ucsd.edu/pub/rinex/>, and the Brazilian Network for Continuous Monitoring of the Institute of Brazilian Geography and Statistics (RBMC/IBGE). <ftp://geoftp.ibge.gov.br/RMC/dados>.

Data from 2001 and 2009 from the stations listed in Table 1 representing maximum and minimum solar activity were used.

Table 1 : RMBC and IGS stations used

City	Abbreviation	Latitude	Longitude
Cachoeira Paulista	CHPI	-22.41°	-44.59°
Porto Alegre	POAL	-30.04°	-51.07°
São Luís	SALU	-02.35°	-44.12°
Arequipa	AREQ	-16.47°	-71.49°

The TEC values were obtained calculating TEC from pseudorange observation and from carrier phase measurement, leveling of the carrier phase with the pseudorange and the absolute TEC uses the Nagoya Model approach (Otsuka et al.,2002).

The Nagoya Model is based on a new technique which makes use of a least square fitting procedure to remove instrumental biases from GPS satellite and receiver. It provides two-dimensional map of absolute TEC as a function of time and location, obtained by the following three steps:

1) The hourly averages of TEC for all satellites are estimated by applying a weight least squares fitting procedure to the GPS data from a single receiver.

2) Using the hourly average obtained in the step1 above, the instrument biases can be computed.

3) The biases are removed from the measured TEC to obtain absolute TEC.

Eventual gaps in the TEC data are interpolated. The extreme points of the gap are fitted to a deformed piece of the mean daily TEC.

Analysis

The spectral analysis was done using the Smoothed Periodogram Method (Spectral Analysis, using FFT, periodogram and eventually tapering, padding, smoothing the periodogram with Daniell filter and testing , 2011) for periodicity and confidence interval.

The spectral analysis was done on each station for 2001 and 2009:

1) Every 10 minute interval yearly data

2) Every day interval yearly data for different hours of the day

3) Every day interval seasonal data for different hours of the day

Results

Figures 1, 2 and 3 shows spectral results from Cachoeira Paulista for the year 2001 of maximum solar activity.

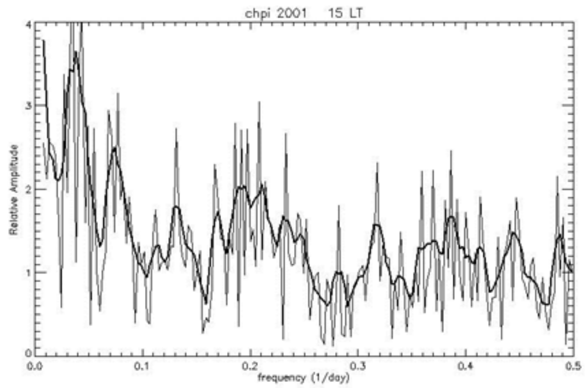

Figure 1: Raw spectra from daily Cachoeira Paulista 2001 with Spectra smoothed by Daniell filter lenght 5

Figure 1 shows the raw spectra with the spectra corresponding to the periodogram smoothed by a Daniell filter of length 5. Combining the spectral data for each hour, Figures 2 and 3 presents the contour map and the shade surface respectively.

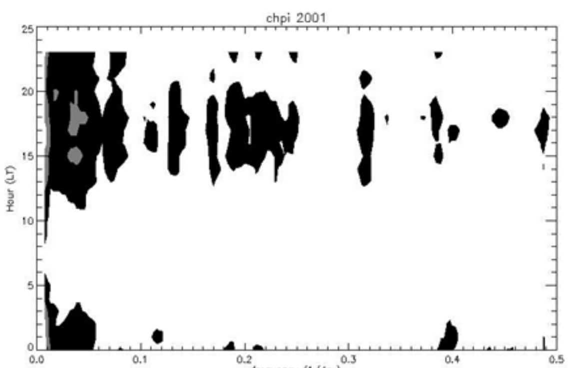

Figure 2: Contour map of Cachoeira Paulista 2001 Spectra

Spectral periods of 26, 14, 8, 5 days are present in Figures 1 and 2. The 14 days is probably due to lunar periodicity.

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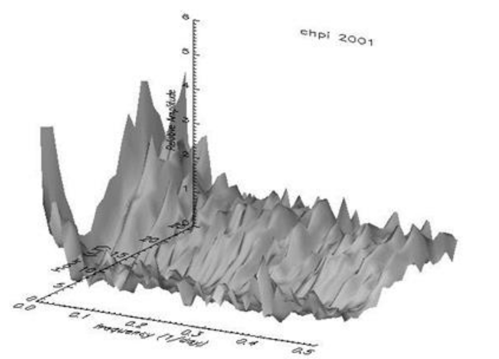

Figure 3: Shade surface of spectra of Cachoeira Paulista 2001 versus hour of the day