The International Beacon Satellite Symposium *BSS2010*
P. Doherty, M. Hernandez-Pajares, J.M. Juan, J. Subirana and A. Aragon-Angel (Eds.)
Campus Nord UPC, Barcelona, 2010

A PRELIMINARY ANALYSIS OF THE SLANT TOTAL ELECTRON CONTENT (sTEC) OBTAINED FROM GPS OBSERVATIONS IN TUCUMÁN REGION AND ITS RELATIONSHIP WITH THE IONOSPHERIC SCINTILLATION

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Key words: sTEC, GPS, Ionosphere.

Summary. In this communication we present the first results of an ongoing study in which GPS observations from the permanent station of Tucumán (Argentina) during the high solar activity period (2000- 2001) are being analyzed. In particular, values of sTEC are being obtained for every satellite and every day by using the method developed by De Lacy et al. (2008)[1]. These values are compared with scintillation index values, S4, provided by the Universidad Tecnológica Nacional de Tucumán and a remarkable coincidence between spatial and temporal abrupt variations of estimated sTEC and high S4 values is being observed.

1 INTRODUCTION

The first objective of this study is to detect ionospheric disturbances in a low latitude area by analysing slant TEC values obtained from GPS observations. The interest of this subject lies in that ionospheric disturbances can produce unwanted effects on electromagnetic signals, which affect satellite communications and, in the case of GNSS observations, can influence precise positioning. We also pay attention to the relationship between sTEC anomalies and scintillation measurements obtained in the Universidad Tecnológica Nacional de Tucumán in order to evaluate the importance of this influence and its evolution along a period of 7 months of high solar activity. The occurrence of plasma bubbles as a possible explanation of the observed STEC anomalies will be considered in a second step. An improved version of the detection technique developed by Portillo et al. (2008)[2] will be applied with this purpose.

2 DATA

Tucumán permanent station (Argentina) is located close to San Miguel de Tucumán city being its geographic coordinates 26º 49' S and 65º 11' W.

GPS observations from September 2000 to April 2001 have been processed. Data are given in periods of 24 hours at a 30 seconds sampling rate. Observables L1, L2, C1 and P2 have been used, where L1 and L2 are the GPS frequencies, C1 is the code for quick measurement of pseudodistance between satellite and receiver and P2 is the precise code in L2. From these observations, graphics of sTEC for every satellite and every day in the studied period have been obtained.

3. METHODOLOGY AND OBTAINED RESULTS

3.1 STEC Estimation

In a first step, a least squares adjustment of observation equations (Eq.1) has been applied. In this expression, i = 1, 2 denote the different GPS frequencies, Pi and Li correspond to the code pseudorange and carrier phase observations, respectively, both expressed in distance units at frequency fi; $k_{1i} = (f_1 / fi)^2$ and ν_P and ν_L represent the measurement noise of code and phase observations. Following De Lacy et al., (2008)[1], ionospheric delays in frequency f_I (J_I), carrier phase initial ambiguities (B_i) and smoothed pseudodistances (ρ) can be obtained for every satellite at every epoch from GPS multi-frequency observations.

$$\begin{cases} P_i(t) = \rho(t) + k_{1i} J_1(t) + \nu_P \\ L_i(t) = \rho(t) - k_{1i} J_1(t) + B_i + \nu_L \end{cases} \tag{1}$$

Estimated ionospheric delays are transformed into sTEC values.

3.2 STEC variations detection

As an example, in Fig. 1, estimated sTEC for some GPS satellites during 7 December 2000 (day 342) is presented. Sudden decreases in sTEC have been detected during the following periods: for satellite PRN08 between 1 and 2 UT; for PRN26 between 6 and 8 UT; for PRN30 between 7 and 8 UT. These variations in sTEC can be related to ionospheric disturbances able to cause scintillation.

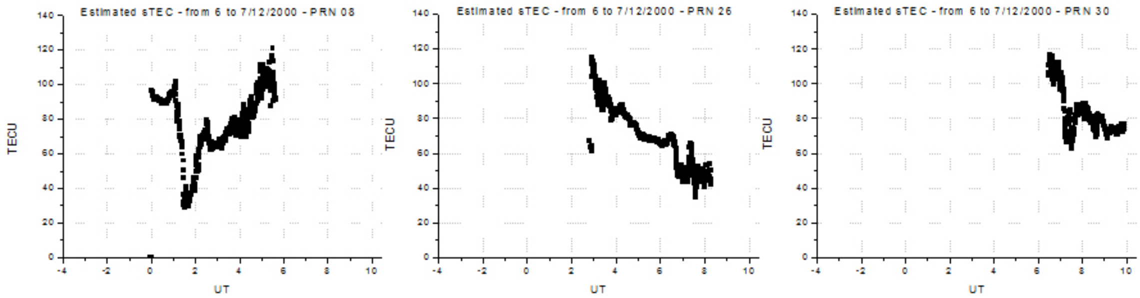

Figure 1. sTEC graphics obtained for GPS satellites PRN08, PRN26, PRN30, corresponding to measurements taken in the night from 6 to 7 December 2000.

The same GPS observation files have been processed by the Geodesia Espacial y Aeronomía (GESA)[3] laboratory, providing sTEC values as well. Fig. 2 shows sTEC obtained by GESA in the night from 6 to 7 December 2000. It can be seen that, for the satellites and periods with sTEC decreases observed in Fig. 1, sTEC values have not been computed by GESA.

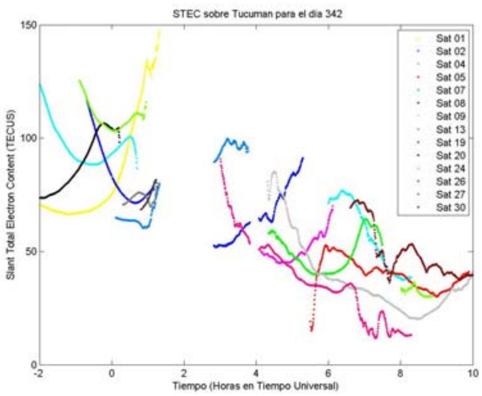

Figure 2. sTEC obtained by GESA from GPS measurements taken in the night from 6 to 7 December 2000.

3.3 Comparison with S4 index

S4 index quantifies the degree of ionospheric scintillation and it is obtained as the standard deviation of the received signal power divided by its mean value. If S4 > 0.1, it is claimed that scintillation exists and, if S4 > 0.5, the scintillation[4] is strong.

In Fig. 3, the sTEC values obtained following 3.1 and S4 index obtained by Tucumán are compared.

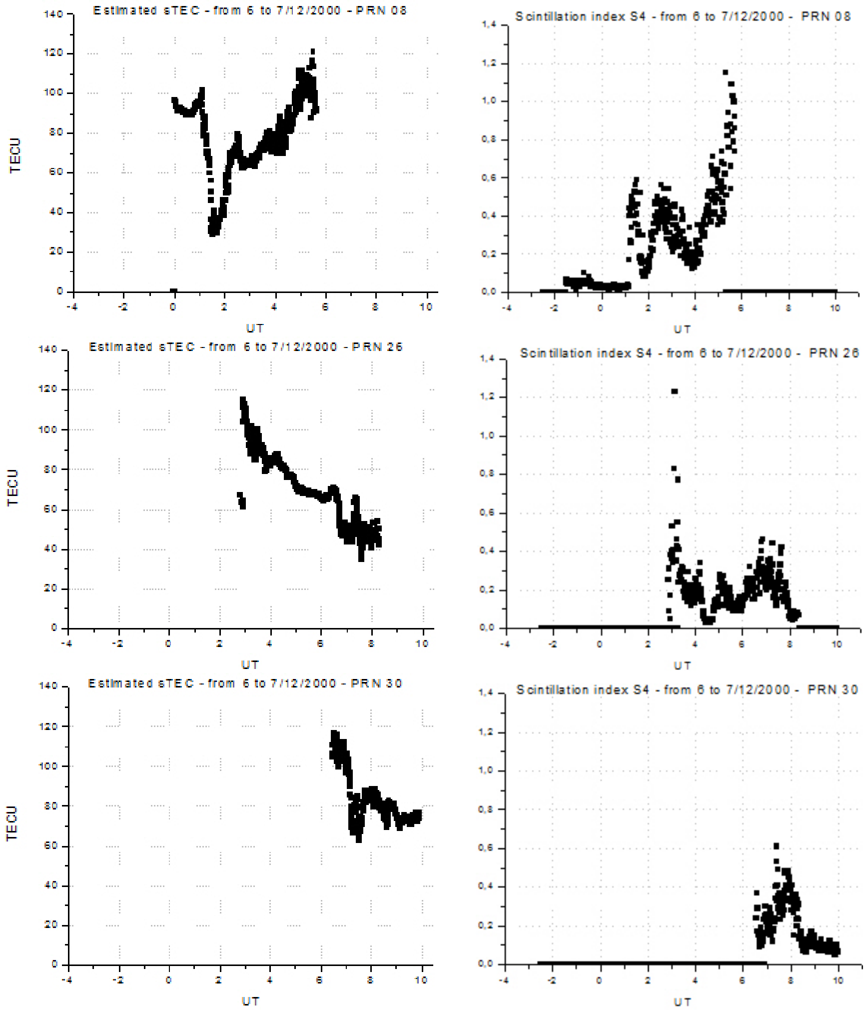

Figure 3: Estimated sTEC obtained with 3.1 (left panels) and Tucumán S4 index (right panels) for the GPS satellites PRN08, PRN26, PRN30 for the night from 6 to 7 December 2000.

For the satellite PRN08, Fig. 3 shows a high decrease of sTEC from 1 to 4 UT, which corresponds to a S4 increase in the same period. It is worth mentioning that the minimum sTEC value is located about 1,5 UT, exactly when a maximum value of S4 can be observed. On the other hand, for PRN26 and PRN30, the same relation can be appreciated during periods 6 to 8 UT, for the first one, and from 7 to 8 UT for second one.

4 CONCLUSIONS

The sTEC values obtained from GPS observations taken at the Tucumán permanent station from September 2000 to April 2001 indicate the presence of important and frequent anomalies as is expected in a low latitude station and a high solar activity period. The high sTEC decreases have been detected for some satellites which correspond to scintillation periods according to S4 index values provided by the Universidad Tecnológica Nacional de Tucumán.

5 AKNOWLEDGMENTS

The authors are very grateful to the Universidad Tecnológica Nacional de Tucumán and GESA for making available numerous S4 and sTEC data. The collaboration of C. De Lacy and A. Portillo is sincerely appreciated. This research is being funded by the Ministry of Science and Innovation of Spain (Project AYA2008-02948) and by the Universidad Complutense-Comunidad de Madrid Programme for the Consolidation of Research Groups (Group 910596)

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