COMPARISON OF IONOSPHERIC TEC OBTAINED FROM FARADAY ROTATION OF GEOSTATIONARY SATELLITE SIGNALS AND FROM GPS DATA

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ABSTRACT

In this paper we compare the ionospheric total electron content (TEC) obtained from Faraday rotation observations carried out at Neustrelitz (Germany), and the total electron content predicted for the same subionospheric points using Global Positioning System data gathered at Wettzell (Germany). Three different periods with data have been compared. In general, the same features for the TEC are reproduced by both results. For two of the compared periods there is a bias between both results, possibly due to the unknown initial polarization, the unresolved ambiguities in the Faraday-derived TEC or to plasmaspheric contributions. Another source of discrepancies between both results are deficiencies in the way of predicting the TEC at Neustrelitz using data from Wettzell.

1. INTRODUCTION

It is possible to obtain measurements of the ionospheric total electron content (TEC) from the Faraday rotation that radio waves from geostationary satellites suffer when crossing the ionosphere.

The ionosphere also introduces a delay in the radio signals from the satellites of the Global Positioning System (GPS) that depends on the ionospheric TEC and on the inverse of the squared frequency of the signal. Then, dual frequency GPS observations can be used to model the ionospheric TEC.

In this paper we present the comparisons of the ionospheric TEC obtained with both techniques for three different periods.

2. GPS AND FARADAY DATA

We have used Faraday rotation observations gathered at Neustrelitz (53.3N, 13.1E) to obtain the vertical TEC at three different epochs. The geostationary satellites observed in each epoch and the corresponding subionospheric points are listed in table I.

Period of comparison	Satellite	Position	Subionospheric point
September 5/6, 1990	OTS-2	5°W	(47.7N,11.5E)
September 8/9, 1991	METEOSAT	10°W	(47.6N,8.7E)
December 1/2, 1991	METEOSAT	10°W	(47.6N,8.7E)

Table I: Faraday rotation observations.

We have used dual frequency GPS data gathered at Wettzell (49.1N, 12.9E) to estimate the ionospheric TEC at the same subionospheric points in the observed epoch.

3. ESTIMATION OF THE TEC

The total electron content of the ionosphere N_F is determined from Faraday rotation observations by (e.g. Davies, 1980):

$$N_F = \frac{f^2}{K_F \cdot M_{400}} \cdot (\Omega_F - \Omega_0 - n\pi) \qquad (1)$$

where f is the radio beacon frequency

$K_F = 2.363$ in S.I. units

M_{400} is the M-factor $M = B \cdot \cos\Theta$ fixed at the value reached at 400 km height along the ray-path

B is the magnetic flux density

Θ is the angle between B and the ray path

Ω_F is the Faraday rotation angle (radians)

Ω_0 is the initial angle of the polarization plane of the antenna

Due to non-zero inclination of the used satellites, the ray path is not fixed in space and, therefore, the magnetic field factor M is modulated by the 24 hour periodicity of the satellite orbit. In the Faraday data used in our analysis this modulation was not corrected since the phase of the satellite motion in the geostationary orbit was unknown.

The absolute position of the antenna on board the satellite was also unknown. Ambiguities of $n \pi$ were unresolved because of the lack of additional ionosonde data.

In the estimation of the TEC using GPS data we have used phase and pseudoranges observations. We have estimated the differential instrumental biases for each GPS receiver and satellite (Wanninger and Sardón, 1993). Once these biases were removed, we obtained for each observation time, the TEC corresponding to the different GPS observation path carried out at Wettzell (Sardón, 1993). With this information we have predicted the vertical TEC at the subionospheric points corresponding to the Faraday rotation observations. GPS data below 20 degrees were neglected to reduce the effect of multipath errors and to avoid the mismodeling at low elevations of the function that maps the vertical TEC to slant TEC.

4. RESULTS AND DISCUSSION

Figure 1 to 3 present the results obtained with both methods for the three periods compared.

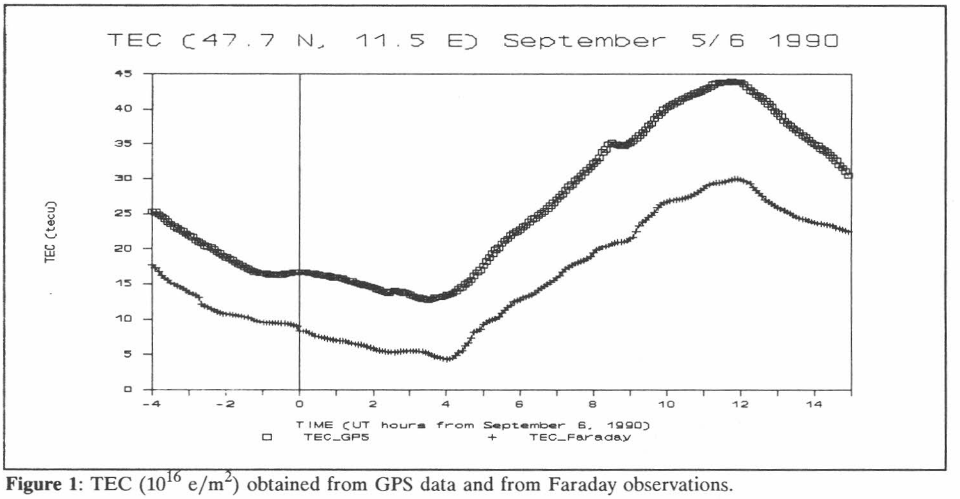

Figure 1: TEC (10^{16} e/m^2) obtained from GPS data and from Faraday observations.

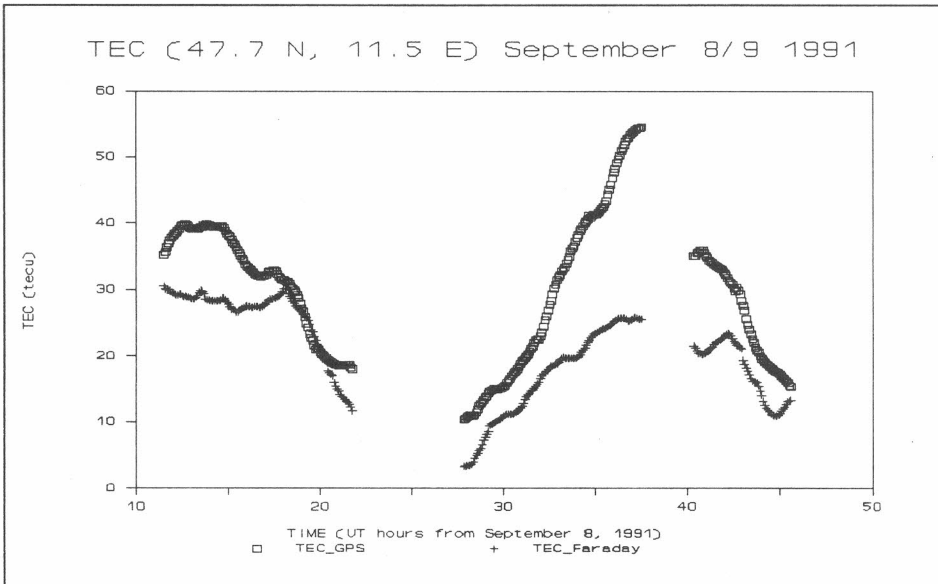

Figure 2: TEC (10^{16} e/m^2) obtained from GPS data and from Faraday observations.

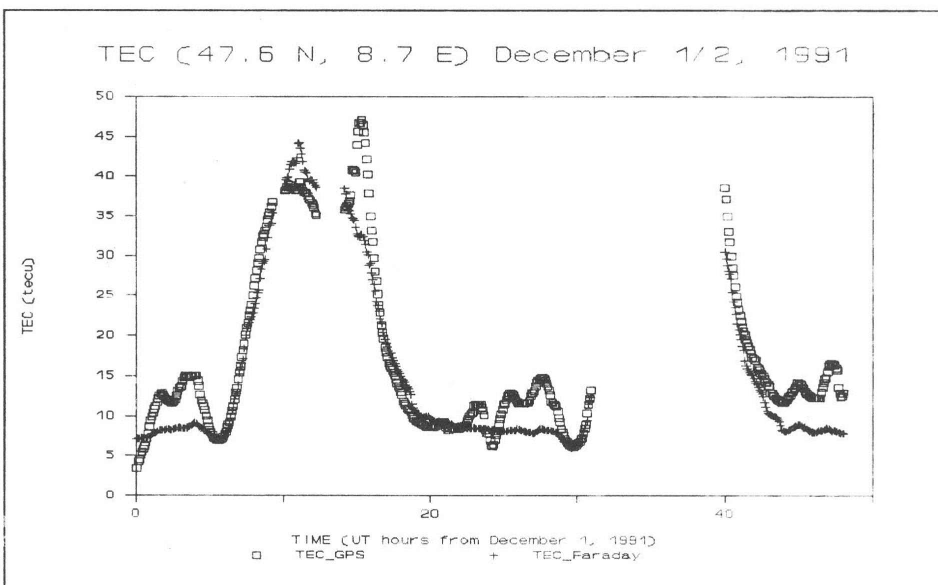

Figure 3: TEC (10^{16} e/m^2) obtained from GPS data and from Faraday observations.

Figures 1 show that the general behavior of the GPS-derived TEC and the Faraday rotation observations is very similar. For September 8/9, 1991 (figure 2), the similarity between both results is not so clear. The remaining differences can be due to the unknown initial polarization Ω_0 , the unknown $n\pi$ and due to the plasmaspheric electron content.

For the December period (figure 3) there is a better agreement in the absolute value of the TEC than for the September periods, but there are some discrepancies in the behaviour of the TEC. The strange behaviour that can be seen in the night time GPS TEC values is likely to be consequence of the low number of satellites observed simultaneously at Wettzell (maximum of three), and the low elevations in some of them. From 10 to 12:15 on day December 1, the situation was very similar. It is not so clear why there is a peak difference at around 15:30 UT between Faraday and GPS data, it might be related to a weakness in the prediction of TEC in Neustrelitz from Wettzell data. More recently an improved method for the prediction has been used and this differences have decreased.

5. CONCLUSIONS

TEC obtained from GPS data and TEC obtained from Faraday rotation observations have been compared for three different periods. For the first of them the same patterns are reproduced by both results. For the second period this is not so clear. And, in the third period the agreement is better in the absolute values obtained for the TEC.

In general, the comparisons are very valuable, but there are some features that have to been studied in more detail.

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