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

CONJUGATE OCCURRENCE OF TEC FLUCTUATIONS DURING GEOMAGNETIC DISTURBANCES

Irk Shagimuratov*, **Andrzej Krankowski**†, **Irina Zakharenkova*** **and Ivan Ephishov***

*West Department of IZMIRAN
Kaliningrad, Russia

†University of Warmia and Mazury in Olsztyn, Geodynamic Research Laboratory
(GRL/UWM)
Olsztyn, Poland

Key words: GPS, Ionosphere, TEC fluctuations, geomagnetic storm.

Abstract. In the paper there are presented similarities and differences in GPS/TEC fluctuation activity for polar, auroral and subauroral areas at northern and southern hemispheres. It is found seasonal effect in development TEC fluctuations in high-latitude ionosphere during severe geomagnetic storms.

1 INTRODUCTION

It is known that GPS radio signals passing the ionosphere suffer varying degrees rapid variations of amplitude and phase (radio scintillations). The scintillations are caused by the presence in the ionosphere irregularities with wide range of scale sizes. Standard GPS measurements with 30 s sample provide a measurements of TEC fluctuations caused by irregularities at high latitudes with scale size larger than 30 km. As measure of fluctuations activity may be used Rate of TEC (ROT).

Small-scale irregularities produce amplitude and phase scintillation which can degrade the transionospheric signals and can influence on the performance of different space communication radio systems[1]. It is the most important to account scintillation and phase fluctuation effects on performance GNSS navigation system and consequently on precession determining of navigations parameters. Large scale irregularities and associated with them TEC fluctuations can complicate phase ambiguity resolution, increase the number of undetected and uncorrected cycle slips and loss of signal lock in GPS navigation[2].

In this paper we present extended and more detailed analyses of TEC fluctuations development in both northern and southern hemisphere and compare winter and summer events (November and July 2004 storms). In the report a special attention will be given to the features of TEC fluctuations occurrence in both hemispheres for conjugated GPS stations. The main phase of both storms started before midnight on July 22-23 and November 6-7 respectively. The Dst index reached -190 nT for July 27 and 370 nT for November 8 respectively. Maximal sum of Kp reached 60 on July 27 and 56 on November 10. The time development of both storms was rather similarly.

2 DATA BASE

GPS observation carried at the Antarctic and Arctic IGS stations were used to study the development of TEC fluctuations in the high latitude ionosphere. The dynamics of high latitude ionosphere is controlled by the geomagnetic field. For correct comparison of TEC fluctuations development we chose stations with closely located geomagnetic coordinates. As measure of phase fluctuation activity we used the values of ROT on 1 min interval. To estimate the intensity of TEC fluctuations we used the Rate of TEC Index (ROTI) based on standard deviations of ROT[3].

3 OBSERVATIONS

3.1 Polar ionosphere

Figure 1 presents a development of the storm in TEC fluctuations (ROT) at conjugate stations MCM4 (north) and RESO (south) for July and November 2004 storms.

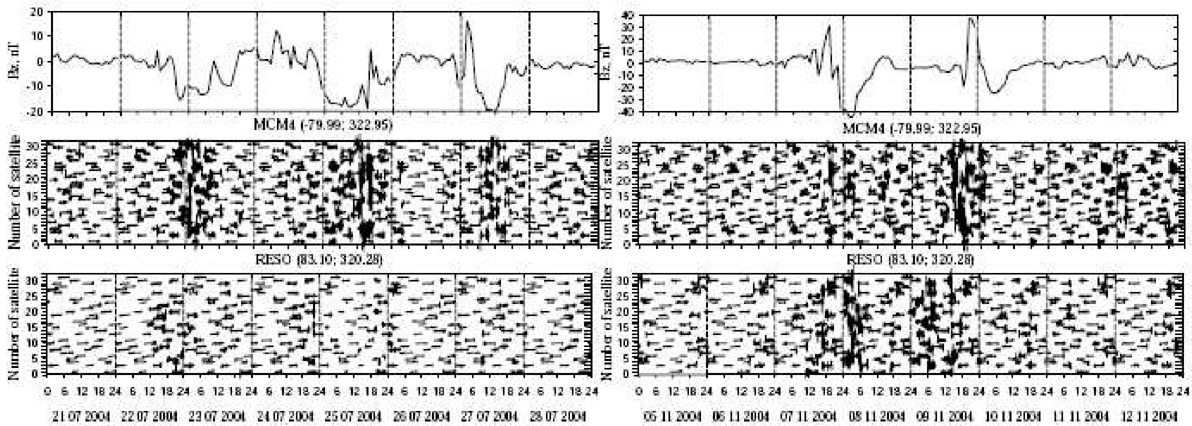

Figure 1: Development of TEC fluctuations on polar stations during July and November 2004 storm

The pictures illustrate the occurrence of TEC fluctuations for all passes of satellites observed at southern and northern hemispheres over a 24 hour interval on quiet and disturbed days, here also presents variations of Bz component of interplanetary magnetic field (IMF) for discussed period. When Bz varied near zero it was observed weak and moderate fluctuations at both stations. During July storm TEC fluctuation activity was more expressed in winter (MCM4 stations), for October storm difference between hemispheres was less pronounced. Strong increasing of TEC fluctuations took place when Bz was negative. The effect was not expressed at RESO station in July storm. For October storm the behaviour of TEC fluctuations at conjugate stations for all satellite passes was rather similar.

3.2 Auroral ionosphere

Figure 2 shows the occurrence of fluctuations over DAV1 and NYAL stations located in heart of auroral oval. The behaviour of fluctuations at both stations is rather similar than differ. It is evident that during all discussed period both stations located within auroral oval. During the most disturbed day the intensity of fluctuation increased and was invariable for the whole day. The development of TEC fluctuation over auroral station is also controlled by behaviour of Bz and was maximal when Bz was negative. At the same time at NYAL station TEC fluctuations was more significantly expressed when Bz is sharply changed sign. During July storm the fluctuation activity was higher at the southern station DAV1 than at NYAL and vice versa for November storm.

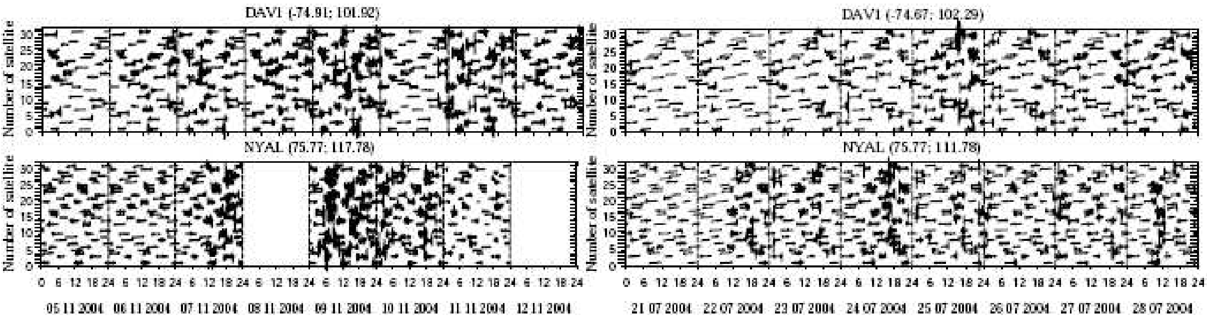

Figure 2: Development of TEC fluctuations at auroral stations during July and November event

3.3 Subauroral ionosphere

In subauroral stations KERG and JOEN (Figure 5) the fluctuations clearly exhibit during the most disturbed days when Bz is negative. The picture of TEC fluctuations at both hemispheres was very similarly for Winter and Summer. The analysis is shown when fluctuations were developed in subauroral ionosphere the ionospheric trough is lowered to $50 - 55^oN$. It is known in that near trough walls, where strong gradients took place, different scale irregularities can be excited. It is caused the increasing TEC fluctuation activity.

4 TEMPORAL AND SPATIAL TEC FLUCTUATIONS INTENSITY

As well as auroral oval the spatial and temporal occurrence of the irregularities can be visually presented in coordinates - Geomagnetic local time and Corrected geomagnetic latitude. As a measure of ionospheric activity we used also the Rate of TEC Index (ROTI)

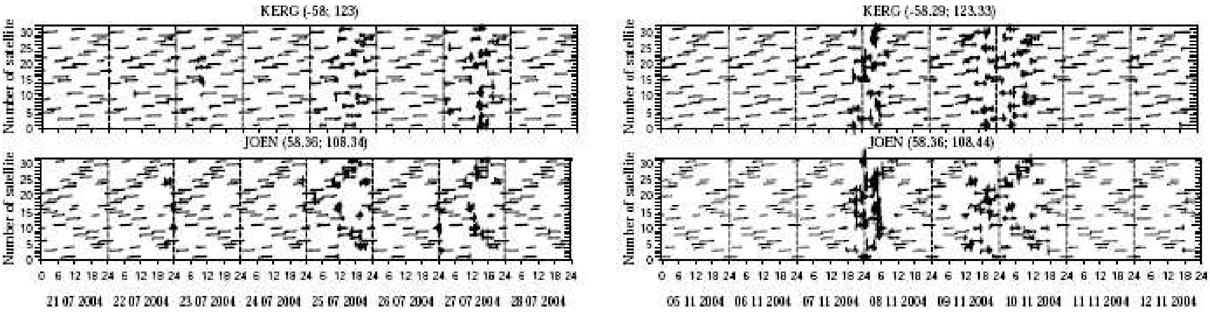

Figure 3: Development of TEC fluctuations at subauroral stations during July and November storms

based on standard deviation of ROT estimated on 10-min interval.

As example Figure 4 illustrates location of TEC fluctuations derived from GPS measurements in Geomagnetic local time and Corrected geomagnetic latitude over different conjugate station during quiet and disturbed for both consideration events. The intensity of the fluctuations is indicated with symbols of different saturation of grey color.

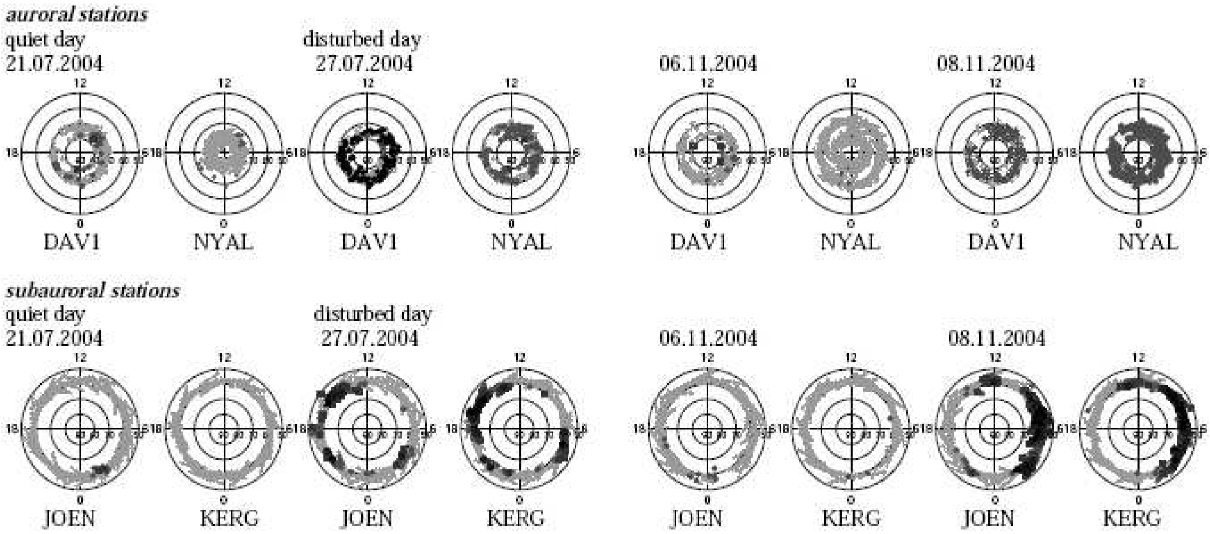

Figure 4: Location of TEC fluctuations derived from GPS measurements in geomagnetic local time for July and November 2004 storms (quiet and disturbed days)

One can see the enhancement of TEC fluctuation activity during storm days when Bz of IMF was strongly negative. Also it is possible to see the seasonal effect in occurrence of fluctuations activity development. Intensity of fluctuations was more pronounced during winter conditions.

5 CONCLUSIONS

The GPS measurements of northern and southern hemispheres were used to study stormtime development of TEC fluctuations at conjugate area in polar, auroral and subauroral ionosphere. During storms the intensity of irregularities essentially increases and its location expands to equator. Maximal activity of TEC fluctuations took place when IMF Bz component was negative. Storm-time development of TEC fluctuations caused by ionospheric irregularities was controlled by UT. At polar stations TEC fluctuations were more expressed at southern (winter) hemisphere. Over auroral stations the difference of TEC fluctuations occurrence was less expressed. During storm the strong TEC fluctuations can be registered at subauroral ionosphere, (on latitudes low than 55 CGL). The seasonal effect in this area also took place.

REFERENCES

[1] S.M. Stankov, N. Jakowski, Ionospheric effects on GNSS reference network integrity, Journal of Atmospheric and Solar-Terrestrial Physics, Vol. 69,485-499, (2007).

[2] JB. Forte, S. Radicella, Geometrical control of scintillation indices: What happens for GPS satellites, Radio Science, Vol. 39, (2004).

[3] X. Pi, A.J. Manucci, U.J. Lindqwister, C.M. Ho, Monitoring of global ionosheric irregularities using the worldwide GPS network, Geophysical Research Letters, Vol. 24, 18, 2283-2286, (1997).