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CASE STUDY OF TEC FLUCTUATION DURING AURORAL DISTURBANCES

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Abstract. In the paper there are presented occurrence of TEC fluctuations in high latitudes ionosphere during September 2011 events. The simultaneously GPS observations from more than 130 stations provided to obtain, similarly auroral oval, irregularity oval. It is shown that irregularity oval very sensitive to changes of solar-geomagnetic activity and can use as indicator space weather conditions.

Introduction

The scintillations of trans-ionospheric radio signals is very well known indicator space weather condition. The electron density irregularities presented in high latitude ionosphere may experience phase and amplitude fluctuations of GPS signals. The information about TEC fluctuations may be obtained using the regular GPS observations provided by the International GPS Service (IGS). The world wide and numerous network GPS stations are very opportunely to monitor the spatial distribution of ionospheric irregularities in planetary scale (*Shagimuratov et al., 2009*). In this report GPS measurements of global IGS network were used to study the storm time occurrence of phase fluctuations (TEC changes) in the high latitude ionosphere during September 2011 events. The GPS stations with geomagnetic coordinates higher than 55°N and different longitudes were involved in this investigation. Dual-frequency GPS measurements for individual satellite passes served as raw data. As a measure of fluctuation activity the rate of TEC (ROT, in the unit of TECU/min, 1 TECU=10^{16} electron/m2) at 1 min. interval was used (*Aarons 1997*), as the measure intensity of TEC fluctuations do index ROTI(*Pi et al., 1997*).

Solar and geomagnetic conditions

In September 2011 took place three moderate geomagnetic storms-9, 17 and 26 September. The development of the storms was rather similar. On recovery phase of 9 and 26 September substorm activity took place In Fig.1. Dst, Kp, AE indices and Bz component of IMF during September 2011 are presented. Over Europe all storms started in daytime. It will be noted the increased auroral activity was observed on the beginning September on background of low geomagnetic disturbances.

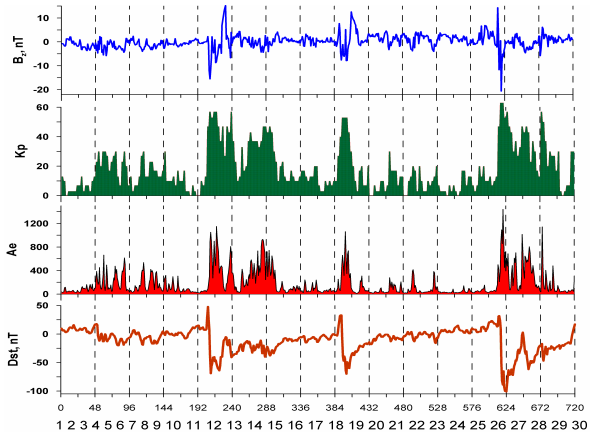

Figure 1. The solar and geomagnetic conditions during September 2011

On the Fig. 2 is presented development TEC fluctuation over subauroral NNVN station. In the quit conditions of 8 September the fluctuations were very low, indicating that the station located outside auroral oval. During driven phase of storm (9 September) strong fluctuations were observed in 15-19 MLT. In this time sharply increase also AE index. the development TEC fluctuations next days were occurred according with development substorm activity on recovery phase storm.

For the isolated storm of 17 September intensive TEC fluctuations were observed during driven phase because recovery phase was quiet. The storm 26 September also followed by substorm activity The TEC fluctuation activity was developed in according to occurrence of substorms.

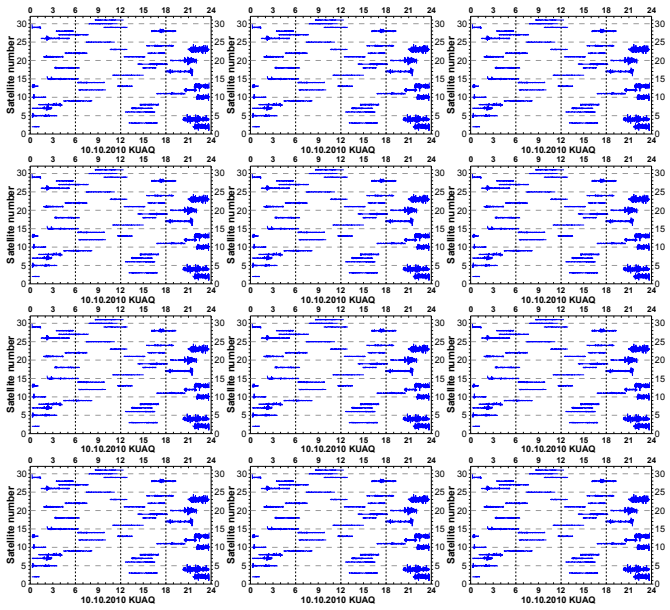

Figure 2. Temporal and spatial occurrence of TEC fluctuations

Temporal and spatial occurrence of TEC fluctuations

The occurrence of TEC fluctuations essentially depend on geomagnetic latitude. Latitudinal behavior of TEC it was analyzed using ROTI measurements over stations located at different latitudes (Fig. 2). For spatial and temporal distribution TEC fluctuations to obtain it was formed images ROTI in Corrected Geomagnetic Latitude (CGL) and Magnetic Local Time (MLT) coordinates. The stations were choused in according their location relative to auroral oval. At auroral station KELY (Fig. 4) low TEC fluctuations were observed all day. During storms the intensity fluctuations increase. In whole development of fluctuations was similar to subauroral NNVN station (Fig. 3) but intensive fluctuations were detected more time interval. Increase of TEC fluctuations were detected at the same UT time, similar NNVN stations. On the Fig. 4 the occurrence TEC fluctuations at RINK station are presented. This station located on polar edgy of auroral oval. The development fluctuations occurred also in according to solar-magnetic activity. At the same time behavior of TEC fluctuations rather is differ against auroral ionosphere. As seen on the picture strong fluctuations were prevailed near day time.

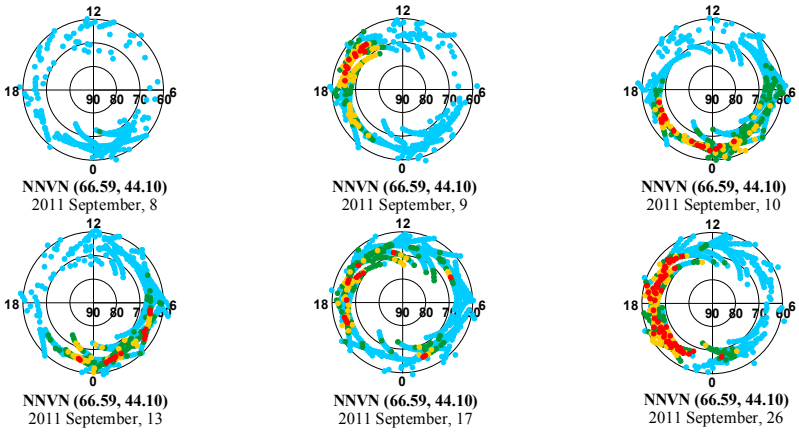

Figure 3. The development of TEC fluctuations over subauroral NNVN station.

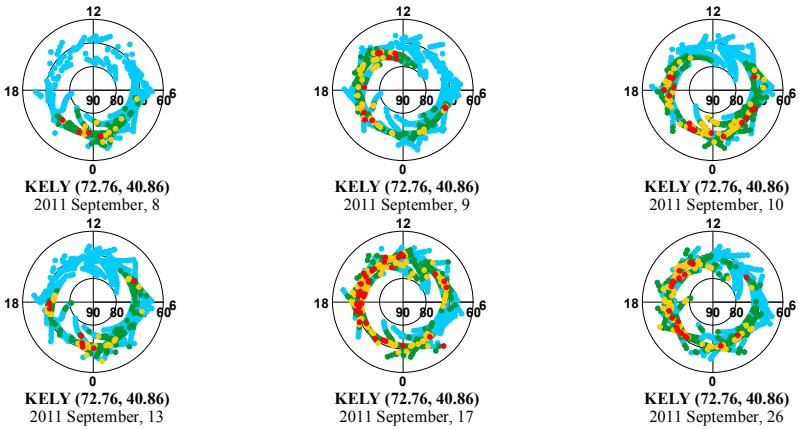

Figure 4. The development of TEC fluctuations over auroral station KELY.

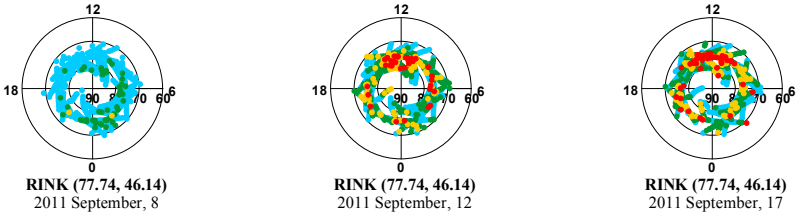

Figure 5. The development of TEC fluctuations over RINK polar station.

Oval irregularities

Based on the daily GPS measurements from 130-150 selected stations, the images of spatial distribution TEC fluctuations (index ROTI) in CGC and MLT) coordinates was formed. Similarly to the auroral oval, these images demonstrate the irregularity oval. The occurrence of the irregularity oval relates with auroral oval, cusp and polar cap. The irregularity oval expands equatorward with increase of the magnetic activity. In Fig. 5, as example, presented dynamics irregularity oval in depended geomagnetic activity. As it seen from Fig.5 activity and intensity TEC fluctuations weak relate with behouver of Kp and more depend on changes of IMF Dynamics of irregularity oval well correspond with AE index.

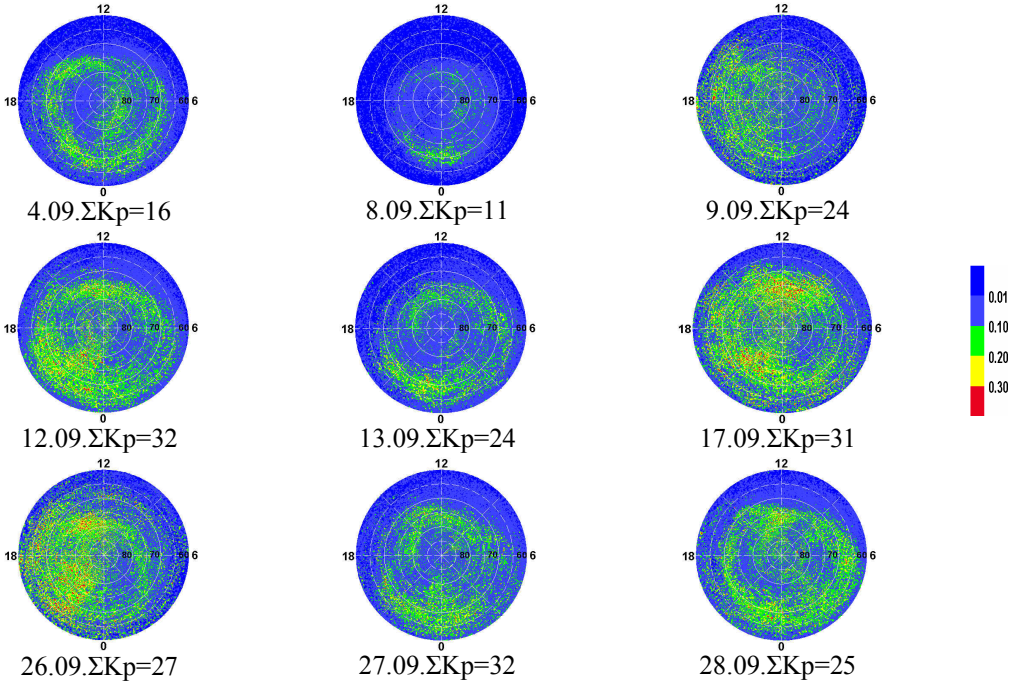

Figure 6. The day by day dynamics of irregularity oval for September 2011 disturbances.

Conclusions

Analyses shoved that fluctuation activity of GPS signals in the high latitude ionosphere is depended on geomagnetic conditions. Intensity of fluctuations essentially increases during geomagnetic storm. Similarly to the auroral oval the spatial distribution of the fluctuations demonstrate the irregularity oval images. The occurrence of GPS- TEC fluctuation is very sensetive to solar –geomagnetic changes and can use to evaluate space weather conditions. The study showed that the operating high-latitudes GPS stations can provide to monitor in near real-time of the space weather.

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References

Aarons J., GPS system phase fluctuations at auroral latitudes, Journal of Geophysical Research, 102, A8, pp. 17219-17231, (1997).

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

Shagimuratov I.I., A. Krankowski, I. Ephishov, Yu. Cherniak, P. Wielgosz, and I. Zakharenkova, High latitude TEC fluctuations and irregularity oval during geomagnetic storms Earth Planets Space, Vol. 64 (No. 6), pp. 521-529, 2012.