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GPS-TEC Fluctuations and Auroral Activity

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ABSTRACT

Summary: In this paper we analyzed latitudinal occurrence of TEC fluctuations related with auroral activity over Europe during the January 7, 2015 geomagnetic storm. The magnetograms of the IMAGE network were used as indicator of auroral activity. We found good similarities between time development of substorm and fluctuations of the GPS signals. The bay-like geomagnetic variations were followed by intensive phase fluctuations at auroral and subauroral stations. These results confirm the equator-ward expansion of the auroral oval during this storm.

1. Introduction

Scintillation of the trans-ionospheric radio signals is a well-known indicator of the space weather condition. Presence of the electron density irregularities at the high latitude ionosphere can lead to the phase and amplitude fluctuations of GPS signals [1]. The low frequency GPS phase fluctuations occur due to electron density changes along the radio ray path, or the total electron content (TEC) changes. Strong TEC fluctuations can complicate the process of phase ambiguity resolution and increase the number of undetected and uncorrected cycle slips [2,3,4]. The GPS scintillations, associated with substorm auroral activity, were studied in [5,6]. The experimental evidence of positioning errors related with spatial and temporal variations in the intensity of auroral arcs was demonstrated by Chernouss [7]. In this paper we use GPS measurements of the global IGS network to study the storm time occurrence of phase fluctuations (TEC changes) in the high latitude ionosphere during January 2015 event. The dual-frequency GPS measurements along individual satellite passes were served as raw data. As a measure of fluctuation activity we use the rate of TEC (ROT, in the unit of TECU/min, 1 TECU=10^{16} electron/m^2) at 1 min interval.

2. The case study

This moderate geomagnetic storm started near 08 UT on 7 January 2015. The peak value of the Dst index reached about -100 nT, Kp was about 6. Maximal auroral activity (index AE) was observed near 09-12 UT when the main phase of the storm was progressed.

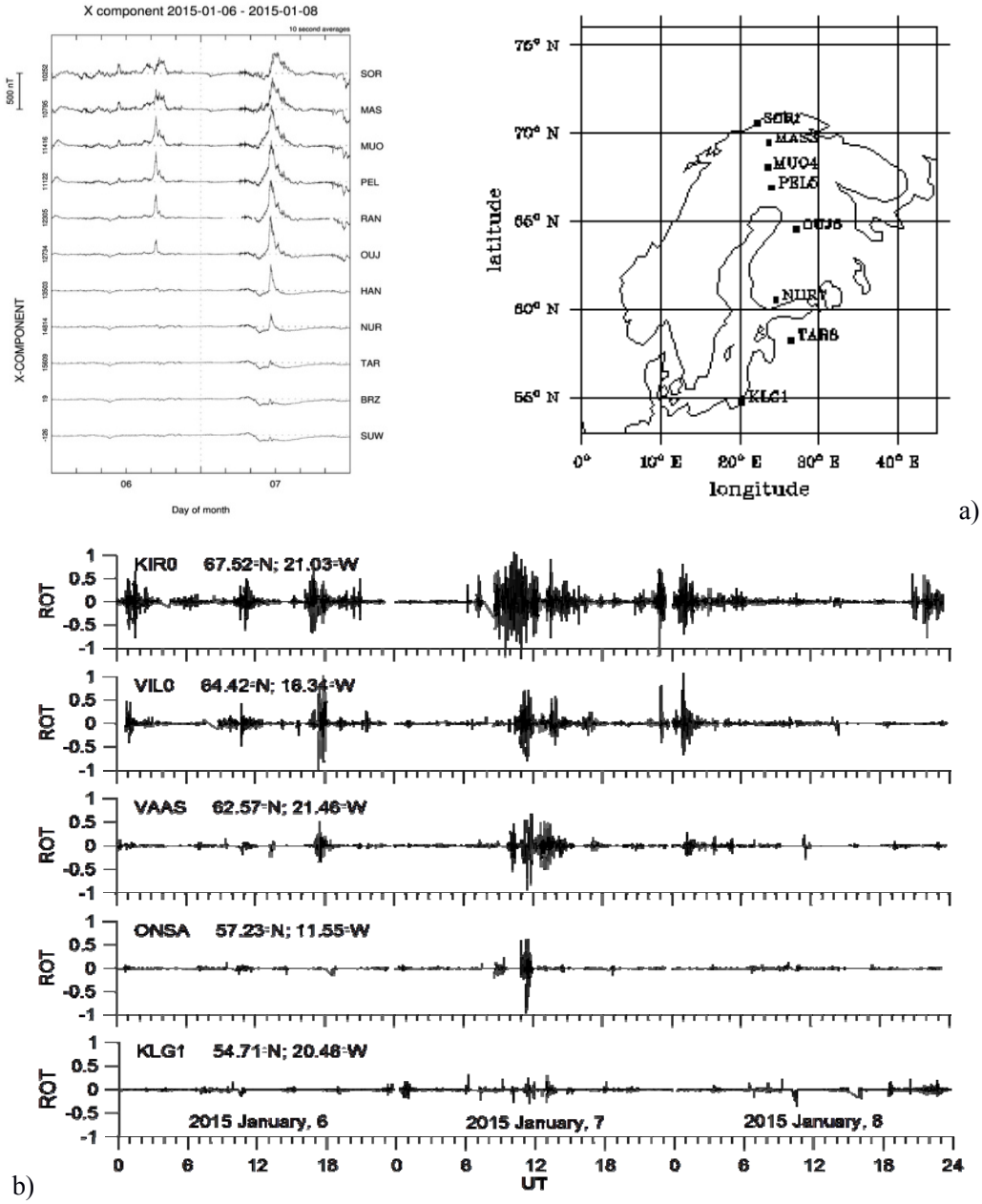

Figure 1.The variations of the geomagnetic field (X-component) at Scandinavian network(a). Latitudinal occurrence TEC fluctuations during auroral activity (b).

Figure 1a shows the magnetic bays on magnetogram of the IMIAGE Scandinavian network (see map). The network includes the stations located in auroral, subauroral and mid-latitude. The strong magnetic activity is occured during day time. The intensity of the magnetic bay decreases from north to south. The strongest magnetic variations were registered near 12UT, when a weak bay was observed as low as at latitude of 55°N.

Figure 1b shows the ROT variations over the GPS stations arranged from north to south. The fluctuations intensity decreases towards lower latitudes. At lower stations the fluctuations were observed also around 12 UT when the magnetic field variation had the strongest intensity.

Occurrence of the high ROT values coincides with variations of the geomagnetic field X-component at different stations of the Scandinavian network. Using GPS ROT variations as well as the pulsations of the geomagnetic field we can determine the source which caused a disruptions of the navigation signal within the ionosphere in the presence of the auroral disturbances, in particular, substorms.

Conclusions

During January 7, 2015 geomagnetic storm the intense TEC fluctuations (ROT) were observed in the auroral and subauroral ionosphere. Joint analysis of the observed phase fluctuations of GPS signals and fluctuations of the geomagnetic field has demonstrated rather good agreement in the conditions of the auroral activity intensification. The analysis shows that position and intensity of the irregularities oval are very sensitive to the variations of the auroral activity and thus the magnetic fluctuation measurements can be used as an indicator of the space weather conditions.

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