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Ionospheric Variations Associated with August 2, 2007 Nevelsk Earthquake

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It was presented the analysis of the ionosphere anomalies, occured prior to the Nevelsk earthquake of August 2, 2002 at 0237 UT with M6.2. For this our study we processed the global TEC maps and measurements provided by IGS network stations. It was revealed the ionospheric anomalies and their statistical parameters. The characteristic anomaly appeared several days prior to earthquake as the day-time significant increase of TEC up to the value of 40-50% relative to the background level.

The several decades there were carried out the extensive studies of electromagnetic and ionospheric phenomena caused by processes in the lithosphere which are related to earthquake preparation. Many scientists, using different techniques of measurements and data analysis, recognized characteristic variations of the electromagnetic fields and other parameters of atmosphere and ionosphere (e.g., see reference list in [1,2] before strong earthquakes. The Earth's upper atmosphere is an indicator of different effects of possible seismic origin: sharp changes in electron and ion density, optical emissions, electron temperature variations; appearances of the large electron density irregularities with different scales, the anomalous electric field penetration from ground through the plasmasphere into the conjugated hemisphere. The physical explanation and morphological characteristics of such variations and the interrelation between pre-seismic processes and the ionospheric anomalies are examined by use of several models [2, 3, 5].

In this study, it is presented the analysis of the ionospheric variations prior to M6.2 Nevelsk earthquake, that took place at the Far East of Russian Federation on August 2, 2007 at 0237 UT. The geographical coordinates of epicenter were 46.6°N, 141.8°E, the depth of seismic focus was about 10 km.

For this work we used GPS observations provided by GPS station YSSK. Figure 1 illustrates the geographical position of earthquake epicenter (red dot), and YSSK GPS station (black dot).

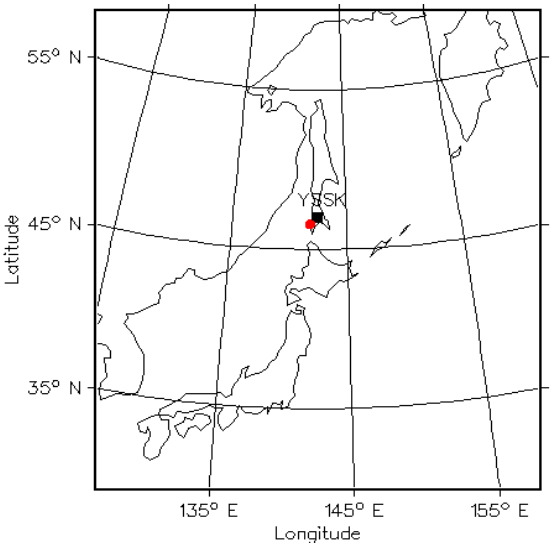

Fig.1: Geographical position of EQ epicenter and YSSK GPS station.

Variations of Dst geomagnetic activity index are presented at Figure 2. The Dst variations does not exceed the value of 50 nT, that indicates that substantial disturbances were absent during selected period months. Insignificant disturbances were observed on July 12–14.

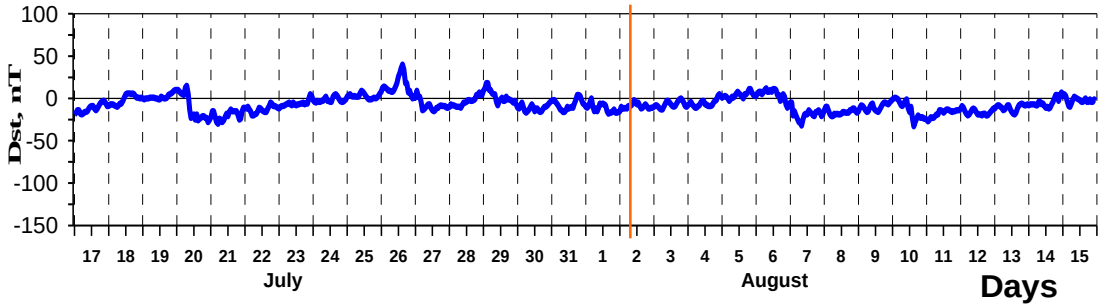

Fig.2. Variations of Dst indices during July-August, 2007

Figure 3 shows daily values of vertical TEC at over YSSK GPS station during July-August, 2007. All measurements are presented in local time (LT = UT + 8h). The actual observations are indicated with a solid black line and represent the vertical TEC in TECU (1 TECU=10^{16} el/m^2) for this station.

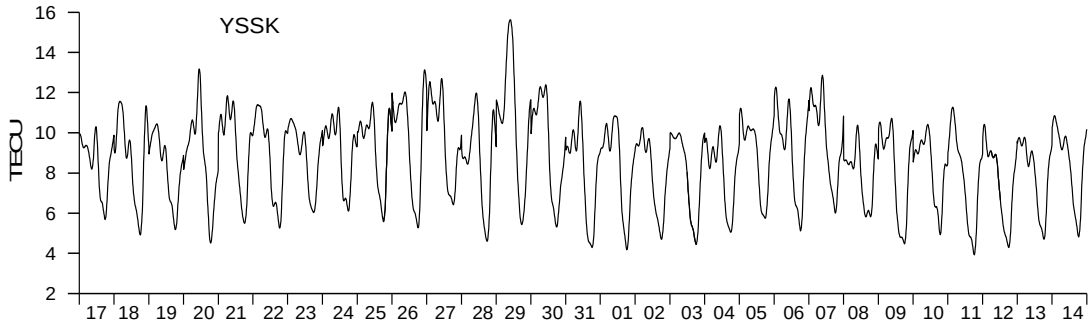

Fig.3: Daily variations for YSSK station during July-August, 2007.

Figure 4 presents the ΔTEC variations ($\Delta TEC=TEC-TEC_{med}$) for selected station. The visual viewing of daily variations shows that 4 day prior to the main event the significant deviations of the current TEC variations from the median meanings were observed.

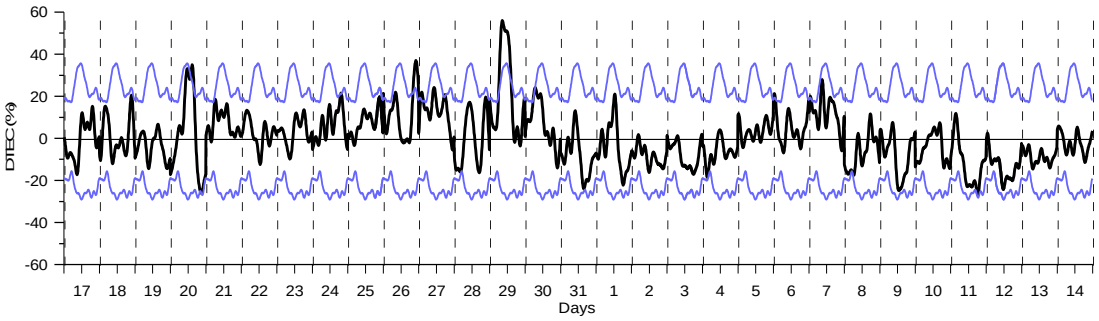

Fig.4: Daily variations of differential TEC estimates for YSSK station during July-August, 2007 in compare with median (blue line).

Diurnal TEC variations for other days of the given period have very similar shape as the median one. Significant enhancement in TEC estimates up to 4-6 TECU was observed during 4 days prior to the EQ event. Negative effect was also observed during evening and night time conditions but its amplitude was much smaller than for positive effect. This enhancement reached the maximal value of 4-6 TECU in absolute values.

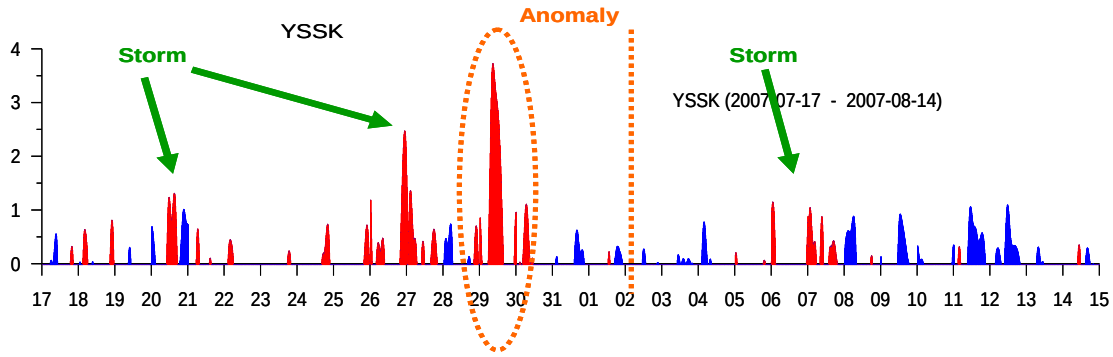

Fig.5: Deviation of TEC from 1 sigma level YSSK station during July-August, 2007 (red – positive, blue –negative values of deviation).

This effect was also registered in TEC variations derived for individual satellite passes (Fig. 6) for permanent station YSSK, located within earthquake preparation zone (Dobrovolsky radius). The TEC values increased on about 5-6 TECU.

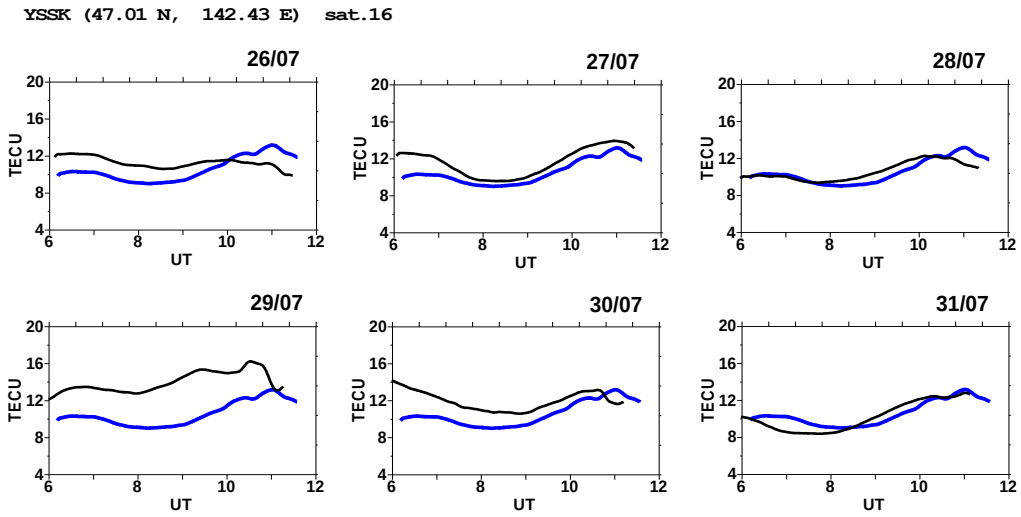

Fig.6: Comparison of TEC values along satellite N16 passes Days of July 26-31 vs July 25 (blue line)

In order to estimate the spatial scale of ionospheric changes over epicenter region associated with this earthquake the global TEC maps at the IONEX format were used. The global TEC maps are routinely generated by IGS community with resolution of 5° longitude and 2.5° latitude and time interval of 2 hours. The differential mapping method of TEC maps comparison was applied when the current day TEC was compared with the quiet time map taking the quiet time variation (as a median for the considered period) as a background. The differential percents TEC map for the moment of the most significant increase TEC values at 8-12 LT of July 29, 2007 is shown in Fig. 6. The ionospheric effect associated

with EQ was found out as the increase of total electron content of the ionosphere, it had a well-defined local character and was situated in the immediate vicinity of the earthquake epicenter area. The zone of the anomaly maximum manifestation (TEC enhancement more than 35%) had spatial scale of about 2000 km in longitude and 1500 km in latitude. The TEC enhancement reached the maximal value of 40-50% to the background conditions and it was situated very close to EQ epicenter position.

According to the series of characteristics (its locality, affinity with the epicenters, dome-shaped zone of manifestation, characteristic time of existence) the revealed anomalies may be associated with precursors of seismic activity.

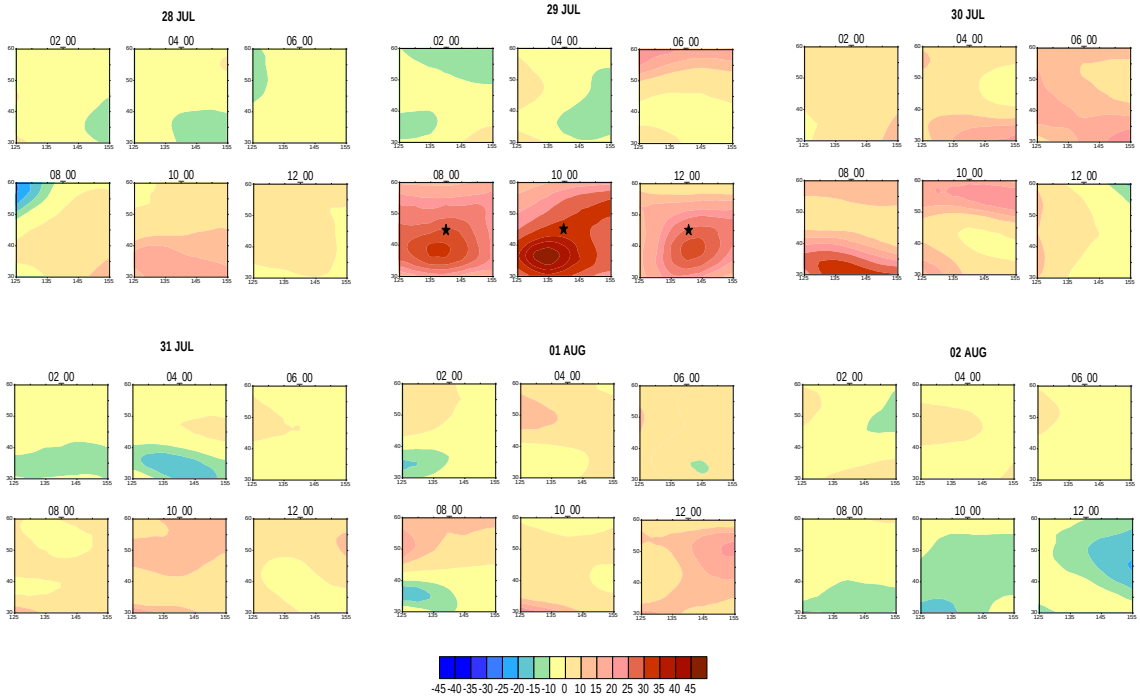

Fig. 6: Differential percentage TEC map for 09 LT (00 UT) of November 26, 2004.
The epicenter position is marked by black asterisk.

The characteristics of the recognized pre-seismic ionospheric modifications are in agreement with the main phenomenological features of the seismo-ionospheric precursors described in more detail in [3, 5]. Very similar results of the pre-seismic TEC increase for November 28, 2004 (M7.0) earthquake in the Northern Japan are presented in [4].

The detailed analysis of GPS TEC estimates revealed the occurrence of pre-seismic ionospheric anomaly in the form of local enhancement of electron content. TEC enhancement reached the value of 4-6 TECU (40-50%). The revealed anomalies have similar, rather specific, features and differ from day-by-day variability for quiet and geomagnetic disturbed conditions.

Acknowledgements

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