THE IONOSPHERE RESPONSE TO THE SUDDEN STORM COMMENCEMENT ON OCTOBER 29, 2003 FROM GPS NETWORKS DATA

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ABSTRACT

For the analysis of large-scale traveling ionosphere disturbances (LS TID) during the large magnetic storm on October 29, 2003 are for the first time used four longitudinal chains of GPS stations. It is showed that the starting moment of the total electron content (TEC) disturbance is late to the moment of the sudden storm commencing (SSC) of about 10-30 min depending on the region. Such disturbances are characterized as large-scale waves of a solitary type with the duration of about 1 hour, which are traveling equatorward from the source located in auroral zone with the velocity from 700 to 1500 m/sec.

INTRODUCTION

There are a lot of works devoted to the researches of LS TIDs with typical time periods of 1-2 hours and waves lengths 1000-2000 km, review of which you can find in [3,4]. It is considered as a rule, that the LS TID are the appearance of acoustic-gravitational waves (AGW), generation regions of which are located in the auroral zones. However, for the formation of the fullest picture of LS TID dynamics we need the larger quantity of statistical data.

The new opportunities for the detailed researching of major features of LS TIDs are presented by the global network of two-frequency multichannel GPS-receivers. In ISTP SD RAS is worked out the technology of a global detecting and monitoring of TEC disturbances on the basis of data processing from the global network of GPS receivers. The goal of this work is to research the major features of LS TIDs of auroral origin during the large magnetic storm on October 29, 2003 (maximal value *Dst*=-345 нТл, *Kp* index up to 9).

GENERAL INFORMATION ABOUT THE EXPERIMENT

With the goal of LS TID dynamics research from all the range of GPS-stations, data of which are presented in Internet, were formed three «meridional chains»: European, West-American and East-American. Moreover, in the work are used the data of Kamchatka regional network of GPS-stations [5]. On the whole there is four chains of GPS-stations located so, that during the geomagnetic disturbances the part of these chains will be in the night and other in the day sectors of the Earth globe.

Geometry of the experiment for October 29, 2003 is shown in the Fig.1. By the points are shown the GPS-stations, by the asterisks is shown the location of selected magnetic stations of INTERMAGNET network. Symbols **A, B, C, D** in the Fig.1 mark the regions of GPS-stations chains locations.

RESEARCHING METHOD AND RESULTS

The method of initial data processing is described in details in [1]. The experiment was made during the several stages. At first from the TEC measurements data at each of the GPS stations the TEC variations *dI(t)* were filtered with the time window of 60 min. Here the data were chosen for the one from GPS satellites, which trajectory appeared to be the most suitable for the LS TIDs registration and had the high quality of data (i.e. the absence of TEC phase measurements failures).

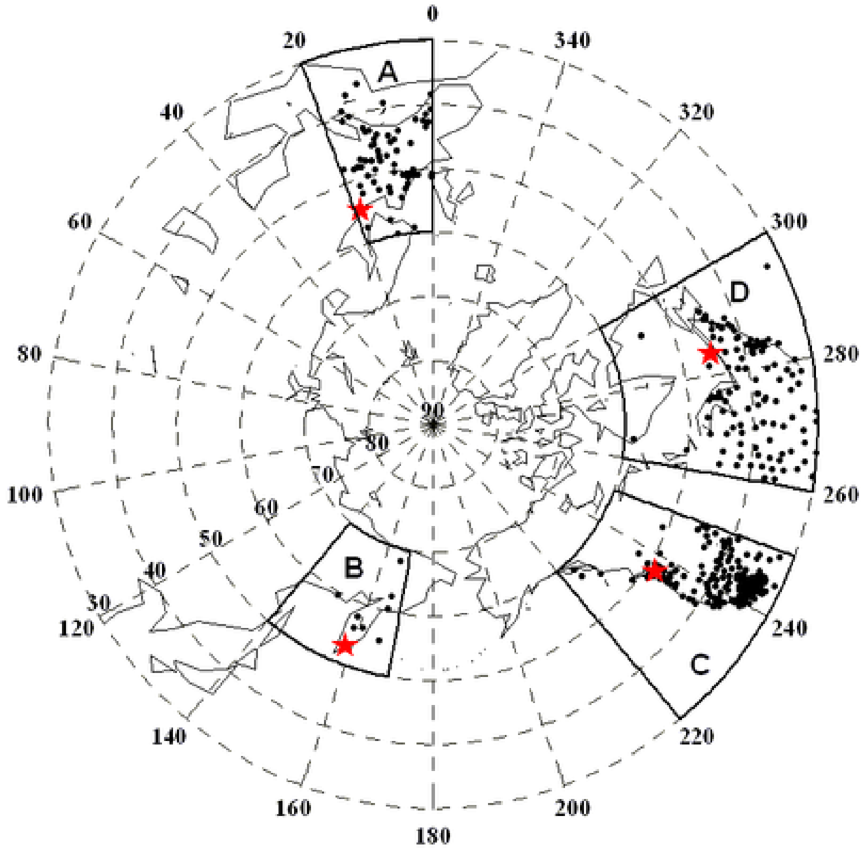

Fig. 1. Geometry of the experiment during the large magnetic storm on 29 of October 2003

Then with the use of the worked out earlier in [1] method here were determined the velocity *V* and direction α of LS TID propagation counted from the geographical North direction clockwise. Method is based on the calculation of the spatial and temporal gradients of TEC according to the TEC measurements at the three located in the space GPS-stations (GPS-array). For the each region were used the all-possible sets (up to 343) of GPS arrays. Data of velocities and directions of the LS TID traveling, and also RMS of this quantities are shown in the Table 1.

Table 1. Results of the velocities and directions calculation for the GPS-stations chains.

Sector	**Velocity V_h, m/s**	**Velocity V_h, RMS**	**Azimuth α, degrees.**	**Azimuth α, RMS**	**Number of GPS – arrays**	**Velocity V_a, m/s**
A	1508	539.6	259.6	46.2	6	1738
B	1013.2	350.3	234.8	31.6	55	1085
C	1090.2	364.3	208	6.6	343	603
D	684.2	309.6	193.6	29.9	57	703

In the Fig.2 for the time interval 06:00 – 08:00 UT, October 29, 2003, are shown the temporal dependencies of filtered at a periods range 30-60 min for the TEC variation sets *dI(t)*, for the regions and satellite numbers (PRN), which names are written over the panels. Variations *dI(t)* are shown with a shift [2], the scale *dI(t)* in items TECU (10^{16} el/m^{-2}) is given by the vertical bar. Out from the Fig. 2 it is seen that the TEC variations are similar in form, but they are moved relatively to each other according to the time. By the point of the one of the curves is marked the minimal value t_{min} of TEC variations, which was fixed for every curve. Analyzing Fig.2 we can make a conclusion that the TEC disturbance is a solitary wave with typical period located in the range of 30-60 min.

Unfortunately, because of the measurements failures, which usually accompany the powerful magnetic storms, part of the GPS-data appeared to be useless for the analysis. By this thing is explained the dots absence in the *dI(t)* variations in the Fig.2.

DISCUSSION

Researching of the temporal dependency of TEC disturbances *dI(t)* (Fig.2) and variations of the Earth magnetic field *H(t)* at the stations located in the regions of TEC registration had shown that the moment of TEC disturbance start is delaying from the moment SSC in 10-30 min depending on the region of registration.

Analysis of the GPS-chains data in various regions of TEC registration for October 29, 2003, had shown that the disturbance has a character of large-scale waves of solitary type with duration of about 1 hour. By the largest values of velocities (up to 1500 m/s) and amplitudes (up to 3.5 TECU) are characterized the LS TIDs registered in the morning and evening sectors of the northern hemisphere (Fig.1 region «A», region «B»). The night sector (Fig.1 region «C», region «D») is characterized by quite a small (up to 1000 m/s, and up to 1.5 TECU) values of the same quantities. Thus, for the day and night sectors there is no great difference in LS TID traveling directions, in both sectors the disturbance is propagating equatorward from the source located in the auroral zone.

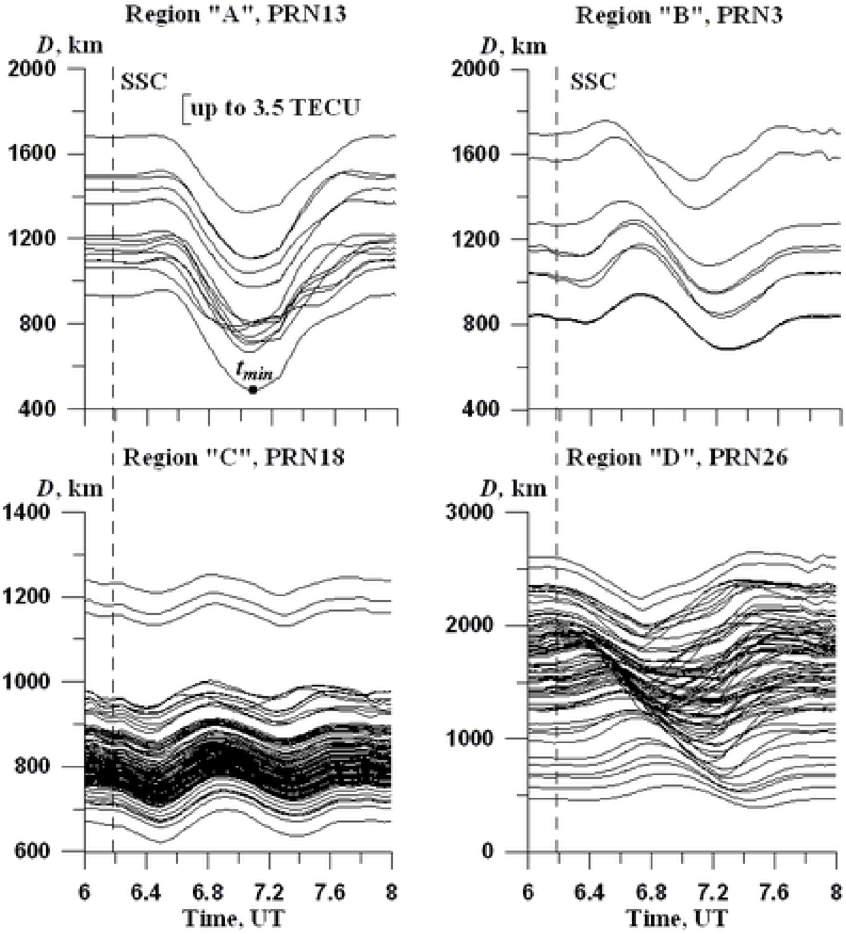

Fig. 2. Dependence of the TEC variations from the distance *D* along the wave vector

In the Fig.3 is presented the dependency of minimal values of $t_{min}(D)$ of TEC variations registered at the GPS-receivers depending on the distance *D* up to this receivers (point). By the solid line is given the approximating linear dependency for $t_{min}(D)$; corresponding velocities of traveling V_a are shown in the Table 1. As we can see from the Table 1, velocities values calculated according to the incline of the approximating straight line coincide on a whole with the values *V* determined with a help of GPS-arrays.

The question about the influence of global propagation features of thermosphere wind during the geomagnetic disturbances at the velocity and direction of LS TID is still open [3, 4].

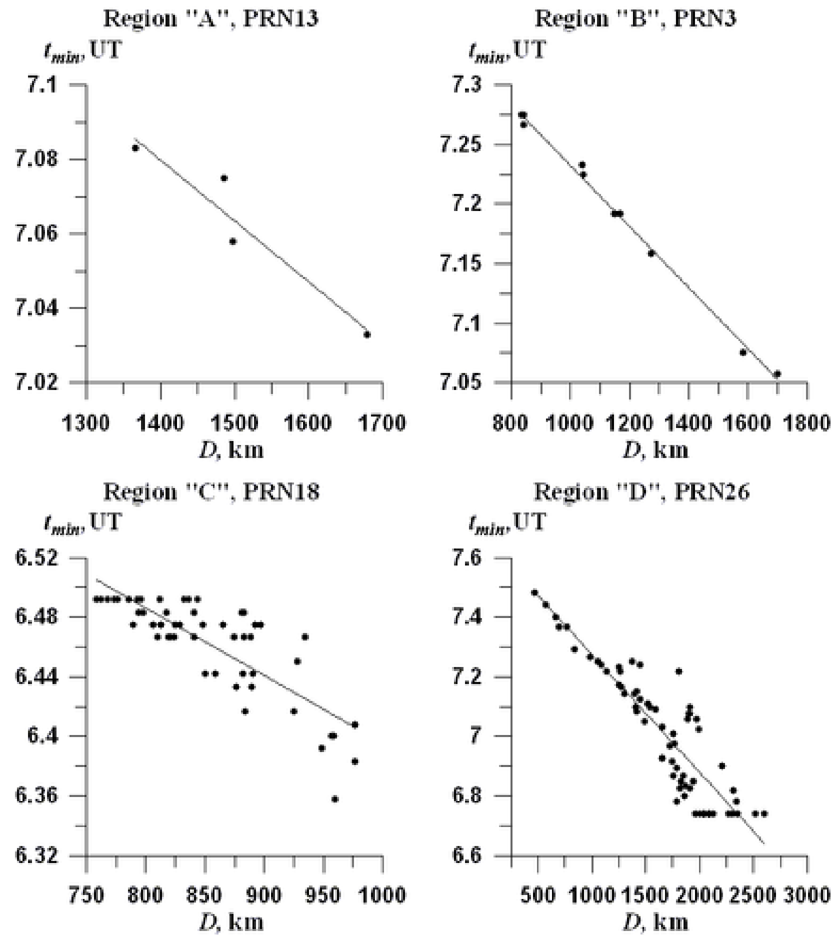

Fig. 3. Dependency of the minimal values $t_{min}(D)$ of TEC variations from the distance D

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