TRAVELING WAVE PACKETS OF TOTAL ELECTRON CONTENT DISTURBANCES AS DEDUCED FROM GLOBAL GPS NETWORK DATA

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Experimental technique I

This paper presents results of studying a global climatology of total electron content (TEC) pulsations obtained by the global GPS network in the course of 30 days characterized by a different level of geomagnetic activity, the number of GPS receivers being used from 100 to 300 (Fig.1). A total number of the "receiver – GPS satellites" radio paths used in the analysis is about 300,000.

Quasi-periodic TEC variations in the range of periods from 10 to 20 min are investigated. The GPS technique makes it possible to determine the parameters of TEC pulsations from the phase variations at two carrier frequencies. To exclude the variations of the regular ionosphere, as well as trends introduced by the motion of the satellite, we employ the procedure of removing the linear trend by preliminarily smoothing the initial series with a selected time window of a duration of about 30 min.

Experimental technique II

The selection of TEC series, which could be ascribed to a class of pulsations was carried out by two criteria (Fig. 2). First of all, TEC variations were selected, for which the value of the standard deviation exceeded a given threshold ε (here $\varepsilon = 0.1$ TECU).

In addition, for each filtered series, we verified the fulfilment of the “quasi-monochromaticity” condition of TEC oscillations, for which the ratio R of a total spectral signal power in the selected frequency band δF in the neighbourhood of a maximum value of the power S_{max}, to a total spectral signal power outside the frequency band δF under consideration exceeded a given threshold (in the present case $R_{min} = 2$).

When the filtered dI(t)-series satisfied the conditions described above, such an event was recognized as TEC pulsations.

Results of observations I

Most often, the observed TEC pulsations represented as wave packets with a duration of the order of 1 hour. It was found that such TEC pulsations were relatively rare events and were observed on no more than 0.1-0.3 % of the total number of radio paths. However, the large absolute number ($\sim 3\times 10^2$) of pulsation events allowed to study their climatology.

Figure 3 presents number of events P(|Dst|) versus the module of Dst-index of magnetic activity. It is seen that the probability to observe pulsations is higher for magnetically quiet days compared with disturbed ones. Thus TEC pulsations are more frequently observed during magnetically quiet periods of time.

Results of observations II

Figure 4 presents a diurnal distribution $P(t_{max})$ of moments t_{max} corresponding to the maximum amplitude of pulsations into a certain packet. It is evident that maximum probability to observe pulsations corresponds to the local noon.

In order to estimate the area covered by pulsations, there were computed various distances dR between points available where pulsations were presented in the certain temporal interval. Figure 5 presents a number of pairs of receivers P(dR) versus a distance dR between them. It seems that pulsations are localized into space. In spite of a long tail of the distribution extending to 2100 km, most of the events are restricted by the distance of 500-600km.

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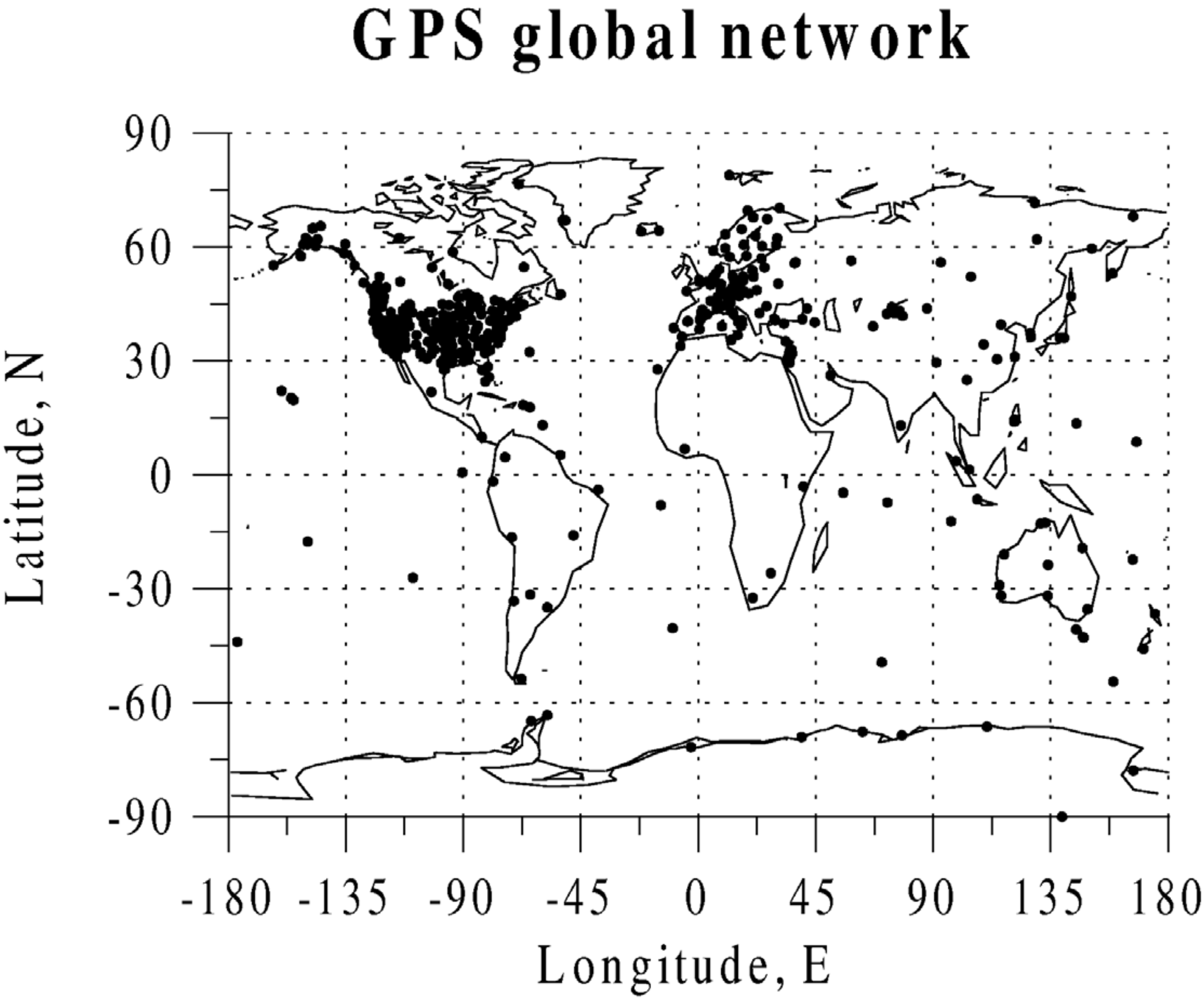
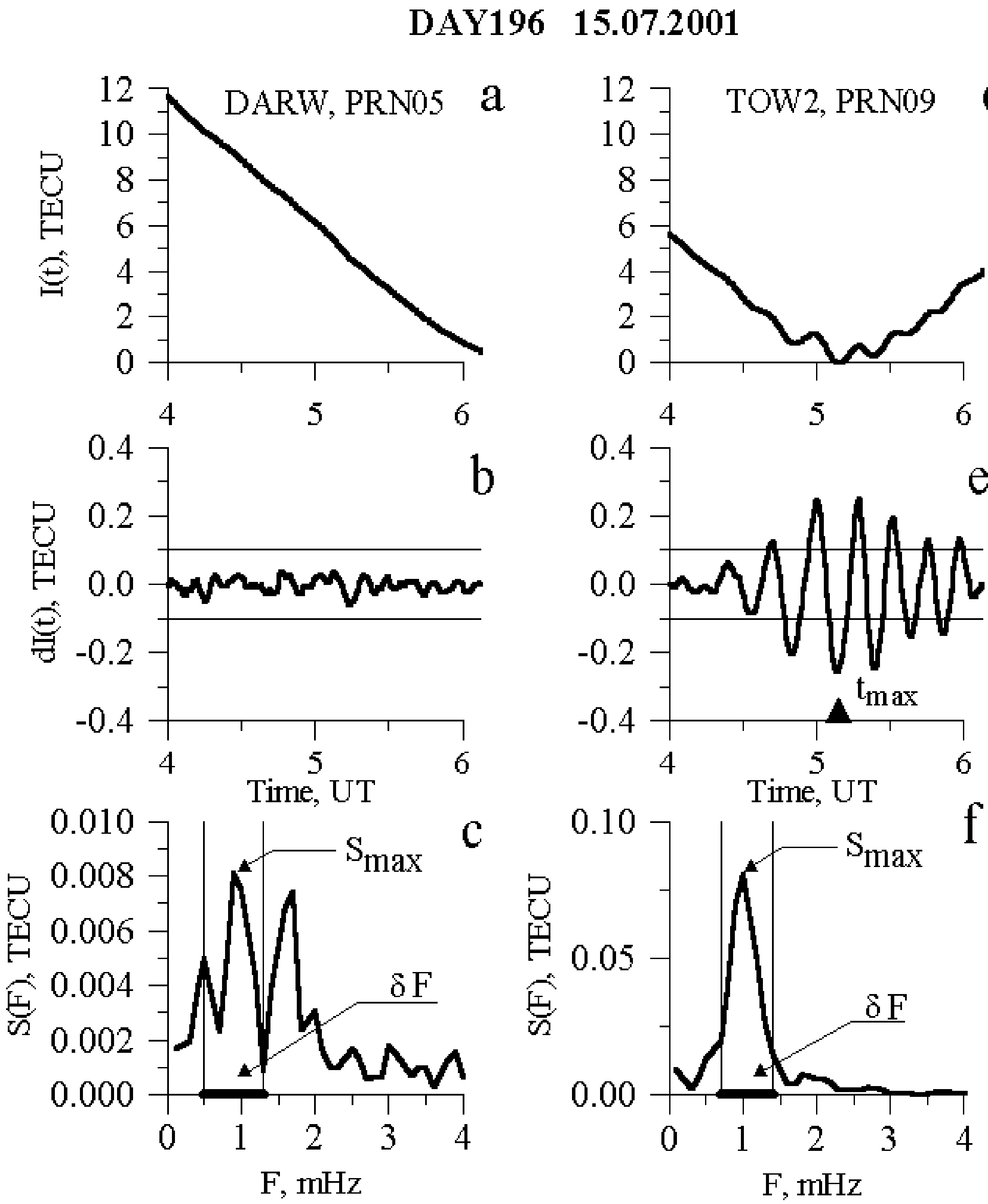
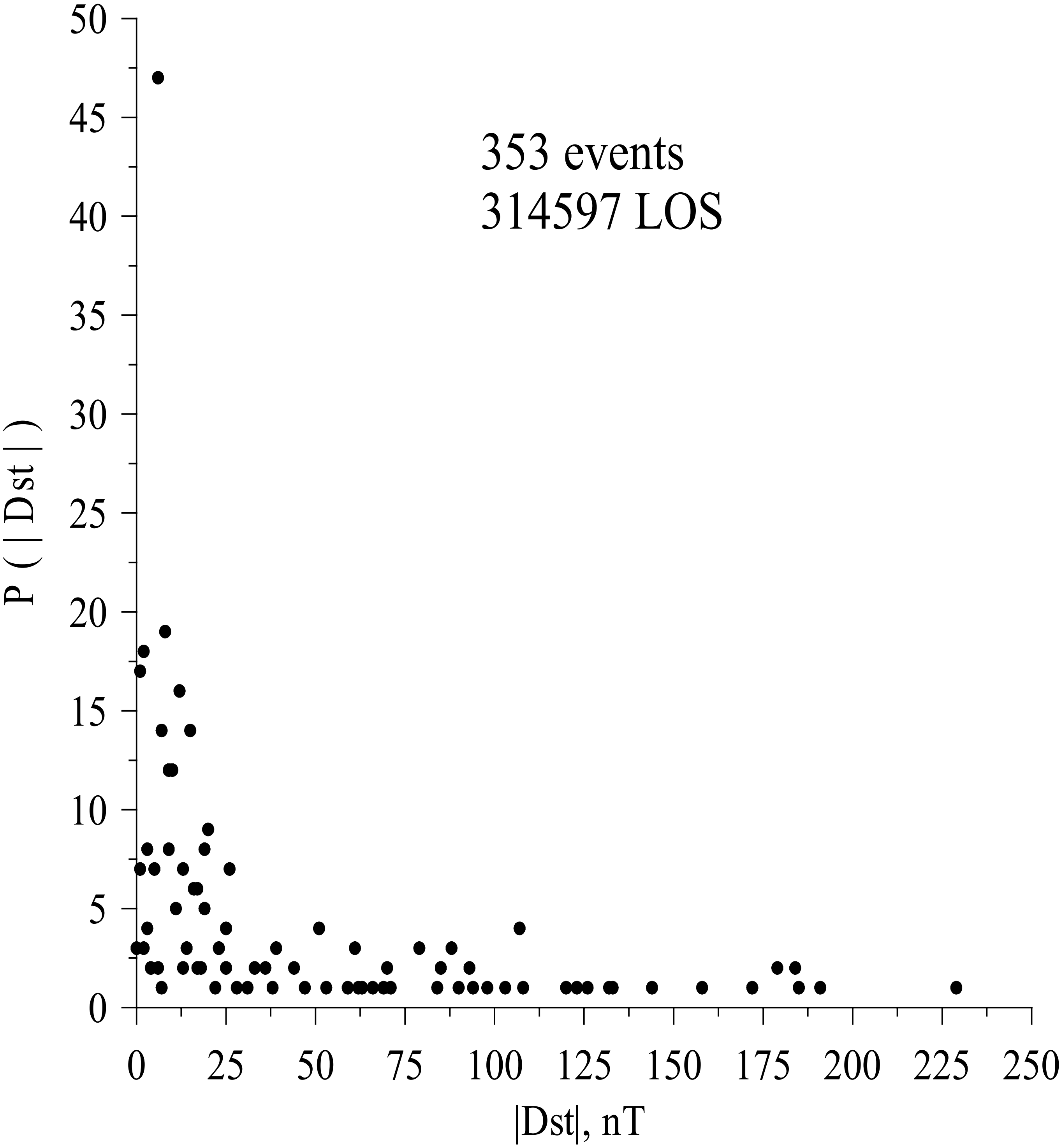


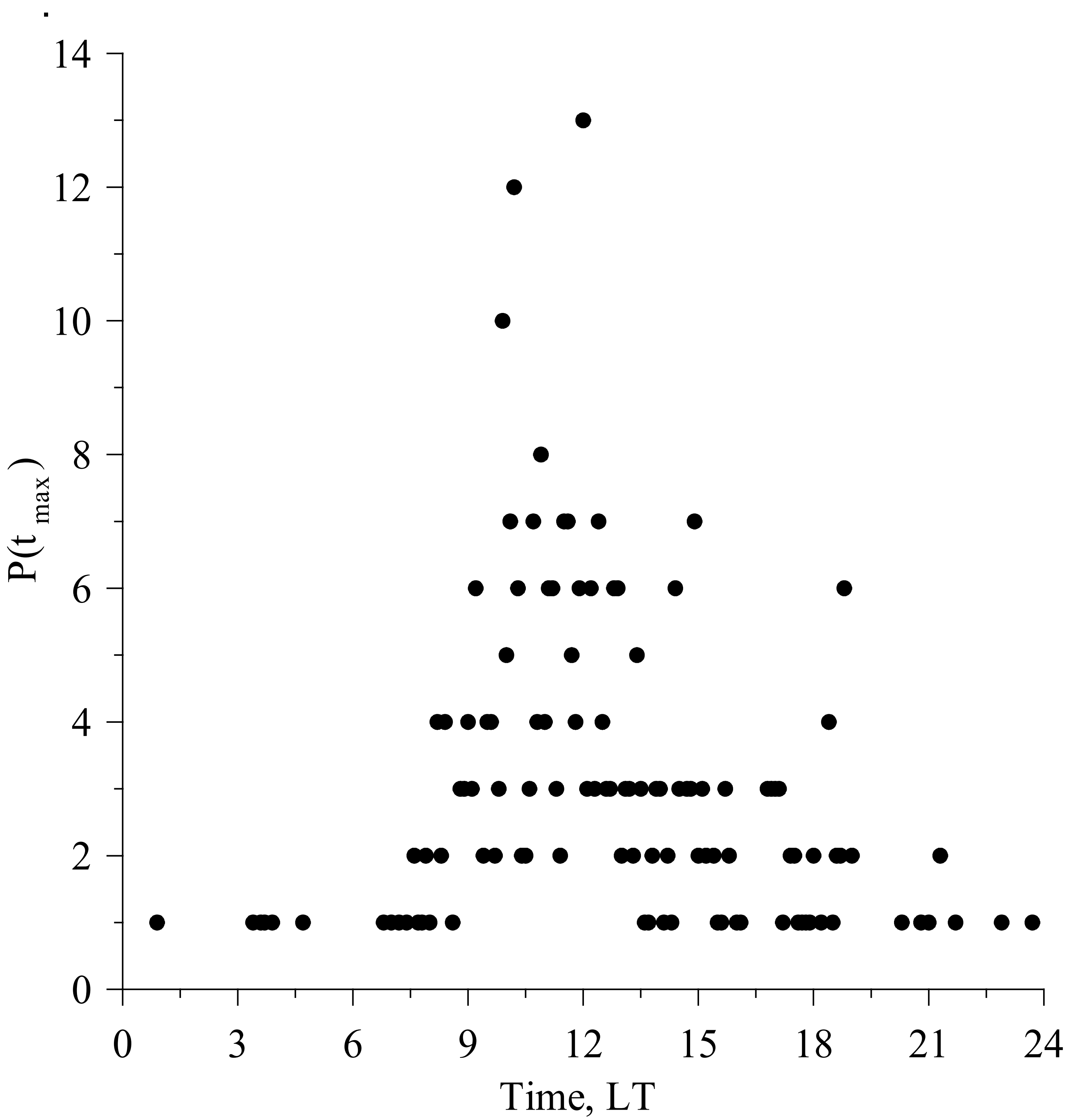
1 Distribution of GPS receivers on the Globe. Points show positions of the receivers. Their large density in North America and Europe allows to estimate a size of the area with the simultaneous ionospheric pulsation events.



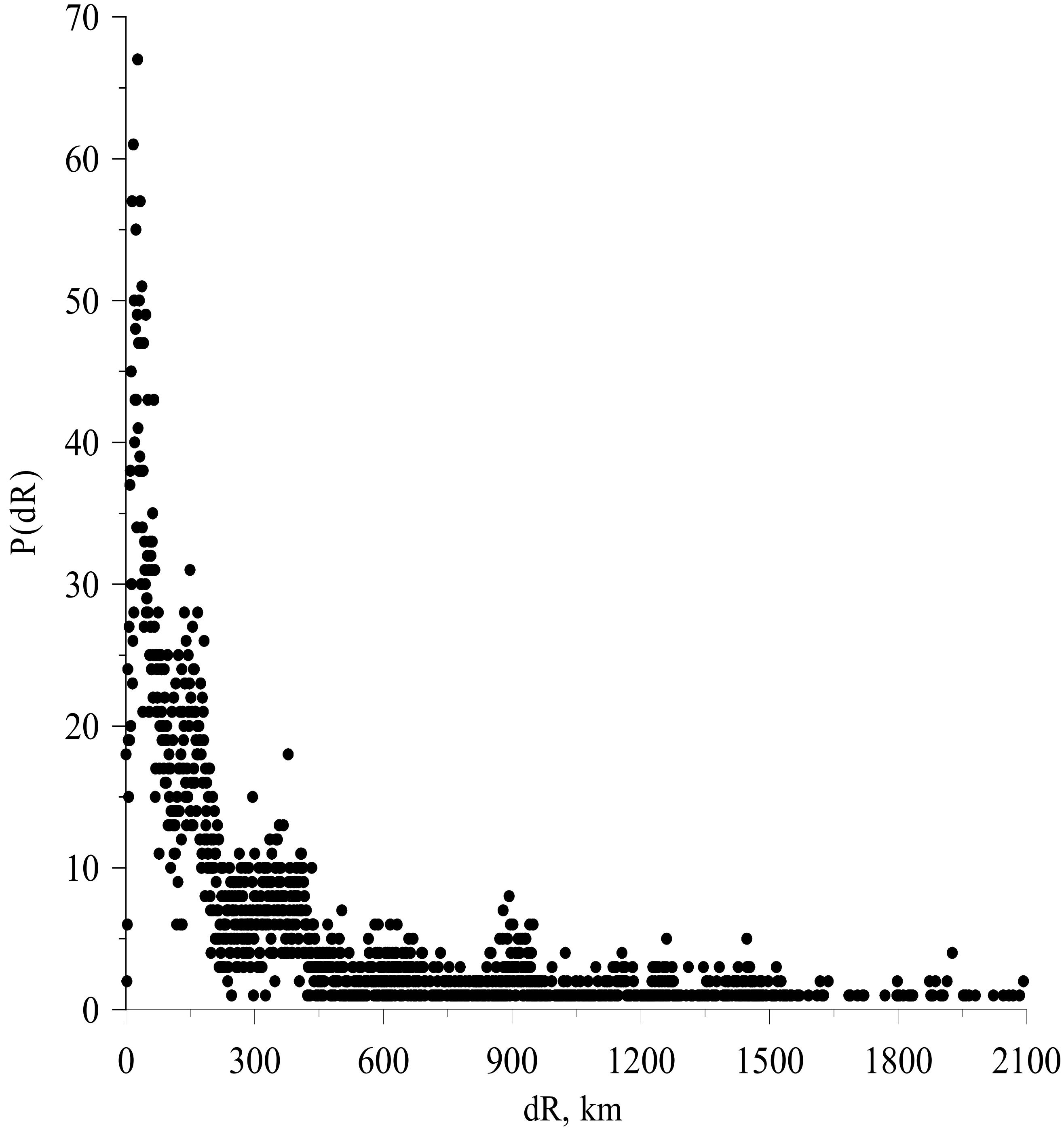
2 Examples of an application of criteria for selection of the TEC pulsations. (a, b) Initial and detrended TEC variations respectively for an event without pulsations. (c) Corresponding amplitude spectrum. (d, e, f) Similar to (a, b, c) except that this event is characterized with pulsations. Thin horizontal lines in (b, e) are thresholds for the amplitude criterion. Thin vertical lines in (c, f) restrict the frequency band near the largest spectral peak.



3 Scatter plot of a number of events versus the module of D_{st}-index of magnetic activity.



4 Scatter plot of a number of events versus the local time in the point of recording TEC pulsations.



5 Scatter plot of a number of events versus a distance between the points where pulsations are simultaneously presented in a certain temporal interval.