The Occurence of the TEC Fluctuations at High Latitudes During Very Low Solar Activity

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INTRODUCTION

The development of the navigational satellite techniques and the growing number of the permanently tracking GNSS stations allow using it for wide range of applications. Certainly the most important application for many non-scientific users is GNSS positioning, especially in real-time. However, these systems are also a powerful tool in atmospheric research. One of scientific applications of GNSS technology are the studies of the space weather. The results of the research carried out during the previous years and the last cycle of the solar activity showed that the ground-based GNSS receivers are very good source of the information about the state and changes of the electron concentration in the upper part of the atmosphere. The increasing number of permanently working GNSS receivers in recent years and their spatial distribution allow presently to create the maps of the TEC fluctuations at high latitudes.

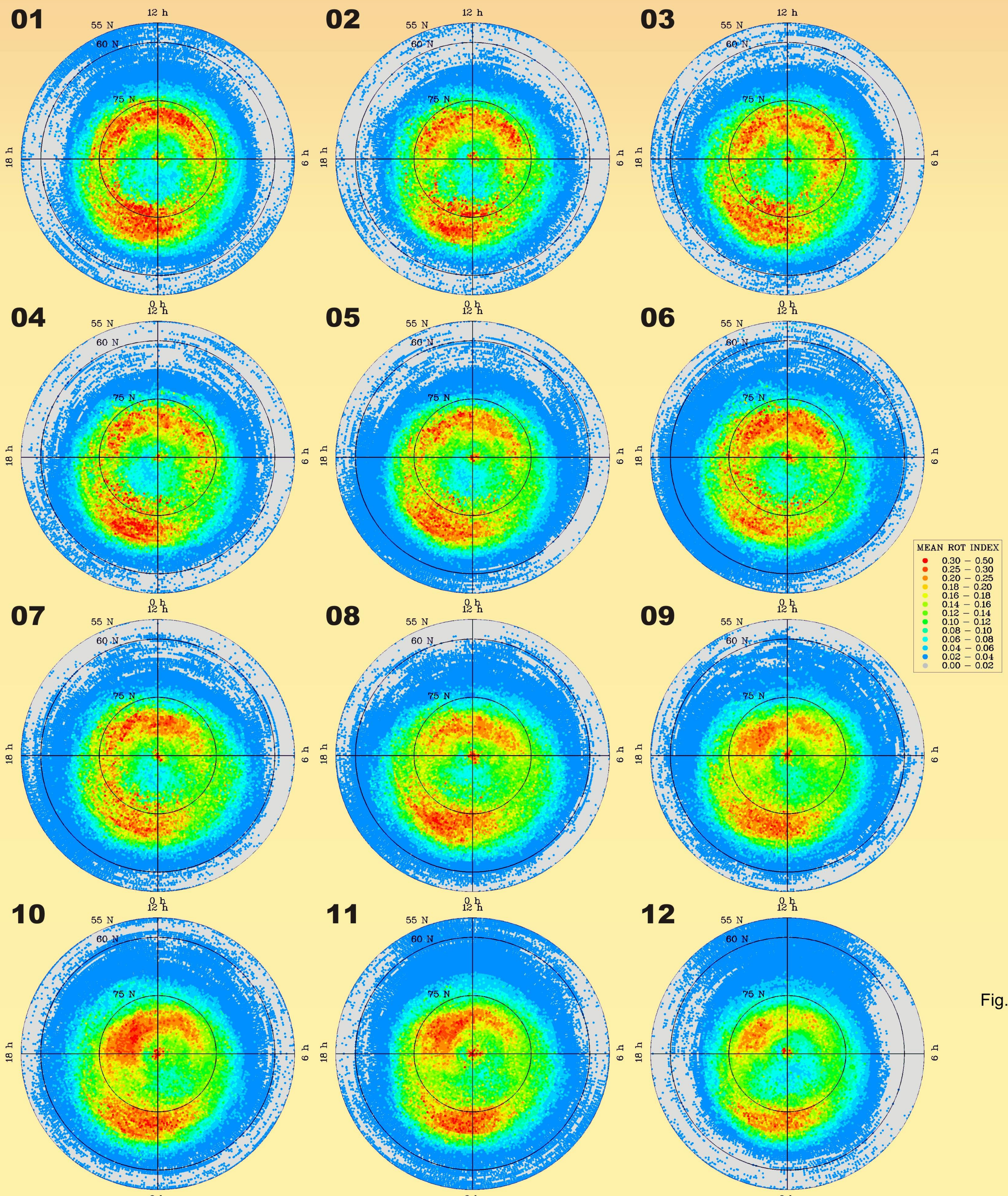

Figure 2 The monthly means of the TEC fluctuations for year 2009

TEC FLUCTUATIONS

In order to create the maps of the ionospheric disturbances we selected over 100 satellite observatories located from 45°N geomagnetic latitude to the North Geomagnetic Pole (Fig.1). Most of the stations belong to the IGS/EPN and POLENET networks or participate in PBO Mission. The spatial distribution of the GNSS receivers is not very regular. There is very low number of the stations on the Russian Federation territory and a relatively low number of sites in Canada.

The main goal of these studies was the analysis of the application of the ground-based GNSS observations to create maps of the electron concentration variability at high latitudes of the northern hemisphere. In our investigations we used ROT (rate of TEC) and ROTI (rate of TEC index) indices. These parameters very well describe the dynamic changes in the concentration of the electrons derived from a single track of GNSS satellite. The first index is defined by the difference of the geometry-free linear combination calculated for two consecutive epochs with time interval of 1 minute. This form of the equation allows avoiding necessity of the ambiguity resolution. This parameter allows detecting the ionospheric irregularities with spatial size of about 30 km and larger. The second parameter – ROTI – is the standard deviation of ROT for 5-minute interval and gives us information about the variability of the electron concentration during a specified time period.

One of our products created using ROTI values are daily maps of the TEC fluctuation occurrence as a function of magnetic local time (MLT). In this case, the geomagnetic longitudes of the obtained ROTI values for the specified time were projected to MLT. These daily maps allow presenting the changes in the earth's ionosphere in dependence on the location of IPPs relative to the Sun. Certainly, the information about the conditions in the ionosphere for a particular geographical region is lost. However, it is a very useful method to demonstrate the daily expansion of the disturbed area for specified local time.

RESULTS

The main goals of the studies were the calculations average values of TEC index rate (mean or median ROT index) at high latitudes during very quiet ionosphere. The previous results obtained for the periods characterized by weak geomagnetic disturbances showed the very good sensitivity of the applied algorithm. Presented results show the monthly averaged TEC fluctuations maps during the most quiet year 2009. The data from each month were averaged for grid with dimensions 0.5 degree (lat) x 2 min (MLT) covering the surface from 55 degree of the north geomagnetic latitude to the pole. The results show the monthly means (Fig. 2), medians (Fig. 3) of ROT index and the differences between them (Fig. 4). In these investigations only days with averaged daily Ap <= 10 were taken into account. There is clearly visible the difference between latitudinal range of the strong TEC fluctuations on the dayside and the nightside ionosphere. The strong fluctuations on the nightside ionosphere appear at lower latitudes than on the dayside. The graphs for each month show that for quiet conditions medians of the ROT index are higher on the dayside, The maps with differences mean – median, which present the occurrence of the very strong TEC fluctuations, show the higher values on the nightside. It means that the variability of the TEC on the dayside is much stable than on the nightside. On the other hand the nightside ionosphere is characterized by appearance of the very strong TEC fluctuations, which are much stronger than the background level (median). The results for all months in 2009 year are very stable. In order to compare these results with moderate disturbed ionosphere the graphs with mean ROT index were created for a few days when ionosphere was more active. Figure 5 shows daily averaged TEC fluctuations for 05.04.2010, 06.04.2010, 02.05.2010 and 04.08.2010.

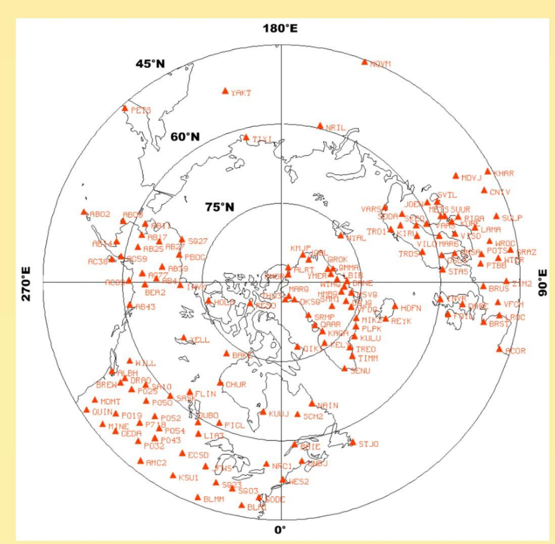

Fig. 1. The location of the GNSS permanent stations used in this study (geomagnetic coordinates)

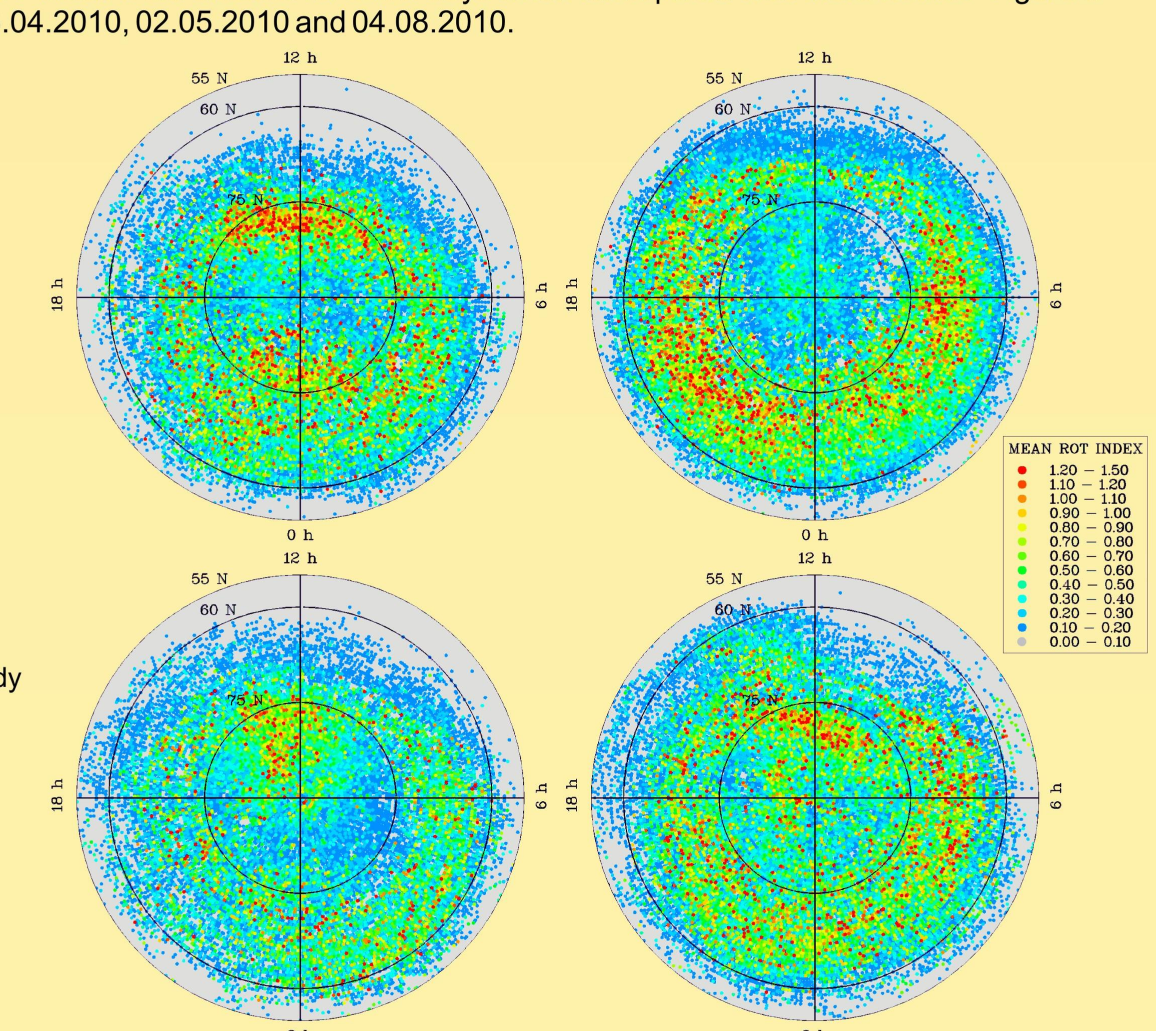

Figure 5. Daily averaged maps of TEC fluctuations for for days 05.04.2010, 06.04.2010, 02.05.2010 and 04.08.2010

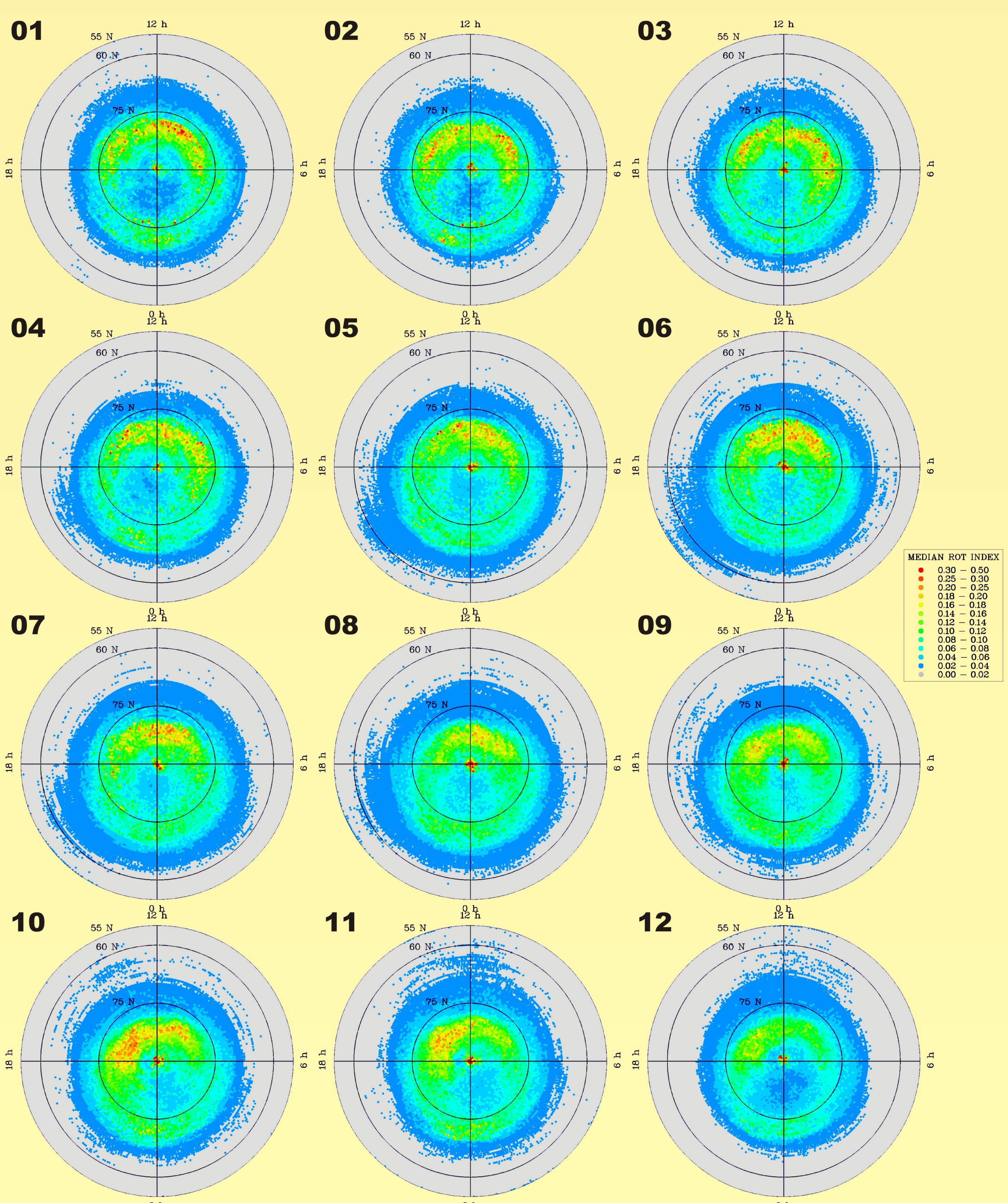

Figure 3 The monthly medians of the TEC fluctuations for year 2009

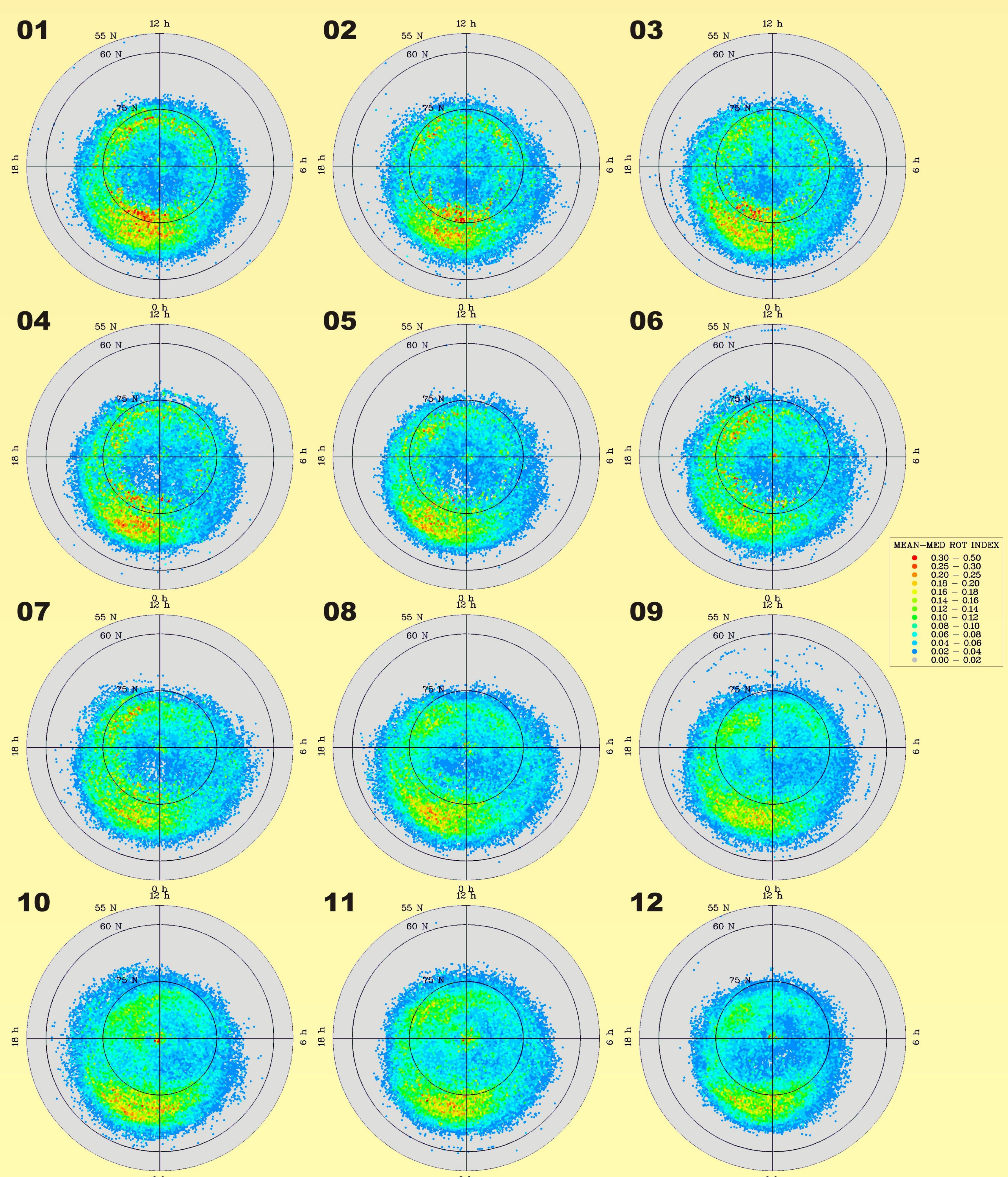

Figure 4. The differences between monthly means and medians of the TEC fluctuations for year 2009