Statistical analysis of ionospheric activity in the period of low solar activity using DPS-4 ionosonde data.

M.V. Tolstikov, A.V. Medvedev, K.G. Ratovsky

Institute of Solar-Terrestrial Physics, P.O. Box 291, Irkutsk, 664033, Russia; e-mail: maxim@iszf.irk.ru

Abstract

In investigation of fundamental problems of ionosphere physics always large attention was given to the observational data during low solar activity, when there was a capability to minimize influence of external factors. On the basis of regular, continuous measurement of the Irkutsk ionospheric sounder the automated method of researches of ionospheric disturbances was designed. Statistical analysis of disturbances of an electron concentration during 2004 - 2009 was done. Main problem of the analysis was determination of total number of perturbed days and determination of total number of wave disturbances depending on a level of solar activity, season and time.

1. Introduction

In investigation of fundamental problems of ionosphere physics always large attention was given to the observational data during low solar activity, when there was a capability to minimize influence of external factors. This paper is devoted to investigation of statistical legitimacies in behavior of ionospheric disturbances depending on a level f10.7, season and time during times of decreasing and minimum of solar activity. Initial data are the electron density profiles measured by Irkutsk ionosonde. The ionosonde measures an electron density Ne(z,t) as function of time and height above Earth surface. All electron density profiles were interpolated to 15 - minute step on time. The skip in the data more than 30 minutes were considered as gaps, skip less than 30 minutes were interpolated. At the next stage disturbances were selected from Ne diurnal variations. For this purpose we used two methods: spectral and integral median.

2. Integral median method

The integral median method is intended for an estimation of total ionospheric activity. Method based on the subtraction median characteristic of diurnal variation of electron density profile from observed electron density profile. The median diurnal profile received by 27 day averaging (13 day up to and 13 after the considered day) electron density profiles. The total ionospheric disturbance was the relative deviation between the observed and 27-day median values:

$$I = \frac{1}{N}\sum_{i=1}^{N}\frac{\left|Ne_i - Me_i\right|}{Me_i} \qquad (1)$$

where Ne_i –electron density, a Me_i – median.

The relative deviation I - was calculated separately for day time and night time. Distribution of relative deviation for 2004-2009 years is shown in figure 1.

978-1-4244-6051-9/11/$26.00 ©2011 IEEE

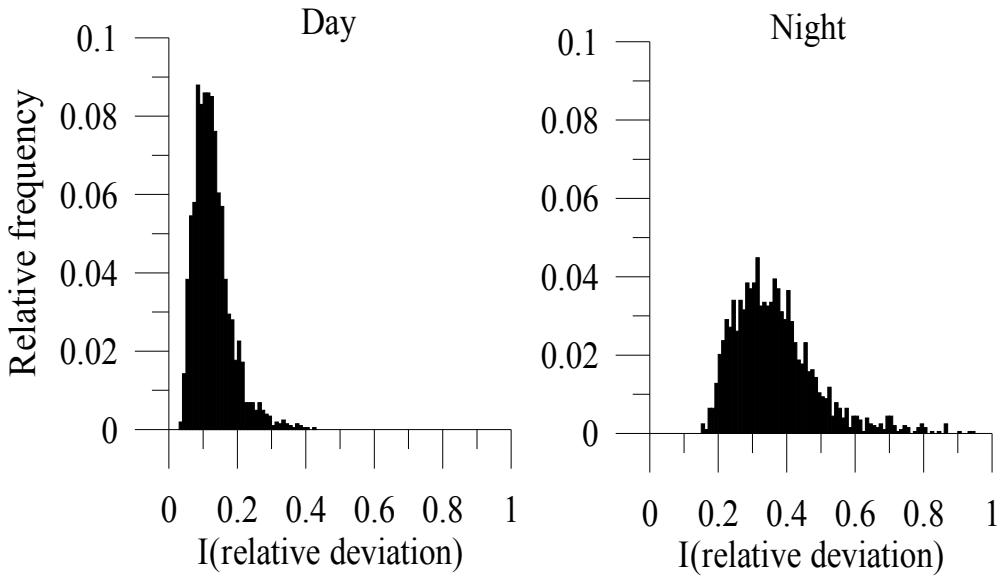

Figure 1. Distribution of relative deviation for 2004-2009.

Distribution of relative deviation essentially differs for the day time and night time. In day time average value I is 0.1283 and standard square deviation is 0.0567. In night time mean is 0.368 and standard square deviation is 0.1356. Distribution of 50% most perturbed days on years is shown below.

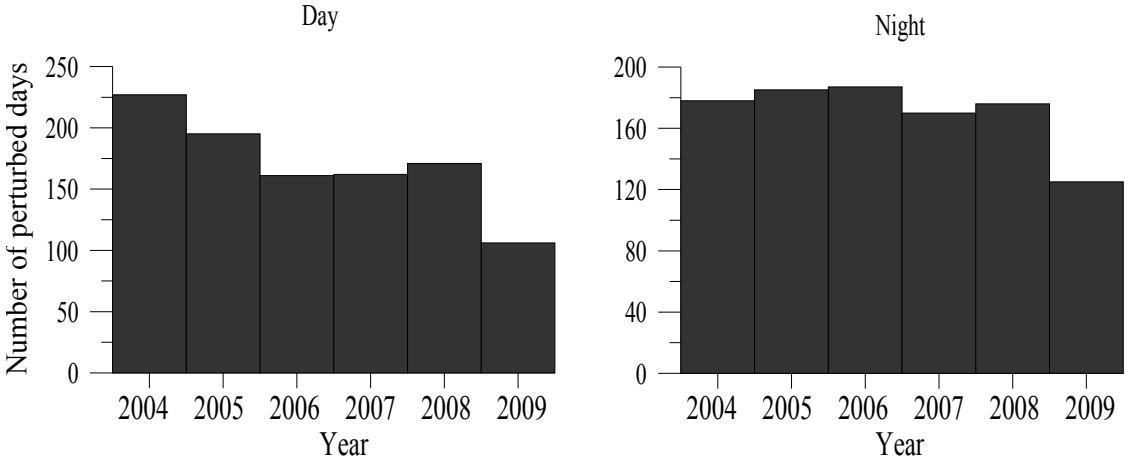

Figure 2. Distribution of 50% most perturbed days on years.

For the daytime, ionospheric activity levels tend to diminish with decreasing solar activity. For the night time ionospheric activities do not show clear solar activity dependence. The interesting result is obtained at the analysis of distribution of the 50% most perturbed days on seasons. The fact of existence of asymmetry of ionospheric activity between winter and summer hemispheres is well-known to the researchers, and the histograms wonderfully illustrates it(se figure 3 below). Day ionospheric activity has more composite nature. Quantity of perturbed days is maximum still in the winter, but the minimum is reached not in a summer solstice, but near to vernal and autumnal equinox.

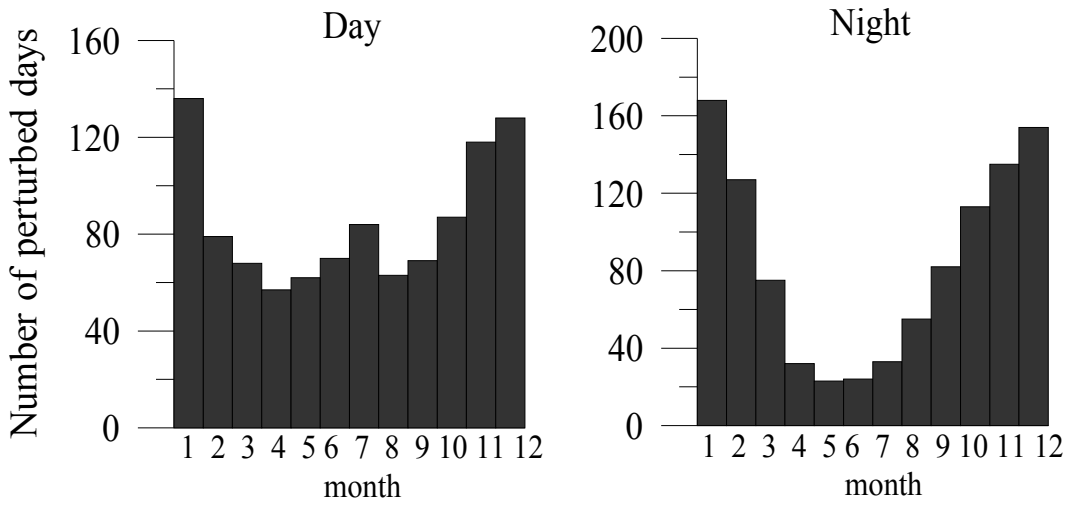

Figure 3. Distribution of 50% most perturbed days on months.

3. Spectral method

The spectral method is used for detection of wave ionospheric disturbances. It is based on the supposition that it is possible to select dominant harmonic from all spectrum of a wave disturbance. If this supposition is performed, then on each of altitudes, in a spectrum of variations of an electron concentration the local maximum on the same frequency should be watched. To eliminate influencing noise threshold on amplitude of a local maximum is set. Thus in this paper the following conditions is criterion of presence of disturbance:

1) There is local maximum in a spectrum on the given frequency at minimum three adjacent altitudes.

2) Local maximum is more then 3% of zero harmonics (mean on a window of the analysis)

3) Local maximum is more than on 20 % surpasses neighbors

At data processing by sliding 12 hour window obtains following results.

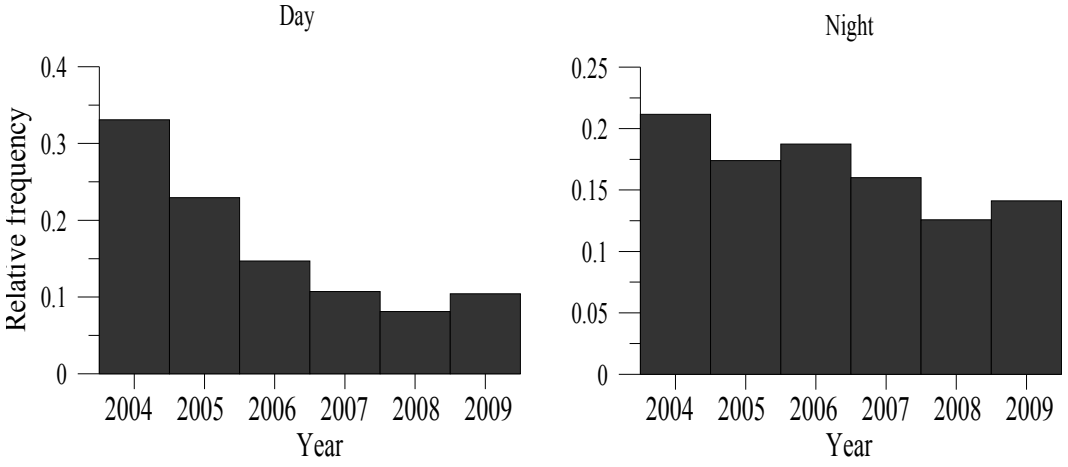

Figure 4. Distribution of wave disturbances on years.

As well as in case of integral median method for the daytime, ionospheric activity levels tend to diminish with decreasing solar activity. For the nighttime, ionospheric activities do not show clear solar activity dependence. Distribution of of wave disturbances on months is shown below.

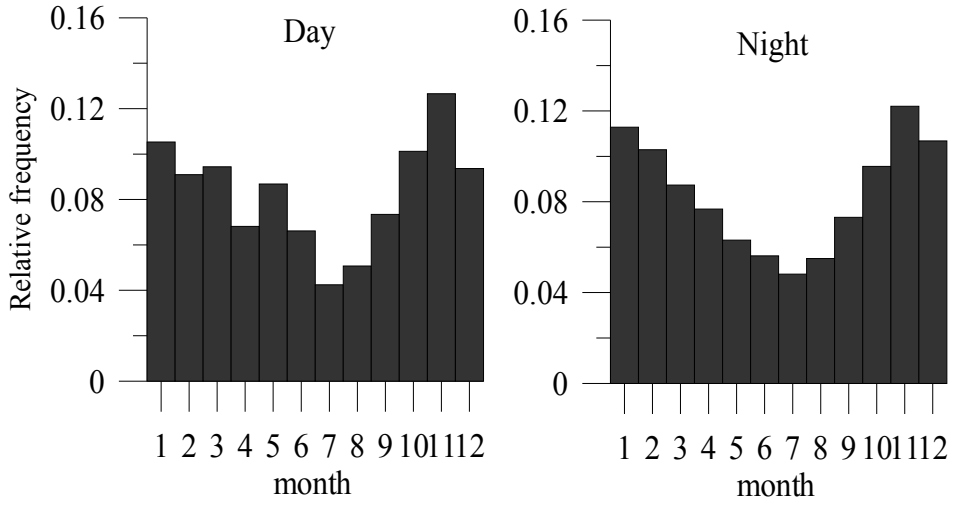

Figure 5. Distribution of wave disturbances on months.

4. Acknowledgments

The present work was done under support of the Russian fund of basic research (grant No. 11-05-00698-a).