EARTH'S MAGNETIC FIELD DYNAMICS: SPACE WEATHER AND SOLAR CYCLE EFFECT EXHIBITING

A.L.Sukharev [1], L.I.Sobitnyak [1], M.I.Ryabov [1], M.I.Orlyuk [2], I.M.Orliuk [2], A.A.Romenets [2]

[1] Odessa observatory "URAN-4" Radio Astronomy Institute of the National Academy of Sciences of Ukraine

[2] Institute of Geophysics of the National Academy of Sciences of Ukraine

ABSTRACT. According to the "Odessa" and "Kiev" observatories total vector magnetic field variations data for 2008-2010 period, dynamics of the space weather manifestations were considered. Wavelet analysis application made the determination of structure changing in circadian period possible. The features of displaying 12, 8 and 6 hour periods are shown. The nature of their correlation and modulation in solar and geomagnetic activity changing is seen. Two stations changes differences that can result from the latitudinal dependence are examined. The existence of "Odessa" magnetic anomaly located on land and at sea is reviewed.

Introduction

The study of solar-terrestrial relations is a fundamental scientific problem. Solar activity affects not only on magnetosphere and the ionosphere of the Earth but it also leads to large changes in the troposphere and influences on the climate (temperature fluctuations, the formation of cloud cover, etc.). In this work, we have used a geomagnetic field variations observational data (full magnetic induction vector) for 2010 year, obtained by magnetic observatories, located near Odessa and Kiev cities (Institute of Geophysics NASU).

Observation and data processing

Observational data – every minute counts of full induction vector of the geomagnetic field (in nT) during the year 2010, received at magnetic observatories near Odessa and Kyiv cities (see fig. 1). Odessa and Odessa region is one of the biggest magnetic anomalies located on the territory of Ukraine. Original data is very noisy and to remove noise and drop-down point and to fill small gaps in the data, we used the method of Fourier-smoothing and approximation, linear trends were also removed.

Two-parametrical analyzing function of one-dimensional wavelet-transformation is well localized in both, on the time and on frequency. That is distinguished from Fourier's usually applied transformation which analyzing function covers the all-time base. Thus it is possible to see detailed structure of process and evolution of a harmonious signal component in time. Continuous wavelet-transformation on the basis of Morlet function was used.

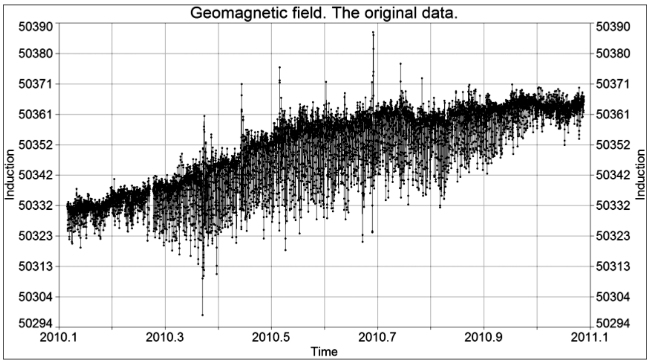

Figure 1: The "Kiev" observatory geomagnetic field original data example

Wavelet and FFT filtering and reconstruction for the isolation of the total spectrum of individual harmonic components corresponding to the bands with the highest spectral power was used. It allowed the detailed consideration of changes in the geomagnetic field oscillation periods, depending on seasons and magnetic storms, and a change in the annual and semi-annual fluctuations in the Black Sea level, which are influenced by the temperature, rainfall and river flow. Numerical used methods are described, for example in the following papers [1, 2].

Geomagnetic field fluctuations

Time series variation of the geomagnetic field induction shows an increasing of linear trend during a year of observation (2010-2011). Wavelet spectra according to "Kiev" and "Odessa" magnetic stations (see fig. 2) show a strong high-frequency part (with the values of 24 hours or less periods) and a weak low-frequency part (with the values of a few tens of day's periods). In addition to the daily period are also highlighted values of 12 and 8 hours periods, data on Kiev – 6 hours (Odessa data is almost invisible during this period). Spectral power of these periods are not evenly distributed in time, it is seen that the oscillation amplitude is low at the beginning and in the end of the year (winter), increases in spring, peaks in summer and fades in autumn [3,4]. 6 hours period has maximum intensity in summer and autumn. It can be seen that values of the periods are unstable and vary greatly in some moments (magnetic storm).

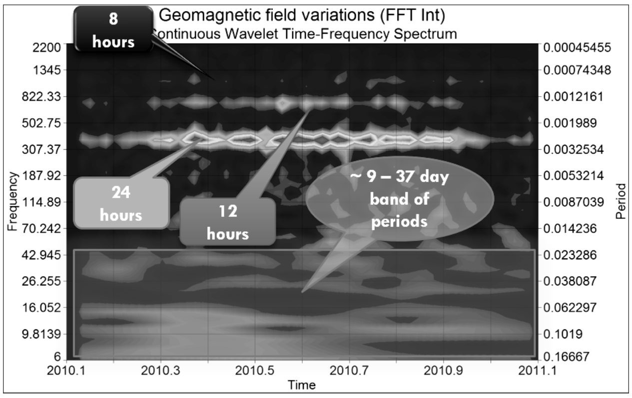

Figure 2: The "Odessa" observatory wavelet spectrum example. Bands of main periods are marked by flags.

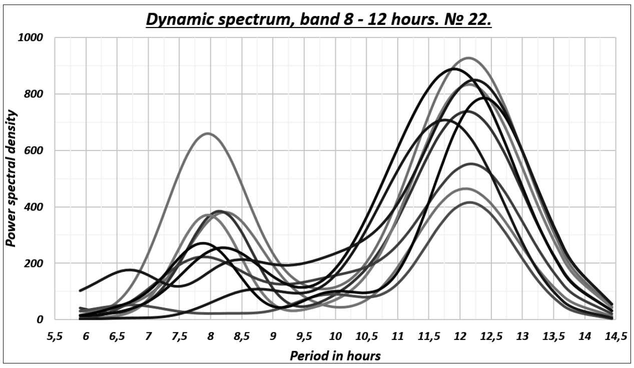

Figure 3: Local wavelet power spectrum example shows changes periods over 10 days. "Odessa" observatory, 8 – 12 hours band.

The greatest changes in the moments of magnetic storms occur in daily (5.5 hours) and semi-diurnal periods (4.7 hours) (see fig. 3). 8 hours period varies less (about 1 hour), 6 hours in Kyiv observations show greater stability, their values vary slightly with time (less than 1 hour) [5].

There are slow changes of the geomagnetic field, for Odessa observations 37, 10 days, and 87, 50 days in Kyiv, and the period of changing this value from 25 to 14 days. With reduction of the oscillation period, amplitude modulation increases.

Conclusions

Geomagnetic field oscillations occur with 24, 12, 8 and 6 hours periods. The period of 6 hours is almost imperceptible for the Odessa data. Fluctuations are unevenly distributed by the time, at the beginning and in the end of the year their amplitude is very weak, in spring the amplitude increases and reaches the maximum in summer decreasing to autumn. The 6 hours period has maximum intensity in summer and autumn.

The founded periods do not have constant values which can change at some hours for some time interval (10 days). The strongest period's jumps are observed at magnetic storms. When disturbance ends, the value of periods comes back to the previous. The greatest changes in values occur in Kyiv data – 21.5-27 hours daily period (Odessa 21-24.5 hours). Values for a twelve hours period for Odessa vary within 12-16.7 hours (Kyiv 12-13.5 hours), shorter periods – about an hour.

Except fast variability of daily scale according to stations of Odessa and Kyiv, there are slower changes of geomagnetic field at more than 10 days scales. For Odessa observations it is 37, 10 days, for Kyiv – 87, 50 days, and also the period with changing value from 25 to 14 days.

The observed periods (6 – 24 hours) belong to solar-daily variations, the period of 25 – 14 days is close by values to the period of planetary scale waves ~ 18 days. The 10-87 days periods are close to the corresponding in solar activity ~ 10, 34, 50, 90 days periods.

Reference

1. Smolentsev N.: 2010, *Wavelet analysis in MATLAB*, St.-Petersburg.
2. Davydov A.V.: 2005, *Digital Signal Processing,* Ekaterinburg.
3. Yanovsky B.M.: 1978, *Terrestrial magnetism,* Leningrad University.
4. Samoylova O.M.: 2012, *Studing's results of magnetic field variations in observatory "Paratunka"*, Kamchatka Vitus Bering State University.
5. Rivin Y.R.: 1989, *Cycles of the Earth and the Sun*, Moscow.