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DYNAMICS OF REGULAR AND INCIDENTAL EVENTS ACCORDING TO THE MAGNETOMETRIC COMPLEX: MATERIALS OF THE "SCHUMAN" PROJECT

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Abstract

In present article the review of results of the analysis of data of the monitoring, which is carried out within the "Schuman" project, is presented. The experimental part of the "Schuman" project is based on two hardware complexes. The first complex - the magnetometric station, registers three magnetic components, two electric, and amplitude envelopes of the acoustic channel. The quantization time of all channels is 0.5 s. The second complex including two induction magnetic field sensors is designed for registration in the Schuman range. The presented work is based on the data of the first complex working at IZMIRAN (Troitsk, Russia). The presented work shows possibilities and quality of the data from the magnetometric complex.

Introduction

Currently within the "Schuman" Project IZMIRAN has been conducting routine observations of geomagnetic variations in the frequency band up to 2 Hz [1]. The current investigations are supported by the magnetometric complex, which is based on a three-component unit of quartz magnetic field sensors. The complex also comprises 2 electric lines terminated with unpolarized electrodes. The electric lines are connected to the measuring unit via channels with conductive decoupling. In addition to electric channels a seismic pickup (via the seismic envelope detection and extraction unit) and a temperature sensor of the magnetic field sensor module are connected. The dynamic range across all channels is 22 discharges with a sampling time of 0.5 s.

The complex capabilities and quality of the data obtained are shown by the examples of recording both episodic events (solar flares of a different class, passing thunderstorm clouds) and routine observations (demonstration of the effect of daylight duration and the Moon on the dynamics of diurnal components in the analysis of extended arrays).

The temporal dynamics of daily values of the geomagnetic components with indications of a human pulse and arterial blood pressure was also correlated, which demonstrates the feasibility of using the monitoring data in the applied research.

Response to incidental events

A typical example the episodic event is a solar flare. The flare-generated additional ionospheric ionization results in the current alteration and perturbation of B-components up to 1÷10 nT during strong flares. Therefore, for a number of X-class flares a direct correlation of the observed perturbations of B*x,y,z*-components and a X-ray flux burst, characterizing the flare, is possible. Such correlation of two events is demonstrated in Fig. 1, where moment X-ray flux data (in arbitrary units) in the ranges 0.5÷4.0 Å and 1.0÷8.0 Å of GOES series satellites [2] are compared with variations of the magnetic components in nT according to IZMIRAN data ("Schuman" project). Along the OX axis the time is given in minutes, T0 is the beginning of the time axis, flare maximum – Tm.

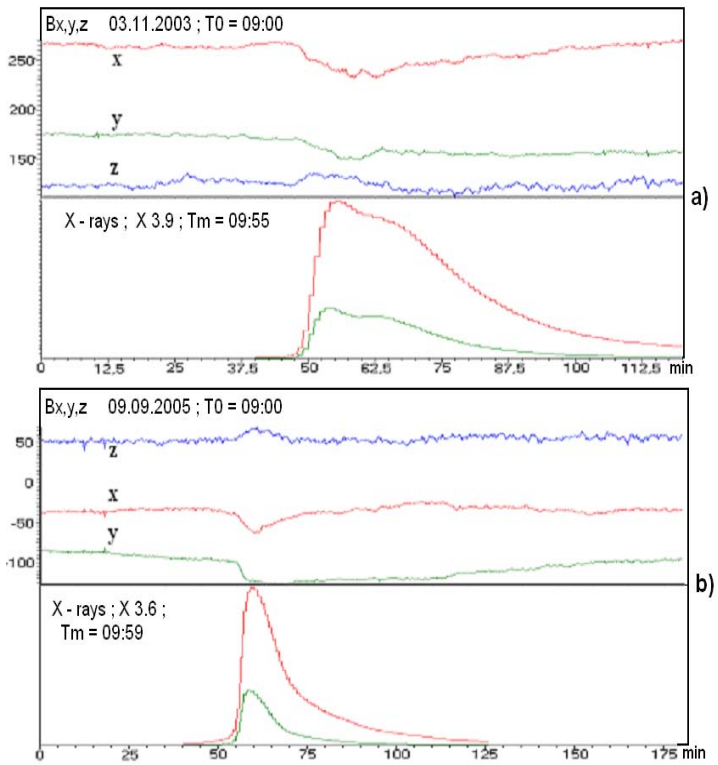

Fig. 1. Direct response to solar flares, X 3.9 – (a) and X 3.6 — (b)

Naturally, in addition to a flash class, the response manifestation accuracy depends on the season and local time. A different degree of the noise level is demonstrated in Fig. 2, where Almaty (“Intermagnet” project) [3] and IZMIRAN data is correlated for a strong X 6.9 class flare. In some cases, the M-class flash response can be also identified. The temporal dynamics of correlation relationships between the magnetic variation components (Fig.3, the lower Figure) clearly identified an M 6.9 class flare moment (Fig. 3, middle Figure). In the temporal dynamics of B*x,y,z*-components no response is visible on the background of significant variations (Fig. 3, top Figure).

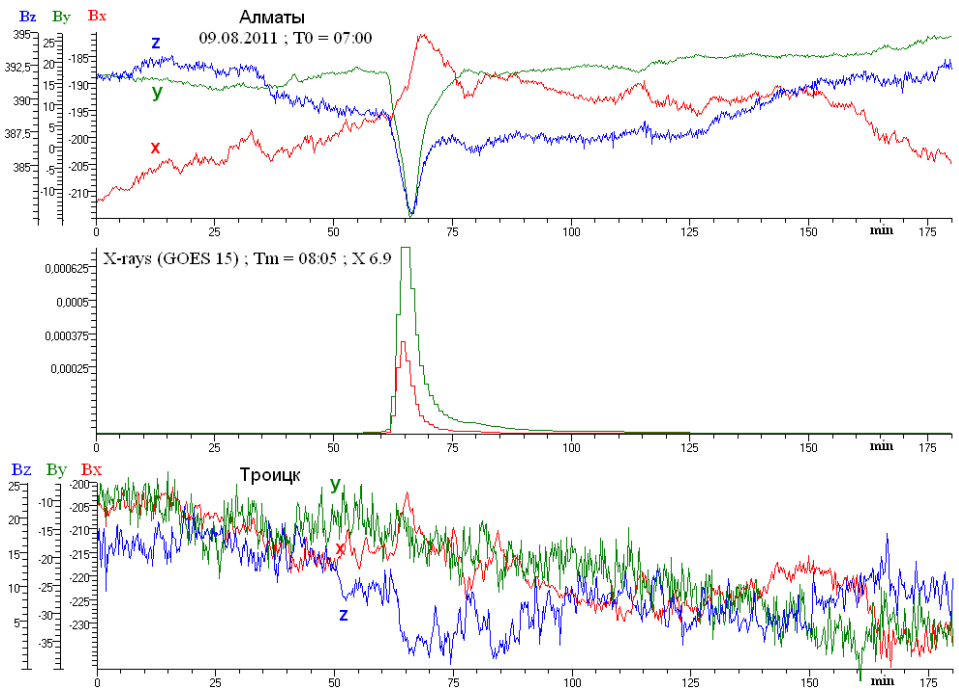

Fig. 2. Comparison of responses to solar flare according to Almaty and IZMIRAN

The example of recording the M 1.9 class seasonal flare in the morning with an aftereffect is provided in Fig. 4. The central part of the Figure highlights a rectangular area with B-component fluctuations and adjacent to the flare. It is quite possible that the observed oscillations are induced by the flash, their period is 3.9 minutes.

Another example of the episodic event is a thunderstorm. Passing through the storm area above the observation point is depicted in Fig. 5. Using E*x,y*-components (in arbitrary units) moments associated with the polarization caused by storm clouds are clearly distinguished. Bursts P1 (P2) on the magnetic

component are characterized by the current alteration in front of (behind) the moving area of the induced charge. The burst size is comparable with the response of strong solar flares.

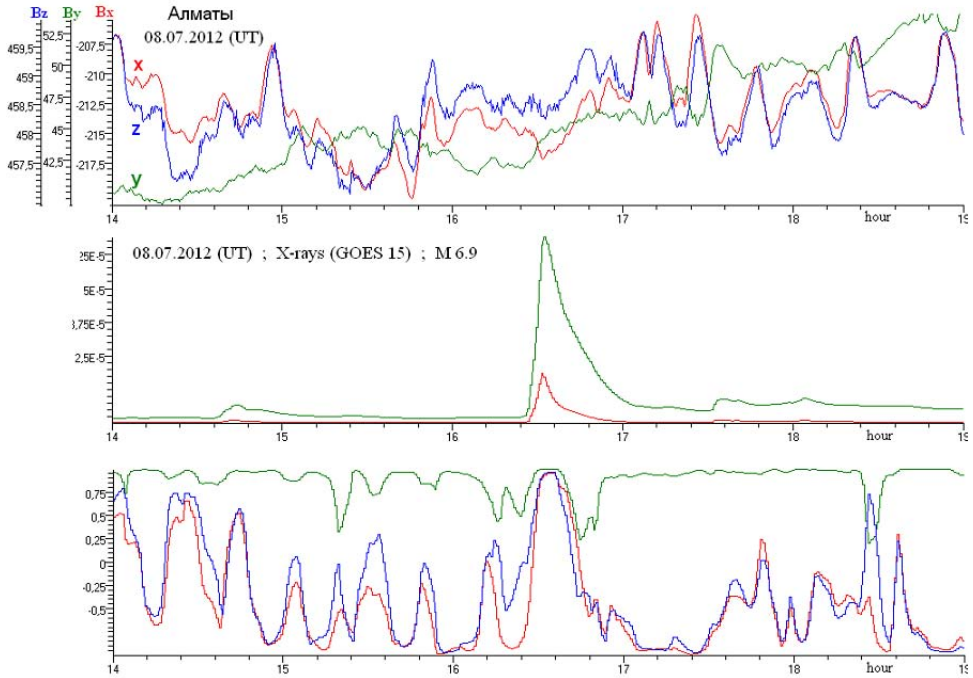

Fig. 3. Identification of a response to solar flare (class M 6.9) according to Almaty

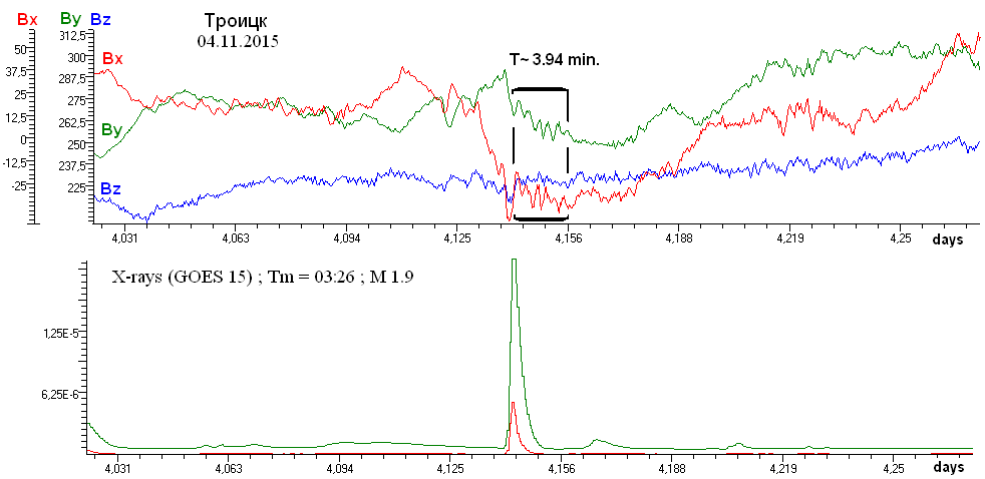

Fig. 4. Seasonal solar flare in the morning according to IZMIRAN (class M 1.9)

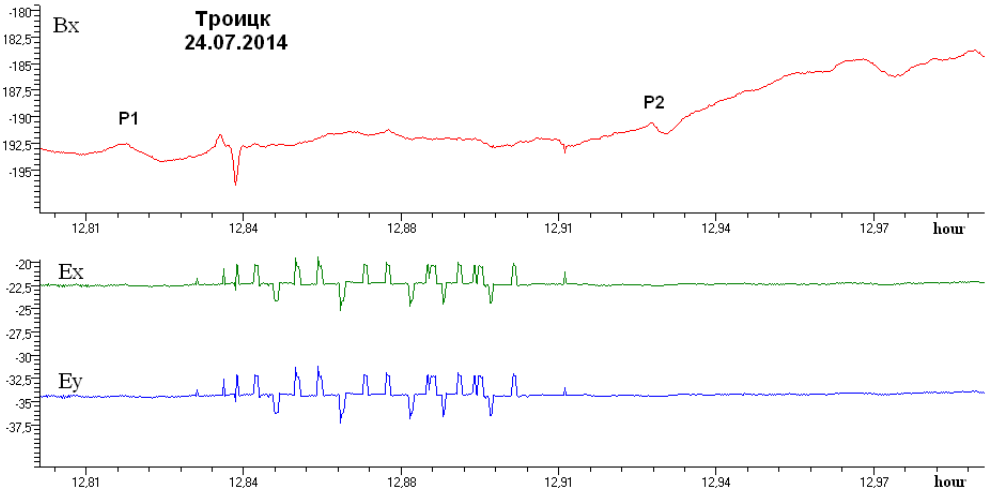

Fig. 5. Passing of a storm over the point of supervision

Assessment of characteristics of the regular events

Episodic events random in character occur against the background fairly regular processes associated with long observation intervals. Therefore, the assessment of baseline states of measured characteristics and their dynamics in the timeframes of different range is of great importance. In Fig. 6 is provided an overview of typical data recorded by the complex for 54 days (from March 6 to April 28, 2003). A detail of the envelope of the acoustic channel So is given in the right lower part of the Figure. A “day off” effect is visible; when on weekends and public holidays the noise level decreases (March 8÷10 was the weekend). In the spectral analysis of variations of the geomagnetic field components oscillation frequencies of the thermal atmospheric tidal waves appear. A complete set of periods contains 24, 12, 8 hours, and other harmonics are distinguished. The application of Hilbert transformation [4] makes it possible to obtain a time dependence of the amplitude of the selected harmonics. The envelopes (amplitudes) of the daily and twenty-minute harmonics for B*x*-components are depicted in Fig. 7. The growing trend of the daily harmonic amplitude (Fig. 7, top Figure) reflects the increase of the light part of a day. The effect of the Moon's phase thereon is distinguished. The net effect of the gravitational forces of the Sun and the Moon occurs near the new moon, when the maximum effect should be expected. The lower part of the Figure shows the component amplitude with a period of ~20 minutes. Its relationship with selected moments of the daily harmonics is clearly seen. It should be noted that on March 17 and April 26 solar flares of X 1.5 an M 7.0 classes (in the morning and in the evening) occurred, that could increase the emissions on day 17 and day 57.

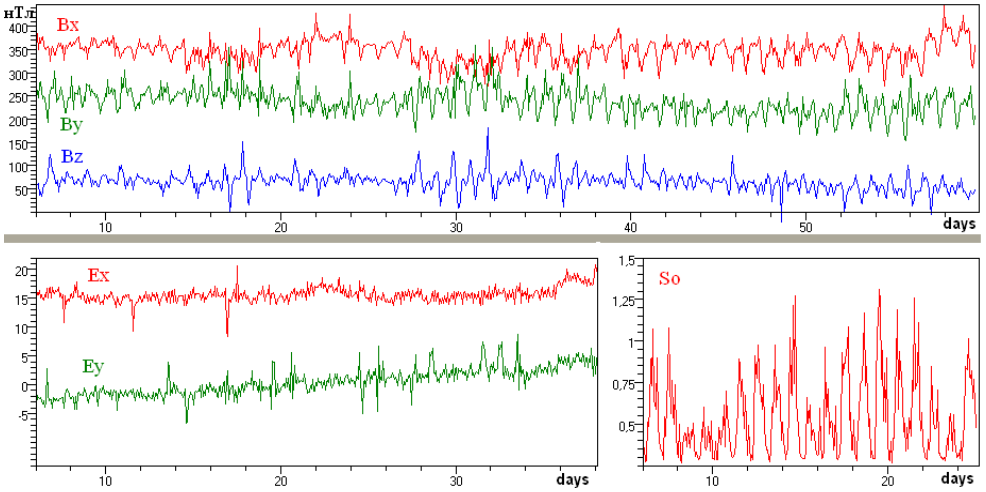

Fig. 6. The overview of data in 54 days

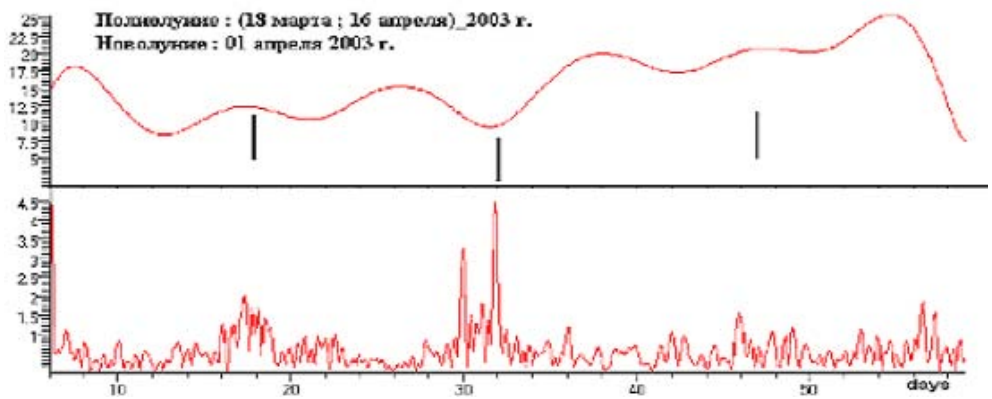

Fig. 7. The envelopes of the daily and twenty-minute harmonics for Bx-components

Connection of arterial pressure and pulse at changes of geomagnetic activity

Data on daily monitoring of systolic blood pressure (SBP), diastolic blood pressure (DBP) and heartrate (HR) for 2000 was applied. The measurements were performed by a patient in the morning and in the evening within the blood pressure self-monitoring program implemented under the care of a physician [5]. To describe a degree of the organism coordination ability, the time dependence of the linear correlation of medical parameters: K1(t) = Corr (HR&SBP; t) – dynamics of correlation coefficient between the heart rate and SBP; K2(t) = Corr (HR&DBP; t) correlations between the heart rate and diastolic blood pressure; K3(t) – correlations between SBP and DBP were used. Their behavior was compared with

the dynamics of daily values of the geomagnetic components. What was the minute data of H, D, Z variations of the magnetic field for 2000 used for, and the envelope of their daily harmonics was selected.

The analysis result for the morning correlation relationships is presented in Fig. 8. It can be seen that the maximum values of daily amplitudes of B-components (in the vicinity of 100 and 200 days) and their fronts are superimposed on the periods when the morning readings of the heart rate and blood pressure changed out most clearly.

We have to add that in the spectra of annual B-component arrays a lunar (27.3 d.) and triple lunar periods are identified. The high-frequency part comprises a period of about 9 and 18 minutes. A similar phenomenon was mentioned above in the analysis of other time array intervals.

Conclusions

The review of the assessment results for the magnetometric complex data was demonstrated. The possibility of correlating and analyzing both minute and annual intervals was shown. The manifestation of responses to various processes of about 5÷20 minutes should be noted. Close time scales in various situations are presented in papers [6, 7].

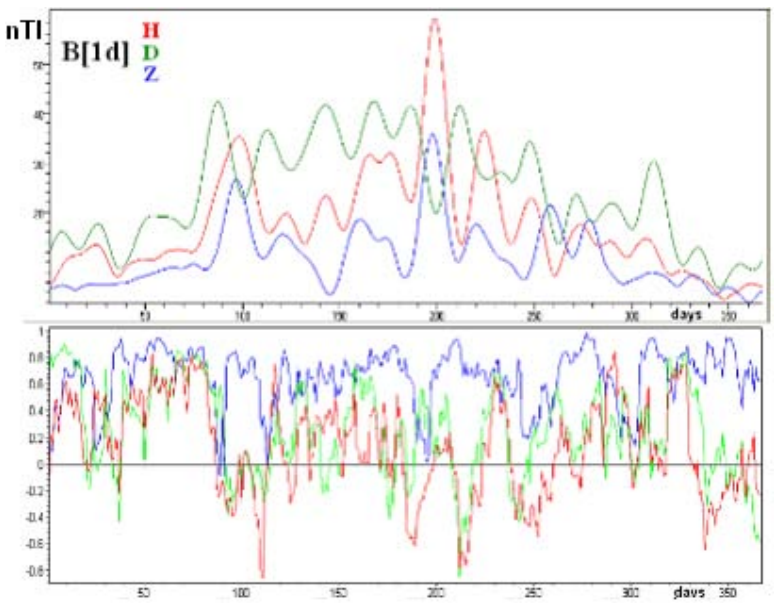

Fig. 8. The envelopes of the daily harmonics for B-components (top Figure) and correlation relations of pulse with arterial pressure (bottom). X axis - days of year; Red dashed line - K1(t); Green dashed line - K2(t); Blue dashed line - K3(t).

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ДИНАМИКА НА РЕГУЛЯРНИ И СЛУЧАЙНИ СЪБИТИЯ ПО ДАННИ ОТ МАГНИТОМЕТРИЧЕСКИЯ КОМПЛЕКС: МАТЕРИАЛИ ОТ ПРОЕКТ “ШУМАН”

Ю. Кукса, И. Шибаев, Д. Теодосиев, Я. Войта

Резюме

В работата е представен обзор на резултатите от анализа на данни от измерване на УНЧ вълни, осъществяван в рамките на проект “Шуман” [1]. Магнитометрическият комплекс регистрира три магнитни компоненти, две електрически и обвиваща на акустичния канал. Динамическият диапазон по всичките канали е 22 разряден с период на квантуване 0.5 сек. В настоящия момент в ИЗМИРАН (Троицк, Русия) се провеждат регулярни наблюдения на геомагнитните вариации в честотния диапазон до 2 Hz. В работата се демонстрират възможностите и качеството на получаваните данни от магнитометрическия комплекс.