

Lunar Phase Effects of Geomagnetic Activity and Ambulance Calls

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Abstract: - The distribution of geomagnetic activity levels and the number of ambulance team calls for the days of a lunar synodic month is discussed. The study is based on the Kp index database and the impersonified BSMP Catalogue of ambulance calls in Petrozavodsk in 2015-2017. The data obtained were processed using the superposed epochs method, a clusterization algorithm and B-algorithm for recognition of the shifts of «regimes». It has been shown that high daily Kp indices are mainly grouped near the new moon, while low Kp indices near the full moon. The distribution of the number of ambulance calls for patients with cardiovascular, psychic and nervous diseases displays a distinctive pattern. The possible mechanisms of the lunar phase effect of geomagnetic activity and the distribution of emergency ambulance calls are discussed.

Key-Words: - Geomagnetic variations, Kp index, number of ambulance calls, lunar synodic month, myocardial infarction, schizophrenia, epilepsy.

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1 Introduction

Variations in the shape of the lunar disk are often attributed to its effect on the physical and psychic condition of man. So far, no convincing mechanism of such an effect has been presented. People commonly respond to its non-existence by ascribing mystic properties to the Moon [1] or by refusing to recognize it [2].

The direct effect on man of geophysical and weather factors accompanying the succession of lunar cycle phases is really hard to prove, because it is hard to identify reasons for it with regard for the individual responses of people. The mechanism of the effect exerted by the Moon on biological objects is commonly sought for by correlating the variability of the external factor with medico-biological indices and trying to reveal periodicities characteristic of this factor in the cyclicity of processes. The results of research are often obtained under incompletely controlled conditions, the data obtained are insufficient, the time taken by monitoring was short, and the results were registered at different places.

Of utmost interest are external factors such as the gravitational effect of the Moon and the Sun, as well as related tidal phenomena, which can be forecasted in space and time on the basis of mathematical

description [3]. Upon transition to a biological level, things do not become as unambiguous as before.

It is generally accepted in the “biological tide” concept that gravity forces affect the water structure and nervous system of the human organism [4]. Variations in the water structure provoke disturbances in the functioning of cell membranes, calcium ion exchange and the shift of the water balance. Nerve gravireceptors generate signals sent to the epiphysis, which produces the hormones melatonin and serotonin. Lunar phase relationships were revealed in the main hormones of the human endocrine system [5]. Changes in the gravity field are assumed to be responsible for the lunar effect exerted by the penetration of E-coli metabolites, which affect human behaviour, into the blood [6].

The negation of the Moon’s gravity effect on biological objects is based on estimation of its effect of the order of 10^{-7} g in comparison with the effects of no less than 10^{-4} g revealed experimentally [7]. To achieve the required sensitivity, the heart beat of the people tested will be terminated and their respiration will be switched off. A geomagnetic field can be a factor related to the Moon. The Earth’s magnetic field as a gravity field efficiently and rapidly transmits information about

environmental changes to organisms. Its vector pattern contributes to the formation of autovibrational systems, and cyclicity is used to synchronize processes. Cyclicity is provoked by the rotation of the Earth around the Sun and its own axis and the rotation of the Earth-Moon system around the barycentre. Data on geomagnetic activity are available in special catalogues [8, 9].

The effect of geomagnetic variations on the condition of man and higher animals is not completely proven, although some progress, provoked by space research and a growing interest in ecology, has been made in the past few years. Attempts to relate geomagnetic field transformations to geological processes, climatic changes and large-scale shifts in the biosphere, are made [10]. Changes in the organisms of people, animals and cells, affected by strong electromagnetic fields and a hypomagnetic medium for a long time, are studied in detail [11-13]. The response of organisms to reproduced records of magnetic storm signals is studied as well [14]. Geomagnetic activity is often interpreted as a factor, which affects the number of ambulance calls [15-17].

Large-scale experiments on people are hard to conduct. Therefore, ambulance call catalogues provide a convincing tool for research. They are compiled in such a way that common processing methods can be used in different regions at different times. They contain information about many patients and the diagnoses of their diseases over a long reporting period. As the time and place of each ambulance call is registered, it is easy to seek for the cause and consequence of a disease and relate them to external factors.

In the present study geomagnetic activity was analyzed together with the number of emergency ambulance calls.

The aim of the analysis was to show the objective picture of the lunar phase distribution of geomagnetic activity levels and the number of ambulance calls with the preset diagnoses of diseases. The tasks of our studies were: to develop an approach to the combined use of catalogues; to construct and analyze distributions for the days of a lunar synodic month; and to identify trends and characteristics in the distributions.

Reference data were provided by evidence for new moons, the time series of Kp index and an impersonified Catalogue of BSMP ambulance calls in Petrozavodsk in 2015-2017. They were processed in the MATLAB computer mathematics system using the superposed epochs method, a K-means clusterization algorithm, B-algorithm for

recognition of the shifts of “regimes” and standard procedures for statistical analysis.

The distributions of daily Kp index values and the number of ambulance calls with known diagnoses for the days of a lunar synodic month for clusters of geomagnetic activity were obtained. Zones with linear trends, showing the succession of “regimes” during a lunar cycle, were identified.

It has been shown that high geomagnetic activity levels ($K_p > 2.6$) predominate on days close to the new moon, while low levels ($K_p < 2$) are recorded on days close to the full moon. In the general distributions of the number of ambulance calls for patients with cardiovascular, nervous and psychic diseases the lunar phase effect is less conspicuous, because it is masked by the distinctive characteristics of the distributions.

The possible mechanisms of the lunar phase effect of geomagnetic activity and the distribution of the number of emergency ambulance calls with selected diagnoses are discussed.

20 Problem Formulation

2.1 Reference data.

Deviations of a geomagnetic field from the norm during a 3-hour period are described by a planetary Kp index in the 0-9 range. Index values of 5 to 9 are consistent with magnetic storms. Data from a website showing Kp index in real time were used for calculating daily Kp index values and their mean square deviation [9].

An impersonified catalogue of ambulance calls is presented as a table in which the lines correspond with calls and the columns with their attributes such as the place of residence, address, age, sex of a patient, the date and time of a call and the diagnosis of a disease in accordance with MCB-10 classification [17]. The total number of calls from 1.01.2015 to 19.12.2017 was 352641. Calls with the diagnoses of diseases determined by an ambulance team member were analyzed. Socially significant diseases, such as myocardial infarction, schizophrenia and epilepsy, were chosen. Data on new moons in the period studied were taken from an Internet source [18].

2.2 Methods for data processing and data analysis.

The distributions of Kp indices and N number of ambulance calls for k events were constructed in MATLAB computer system, calculating the number $f_k(x)$ from the variable x using the formula:

$$f_k(x) = f_{k-1}(x) + \delta_k(x) \quad (1)$$

where $k=1, 2, \dots, N$; $f_0(x)=0$; $\delta_k(x)=1$, if $h < x < h + \Delta h$, and $\delta_k(x)=0$, if $x < h$ or $x > h + \Delta h$, where k is the number of calls, h and Δh are the count and step of a histogram, respectively.

The distributions of Kp index values and the number of ambulance calls for the days of a lunar synodic month were constructed using the superposed epochs method [19], in which the day of a new moon was the first count of distribution and the total number of counts with regard for the length of a lunar synodic month (29.5 days) was 30. The K-means algorithm with 5 clusters [20] was used for the clusterization of geomagnetic activity. The linear trends of distribution «regimes» were constructed using B-algorithm in the MATLAB system [21]. For the algorithm to function, the parameter ρ , connected with the length of the sites of the initial division of distribution, the confidence level α , used for comparing the trends of neighbouring sites, the parameters b and n responsible for the variation range of site boundaries and the number of iterations of the optimization procedure were preset. The parameter ρ was chosen in the range 0.18-0.24 with regard for the small size of the distributions analyzed and the convenience of short intervals when tracing variations in the trends. The confidence level α , used for checking statistical hypotheses, was no more than 0.05. The parameter b was assumed to be 1 or 2, the parameter n to be 10.

Regression and comparison of the mean values of samples were used as standard procedures for statistical analysis. To obtain the time distribution trends of daily Kp index values and the number of ambulance calls with preset diagnoses, regression was done using a polynomial in the 10-th degree and MATLAB «polyfit» and «polyval» commands. The comparison of the mean values of data samples was checked with Student criterion accomplished by MATLAB «ttest2» commands [22].

30 Problem Solution

The time distributions of mean daily Kp indices and the number of ambulance calls for myocardial infarction, schizophrenia and epilepsy are shown in Fig 1.

Fig. 2 shows the results of the clusterization of mean daily Kp index values after the «K-means» algorithm for five clusters.

Shown in Fig. 3 are the distributions of the daily Kp index and its cluster components on the days of a lunar synodic month and the results of their processing with B- algorithm.

Fig. 4 shows the distributions of the number of ambulance calls for patients with myocardial infarction on the days of a lunar synodic month and its components consistent with geomagnetic activity clusters, and linear trends.

The distributions of the number of ambulance calls for patients with schizophrenia and epilepsy, similar to those in Fig. 4, are shown in Figs 5 and 6, respectively.

The distribution of the daily Kp index for the days of a lunar synodic month on full moon days displays a well-defined minimum (Fig. 3a, b). The minimum is dependent on components with high geomagnetic activity levels (Fig. 3 g, h). Low levels display a reverse pattern: their maximum activity is observed on full moon days and their minimum activity on days closer to a new moon (Fig. 3 d, e). Distribution trends shown in Fig. 3 c-h support the presence of 4-6 local increased and decreased geomagnetic activity «regimes» reflecting the lunar phase dependence of the daily Kp index and its cluster components.

The distributions of cluster components (Figs. 4-6) for ambulance calls resemble those of Kp indices, but the total distributions of the number of ambulance calls with registered diagnoses for the days of a lunar synodic month are different. For patients with myocardial infarction many emergency ambulance calls are made on new moon and full moon days. For patients with schizophrenia the maximum number of calls is made on the 8th day of a lunar synodic month.

For patients with epilepsy most calls are made in the late half of the lunar cycle. The main and cluster distribution trends of these diseases are also different. In addition to interval analysis of trends, mean Kp index values and the number of ambulance calls for each day of a lunar synodic month were compared. In Figure 3, for example, the difference of the mean values 2.60 and 1.80 with the confidence level $\alpha < 0.01$ is confirmed for the counts of total Kp index distribution with the

numbers 4 and 17 and for counts with the numbers 16 and 26 (1.87 and 2.74). The mean numbers of daily ambulance calls on the 10th and 17th days of

the lunar cycle, 1.54 and 2.25, in the distribution in Fig. 4a differ with the confidence level $\alpha < 0.05$.

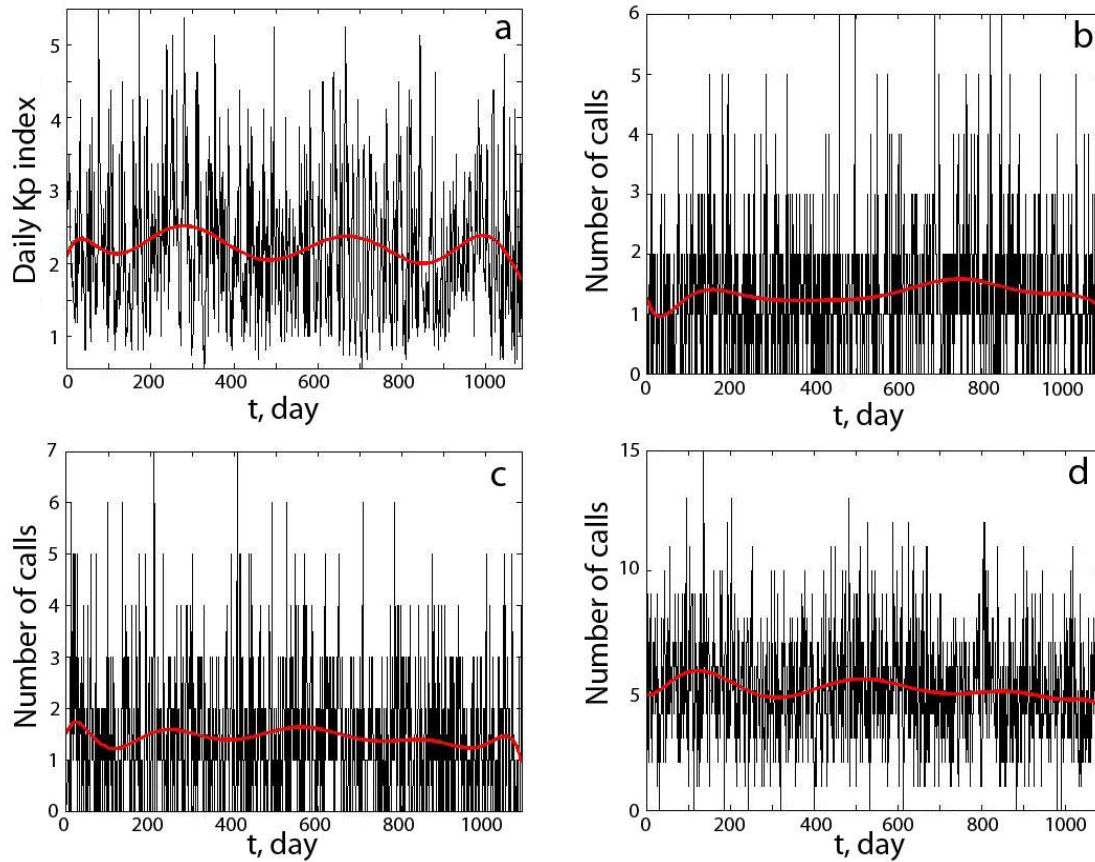


Fig. 1 Distribution of daily Kp index (a) and the number of ambulance calls for patients with myocardial infarction (b), schizophrenia (c) and epilepsy (d). Distribution trends (--) were obtained by regression of distributions using a polynomial in the 10th degree.

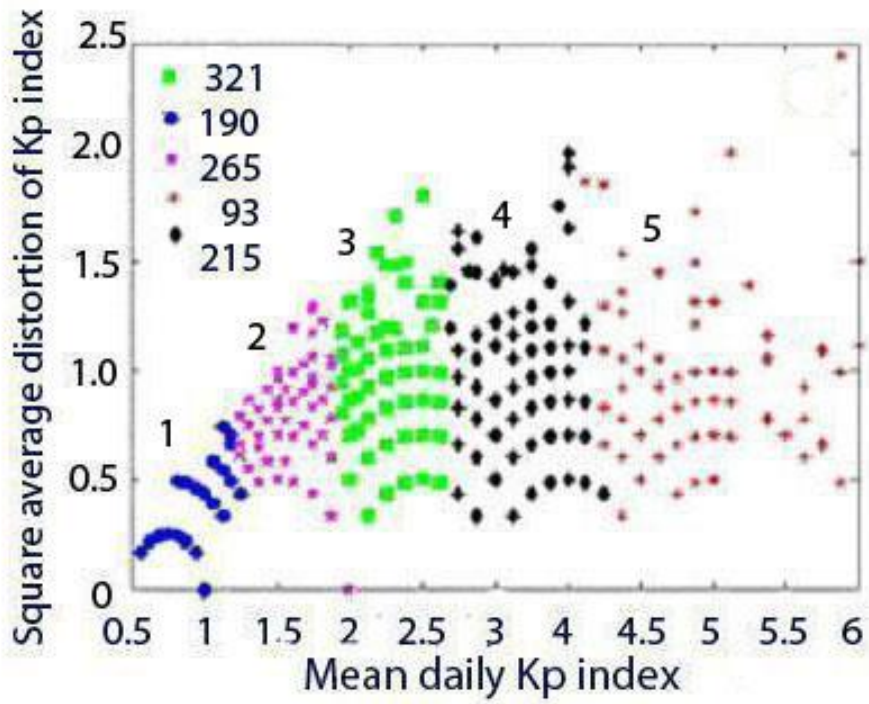


Fig. 2 Cluster analysis of daily Kp index values (Fig.1a).

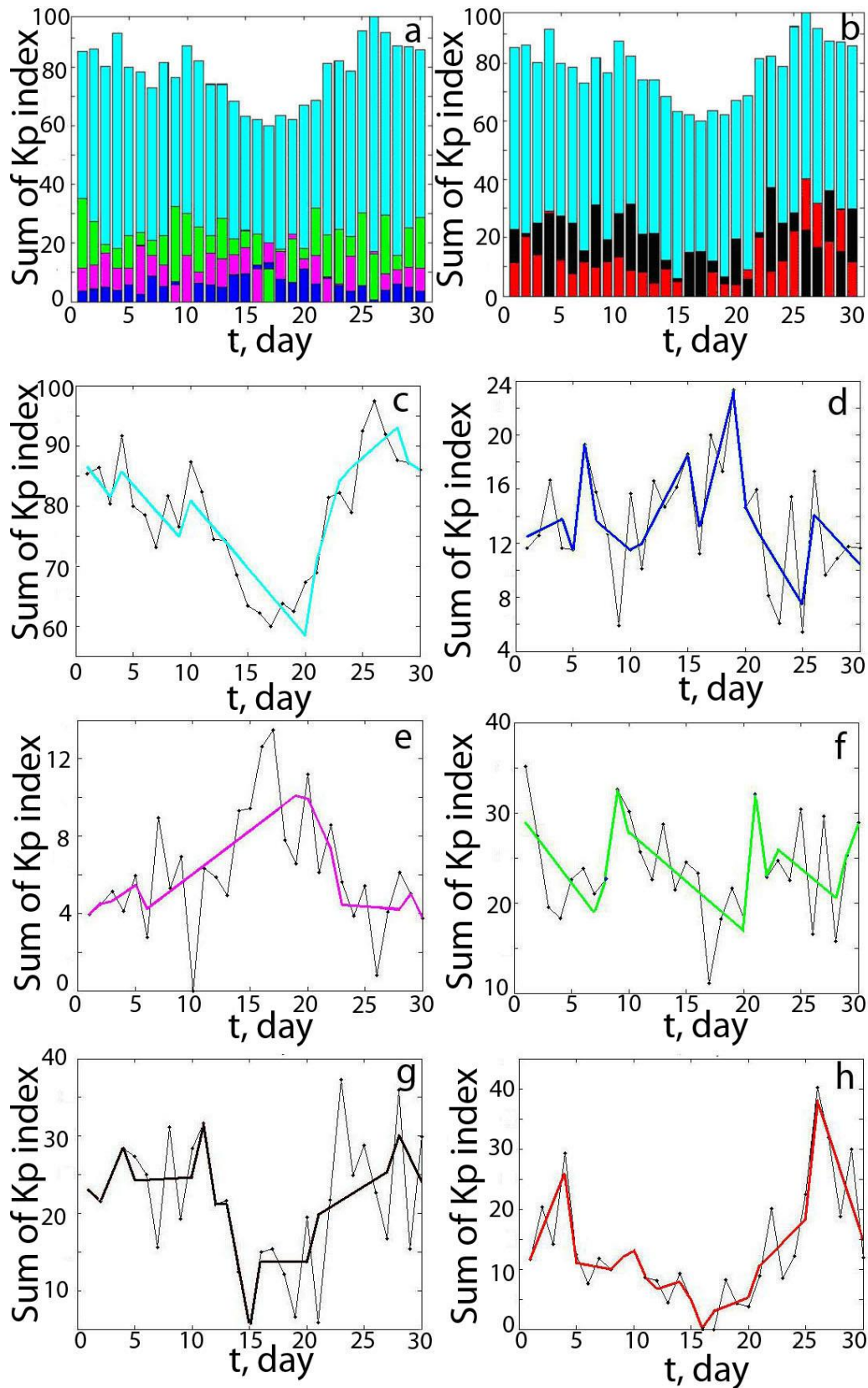


Fig. 3 Daily Kp index distribution for the days of a lunar synodic month for clusters in Fig.2: 1-3 (a), 4-5 (b). The results of the processing of daily Kp index distribution (c) and the corresponding distributions of clusters 1-5 (d-h) using B-algorithm. The colour of the trends and counts of the histograms is consistent with those of clusters in Fig.2

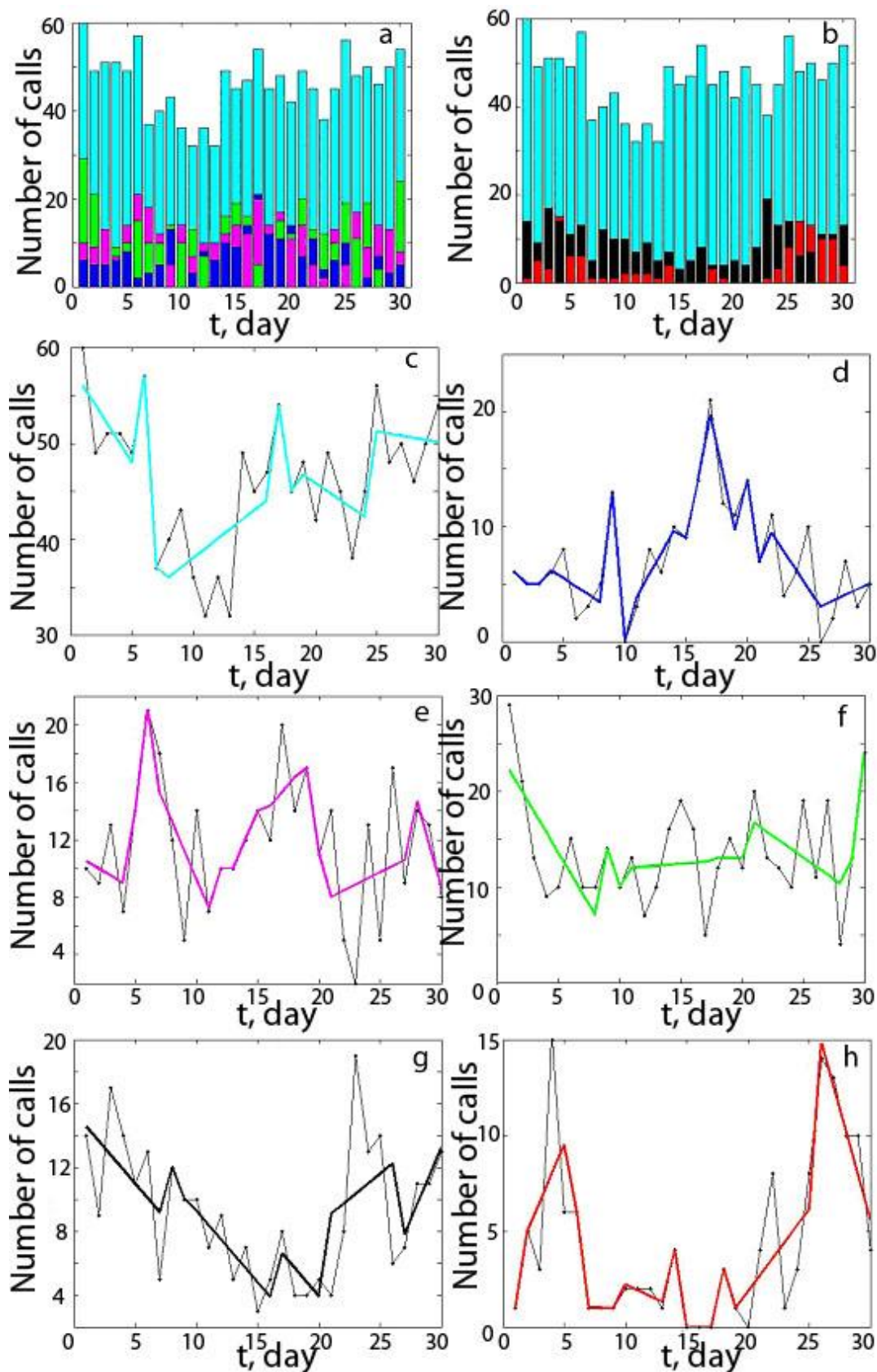


Fig. 4 Distributions of the number of ambulance calls for patients with myocardial infarction for the days of a lunar synodic month for clusters in Fig.2: 1-3 (a), 4-5 (b). The results of processing of the total distribution (c) and corresponding distributions of clusters 1-5 using B-algorithm (d-h). The colour of the trends and counts of the histograms is consistent with that of clusters in Fig.2.

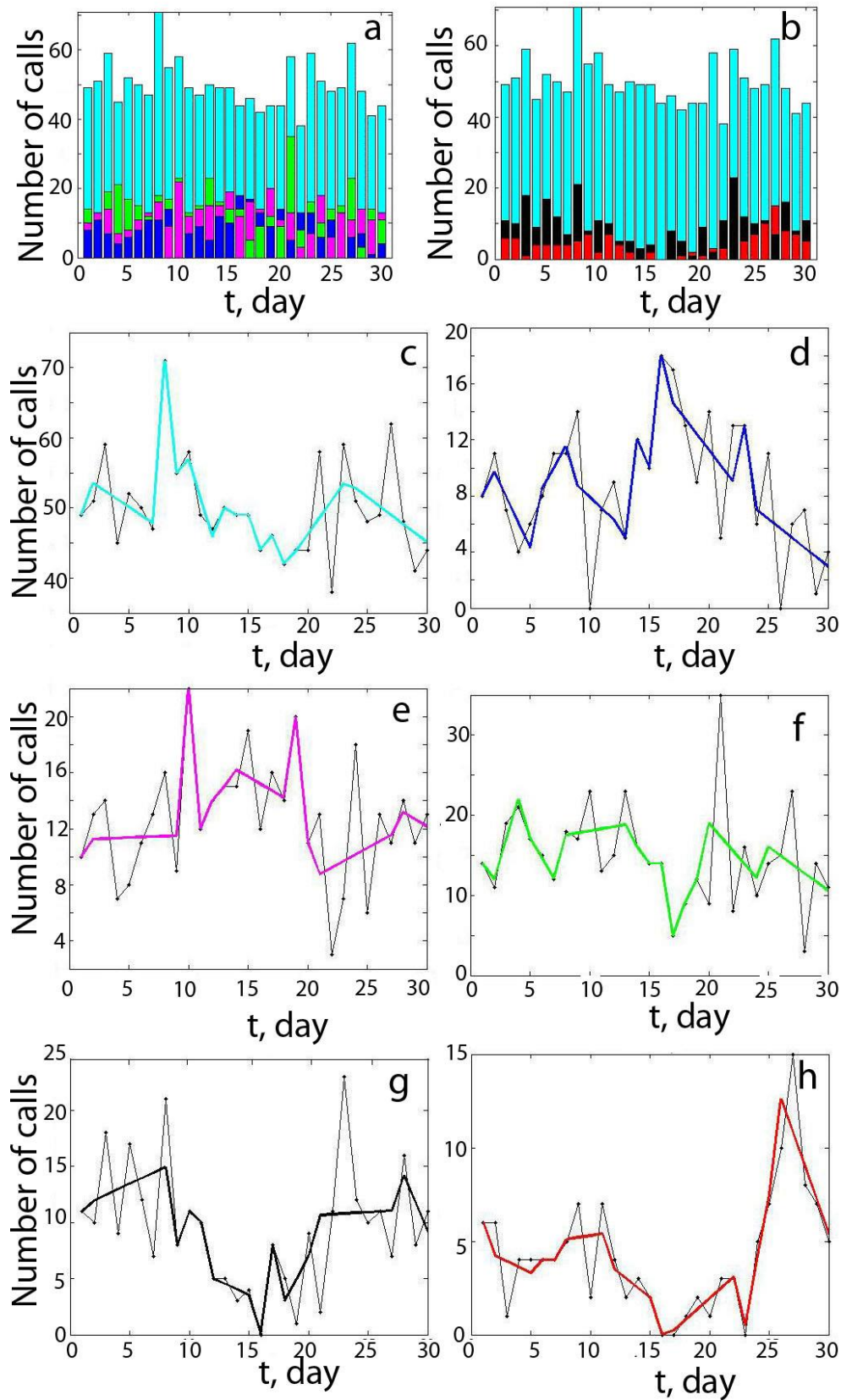


Fig. 5 Distribution of the number of ambulance calls for patients with schizophrenia for the days of a lunar synodic month for clusters in Fig.2: 1-3 (a), 4-5 (b). Results of processing the total distribution (c) and corresponding distributions of clusters 1-5 using B-algorithm (d-h). The colour of the trends and counts of the histograms is consistent with that of clusters in Fig.2

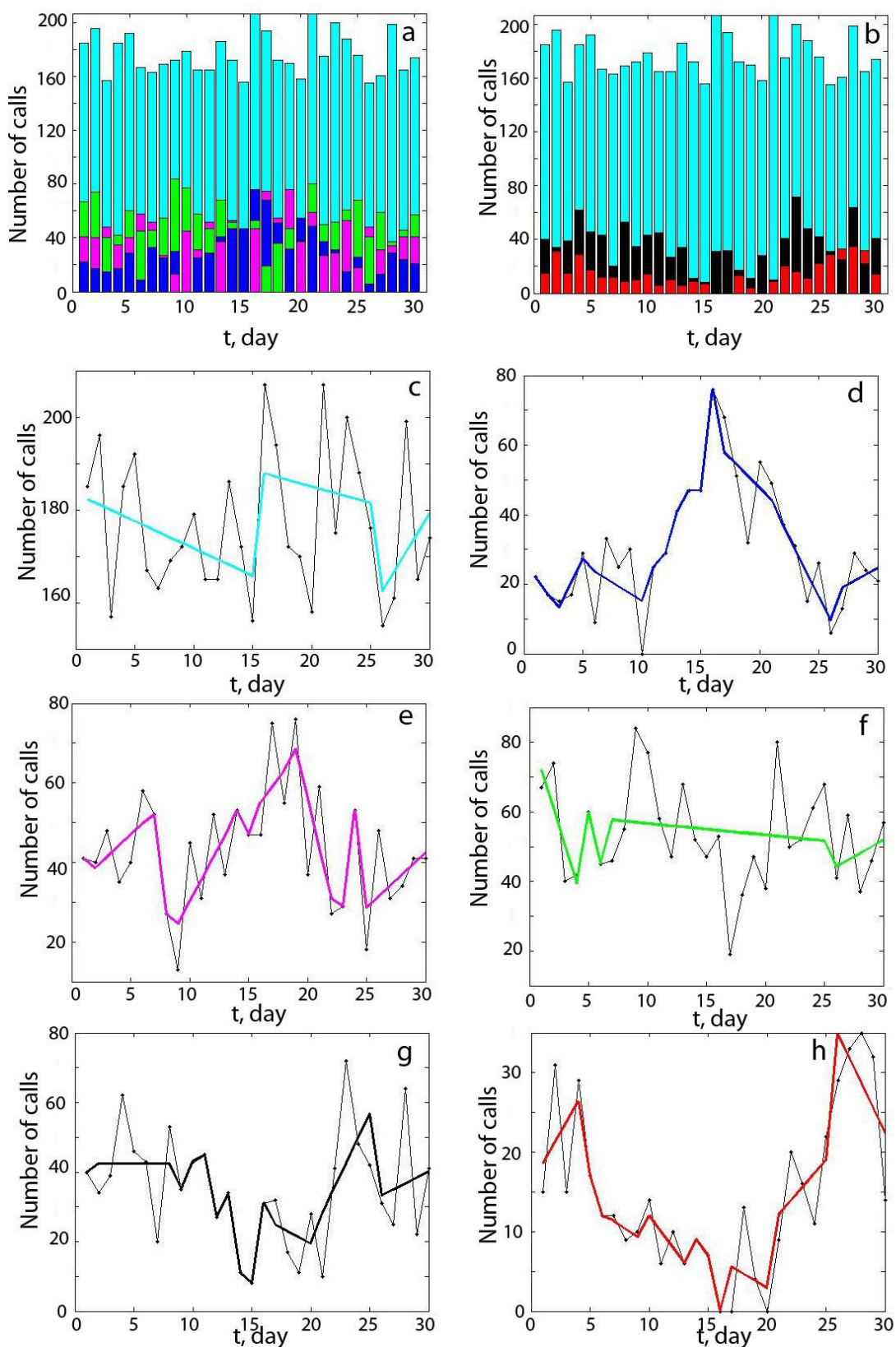


Fig. 6 Distributions of the number of ambulance calls for patients with epilepsy for the days of a lunar synodic month for clusters in Fig.2: 1-3 (a), 4-5 (b). Results of processing of the total distribution (c) and corresponding distributions of clusters 1-5 using B-algorithm (d-h). The colour of the trend and counts of the histograms is consistent with that of clusters in Fig.2

Comparison of the mean daily values of the number of ambulance calls for patients with epilepsy, made for consecutive days with the confidence level $\alpha < 0.05$ has revealed differences in counts with the numbers 15, 16 and 20, 21. No significant differences for the number of ambulance calls for patients with myocardial infarction and schizophrenia have been detected. The mean daily numbers of ambulance calls for patients with schizophrenia on the most contrasting 7th and 8th days of the lunar cycle were 1.34 and 2.03, respectively (Fig. 5c).

To check the effect of a geomagnetic activity level on the frequency of emergency ambulance calls, the mean values of the number of ambulance calls for combinations of geomagnetic activity clusters for the days of a lunar synodic month were compared. No differences between mean values for samples corresponding to three clusters with low Kp indices and two clusters with high Kp indices with a probability in excess of 0.95 have been revealed.

4. Discussion

The lunar phase effect of geomagnetic activity can be explained by various mechanisms, considering that geomagnetic field variations are generated by the corpuscular radiation of the Sun by «solar wind» and processes in the earth core.

The Earth is protected from solar wind by the magnetosphere, which has a distinctive elongated shape. On the day side, its size of 10-15 Earth's radii (RE) is responsible for solar wind pressure. On the night side, the length of the magnetosphere is over 200 RE [23]. The Moon's orbit with a radius of about 60 RE intersects the magnetosphere. On the Sun's side, the Moon partly overlaps, partly reflects corpuscular radiation and interacts with the magnetic field frozen into its plasma. The magnetosphere responds to the movement of the Moon. In this interval of the cycle by restructurings dominated by high Kp index values. The Moon occupies a position on the side opposite to the Sun in the full moon phase; being inside the magnetosphere, the Moon is shielded by it. At this time, geomagnetic activity is mainly low. According to [7], the lunar phase cyclicity of

geomagnetic activity is related with the Sun's natural rotation with a period of 28 ± 2 суток, modulating "solar" wind flow, rather than to the position of the Moon on the orbit. The lunar phase effect of geomagnetic activity could be the manifestation of the different gravity effect of the Moon and the Sun on the Earth in lunar cycle phases. In the new moon phase, the gravity forces of the Moon and the Sun affecting the Earth's internal, non-spherical, unbalanced shells are co-directed and in the full moon phase they are distributed in opposite directions. Such differences can be responsible for differences in endogenous activity levels and geomagnetic field generation [24-26, 10]. The total distribution of Kp indices (Fig.3) can be represented as being composed of the distributions of the number of days of geomagnetic clusters weighed by mean Kp index values. The lunar phase effect of geomagnetic activity was estimated by variable grouping of high and low Kp index values for the days of a lunar synodic month and by weighing cluster distributions by the mean Kp index values of clusters.

The latter factor in the distributions of the number of ambulance calls for the days of the lunar synodic month is less conspicuous. The similar mean daily numbers of ambulance calls of different clusters make weighing of cluster distributions inefficient and give rise to the distinctive characteristics of total distributions.

The absence of significant differences in the mean daily numbers of ambulance calls for patients with the diagnoses discussed could be due to the insufficient amount of data for a three-year period in the catalogue. Catalogues covering longer monitoring periods are likely to clear up this matter when processing data with a greater number of samples.

An increase in the number of ambulance calls for patients with myocardial infarction (Fig.4) close to a new moon and a full moon is consistent with conclusions in [27]. The increasing number of calls on new moon days with high Kp index values and on full moon days with low Kp values indicates the adaptation of the human cardiovascular system to a common geomagnetic variation level. The effect of geomagnetic variations on the human blood circulating system during magnetic storms and on

days with quiet cosmic weather is indicated by a decline in blood flow rate [28]. A decline in blood flow rate enhances the risk of thrombus formation and cardiovascular pathology [29, 30].

Evidence for the effect of the Moon on the psychic condition of man is contradictory. In some studies, analysis of the frequency of visits to psychiatric clinics and counting the symptoms of mental disorders in different lunar cycle phases has not revealed significant differences [31]. However, monitoring conducted at a specialized mental hospital in Kharkov, Ukraine, has shown that many cases of hospitalization of people with schizophrenia takes place upon weakly perturbed ($A_K=20-29$) and moderately perturbed geomagnetic fields ($A_K=30-49$) and patients with a paranoid form upon very mild perturbations ($A_K=8-14$) [32, 33]. On some days, the number of hospitalized patients is more than twice the mean monthly values. Patients were highly sensitive a change in the negative sign of the interplanetary magnetic field sector to a positive one. Simultaneous variations in solar activity series and hospitalization into mental hospitals in Moscow and Kazan were reported in [34].

The growing number of ambulance calls on the 8th day of a lunar synodic month (Fig.5) seems to be triggered by a change in geomagnetic activity “regime”.

The increase in the mean number of ambulance calls for patients with epilepsy in the late half of the lunar cycle (Fig. 6) is interpreted in accordance with the conclusions [35] showing the growth of spasmodic activity on full moon days and in the last quarter of the lunar cycle.

5. Conclusion

The superposed epochs method and the clusterization algorithm were used for constructing the distribution of the daily Kp indices of geomagnetic activity and the number of emergency ambulance calls for the days of a lunar synodic month for various geomagnetic activity clusters. Distribution trends were obtained using B-algorithm for recognition of the shifts of «regimes».

The lunar phase effect in the distribution of daily Kp indices and their linear trends is indicated by the grouping of high geomagnetic activity levels near a new moon and low levels near a full moon and results from the weighing of cluster distributions with the mean Kp index values of clusters. This effect is not so conspicuous for the distributions of the number of ambulance calls for patients with the diagnoses chosen due to the similarity of the mean daily values of the number of ambulance calls in different geomagnetic clusters. The distribution of each of the diseases analyzed displays some distinctive characteristics of its own. The results of the study could be of interest for specialists in chronobiology and chronomedicine. They could be used for planning medical care programmes for the populations.

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Contribution of individual authors to the creation of a scientific article (ghostwriting policy)

As the only author Belashev B.Z. is responsible for all sections of the article.