Ministry of Education of Russian Federation

THE RUSSIAN STATE HYDROMETEOROLOGICAL UNIVERSITY

Allowed for defender by the head of department: prof. A. S. Gavrilov

The department of the Meteorology, Climatology and Atmosphere Environment

BACHELOR GRADUATION WORK

The influence of geoheliophysical factors upon the human health

Done by student:
E. G. Yanovskaya
group MA-434
Supervisor: O. M. Stupishina,
Consultant: E. V. Podgaisky.

Saint-Petersburg, 2007

CONTENTS

INTRODUCTION

It is well known that climate and weather contribute to general state of human health. As the great ancient Greek philosopher, scientist and physician Hippocrates had written in his famous work "Aphorisms" (which became available nearly 400 years b. c. and since then have not lost its importance): "Of natures *(human bodies)*, some are well- or ill-adapted for summer, and some for winter. Of diseases and ages, certain of them are well- or ill-adapted to different seasons, places, and kinds of diet. Of the constitutions of the year, the dry, upon the whole, are more healthy than the rainy, and attended with less mortality. All diseases occur at all seasons of the year, but certain of them are more apt to occur and be exacerbated at certain seasons".

The beginning of scientific medical climatology is attributed to Paracelsus (von Hohenheim, 1493-1541), who confirmed that "for the one, who studied the winds, lightning and weather, origin of diseases is known". The great mathematician and philosopher G. Leibniz (1646-1716) offered statistical data-processing method for health disfunction due to weather conditions. Goethe, who published the well-known writing "The experience of weather studying" (1825), noticed that at high barometric value he worked easier, than at low atmospheric pressure. The beginning of medical meteorology traditions in Russia can be found in M. V. Lomonosov’s writings (1711-1765), where weather influence on human was repeatedly mentioned. A. I. Voeykov (1842-1916) was the founder of climatological science in Russia. In his treatises, especially in "On Healing Terrains", it was persistently pointed out to the necessity of using information about climate for medical treatment. A. L. Chizhevsky was the first to begin studying of ambient influence upon human health. He called the science “Heliobiology”. In his investigation, general biology and physiology were closely related to physiology and medicine. Nowadays, researchers of solar physic are studying "Heliobiology", meteorologists are dealing with “Biometeorology”, and physicians are researching "Human ecology". However these studies are conducted without much coordination that hinders integrated estimation of ambient influence.

Nowadays many hypotheses have got its scientific acknowledgement. Now we can realistically confirm that the climate and its individual parameters (temperature, humidity, air pressure, wind, cloudiness and etc.) can either favour physiological processes in human organism, or bring it to breach, to the so-called "meteotropic" reactions. Under the long-term exposure to adverse climate factors certain "meteotropic" diseases could appear. On the other hand, certain climate conditions (marine or Alpine climates), can be used as natural therapeutic facilities, facilitating recovery from many diseases. With this in mind, one should take into account that the same value of the meteorological parameter has different influence on human body, depending on local conditions and individual particularities of the organism. It is specifically noted that sharp and short fluctuations of the atmospheric state primarily affect those who are sick or hypersensitive to weather. Such people are called meteolabile or meteotropic. Meteosensitivity is not a constant physiological feature of the organism. The frequency of meteorological reactions changes with age: at mature age with the increase of chronic diseases, the meteotropic reactions appear among 58% practically healthy and 70% sick and weakened people. Besides, meteosensitivity for urban population is 1,5-2 times higher, than for rural one. Specialists assume that in recent years the number of people with increased meteosensitivity, including children, has risen. In the course of time, as a result of ubiquitous changes of ecological situation and climate, which are accompanied by reduction of general resistivity to external influence, the sensitivity to weather and climate factors might increase. Thus, meteotropic reactions are originated from disbalance between the organism and environment. Meteorological conditions and climate could play the role of “trigger”, bringing to deterioration of health level, to intensification of diseases. But they cannot be the reason for the disease.

To prevent meteopatic reactions of human organism, it is necessary to estimate the biometrical indexes (parameters) and to conduct medical-geographical mapping of human habitat.

THE INFLUENCE OF NATURAL FACTORS UPON HUMAN ORGANISM

Of the many environmental influences on the human body, the effects arising from the climate are among the most significant. indeed, several specific disorders occur only under particular climatic conditions, obvious examples being heat-stroke and frostbite. In other cases the link with climate is not direct but is nonetheless important. Thus the many diseases such as malaria, yellow fever and river blindness which are transmitted via insect-borne infections are confined to areas having climates where insects such as mosquitoes, ticks and fleas flourish. The appropriate climates are fairly well understood, but changes in environmental conditions such as drought or deforestation may alter the number and distribution of organisms such as insects which transmit diseases to people.

Another example is eye disorders, such as cataract which seems to be more prevalent in areas of high exposure to sunshine rich in ultraviolet radiation. It has been suggested that ultraviolet radiation can cause the formation of cataract-inducing oxidizing agents within the eye.Weather and climate have a considerable influence on asthma, hay fever and other respiratory disorders caused by various allergens (pollens and pollutants). The production of such agents as well as their subsequent spread and concentration are all very much dependent on the prevailing meteorological conditions. [*climate and human health; Laurence S. Kalkstein, W. John Maunder, Gerd Jendritzky; Geneva, Switzerland-1996*]

Atmospheric conditions influence the growth and development of almost all life forms. Weather and climate also have an influence on man and his health. We can differentiate between direct and indirect meteorological influences. There are two types of influences: direct and indirect.

Direct influence. The most important direct influences are extreme weather situations, such as storms (hurricanes), extreme heat or cold, floods, drought or avalanches. All of these occurrences can endanger the health and even the lives of human beings. The damaging effects of too much UV radiation have also been proven. In particular, an increase in the incidence of skin cancer and eye cataracts has been established. Another of the direct influences is what we know as "meteorosensitivity". 30 to 50% of the population suffers under certain weather conditions. Well known in this respect are the influence of the Föhn wind, the Bise (a cold wind in Switzerland) and changes in the weather in general. The symptoms of meteorosensitivity are manifold. It is accepted that the weather can be an extra stress factor, as the human organism has to adapt to changing conditions in the atmosphere (changes in the weather).

Indirect influence. Human health is indirectly influenced by pathogens, air pollution and allergies. Many transmitters of illnesses are dependent on meteorological conditions. The distribution of air pollutants is also closely related to meteorology. Air pollution can have a negative influence on people with respiratory diseases, such as asthma or chronic bronchitis. Allergies can be triggered by, amongst other things, pollen, fungal spores or dust mites.

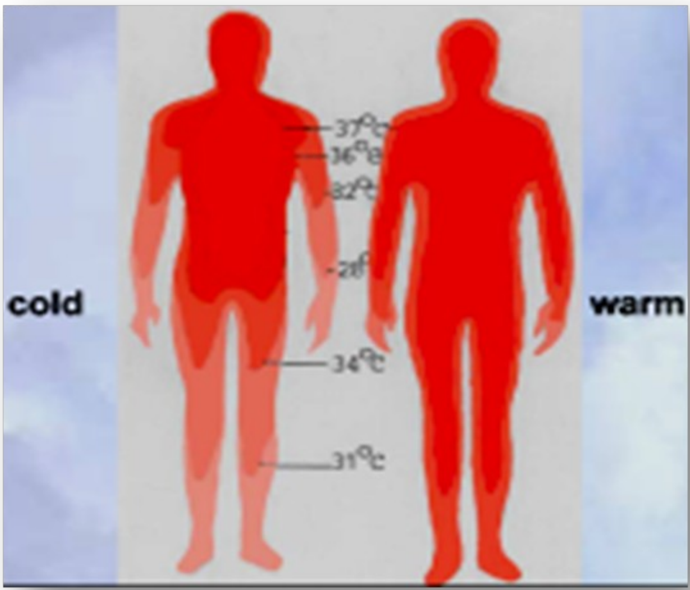
Although these negative influences exist, we must not forget the positive ones. For centuries we have known about the beneficial effects on our well-being of a stay at a health resort in the mountains or beside the sea. Meteorological elements such as sunshine, wind and certain temperature conditions stimulate the human organism. Also, a specific dose of UV radiation is vital for human health (it helps the body manufacture Vitamin D).

Health and global warming. Because of increased concentrations of greenhouse gases in the atmosphere, we can count on a warmer climate. Changes in air temperature, air humidity, UV radiation and precipitation affect human health both directly and indirectly. For example, mild winters can reduce the number of deaths caused by the cold, whereas hot summer temperatures can increase the death rate. Pathogens are able to develop and spread more rapidly. This could mean that, in the future, malaria may crop up in areas where it is not to be found today. [*http://www.meteoschweiz.ch/web/en/weather/health.html*]

The influence of the atmosphere upon human (organism)

1. Temperature.

The assessment and forecast of the thermal environment is therefore an important task for public information, allowing people to optimize their comfort, performance and health. Previously due to lack of knowledge and technology, later also by ignorance, more than 100 simple thermal indices - most of them two-parameter indices - have been developed in the last 150 years to describe the complex conditions of heat exchange between the human body and its thermal environment. Among them some well-known and still popular examples are the heat index and the wind chill index. However, due to their simple formulation, these indices never fulfilled the essential requirement that there must be a unique thermophysiological effect for each index value, regardless of the combination of the input meteorological values.



The body reacts to heat by increasing the blood flow to the skin's surface, and by sweating. This results in cooling as sweat evaporates from the body's surface and heat is carried to the surface of the body from within by the increased blood flow. Heat can also be lost by radiation and convection from the body's surface. There is a notion of heat stress. Heat stress occurs when the body's means of controlling its internal temperature starts to fail. Heat stress can affect individuals in different ways, and some people are more susceptible to it than others. Typical symptoms are: an inability to concentrate; muscle cramps; heat rash; severe thirst - a late symptom of heat stress; fainting; heat exhaustion - fatigue, giddiness, nausea, headache, moist skin; 1 heat stroke - hot dry skin, confusion, convulsions and eventual loss of consciousness. This is the most severe disorder and can result in death if not detected at an early stage.

2. Humidity

Both very low or high relative humidity may cause some physical discomfort, as the relative humidity of the air directly affects temperature perception (3). Extremely low (below 20%) relative humidity may also cause eye irritation and moderate to high levels of humidity have been shown to reduce the severity of asthma (6). Several reports, apparently based on the experience of physicians with patients who complained of dryness of the nose and throat during low relative humidity, have also argued that indoor relative humidity should be kept above 30 to 40% in order to prevent drying of the mucous membranes and to maintain adequate nasal mucus transport and ciliary activity (7-10).

[http://www.pubmedcentral.nih.gov/picrender.fcgi?artid=1474709&blobtype=pdf]

3. Pressure

Frontal passages may have a profound impact on well-being and mortality as large variations in weather conditions can occur in a very short time. Rapid changes in temperature have been shown to produce a number of physiological changes in the body. Rapid drops may affect blood pH, blood pressure, urinatian volume, and tissue permeability (Persinger, 1980). Outbreaks of epidemics may also be related to frontal passage. In his study of 59 years of data, Donle (1975) noticed sudden large increases in influenza outbreaks in Germany, Norway, and Switzerland often followed the passage of a surface trough. In general, these outbreaks occurred simultaneously with the influx of cold air over northern and western Europe (the passage of a surface wave is often followed by a rapid influx of cold air). The influenza outbreaks in Europe most frequently occurred between January and March, when cold air masses most commonly intruded over the area.

A number of studies have also found relationships between the numbers of reported migraine attacks and rapid changes in barometric pressure. Cull (1981) found fewer occurrences of attacks when barometric pressure was low. This was partially attributed to a decrease in sunshine during low-pressure intrusions, as solar radiation is a suspected triggering mechanism for migraine onset. However, a Canadian Climate Center study (1981) found that migraines were most likely to occur on days with falling pressure, rising humidity, high winds, and rapid temperature fluctuations.

Rosen (1979) cites some startling relationships between pressure changes and human well-being. He describes research that indicates that cancer mortality rates seem to increase during low-pressure fluctuations, and deaths from circulatory diseases seem to increase during high-pressure fluctuations. He notes that rapid pressure fluctuations may penetrate buildings and propagate wave energy from their source like ripples in a pond. Humans appear to be quite sensitive to such changes.

The reduction of solar radiation by cloud cover may also have effects on well-being. By increasing the brightness level, the autonomic nervous system is affected by constriction changes in the eye pupil. According to Persinger (1980), this increases the rate of physical activity and leads to a general feeling of well-being. Wolfe (1981) notes that the sun's rays cause chemical changes in neurotransmitter or hormone synthesis in the brain, perhaps stimulating production of the hormone epinephrine, which st imulates the mind and body. Conversely, very low light intensities are often associated with states of relaxation, tiredness, and sleepiness. [*http://www.ciesin.columbia.edu/docs/001-338/001-338.html*]

The influence of solar activity upon human

Space weather has great impact on humanity. Space weather, by its definition is collective set of events on the Sun, in the solar wind, magnetosphere, ionosphere and thermosphere, which can undermine stability and reliability of the cosmic and ground-based technical systems, and also affect vital activity of life (USA National Space Weather Program, 1995). Technical progress raises requirement of studies revealing correlation between the space weather elements and variable space weather induced changes in biological functionality. It is obvious that these variations will have very complex effects on humans. In particular, it is well known that the adverse space conditions can cause different functional abnormalities in people suffering from the cardiovascular diseases. However, in many cases this kind of conclusion cannot be reliable, as in addition to inherent errors associated with particular data processing statistical method, there are also misleading subjective feelings of particular individuals, who may report varying response to the same stimuli.

It is conventional that space weather is well reflected in the basic biological rhythms of life and may induce either stimulation or breakdown of the rhythmicity (Breus et al., 1995; Бреус и др., 2002). All depends on the parameters of external stimuli, particular biorhythm of the organism and on physiological parameters governing these biorhythms. It is well known, that humans have two apparent biological rhythms: heartbeats and respiratory rhythm. In addition, humans have not very well defined number of hidden biorhythms. It seems that these obscure biorhythms have the smaller frequencies then apparent ones. For instance, frequency analysis of cardiograms shows that they have not only heartbeats (T_1=1c) and respiratory rhythm (T_2=4.5c), but there are oscillations with more long-term periods (T_3=11÷14c) and (T_4=29÷34c). They can be considered as shortest hidden biological rhythms. The next is a circadian rhythm, which appears practically in all physiological parameters, including apparent and short hidden biological rhythms. Another hidden biological rhythm can be revealed in cycling elevation of arterial pressure and complication of cardio-vascular diseases, as well as in periodicity of mortality rate caused by myocardial infarctions. This rhythm has 7 day cycle and/or periodicity with the same repetition factor. These rhythms are affected by seasonal variations and are modulated by the cycling in solar activity. Current level of helio-medicine does not allow exact estimation of the element in space weather, which affects each of above listed biological rhythms. Noteworthy, those apparent and short-period hidden biorhythms, which are evident in cardiograms, are synchronized with the regular short-period geomagnetic pulsations *Pc1* (T_{pc1}=0.2÷5c), *Pc2* (T_{pc1}=5÷10c) and *Pc3* (T_{pc1}=10÷45c), and also with a irregular pulsation Pi1 (T_{pi1}=1÷40c). Seven-day and biorhythms with same repetition factor can be linked to the sector structure of interplanetary magnetic field (Khomeriki et al., 1998).

It is obvious, that the manifestation of space weather on the Earth is extremely variable due to the structural peculiarities of geomagnetic field. Polar and sub-auroral areas are especially loaded by the cosmic factor. This is caused by charged particles of the solar wind, which through the polar cusps directly leak into the ionosphere layers and atmosphere. The equatorial belt is also a peculiar area of ionosphere, in which permanently operates the powerful disturbing factor, equatorial ionosphere electrojet.

Space weather has the relatively regular characteristics in the middle latitudes. The structural peculiarities of middle-latitude ionosphere and dipole configuration of geomagnetic field contributes to an effective work of ionosphere-earth waveguide, where regular short-period geomagnetic pulsations and low-frequency electromagnetic waves propagate most effectively. In this area, along with permanently operating elements of cosmic weather, sporadic factor and global geomagnetic storms caused by Sun flares also have to be noted. It is clear in helio-medicine that this factor adversely affects human organism, because most abrupt complications of various diseases, including cardio-vascular, are correlating with this factor. However, at the middle latitudes the intensity of global geomagnetic storms is roughly half order of magnitude less then at higher latitudes. Therefore, their influence on the organism is less significant. [*Amiranashvili A., Gheonjian L., Ghurtskaia N. Kereselidze Z., Lominadze J., Lomouri M.,* ***SPACE WEATHER AND ITS BIOLOGICAL IMPLICATION IN THE MIDDLE LATITUDES;*** *weather & biosystems proceedings of international conference; 11-14 October 2006; Saint-Petersburg*]

The analyzing methodology of helio-geophysical factors influence upon human organism

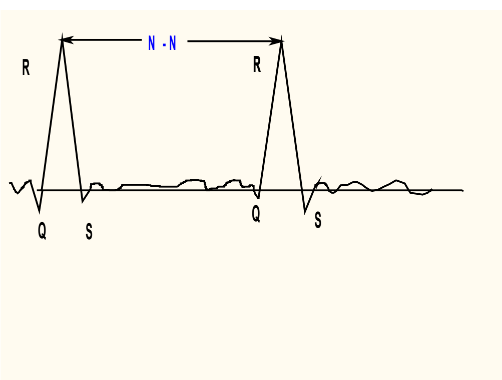
2.1 Initial data, used for the analysis

Medical data (HVR & SDNN parameters description)

The last two decades have witnessed the recognition of a significant relationship between the autonomic nervous system and cardiovascular mortality, including sudden cardiac death. [*A. John Camm, Marek Malik and others, 'Heart rate variability' - European Heart Journal (1996)* ***17,*** *354–381 London, U.K*].

There are some markers for cardiac autonomic activity changes. Heart rate variability (HRV) represents one of the most promising such markers. The apparently easy derivation of this measure has popularized its use. As many commercial devices now provide automated measurement of HRV, the cardiologist has been provided with a seemingly simple tool for both research and clinical studies[5]. However, the significance and meaning of the many different measures of HRV are more complex than generally appreciated and there is a potential for incorrect conclusions and for excessive or unfounded extrapolations.

Variations in heart rate may be evaluated by a number of methods. Perhaps the simplest to perform are the time domain measures. With these methods either the heart rate at any point in time or the intervals between successive normal complexes are determined. In a continuous electrocardiographic (ECG) record, each QRS complex is detected, and the so-called normal-to-normal (NN) intervals (that is all intervals between adjacent QRS complexes resulting from sinus node depolarizations), or the instantaneous heart rate is determined.



Statistical methods

From a series of instantaneous heart rates or cycle intervals, particularly those recorded over longer periods, traditionally 24 h, more complex *statistical time-domain measures* can be calculated. These may be divided into two classes,

a) those derived from direct measurements of the NN intervals or instantaneous heart rate,

b) those derived from the differences between NN intervals. These variables may be derived from analysis of the total electrocardiographic recording or may be calculated using smaller segments of the recording period. The latter method allows comparison of HRV to be made during varying activities, e.g. rest, sleep, etc.

The simplest variable to calculate is the *standard deviation of the NN interval* (SDNN), i.e. the square root of variance. Since variance is mathematically equal to total power of spectral analysis, SDNN reflects all the cyclic components responsible for variability in the period of recording. In many studies, SDNN is calculated over a 24-h period and thus encompasses both short-term high frequency variations, as well as the lowest frequency components seen in a 24-h period. As the period of monitoring decreases, SDNN estimates shorter and shorter cycle lengths. It should also be noted that the total variance of HRV increases with the length of analysed recording[19]. Thus, on arbitrarily selected ECGs, SDNN is not a well defined statistical quantity because of its dependence on the length of recording period. Thus, in practice, it is inappropriate to compare SDNN measures obtained from recordings of different durations. However, durations of the recordings used to determine SDNN values (and similarly other HRV measures) should be standardized. As discussed further in this document, short-term 5-min recordings and nominal 24 h long-term recordings seem to be appropriate options. [*A. John Camm, Marek Malik and others, 'Heart rate variability' - European Heart Journal (1996)* ***17,*** *354–381 London, U.K*].

There are several characteristics of Heart Rate Variability, but it will be taken into account only SDNN parameter. According to medical advisers' opinion, this value has the main importance for this analysis. So I have analysed SDNN in my presented work.

Helio- and atmosphere data

The set of environmental parameters, taken into account for the study:

Solar activity parameters:

The solar activity can be presented by 2 components: the first one represents the global activity variations, the second one represents the solar flares activity.

- The integral solar radioflux at 10,7 cm wavelength – the index of solar activity global variations (the total solar activity can be determined by the active areas number and sizes at the visible solar disk. Different indexes can be applied for its characterisation: Wolf number, value of the global radio emission flux. The latter is the most convenient for the analysis, since it measures precisely, continuously, and it is subject to diurnal averaging).

- The number of solar flares in soft X-ray band –the index of solar activity flare component. It is well combined with flares in optical range, thus it gives the opportunity to take into account 2 types of solar flares variations.

In this study the following atmosphere parameters were taken into account:

- atmospheric pressure
- air temperature
- relative humidity
- cloudiness
- wind speed

The first stage of the work was to collect appropriate meteorological, solar and medical data for the first six months of 2006. Meteorological data were retrieved from Voyejkovo weather station located 12.5 km from Saint-Petersburg; 59°58'N 30°18'E. Solar data were obtained from ttp://www.ngdc.noaa.gov/stp/stp.html (center A of solar-geophysical data, USA, Boulder). Medical data were provided by Mechnikov State Medical Academy in St Petersburg.

2.2 The analyzing method

Before the methods of the analysis can be described, one should consider possible errors, which could appear during the analysis.

1. There is a risk of error in considering in-phase variations of environmental parameter with variations of organism state parameter as dependent from each other, while in reality, these two values were only changing simultaneously due to the third parameter, which wasn't taken into account in this analysis. It is a classical error, which appears during the correlation analysis.
2. There is a risk of error in considering the former parameter (ambient parameter which was taken into account of investigation) as an agent of the third unaccounted ambient parameter. The influence of the third one upon human organism could be understood as an influence of the first accounted parameter, whereas there wouldn't be a connection between these factors, and its in-phase variations only demonstrate the same sensitivity to the uncounted parameter variations (may be more than one factor).
3. There is a risk of error opposite to the one described: in missing the connection between concrete ambient parameter variations and SDNN parameter variations, whereas this connection exists, but reveals differently, depending on different conditions.

There are some reasons for this error:

a) People of different gender, age and diagnosis can react differently on the same external impacts.

b). People of different gender, age and diagnosis can respond to the different ambient parameters.

Reasons, written above represent the concept of 'individual reaction'. It means that each person can respond differently, but it is also known and mentioned by medical advisers that there are some days, when significant groups of patients have the same changes in the state of their health. On some days, their state is getting worse, while on other days it is getting better.

4. There is a risk of error in assuming that the organism changes do not depend upon ambient parameters fluctuations, if these changes occur under variation of different ambient parameters. Reason for this error could be the same respond of the organism to the impact of different factors.

5. There can be an error in missing the connection between ambient variations and organism variations, if this connection has particularities, which could appear at the limited time intervals (for example: season particularities or particularities of solar activity cycle)

6. There is a risk of error in missing the connection between ambient variations and health level variations, if this connection reveals itself at variations of deviations with respect to the mean level. This level is established at the definite time interval (for example: deviations from the level, typical for specific phase of solar activity). One needs to take into account the fact that different ambient parameters have their own intervals of stable behavior particularities (for example: 27/2 days for Sun, about 7 days for pressure and etc.)

7. There is a risk of error in missing the connection between ambient parameters variations and health level variations, if there is a time lag in revealing such a connection (for instance: the ambient parameter changes being analyzed occur earlier than the changes in health level).

8. There is a risk of error in missing the connection between ambient parameters variations and health level variations, if both variations occur with the time lag and both are responses to the third unaccounted factor. In this case the ambient parameter changes being analyzed occur later than health level changes (though these changes follow one another in a regular manner)

Thereby, keeping in mind the possibility of the errors, let's formulate initial notions needed to identify external ambience influence (or its absence) upon health level. As a solution to the problem we will consider the identification of the most probable factors that cause specific changes in health level.

1. Let's determine the notion of "health level changes"

a) Changes can occur at a level of inner organism systems abnormalities (for instance changes of heart rate variability) In this case the analysis leads to identification of the mechanism by which the environment influences upon human body.

b) changes could lead to the so-called "clinical outcome"[Р.Флетчер, С.Флетчер, Э.Вагнер «клиническая эпидимиология:основы доказательной медицины»-М; изд. Медиа Сфера, 1998]. This concerns diseases onset, inadequate response to the treatment provided and lethal outcome. In this case the analysis allows to determine the factors of risk for health and life. It can be the guiding principle for physicians and patients at risk.

One should distinguish between these two types of analyses, since their merging leads to undervaluing the importance of each particular analysis. There is an opinion that analyzing of "clinical outcome" type has less importance than "the mechanism identification", whereas practical value of the latter for warning service, for example, is obviously higher than that of the first type. Alternatively, it could also lead to fast-ripening formulations and false reasoning to "adverse" days if mechanisms of the processes were not studied well.

We investigate the first type of health level changes in the presented work – the SDNN variations are the cardio-vascular system variations and they occur at a level of inner organism systems abnormalities.

Let's denote health level change occurrence as "the medical event".

2. Let's determine the notion of "ambient parameter"

a). The parameters to be studied could be variable characteristics of such environmental layers that are located in close vicinity to human body, for example, parameters of the atmosphere. In this case the parameters can work as direct factors, influencing human organism.

b). The factors to be studied can be indexes of external environment disturbances manifestation for the person, for example, indexes of solar activity changes. In this case the parameters can play the role of triggers to the disturbances, transmitting disturbances from the media to the human organism by means of its agents. Alternatively, it can play the role of indicators to possible deterioration of human health. Studying these parameters facilitates practical prevention of possible dangerous clinical outcomes.

We assume that both types of analyses are needed, subject to clear understanding of limitations related to the results and conclusions made.

3. Let's determine the analysis procedure.

a) To exclude the errors, described in statement 3, at first stage of the study we conducted statistical analysis of medical data, i.e., we combined the data into the groups which were homogeneous to the most medical factors. As a result we obtained a group of patients with the same gender, age and diagnosis.

b) Within this group, following medical advisers opinion we set the notion of "normal" and "abnormal" values for SDNN parameter.

c) To exclude the error described in statement 5, we considered the medical data described above for various seasons, with due account to the fact that the season corresponds to specific phase of solar activity (including transitional phase).

d) To exclude the errors, described in statements 5, 6, ambient parameters variations are considered from 2 standpoints:

- parameter values are taken in initial (absolute) units. By doing so, one can identify the existence (or absence) of differences in health level changes at large time intervals. These time intervals are characterized by relatively stable value of the analyzed parameter. For instance, it could be determined if there are differences in health level at different phases of solar activity cycle.

- parameter values are taken in relative units of deviations from average seasonal level. In this case one can identify the existence (or absence) of differences in health level changes at short time period.

For example, it can be determined if there is a difference in health level at deviations of atmospheric pressure for a few hPa.

e) To exclude the errors, described in statements 7,8, the ambient parameters variations are considered at ± 5 days interval from the day when the health level changes were registered.

f) To exclude the errors described in statement 3.c, the final conclusions are made only after all ambient parameters have been analyzed. The reason for this is in possible alternation of ambient parameters, which cause the same response of the organism.

g) To exclude the errors described in statements 1, 2, 4 the result should be presented as a set of ambient parameters, characterizing the day of medical event registration.

4. Let's determine the method to be used for reliability check of results derived and, accordingly, the relevance of the conclusions made:

- Reliability of mean variance is ascertained by checking similarity hypothesis. Due to the fact that most environmental parameters are far from normally distributed, robust methods (Kruskal-Walles) are used to check mean variance.
- Comparative analysis of "norm" and "anomaly" clusters characteristics is to be provided twice: at first using the absolute units, then using the deviation units from the average level of the parameter stabilty.
- The significance level for variance can not be assigned a priori. It should be considered on a case-to-case basis, thus allowing to determine the probability of variance.

As the study outcome, let's consider the ambient parameters quantification at the day of medical event registration for "norm" and "anomaly" clusters and ambient parameters difference probability determination for various clusters.

Ambient parameters variations for ±5 days interval from the medical event registration will be processed by the method of epoch superposition. The reference day will be the day of medical event registration.

The behavior of the ambient parameter under study is initially determined for “normal” cluster. This cluster is then considered as the control group, and the case control method is used to compare the behavior of “anomaly” (“lower”) group to the outcomes of “normal” one.

Behavior features of the ambient parameter in question related to the “anomaly” group are then identified.

So, let’s provide a summary to the methods applied:

1. Robust methods for checking similarity hypothesis (Kruskal-Walles methods)

2. The method of epoch superposition

3. Case control method

5. Parameters written above are subject to analysis in the form of:

- Averaged diurnal values (as a median)
- Diurnal values range (diurnal amplitude)
- Diurnal maximum
- Diurnal minimum
- Diurnal dispersion (as standard deviation)

THE ANALYSIS AND RESULTS

In the work proposed the investigation of weather conditions corresponding to the day when various heart rate variability values (SDNN parameter) were registered was conducted during the time period from January, 1 till the June, 1, 2006.

Pre-processing of the Medical data.

A group of male patients of the same age, gender, and diagnosis was selected for the analysis. Statistical study was conducted inside the group to single out 2 clusters: "normal" and "abnormal". The essence of the study was to construct SDNN parameter distribution and to determine its characteristics dispersion: mean deviation, upper and lower quartiles. SDNN values within the limits of mean deviation were considered as the norm; values at the lower and upper quartiles were taken as "abnormal". But according to Medical advisor's opinion, the notion "normal" was enlarged, and upper quartile SDNN values were included into "normal" cluster. Fig 1.

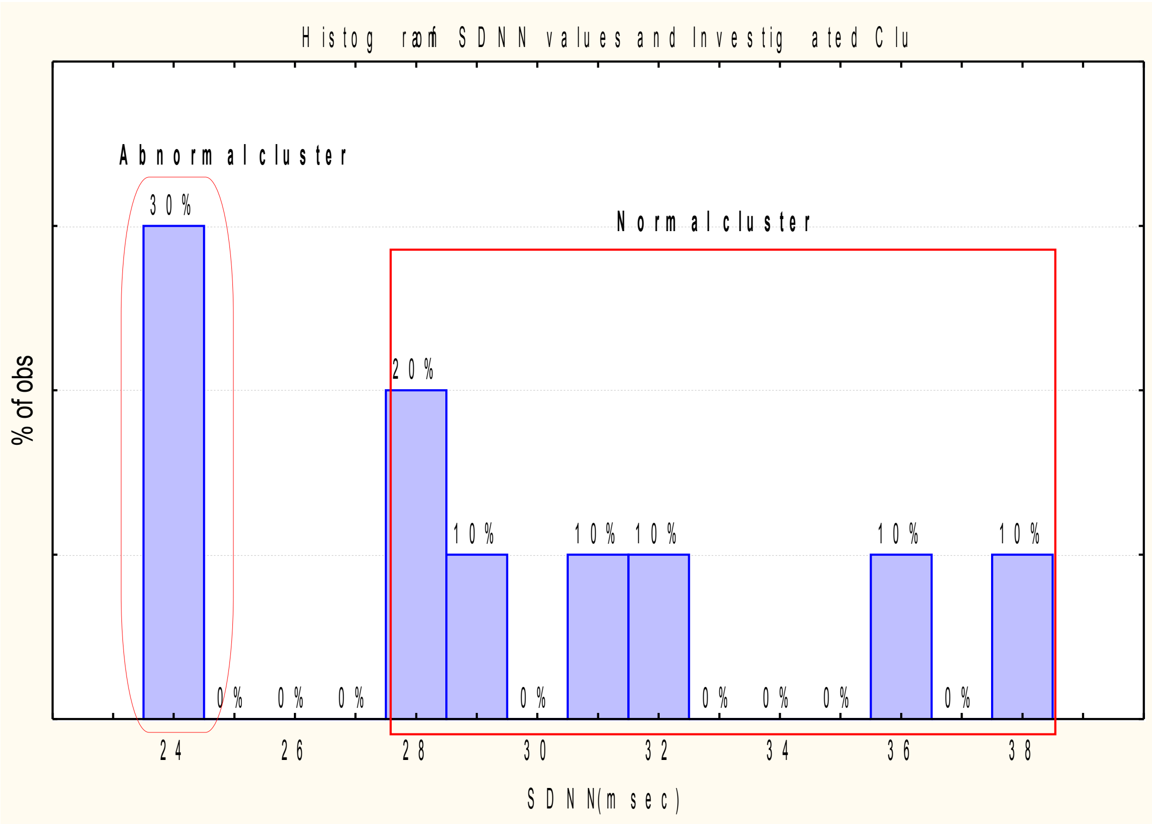


Fig.1

Each SDNN value was registered once per day, hence, each SDNN registration date corresponds to the point in each cluster. Thus, it gives the possibility to represent both clusters as the set of normal and abnormal SDNN registration dates.

Thus, 2 sets of dates were taken for analysis. It is needed to select weather conditions (environmental parameters) for these dates and to compare them to each other.

Selection and preprocessing of environmental parameters

In this investigation both Earth and Space weather are considered. As it was already written above, as the space weather parameters the following characteristics were taken:

- The integral solar radioflux at 10,7 cm wavelength
- The number of solar flares in soft X-ray band

Meteorological data were received as three-hour parameters registrations. In order these data to be presented for certain day weather conditions estimation, the data had to be processed. Statistical diurnal characteristics of each environmental parameter were calculated:

- Diurnal median value
- Diurnal minimum value
- Diurnal maximum value
- Diurnal amplitude value (range)

With these characteristics, a database was created. The example of such database for atmospheric pressure values represented in Table 1.

	1 Date	2 Valid N	3 M ediai	4 M inim	5 M ax im	6 Rang e	7 Season
1-Jan-06	1-Jan-06	8	1017,50C	1015,00C	1020,70C	5,7000	w inte2006
2-Jan-06	2-Jan-06	8	1023,35C	1022,00C	1025,80C	3,8000	w inte2006
3-Jan-06	3-Jan-06	8	1029,20C	1026,50C	1032,80C	6,3000	w inte2006
4-Jan-06	4-Jan-06	8	1040,65C	1034,50C	1044,90C	10,4000	w inte2006
5-Jan-06	5-Jan-06	8	1044,15C	1039,60C	1045,40C	5,8000	w inte2006
6-Jan-06	6-Jan-06	8	1036,55C	1035,60C	1039,00C	3,4000	w inte2006
7-Jan-06	7-Jan-06	8	1037,00C	1035,80C	1037,50C	1,7000	w inte2006
8-Jan-06	8-Jan-06	8	1033,75C	1032,90C	1036,40C	3,5000	w inte2006
9-Jan-06	9-Jan-06	8	1031,40C	1028,10C	1032,60C	4,5000	w inte2006
10-Jan-0	10-Jan-06	8	1025,60C	1018,40C	1027,40C	9,0000	w inte2006
11-Jan-0	11-Jan-06	8	1025,60C	1018,40C	1027,40C	9,0000	w inte2006
12-Jan-0	12-Jan-06	7	1007,70C	1005,60C	1015,10C	9,50000	w inte2006
13-Jan-0	13-Jan-06	8	1023,30C	1017,70C	1025,60C	7,9000	w inte2006
14-Jan-0	14-Jan-06	8	1028,10C	1025,20C	1029,80C	4,6000	w inte2006

Table 1

The following parameters characteristics were analysed:

1. The considered parameter deviation from median value, calculated according to the daily values for the whole season. Let's denote this median value as the "background value". For example, for winter 2006 the following medians were obtained (winter average) for atmospheric pressure diurnal characteristics.

Variable	Descriptiv Median
Median	1019,950
Minimum	1018,300
Maximum	1021,300
Range	4,200
Variance	2,162
Std.Dev.	1,470

Table 2

2. The deviations from average level of the parameter, determined by running average with the time interval (window), corresponding to the natural parameter variations period (parameter stability level). It is set to 27 days for solar activity, 7 days for pressure and 3 days for other parameters (because of its significant variability)

At fig.2 one can see the example of seasonal background level determination, which corresponds to pressure natural variations period. There are several pressure characteristics: diurnal maximum, diurnal median and diurnal minimum.

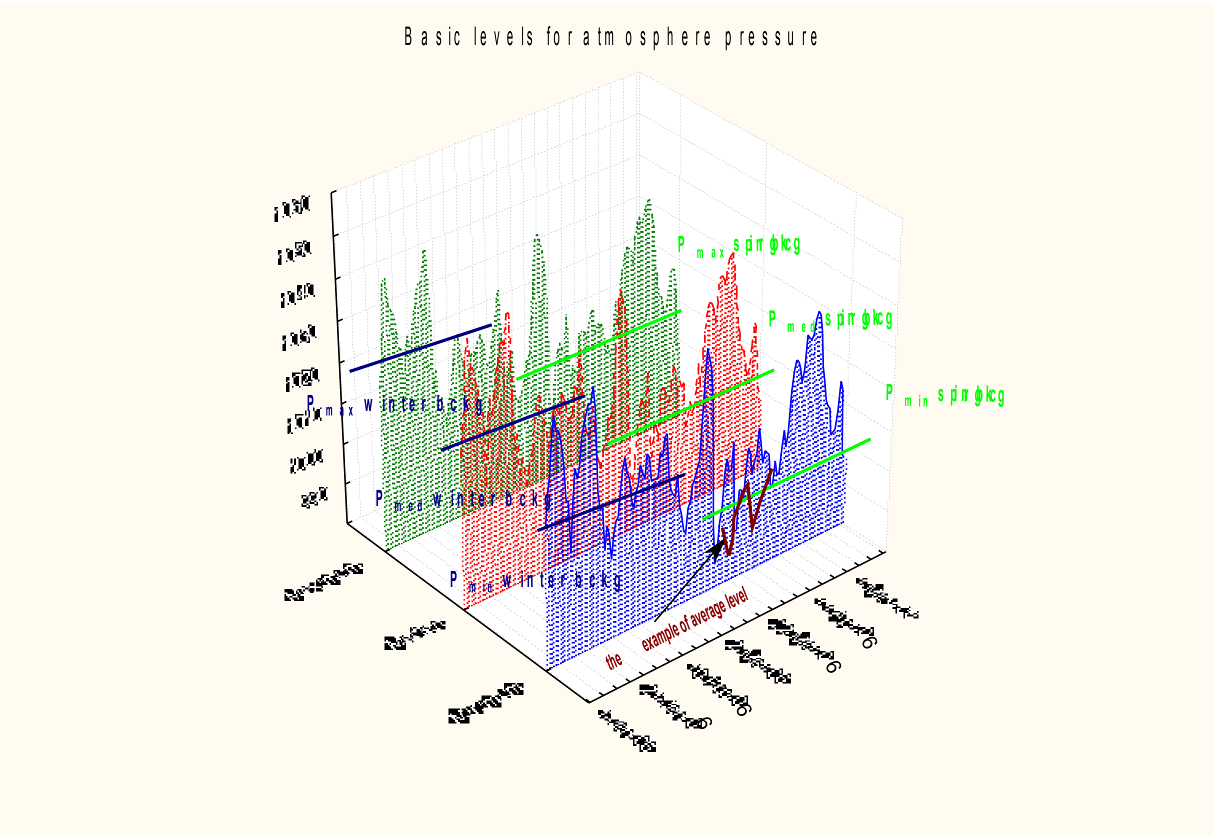


Fig.2

As follows from the graph, studies of 2 types' deviations are important: the average parameter level, determined by its natural variations period, could be higher or lower than seasonal background level. Both deviations could be important factors and can cause certain organism response. It is impossible to assert beforehand what kind of deviation is more important. Moreover, different organism responses can develop at the high or low level of seasonal background value.

3. The deviation values of the parameter, considering at the time interval ± 5 days from the reference day (the day of medical event registration). The reason is the possibility of organism response time discrepancy with the time of ambient parameter disturbance registration.

The results of analysis.

In table 3 the analysis results for winter 2006 are presented. At the first column one can see parameter values seasonal medians, at the second columns there are background comparative descriptions relative to other winters, the third column represents the phase of solar activity, the 4-th and the 5-th columns show the deviations of the parameters from the background, at the days when low SDNN were registered. The 7-th and 8-th show the same information for the days when normal SDNN were registered. At the 6-th column there are significant levels of difference between mean parameters values of different clusters. The significant levels which show the reliable difference are marked. It is obviously that the reliability of difference is different for each parameter.

	1 Backg round	2 backg rou descriptio	3 phase	4 Lowe from bckg	5 Lower from bckg description	6 p initial	7 Normal from bckg	8 Normal from bckg description
RF 10,7	84,0000	lower	min	-1,00	lower than bck	0,25	0,00	bckg level
X Rc	0	low	min	0,00	bckg level	1	0,00	bckg level
Wind speed max	winter 3,0	normal		0,00	bckg level	1	0,00	bckg level
Wind speed min	winter 1,0	normal		-1,00	lower than bck	0,9	-1,00	lower than bck
Wind speed medi	winter 3,0	high		-1,00	lower than bck	0,9	1,40	higher than bck
Wind speed range	winter 2,0	normal		-1,00	lower than bck	0,89	-1,00	lower than bck
P max	winter 1021,3	high		-10,00	lower than bck	0,73	0,00	bckg level
P min	winter 1018,3	high		-10,30	lower than bck	0,73	0,70	higher than bck
P median	winter 1019,95	high		-10,95	lower than bck	0,73	0,05	higher than bck
P range	winter 4,2	low		-0,01	lower than bck	0,56	-2,04	lower than bck
Hum max	winter 90	low		-3,21	lower than bck	0,73	2,98	higher than bck
Hum min	winter 77	low		0,48	higher than bckg	0,21	-10,81	lower than bck
Hum median	winter 85,5	low		-4,75	lower than bck	0,21	-8,88	lower than bck
Hum range	winter 12	normal		1,58	higher than bckg	0,21	5,76	higher than bck
cloud max	winter 6	normal		1,00	higher than bckg	0,8	1,00	higher than bck
cloud min	winter 0	normal		0,00	bckg level	0,9	0,00	bckg level
cloud median	winter 5	normal		0,00	bckg level	0,9	0,00	bckg level
cloud range	winter 3	normal		4,00	higher than bckg	0,12	2,00	higher than bck
T max	winter -3,8	low		-3,65	lower than bck	0,08	5,88	higher than bck
T min	winter -9,4	low		-0,50	lower than bck	0,2	9,40	higher than bck
T median	winter -5,8	low		-4,20	lower than bck	0,08	-5,80	lower than bck
T range	winter 3,8	normal		-0,50	lower than bck	0,73	0,06	higher than bck

Table 3.

The analysis of the results obtained gives the possibility to make the following conclusions:

1. In spring of 2006 there were no low values of SDNN parameter inside the group (male, acute myocardial infarction), while in winter such values were observed

2. In winter of 2006 low values of SDNN observed at solar activity low level (values of Radioflux at 10.7 cm wavelength were lower than background), while the norm of SDNN were observed at background level of RF 10.7. The difference probability equals 75% (P difference=1-importance level*100%=(1-0,25)*100%)

3. Small SDNN were observed in winter 2006 under low values of:

- wind speed (except for diurnal maximum)
- atmosphere pressure (all characteristics)
- relative humidity (diurnal median)
- temperature (all characteristics)

4. Normal SDNN either small SDNN observed at the low values of:

- wind speed diurnal minimum
- wind speed diurnal amplitude
- atmosphere pressure diurnal amplitude
- relative humidity diurnal minimum and median
- air temperature diurnal median

5. Unlike the small SDNN, normal SDNN values observed at heightened values relative to the background of:

- wind speed diurnal median (but the difference between mean values of this parameter for comparing clusters is doubtful, the probability difference equals 10%)
- atmosphere pressure diurnal minimum and median (but the difference between mean values of this parameter for comparing clusters is doubtful, the probability difference equals 27%)
- relative humidity diurnal maximum
- relative humidity diurnal amplitude

- cloudiness diurnal amplitude
- cloudiness diurnal maximum
- air temperature values (except for median)

6. The highest reliability of difference between compared clusters parameters is typical for the following parameters:

- solar activity level (value of radioflux at 10.7 cm wavelength)

* relative humidity (all characteristics, excluding diurnal median)
* air temperature

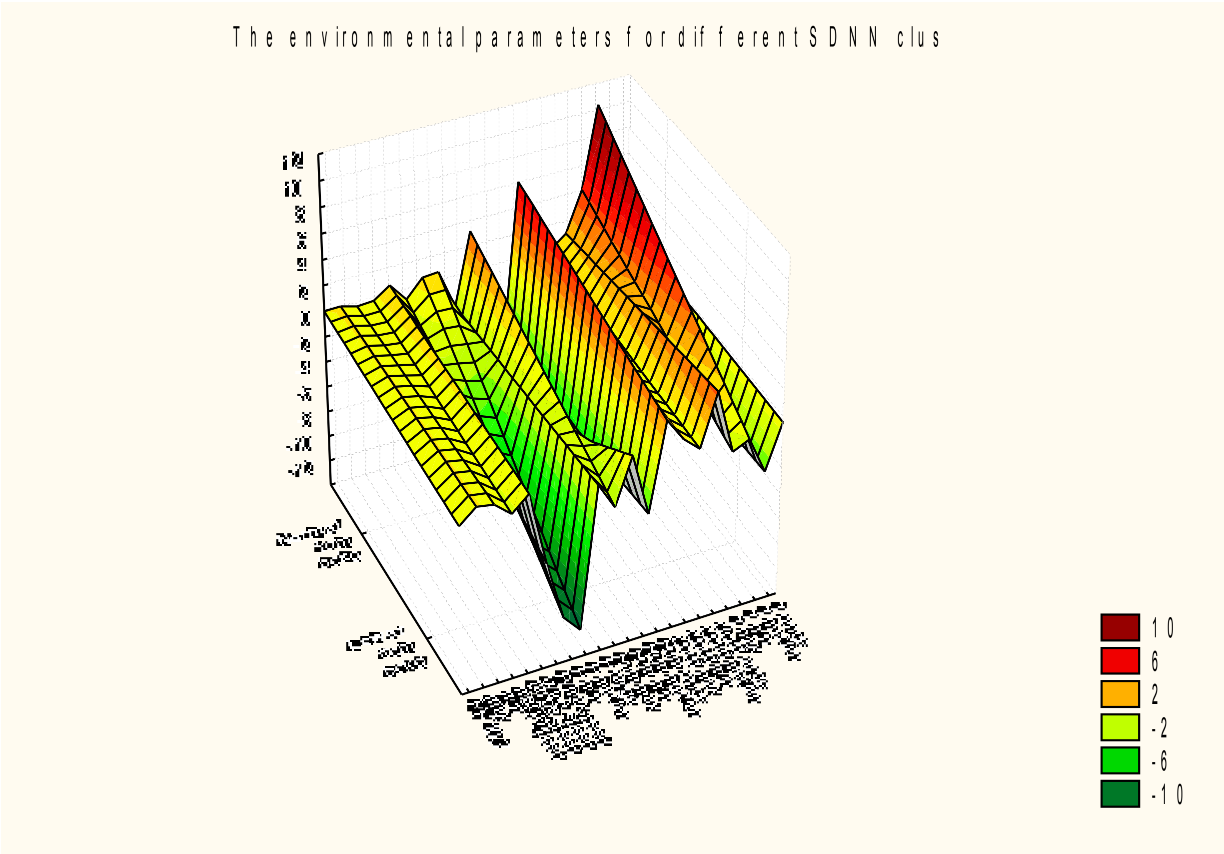


Fig.3

In Fig.3 one can see the difference of ambient parameters values for SDNN different clusters, taken in deviation units from background seasonal level.

For parameter deviation values at the day of certain SDNN registration, the similar analysis was provided. Table 4.

	1 lower from average	2 lower from average description	3 $p_{dev.}$	4 normal from average	5 normal from average decription
RF 10,7	1,60	higher than ave	0,73	1,60	higher than avera
X Rc	0,00	average level		0,00	average level
Wind speed max	0,30	higher than ave	0,72	0,00	average level
Wind speed min	0,00	average level	0,71	0,00	average level
Wind speed media	0,60	higher than ave	0,9	0,00	average level
Wind speed range	0,32	higher than ave	0,9	0,00	average level
P max	-0,80	lower than aver	0,09	1,66	higher than avera
P min	-1,00	lower than aver	0,02	1,60	higher than avera
P median	-1,50	lower than aver	0,01	1,62	higher than avera
P range	-0,13	lower than aver	0,08	-1,04	lower than avera
Hum max	-1,70	lower than aver	0,4	0,00	average level
Hum min	7,10	higher than ave	0,14	-4,10	lower than avera
Hum median	0,00	average level	1	0,00	average level
Hum range	-8,43	lower than aver	0,3	3,50	higher than avera
cloud max	2,66	higher than ave	0,17	0,31	higher than avera
cloud min	0,00	average level	0,55	0,00	average level
cloud median	1,62	higher than ave	0,3	0,00	average level
cloud range	2,66	higher than ave	0,03	0,30	higher than avera
T max	-0,80	lower than aver	0,3	0,68	higher than avera
T min	1,30	higher than ave	0,7	0,20	higher than avera
T median	0,30	higher than ave	0,56	0,00	average level
T range	-2,25	lower than aver	0,57	-0,78	lower than avera

Table 4.

The analysis of the results obtained gives the possibility to make the following conclusions:

1. Small SDNN observed at low values of:
   - atmosphere pressure (all characteristics)
   - relative humidity diurnal amplitude
   - air temperature diurnal maximum
   - air temperature diurnal amplitude
2. Normal SDNN either small SDNN observed at the low values of:
   - pressure diurnal amplitude, while deviation from average level (for 7 days) differed with high reliability: the normal values were observed at smaller value of diurnal amplitude (the reduction from average level at 1.04 hPa was registered) the difference probability was equal to 92%. For small SDNN cluster diurnal amplitude value was close to the average level for 7 days.

- air temperature diurnal amplitude

3. The normal SDNN values, unlike small SDNN cluster, were observed at high values relatively to average level of the parameters stability:

- atmosphere pressure (all characteristics, except for diurnal amplitude), the difference probability is very high (91% for pressure maximum, 98% for pressure diurnal minimum, 99% for diurnal median value)
- relative humidity diurnal amplitude, difference probability 70%
- air temperature diurnal maximum, difference probability 70%

4. Air temperature diurnal amplitude, like pressure amplitude, deviated from the average level with the same sign for both days groups. However, the deviation value was different with the high probability of 97%

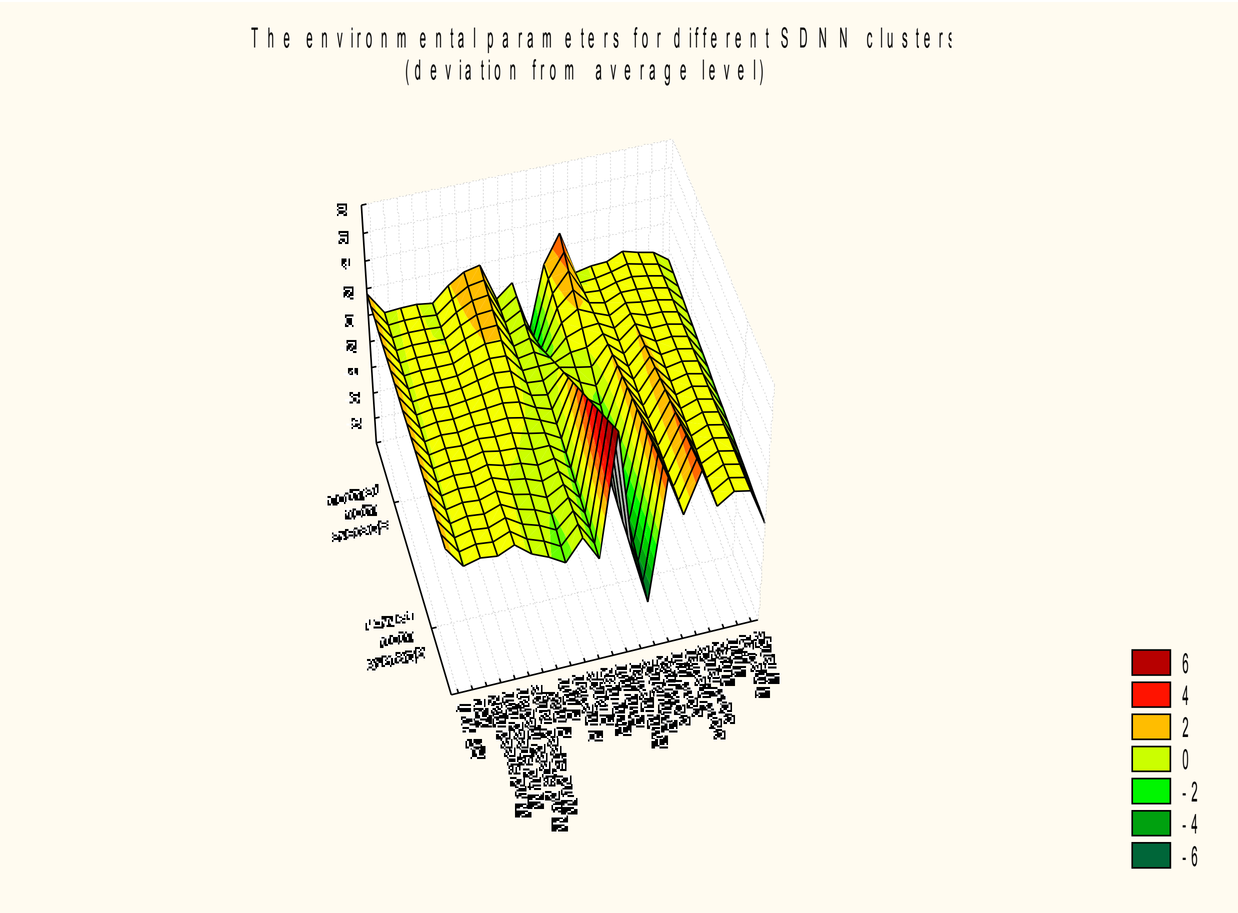


Fig. 4.

Fig.4 illustrates the difference of ambient parameters values for both SDNN clusters in deviation units from the average level, which was derived from natural variations period of each parameter.

Parameters variations comparative analysis at the day of normal SDNN registration in winter and spring of 2006 give the possibility to mark the variations pattern that is invariant by season and different features typical for a certain season.

	1 Normal from bckg Winter	2 Normal Winter	3 Normal from bckg Spring	4 Normal Spring
RF 10,7	0,00	bckg level	0,00	bckg level
X Rc	0,00	bckg level	0,00	bckg level
Wind speed max	0,00	bckg level	0,00	bckg level
Wind speed min	-1,00	lower than bckg	0,00	bckg level
Wind speed median	1,40	higher than bckg	-0,10	lower than bckg
Wind speed range	-1,00	lower than bckg	-0,50	lower than bckg
P max	0,00	bckg level	-5,45	lower than bckg
P min	0,70	higher than bckg	11,80	higher than bckg
P median	0,05	higher than bckg	9,73	higher than bckg
P range	-2,04	lower than bckg	-0,43	lower than bckg
Hum max	2,98	higher than bckg	3,98	higher than bckg
Hum min	-10,81	lower than bckg	8,69	higher than bckg
Hum median	-8,88	lower than bckg	-1,12	lower than bckg
Hum range	5,76	higher than bckg	-12,24	lower than bckg
cloud max	1,00	higher than bckg	2,00	higher than bckg
cloud min	0,00	bckg level	0,00	bckg level
cloud median	0,00	bckg level	3,00	higher than bckg
cloud range	2,00	higher than bckg	0,00	bckg level
T max	5,88	higher than bckg	-5,87	lower than bckg
T min	9,40	higher than bckg	-1,80	lower than bckg
T median	-5,80	lower than bckg	4,72	higher than bckg
T range	0,06	higher than bckg	-3,29	lower than bckg

Table 5.

Empirical data analysis gives the possibility to make the following conclusions:

1. In winter and in spring of 2006, normal SDNN was observed at solar activity background level.

2. In winter and in spring of 2006, the norm of SDNN was observed at cloudiness diurnal minimum background level.

3. In winter and in spring 2006 the normal SDNN values observed at the same atmosphere pressure deviation from background level (except for diurnal maximum pressure)

The other parameters were different.

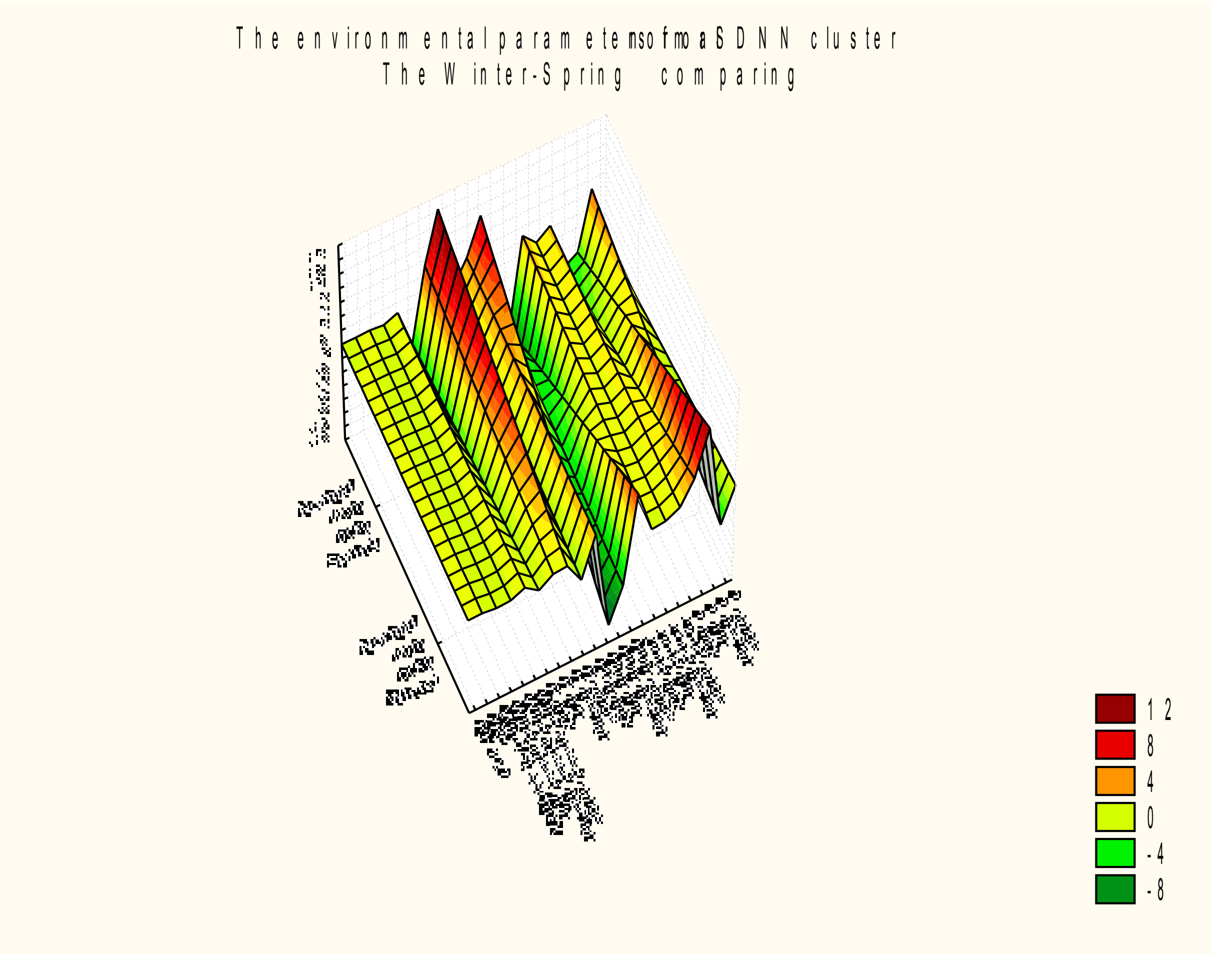


Fig. 5.

Thus, the general conclusions are:

1. The highest reliability of difference between parametric values of the clusters compared in absolute deviation from background level is typical for the following parameters:

- solar activity level (the value of radioflux at 10.7 cm wavelength)
- relative humidity (all characteristics, excluding diurnal median)
- air temperature

2. The difference in deviation units from average level, is expressed more clearly than in absolute units deviations from background level, the difference probability is higher:

2.1 The normal SDNN values, as the low ones, were observed at low values of following parameters:

- Diurnal pressure amplitude, herewith, the value of average level deviation (for 7 days) differed with high reliability: the normal values were observed at lower value of diurnal amplitude (difference probability 92%) - for lower SDNN cluster the diurnal amplitude values, close to average for 7 days are typical; but for normal cluster the decreasing of diurnal amplitude at 1.04 hPa is registered.
- Diurnal air temperature amplitude

2.2 Together with diurnal pressure amplitude, air temperature range increased for both analysed day groups, however the deviation value was different with high probability of 97%.

2.3 The normal values of SDNN, unlike the lower values, were observed at the higher than average levels for 7days:

- atmospheric pressure (all characteristics, except for diurnal amplitude), the reliability of difference is very high (91% for diurnal pressure maximum, 98% for diurnal pressure minimum, 99% for diurnal pressure media)
- diurnal relative humidity amplitude, the difference reliability 70%
- diurnal air temperature maximum, difference reliability 70%

2.4 The small SDNN values were observed at low atmospheric pressure, which was lower than background and average levels.

3. The normal SDNN values observed in winter and in spring of 2006 at:

- solar activity background level
- background level of diurnal cloudiness minimum
- at the same deviation from background level of atmospheric pressure (except diurnal pressure maximum)

The conclusions listed above are true for certain time period and for certain people groups. The follow-up work envisages the time period enlargement for experiment, the people groups investigation at other treatment stages, enlargement of environmental parameters complex taken into account. The study was contracted by Mechnikov State Medical Academy in St Petersburg.

REFERENCES

1. http://www.ngdc.noaa.gov/stp/stp.html

2. Laurence S. Kalkstein, W. John Maunder, Gerd Jendritzky; "Climate And Human Health"; Geneva, Switzerland-1996.

3. *http://www.meteoschweiz.ch/web/en/weather/health.html*

4. *http://www.pubmedcentral.nih.gov/picrender.fcgi?artid=1474709&blobtype=pdf*

5. *http://www.ciesin.columbia.edu/docs/001-338/001-338.html*

6. Amiranashvili A., Gheonjian L., Ghurtskaia N. Kereselidze Z., Lominadze J., Lomouri M., SPACE WEATHER AND ITS BIOLOGICAL IMPLICATION IN THE MIDDLE LATITUDES**;** weather & biosystems proceedings of international conference; 11-14 October 2006; Saint-Petersburg.

7. A. John Camm, Marek Malik and others, 'Heart rate variability' - European Heart Journal (1996) **17,** 354–381 London, U.K.

8. Р.Флетчер, С.Флетчер, Э.Вагнер «клиническая эпидимиология:основы доказательной медицины»-М; изд. Медиа Сфера, 1998.

9. Solar geophysical data explanation of data report NOAA-№1426 February-2006.

10. "Illustrated glossary for solar and solar-terrestrial physics"; Edited by A. Bruzek and C. J. Durrant; Fraunhofer Institute, Freiburg D. Reidl publishing company, Dordrent, Holland/Boston USA-1977.

11. Schurmans C. J. E., A. H. Oort "A statistical study of pressure changes in the troposphere and lower stratosphere after strong solar flares". Pure Appl. Geophysics-1969.

12. Дж. Герман, Р. А. Голдберг "Солнце, погода и климат"; Л. Гидрометеоиздат, 1981.