The relation of the human cardiac-events to the environmental complex variations

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Abstract. The paper presents some results of the investigation of the environmental parameters complex (Weather Complex) and its influence upon the human health. We have analyzed the variations of Terrestrial and Space Weather characteristics in days with sudden increases of Ischemia cases in Saint-Petersburg. In the frame of our study we have found that Weather Complexes had significant different status when matching alternative medical events: maximal daily number of Ischemia cases in the sample of the inhabitants of the one Saint-Petersburg’ district vs. absence of such cases in the sample. All changing of the important parameters began before the dramatic events. This fact gives us the possibility for the development of the forecast for the dangerous situation.

1. Introduction
We are living in the unstable environmental conditions. Do we sense all these variations: solar impact on the Earth, variations of the geomagnetic field, storms and relative slow changes of atmosphere parameters? We must feel all these disturbances. We have much information from the investigations of last times [1-5] as well as from previous years study [2]. But often we think that our organism senses only disturbances that are nearest to us – atmosphere variations or, as addition, geomagnetic storms [3, 4]. As we know, the Sun governs geomagnetic disturbances, and the Sun affects the ionosphere and atmosphere [8, 9]. And solar own electromagnetic impulses (e.g. solar radio bursts, X-ray bursts, optical flares) go to the Earth only 8.3 minutes. Also we must keep in mind that for these electromagnetic impulses the terrestrial atmosphere is transparent in radio-wave band. So may we sense these impacts? Our previous studies [6, 7] show the probability of such sensitivity. In this paper we present some results of the investigation of the environmental parameters complex and its influence upon the human health. We have analyzed the variations of Terrestrial and Space Weather characteristics in days with sudden increases of Ischemia cases in Saint-Petersburg. This kind of the medical material was offered us by the physicians who are interested in the investigation of the circumstances of cardio-catastrophes in the city.
2. Experimental data

2.1 Medical data

The medical material is the daily number of Ischemia cases in one of Saint-Petersburg districts (from the call logs of medical officials). We have analyzed environmental circumstance of two alternative events: the days with Ischemia cases maximal number (“Max” in this work) vs. the days of such cases absence (“Nobody” in this work). We have calculated maximums separately for Ischemia cases in different gender groups but “Nobody” means the empty days for these events at all – nobody in the men group and the same in the women group. The observed time-interval: 19.12.2005 – 31.12.2009. The whole number of Ischemia cases – 15122.

2.2 Environmental data

1. Daily indices of Solar Activity (SA) global variations (the full radio flux on \( \Phi = 10.7 \) sm, Wolf-number, the daily sum of the area of all observed sunspots, the number of the new Active Regions per day) [10];
2. Daily characteristics of the SA flare-component in various bands of the electromagnetic spectrum (optical-, radio-, X-Ray–band) [10];
3. Daily variations of Interplanetary Space characteristics in the Earth Vicinity (\( e^-, p^+, a \)-particle fluxes) [11];
4. Daily Geomagnetic Field (GF) variations (K-indices on high terrestrial latitudes; K-indices on middle terrestrial latitudes; GF x-,y- and z-components on the latitude of Saint-Petersburg) [10, 13].
5. Ionosphere phenomena (sudden ionosphere disturbances) [12].
6. Atmosphere parameters (the atmosphere pressure, the nebulosity, the wind speed, the humidity, the air temperature, the dew point temperature and oxygen content in the air) (Saint Petersburg meteorology station, #26063, \( 59°58'N 30°18'E \)).

These environmental characteristics for days of Ischemia cases were investigated in the frames of exact terrestrial calendar seasons close to the SA minimum between 23-rd and 24-th cycles.

3. The method

We understand that the environment is a multi-component system so we must try to investigate its complex influence on the human health. For this purpose we have created the most representative collection of the environmental parameters as we can do now. The content of this collection is described above. Here we say only that this sample of the environmental parameters is the rush scheme of the solar-terrestrial connections and describes the probable consequence of the factors that can affect any bio-system on the Earth surface. Figure 1 shows the complication of these connections: different environmental levels interact between each other [8, 9] and may impact the bio-system together or in sequence. We took this image of the environmental activity as the work scheme for our study.

![Figure 1. The work scheme of the environmental impact on any bio-system on the Earth surface.](image-url)
daily range). In this work the whole number of the independent environmental parameters is 363 (taking into account the aforesaid daily statistics of each environmental characteristic).

We have done the conjunction between the environmental parameters variation and exact medical category (“Max”-“Nobody”) by the following procedure: the day of the registration of each medical category was described by the complete environmental parameters set for the observation day (the whole 363 parameters complex).

The heterogeneous data are the problem for the investigation if we want to study them together. So with the aim to uniform them we use the procedure of standardizing them to their seasons normal level which we defined as the season median, i.e. the median which was calculated for each environmental parameter by the sample of a calendar season size.

\[ x_{st} = \frac{x - x_{0.5 \text{season}}}{\sigma_{\text{season}}} \]  

where:
- \( x \) is the certain value of the certain parameter that was measured in its own units,
- \( x_{0.5 \text{season}} \) is the parameter’s median value that was calculated from the sample of the calendar season size,
- \( \sigma_{\text{season}} \) is the standard deviation of this parameter from this sample,
- \( x_{st} \) is the standardized value of the parameter mentioned above.

After this procedure all environmental parameters which were in their own measurement units became uniform. And:
1. We can work with the whole environmental complex: the collection of different parameters transforms to the sample with members of uniform units (now the unit is the characteristic of the deviation from the center of the season distribution in a scale of season standard deviation), then we can calculate descriptive statistics for this sample and so we can describe the whole environmental sample by its mathematical expectation, variance, etc.;
2. We can estimate the deviation of the whole environmental complex from the normal level of exact calendar season (if the median of the whole environmental sample is close to 0 then we can conclude that the environment is close to the season normal level);
3. We can compare environmental complexes those are corresponding to the different clinical outcomes by their descriptive statistics. If environmental complexes descriptive statistics are different for days with different Ischemia cases number than we can assume the reliable different environmental conditions for such outcomes.
4. We can deduce the behaviour of those environmental complexes through the folder epoch interval and try to catch some feature of this line in the certain days. The last allow us to catch the day of the maximal difference between those complexes. The reason of this Maximal-Difference-Day (“MaxDifDay” in this work) pursuit is the looking for the reliable base for the forecast of the risk situation for the human health. We try to catch two MaxDifDays: (1) the day of the maximal difference between aforesaid complexes in the half-interval of an epoch folder (before the key-day – the day of the medical event) – it should give us the desired forecast information; (2) the day of the mentioned above maximal difference in the whole folder epoch interval – if this day appears after the key-day of the medical event it should show us that the medical event locates on the line of the weather changing. The last should open the new seeking of environmental parameters those can be the precursors of such weather changing so would be useful for the forecast elaboration.

We have developed the procedure of MaxDifDays seeking as follows:

The parameters sets are very similar to cluster sets from the mathematical apparatus of Cluster Analysis. This fact allows us using some method from this analysis - exactly the determination of the distance between clusters to lay down the maximal distance and point the day when it occurred. We use the Euclid’s distance between the clusters in this work:
distance \( (X,Y) = \|X, Y\| = (\sum_{i=1}^{n}(x_i - y_i))^\frac{1}{2} \), \hspace{1cm} (2)

where:
- \( X \) and \( Y \) are the environmental parameters clusters, corresponding to different medical events (“Max”-“Nobody”);
- \( x_i \) and \( y_i \) are the exact values (standardized values) of each parameter that belongs to the exact environmental set;
- \( n \) is the total number of the parameters in the set.

For the accurate estimating of this distance we should consider the intrinsic variance of each parameter by guide cosine:

\[
\cos \alpha_i = \frac{(x_i - y_i)}{\|X, Y\|} \hspace{1cm} (3)
\]

Then normalize the decision distance to the maximum of this value:

\[
\cos \alpha_{max} = \max(\cos \alpha_i) \hspace{1cm} (4)
\]

\[
IInnerSpread = \left( \frac{\cos \alpha_{max}}{\left( \sum_{i=1}^{n} \cos^2 \alpha_i \right)^\frac{1}{2}} \times \frac{\cos \alpha_i}{\cos \alpha_{max}} \right)^\frac{1}{2} \hspace{1cm} (5)
\]

Thus, we have: (1) the correct value of the distance between environmental parameters sets:

\[
Distance (X,Y)_{correct} = distance(X,Y) - (InnerSpread) \hspace{1cm} (6)
\]

and (2) the rating of the environmental parameters under investigation by their guide cosine in MaxDiffDay. The last allows us selecting the important parameters among which guide cosines are the largest— it means they are really different when match different medical events so may be responsible for the circumstance of these medical events.

4. Results
1. In the folder epoch interval the behaviour of the complete environmental parameters sets (Weather Complexes) is very specific for events “Max” and distinctly differs from those for “Nobody”. It is obvious in the figures (2-9) where one can see the dramatic declinations from the season normal level of the environmental set which relates to events “Max” when such set for “Nobody” is very close to the season normal level through the whole time-interval in any calendar season.
Figure 2. The behaviour of the Weather Complexes in the folder epoch interval for the different medical events in a key-day. Ischemia cases in the men-group (Max) vs. the absence of the Ischemia-cases in any gender group (Nobody). Spring-times of the observing time-interval.

Figure 3. The behaviour of the Weather Complexes in the folder epoch interval for the different medical events in a key-day. Ischemia cases in women-group (Max) vs. the absence of the Ischemia-cases in any gender group (Nobody). Spring-times of the observing time-interval.

Figure 4. The behaviour of the Weather Complexes in the folder epoch interval for the different medical events in a key-day. Ischemia cases in men-group (Max) vs. the absence of the Ischemia-cases in any gender group (Nobody). Summer-times of the observing time-interval.
Figure 5. The behaviour of the Weather Complexes in the folder epoch interval for the different medical events in a key-day. Ischemia cases in women-group (Max) vs. the absence of the Ischemia-cases in any gender group (Nobody). Summer-times of the observing time-interval.

Figure 6. The behaviour of the Weather Complexes in the folder epoch interval for the different medical events in a key-day. Ischemia cases in men-group (Max) vs. the absence of the Ischemia-cases in any gender group (Nobody). Autumns-times of the observing time-interval.

Figure 7. The behaviour of the Weather Complexes in the folder epoch interval for the different medical events in a key-day. Ischemia cases in women-group (Max) vs. the absence of the Ischemia-cases in any gender group (Nobody). Autumn-times of the observing time-interval.
Figure 8. The behaviour of the Weather Complexes in the folder epoch interval for the different medical events in a key-day. Ischemia cases in men-group (Max) vs. the absence of the Ischemia-cases in any gender group (Nobody). Winter-times of the observing time-interval.

Figure 9. The behaviour of the Weather Complexes in the folder epoch interval for the different medical events in a key-day. Ischemia cases in women-group (Max) vs. the absence of the Ischemia-cases in any gender group (Nobody). Winter-times of the observing time-interval.

2. MaxDifDays on the half-interval of the folder epoch is not invariable from season to season but their distribution modes are in (-5)-day, (-4)-day, (-3)-day and key-day. We can see that in Figure 10. So we have some points for the forecasts of “Max”-events.

Figure 10. The distribution of the days of the maximal difference between Weather Complexes on the half-interval of folder epochs. Different gender groups of Ischemia cases.

3. We have found out the exact environmental parameters which significantly differs when matched different events (“Nobody”-“Max”). They have the largest guide cosine in MaxDifDays. Also, we found out the days when these parameters begin to change their status before the “Max”-event. This fact is useful for the forecast base and we mark it as “possible forecast lead time” in the tables’ headings. Tables (1-3) show these environmental parameters and point out the environmental level of theses parameters belonging.
Table 1. Space Weather (Earth Vicinity) parameters which were of significant difference when matched different medical events (“Max”-“Nobody”).

| The environmental parameter                                                                 | Possible forecast lead time                  |
|---------------------------------------------------------------------------------------------|----------------------------------------------|
| Solar wind Plasma Flow Pressure - daily coefficient of variation                            | 4-3 days before medical event “Max”           |
| Plasma Flow Speed - daily median                                                           | 4-3 days before medical event “Max”           |
| The daily integrated proton fluxes of energies > 100 MeV                                    | 3 days before medical event “Max”             |
| Solar Wind Plasma Flow Longitude Angle, Geocentric Solar Ecliptic System (GSE), daily maximum| 1 day before medical event “Max”              |

Table 2. Space Weather (Geomagnetic Field) parameters which were of significant difference when matched different medical events (“Max”-“Nobody”).

| The environmental parameter                                                                 | Possible forecast lead time                  |
|---------------------------------------------------------------------------------------------|----------------------------------------------|
| Geomagnetic Field z-component Magnitude, Geocentric Solar Ecliptic System (GSE) - daily maximum| 1 day before medical event “Max”              |
| Geomagnetic Field Magnitude Average $|B| = 1/N \sum |B|$ (N= number of points in the observation sample) - daily coefficient of variation | 2-3 days before medical event “Max”          |

Table 3. Terrestrial Weather (Air Temperature, Humidity) parameters which were of significant difference when matched different medical events (“Max”-“Nobody”).

| The environmental parameter                                                                 | Possible forecast lead time                  |
|---------------------------------------------------------------------------------------------|----------------------------------------------|
| Air temperature – daily maximum                                                            | 1 day before medical event “Max”              |
| Air temperature – daily median                                                             | 1 day before medical event “Max”              |
| Air temperature – daily minimum                                                            | 1 day before medical event “Max”              |
| Temperature of Dew Point– daily maximum                                                    | 1 day before medical event “Max”              |
| Temperature of Dew Point– daily mean                                                       | day before medical event “Max”               |

4. In the time-frames of our study we have estimated some conditions when the same environmental parameters can frequently be important. These conditions are shown in Table 4.

Table 4. The condition for the repeating of certain parameters importance (parameters are listed above in the previous tables).

| The phase of Solar Activity cycle | The calendar season | Gender group |
|-----------------------------------|---------------------|--------------|
| any                               | autumns             | women        |
| the fall branch                   | summers             | women        |
| the fall branch                   | winters             | any          |
| the fall branch                   | springs             | women        |
| the fall branch                   | autumns             | women        |
| minimum SA                        | autumns             | men          |
| minimum + rise branch             | autumns             | women        |
| minimum + rise branch             | summers             | women        |
| minimum + rise branch             | springs             | any          |
5. Conclusions

1. In the frame of our study we have found that Weather Complexes had significant different status when matching alternative medical events: maximal daily number of Ischemia cases in the sample of the inhabitants of one Saint-Petersburg’s district vs. absence of such cases in the sample. But these differences were not exactly in a day of concrete medical events. So, we can suppose that the dramatic medical events were placed on the line of the weather (Space and Terrestrial) changing.

2. In the frame of our study we have found out the concrete environmental parameters which may be responsible for the creation of the environmental circumstance for the alternative medical events.

3. In the frame of our study we have found the condition for the repeating of certain parameters importance.

4. We can do most generalization of the previous point (exact common repeating time-interval and exact common repeating parameters) for the women-group.

5. Space Weather characteristics were different more frequent than those of Terrestrial Weather when they corresponded to different medical events.

6. All changings of important parameters began before the dramatic events. This fact gives us possibility for the development of forecast for dangerous situations.

6. References

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