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About relationship between hard cosmic rays flux and trauma leaps in assessing the human factor in 2007–2012 in Vilnius city

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Abstract

The stable short – term prognostic relationship between a decrease of hard cosmic ray flux (HCRF) near the ground surface and subsequent leaps in traumatism occurrence within 1–3 days is known. A gamma spectrometer with a scintillation detector was used to register the HCRF near the ground surface. To achieve effective results from analysis, the criterion of a continuous decrease of HCRF was chosen 200 impulses or more within 4 hours. The present study was restricted to time periods when the cosmophysical and medical data could be compared. A correlation between HCRF decrease and increase of trauma number after 1–3 days was determined. For the short – term prognosis of trauma leaps in 2007–2012 exceeding average monthly value by 10% and more in 1–3 days after HCRF decrease the high efficiency of the results 50–80% was obtained.
The human factor has an additional influence in trauma leaps, which was considered in these studies. However, this impact is problematic to define from the whole external influences on human health. As far as number of leaps in trauma depends on the day of week with a minimum values on Tuesday and Wednesday and maximum value on Friday and Saturday. Based on an assessment the human factor has improved trauma leaps prediction results.

Keywords: Hard cosmic ray flux; traumas; human factor.

1. Introduction

The connection between the living organism, people and natural and anthropogenic factors is well known. At the same time, it is necessary to take into account the natural factors that have a harmful affect on people, namely such as changes in meteorological and geomagnetic processes, solar activity variations and others [1–9]. Their after-effects are different and can affect all human systems. In present study the traumatism leaps only are taken into consideration. Natural influence on trauma number change is well known [10]–[14].

It is found out that above mentioned phenomena affect cosmic ray flux from Galaxy too. Really near ground surface is registered only a secondary cosmic ray component. That is why its variation show external sources affect on human organism [10]–[14]. To analyse this fact the hard cosmic ray flux (HCRF) was chosen, which in a more correctly illustrate a situation. So, HCRF can be used as an indirect indicator to predict an external affect on people. In this investigation the after-effects of mentioned affect is analysed for the case of human trauma number variations.

Obtained trauma data varies all the time. There are a short – term fluctuations, which are dependent on the day of week.

In the most other analyses, in time series analysis it is assumed that the data consist of a systematic pattern (usually a set of identifiable components) and random noise (error) which usually makes the pattern difficult to identify. Most time series analysis techniques involve some form of filtering out noise in order to make the pattern more stable.

Most time series patterns can be described in terms of two basic classes of components: trend and periodical. The former represents a general systematic linear or (most often) nonlinear component that changes over time and does not repeat or at least does not repeat within the time range captured by our data (e.g., a plateau followed by a period of exponential growth). The latter may have a formally similar nature (e.g., a plateau followed by a period of exponential growth), however, it repeats itself in systematic intervals over time. Those two general classes of time series components may coexist in real-life data.

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Traumatism's data is also has periodic component. Periodic component of this date is forming due to the human effect – the dependence on the day of week. The author suggests to eliminate periodic component. This will clarify the trauma leaps by HCRF variations forecast.

The purpose of the seasonal decomposition method is to isolate periodical component, that is, to de-compose the series into the trend effect, seasonal effects, and remaining variability. The "classic" technique designed to accomplish this decomposition is known as the Census I method. This technique is described and discussed in detail in [15] and [16]. The general idea of seasonal decomposition is straightforward. In general, a time series like the one described above can be thought of as consisting of four different components Eqn (1) and Eqn (2): (1) A seasonal component (denoted as S_t, where t stands for the particular point in time) (2) a trend component (T_t), (3) a cyclical component (C_t), and (4) a random, error, or irregular component (I_t). The difference between a cyclical and a seasonal component is that the latter occurs at regular (seasonal) intervals, while cyclical factors have usually a longer duration that varies from cycle to cycle. In the Census I method, the trend and cyclical components are customarily combined into a trend-cycle component (TC_t). The specific functional relationship between these components can assume different forms. However, two straightforward possibilities are that they combine in an additive or a multiplicative fashion:

Additive model:

$$X_t = T_t + C_t + S_t + I_t \tag{1}$$

Multiplicative model:

$$X_t t = T_t * C_t * S_t * I_t \tag{2}$$

Here X_t stands for the observed value of the time series at time t. Given some a priori knowledge about the cyclical factors affecting the series, the estimates for the different components can be used to compute forecasts for future observations. However, the Exponential smoothing method, which can also incorporate seasonality and trend components, is the preferred technique for forecasting purposes [15]–[16].

2. Material and methods

The monitoring of hard cosmic rays flux (HCRF) was carried out by a gama – spectrometer with scintillation detector [17]–[21]. The detector of device made of crystal NaI(Tl) (6,3×6,3 cm) was covered with a lead protection of 12 cm thick to absorb the mild component of cosmic radiation (Styra et al.2005). The operating stability of this device was controlled by ^{137}Cs radionuclide radiation. Measurements were carries out continuously every 15 min. The experimental error was 1% at the probability of 95%. Deviations from the average HCRF value exceeding this error within a 1 h time interval were considered as an external affect on the gamma – spectrometer and were used to analyse the obtained information. More then 210000 HCRF measurement results were analysed.

Data of traumas over a period of 72 months (2007–2012) were obtained from the Vilnius ambulance service. The number of trauma cases was defined by the number of ambulance calls. Information on trauma was selected for all age groups in accordance with the international codes for identification of diseases (ICD). Heart diseases were selected according to the ICD codes S00-T88 (injury, poisoning and certain other consequences of external causes). The total number of trauma cases was used for data analysis. During this time there were 90000 traumatism – related ambulance calls. The number of traumatism cases per day exceeding an average monthly value by 10% and more was considered as an effect. The days when traumatism leaps were observed were taken as a basis for the analysis of HCRF changes that had occurred 1–3 days before the leap in traumatism incidence.

The trauma leaps by HCRF variations forecast and processing of the experimental results were carried out as follows:

1. Registration of impulses number generated by the flux of cosmic particles every 15 minutes in the energy range from 300 keV to ∞ was brought into a 1 h time interval.
2. A decrease in HCRF values (more then 200 impulses) for a 4 h period during any day was used as the threshold value for selection.
3. The number of CVD cases per day exceeding an average monthly value by 10% and more was used as an effect.
4. A correlation between HCRF decrease and increase in trauma number, exceeding the monthly average value by 10% within 1–3 days was determined.
5. The seasons of the year and the patients' age were not considered.

3. Results

The cosmic and environmental influence in total sometimes have a negative affect on people, including the number of injuries events. It is known that human well-being depends on the human factor. In a present work the trauma leaps prognosis after HCRF variations is carried out. For this purpose it is necessary to compare HCRF variation values and trauma leaps number. It is known that traumatism data depend on the day of week [13], [14]. Trauma data allocation by the week's days in 2007–2012 is presented in Table 1.

Table 1. Dependence of trauma leaps number exceeding the monthly average values by 10% on days of the week during 2007–2012

Day of week / Years	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
2007	20	5	5	14	24	29	13
2008	15	9	7	5	20	24	19
2009	17	5	7	11	28	24	10
2010	10	6	7	4	19	22	10
2011	5	6	4	4	20	24	8
2012	2	4	6	23	22	5	4

Using the statistical processing method for measurement results the in the table obtained data can be described theoretically. Here was applied a Fourier transform method. This method finds for study signal spectral composition and determines its components frequents. Fourier transformation performed for traumatism data registered separately for each year. As an example in Figure 2 shown trauma numbers changes in 2011 after Fourier transformation.

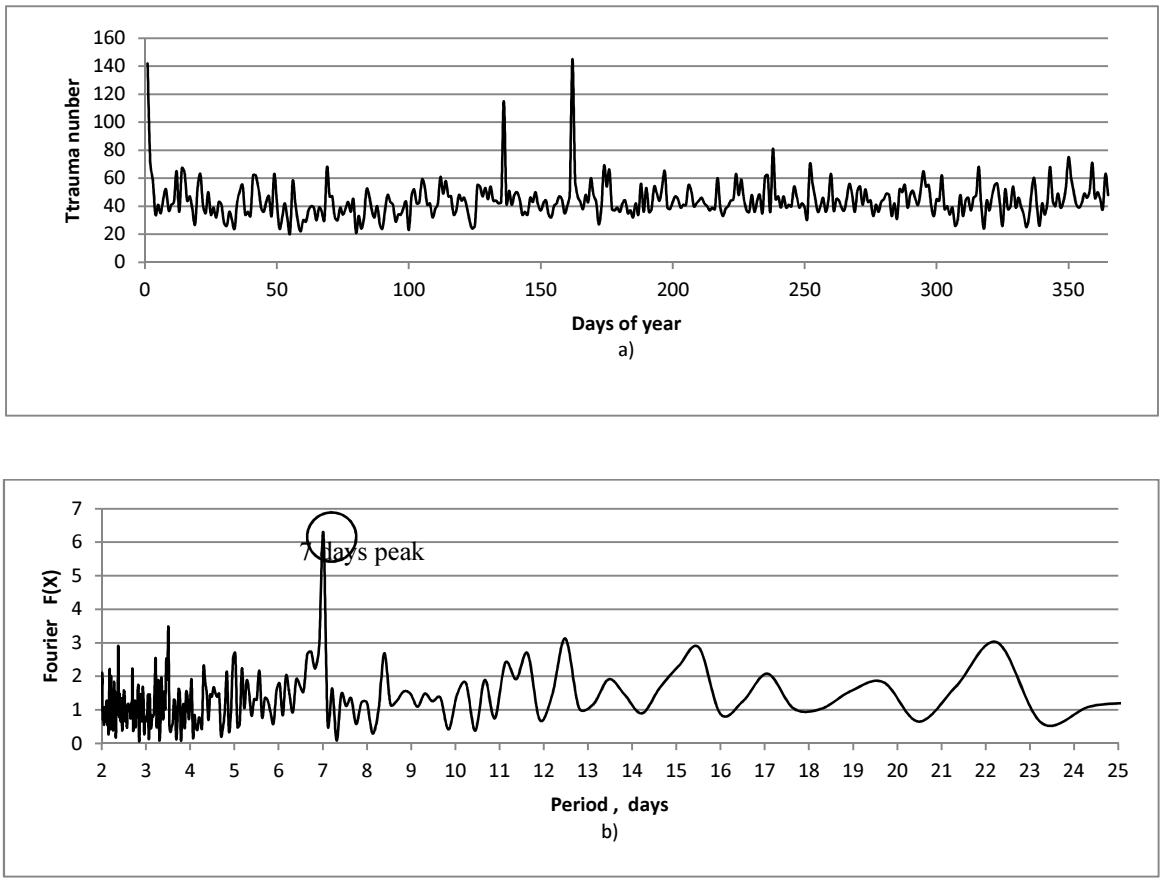

Fig. 2. Trauma number in 2011: a) Original traumatism; b) Fourier transformation of trauma number result

In the Fourier transform the largest peak has place after 7 day period. It means that there is dependence on day of the week. The similar results are obtained in the other years (2007–2012).

In order perform trauma leaps prediction by HCRF changes it is necessary to eliminate the human factor. For this purpose was used traumatism data correction, e. g. to remove the periodic component of the days of week.

The obtained results are illustrated in Figure 3.

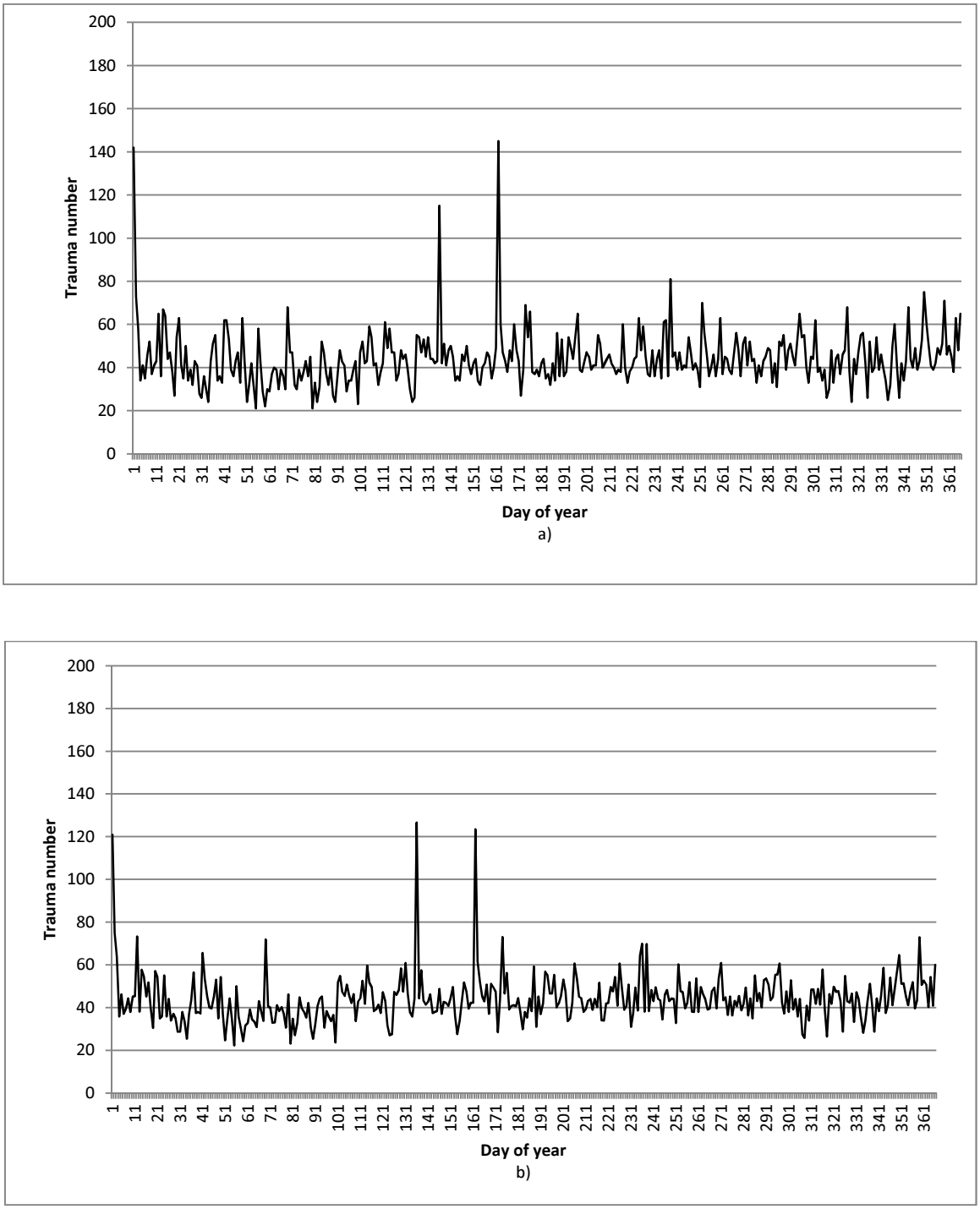

Fig. 3. Trauma number in 2011: a) – original trauma data; b) – corrected trauma data

Comparing *a* and *b* graphics in Figure 3 was determined the approximately same course of trauma changes for the original and the adjusted data. But their amplitude changes in different days are different.

There is a problem that information on ambulance calls which often arrive about midnight or after it. Because the prognosis of trauma leaps is considered within 2 days simultaneously. The forecast results trauma leaps by HCRF decreases within 1–3 days in 2007–2012 are illustrated in Tables 2–3. The data in these tables show the highest connection between HCRF decrease and trauma leaps within 1–3 days. In all cases (Tables 2–3) the maximum correlation between above stated parameters change was in 2007 and 2009. Minimum forecast results is given in 2008 and 2010.

Table 2. Trauma number exceeding the monthly average values by 10% and the number of occurrences of this increase as predicted according to a decrease in HCRF of ≥ 200 imp/h in time range of 4 h and more in Vilnius city in 2007–2012. Prognosis of an increase in trauma leaps cases is given in 1–3 days

Months	Increase of trauma numbers of 10% above the average monthly value						Number of occurrences in 1–3 day intervals					
	2007	2008	2009	2010	2011	2012	2007	2008	2009	2010	2011	2012
January	8	6	5	4	7	4	3	2	1	3	6	3
February	6	12	9	7	7	9	5	4	5	7	5	8
March	8	8	6	7	6	6	6	4	4	0	5	6
April	9	10	12	6	5	8	8	10	9	0	4	7
May	11	6	9	10	5	10	9	5	7	0	5	6
June	8	9	10	7	5	7	7	6	9	0	3	2
July	9	9	7	3	7	10	9	7	4	3	2	4
August	13	8	6	5	6	9	13	5	3	4	5	6
September	5	12	11	7	6	7	4	9	6	4	6	5
October	9	7	9	5	5	8	6	4	9	4	3	8
November	8	7	9	8	5	8	6	0	9	8	4	1
December	8	10	9	8	6	8	8	0	8	7	4	5
Total	102	104	102	77	70	94	84	56	74	40	52	61
Total, %							82	54	73	52	74	65

Table 3. Corrected trauma number exceeding the monthly average values by 10% and the number of occurrences of this increase as predicted according to a decrease in HCRF of ≥ 200 imp/h in time range of 4 h and more in Vilnius city in 2007–2012. Prognosis of an increase in trauma leaps cases is given in 1–3 days

Months	Increase of trauma numbers of 10% above the average monthly value						Number of occurrences in 1 – 3 day intervals					
	2007	2008	2009	2010	2011	2012	2007	2008	2009	2010	2011	2012
January	4	4	3	3	7	7	1	1	1	2	5	4
February	8	11	7	7	6	7	7	4	3	7	5	7
March	11	9	4	8	3	3	10	6	2	0	3	2
April	10	10	3	7	6	7	8	9	3	0	4	6
May	12	8	6	10	4	7	9	7	5	0	4	4
June	9	8	5	8	4	4	5	5	4	0	2	2
July	8	8	7	3	7	9	7	7	6	3	2	4
August	10	5	3	5	5	5	10	4	2	4	4	4
September	5	10	6	7	4	2	5	5	5	4	4	1
October	6	10	4	6	5	9	2	8	3	5	3	9
November	7	7	5	8	2	10	6	0	5	8	1	4
December	7	10	3	6	4	4	7	0	3	5	2	2
Total	97	100	56	78	57	74	77	56	42	38	39	49
Total, %							79	56	75	49	68	66

A comparison of Tables 2 and 3 data shows that mathematical correction in a certain degree decrease number of trauma leaps because of human factor removal. However the prognostic results of trauma leaps number after HCRF decrease in majority of the cases becomes almost the same in per cent. The annual data confirm this fact.

4. Conclusion

The prognostic connection between hard cosmic rays flux decrease and trauma leaps in 1–3 days in Vilnius city is obtained. The influence of human factor on trauma leaps is found out. The maximum trauma leaps has place in Friday and Saturday.

Using Fourier transformation method, the human factor after – effect was removed.

Annual number of original and corrected data in 2007–2012 was different; however the same results in per cent units were satisfactory.

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