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ON POSSIBILITY OF SHORT-TERM PROGNOSIS OF CYCLONIC ACTIVITY AFTER-EFFECTS IN VILNIUS BY VARIATION OF HARD COSMIC RAY FLUX

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Abstract. Analysis of hard cosmic ray flux (HCRF) variation at an energy interval 1.2–1.6 MeV was carried out in Vilnius. Connection between HCRF decrease at the mentioned energy interval and the minimum atmospheric pressure in 3–6 days is defined. This phenomenon is registered from 8 up to 13 hours. According to the time interval of HCRF decrease, for instance 8–9 and 9–10 hours, the minimum pressure in Vilnius takes place in 3–4 days, and at time intervals 11–12, and 12–13 hours – in 5–6 days. Realization of this prognosis at one of the presented time intervals was 56–67% in 2002–2003. The same investigation results, with the assumption of atmospheric pressure decrease from 1005 hPa and less, showed a high efficiency of prognosis of the minimum pressure in Vilnius at all the time intervals during 6 days – 92%, and 82% in 2002 and 2003, correspondingly.

Keywords: hard cosmic ray flux (HCRF), atmospheric pressure, cyclone, anticyclone, short-term prognosis.

1. Introduction

Nowadays a principal consideration is directed to the anthropogenous influence on the human organism. By definition, all pollution forms have some harmful effect on humans, animals, plants or other materials in the environment (Styra *et al.* 2007). However, important factors having negative effect on man are natural sources, for instance, geomagnetic field, meteorological processes, earthquakes, hurricanes, etc. (Чижевский 1976; Stoupel 1999; Styra *et al.* 2005). It is obvious that it is impossible to stop a natural cataclysm; however, its prediction enables to undertake precautions for reducing after-effects and lowering of both moral and material damages.

One of the main natural factors often influencing the human organism is the intensive variations of a geomagnetic field and, as a consequence, the change of meteorological situations (Стыро 1983). It is found out that the variations of a geomagnetic field occur some days earlier than the change of meteorological processes. Therefore, this fact can be used as both a prognostic indicator in meteorological situation change and external influence on the human organism (Styra *et al.* 2004; Mc Gregor 2001).

However, the direct measurements of variations of a geomagnetic field near the ground surface are rather inexact because of their small values, on the one hand, (from several units up to hundreds nT (Stoupel 1999)) and because of presence of natural hindrances, which often exceed the results of direct measurement, on the other hand.

Therefore, in the present paper the indirect indicator of geomagnetic field variations – hard cosmic ray flux (HCRF) – was chosen. At the ground surface HCRF represents a flux of secondary cosmic radiation whose variations are connected with the change of meteorological processes in some days (Стыро 1984). This change means the baric field structure change in the observation area.

However, connection between the above mentioned parameters is problematic, and for its definition, a statistical information is necessary. It is known that the large-scale variations of atmospheric pressure are connected with moving of cyclones or anticyclones over the observation station.

In the case of the approach of cyclones the absolute values of HCRF near the ground surface decrease, and in the case of anticyclones they increase. Such results are registered for some days before the extreme atmospheric pressure formation over the observation station. In the day of observation the anti-correlation between HCRF and atmosphereic pressure takes place.

This is a natural phenomenon as far as in cyclones the thickness of air layer above the measuring installation decreases, allowing a greater number of particles to reach the ground surface, and in anticyclones it is on the contrary.

It is known that the secondary cosmic radiation consists of 70% of muons. Their maximum concentration is at an altitude of approximately 15 km (Ziegler 1998). Due to a short time of their existence (2 μs) (Ziegler 1998) these particles don't reach the ground surface from the mentioned altitude, therefore, the muon flux is registered at a lower altitude of the atmosphere.

The vertical flow of air in cyclones is directed upwards and moves the muons away from the ground sur-

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face; in anticyclones, on the contrary, the muons are brought to it. That is why decrease or increase of the number of the particles is registered accordingly to the approaching baric field.

The transfer of air mass is accompanied not only by the change of atmospheric pressure, but also by temperature, humidity and various microparticles. All these factors influence the human body. It is necessary to remark that the geomagnetic field variations are observed before the change of meteorological situations. Hence, the main task of the present investigation is to discover a short-term prognostic connection between the variations of HCRF and the atmospheric pressure.

2. Investigation method

The measurements of HCRF were carried out by a gamma-spectrometer with the scintillation detector NaI(Tl) (Styra *et al.* 2004; Береснев *и др.* 1988; Стыро *и др.* 2003) (Fig. 1). The detector was located in a lead protection with the thickness of walls of about 12 cm. This protection completely absorbs the flux of mild cosmic radiation which brings in discrepancies to the observation results. A significant part of this component is not of a cosmic origin; it can be the product of radon decay or atmospheric radioactive elements.

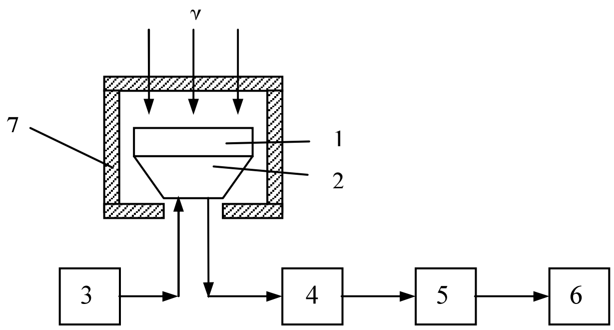

Fig. 1. Block-scheme of gamma-spectrometer: 1 – scintillation detector NaI(Tl); 2 – photomultiplier; 3 – high-voltage stabiliser; 4 – linear amplifier; 5 – impulse analyser; 6 – registration device (computer); 7 – lead protection

Penetrating through the lead protection muons and gamma quanta form light flares in the crystal NaI(Tl). The distribution of these flares by energies is carried out by an analyser of impulses and their number is registered by a computer. The measurements of HCRF were carried out continuously every 15 min. The meteorological data were obtained from the Hydrometeorological Service of Lithuania. Investigation of the prognostic connection of HCRF variations and atmospheric pressure in Vilnius was carried out on the basis of the integral flux of HCRF in the range of 0.3–4.0 MeV and on that of an energy interval 1.2–1.6 MeV. The total number of observation results of HCRF for 2002–2003 was over 70 000.

According to the paper (Стыро 1986), the prognosis of atmospheric pressure decrease by HCRF decrease is possible only from 8 to 13 hours at individual time intervals. Therefore, in the present investigation the time interval was divided into four intervals: 8–9, 9–10, 11–12 and 12–13 hours. This fixing of time for the analysis of HCRF variation has an approximate character, and the HCRF variation values can be outside the range of these time intervals.

The realization of prognostic effect takes place in the case of HCRF decrease according to proposed criteria and atmospheric pressure decrease up to 4 hPa and more in 3–6 days and also without criterion at the above stated time intervals.

3. Measurement results

It is found out that the values of HCRF near the ground surface are rather stable and their variations don't follow out the range of the experimental error. Sometimes this stability is broken. The instability can't be for long; still in some cases it is possible to be for some days.

The instability of a geomagnetic field is connected with variations of atmospheric processes. Their qualitative connection is obvious. For the definition of quantitative connection, a detailed analysis of the experimental data was carried out.

The present investigation determines connection between HCRF variations and the decrease of atmospheric pressure in some days in Vilnius. Such a connection is presented in papers (Стыро 1983; Стыро 1984; Стыро и Астраускене 1988). However, these variations of HCRF were analysed at an energy interval 0.5–0.8 MeV.

For definition of quantitative connection between changes of the considered parameters it is necessary to use a number of empirical criteria. The analysis of data was carried out in two ways. The first one is the analysis of deviation of HCRF daily values from the monthly average, and the second one is study of the difference of the obtained values within two successive days both for integral spectrum and for an energy interval 1.2–1.6 MeV. An empirical criterion wasn't chosen to define correlation between HCRF integral spectrum and atmospheric pressure decrease. The maximum value of correlation coefficient between them appeared to be 0.4 which confirms lack of correlation.

The other results occurred after the analysis of HCRF variations at an energy interval 1.2–1.6 MeV. Using this interval, the coefficients of correlation were 0.6–0.7.

It has been established (Стыро 1986) that HCRF decrease predicted the minimum atmospheric pressure in Vilnius, depending on the interval of time, where HCRF was registered. This fact in particular on HCRF decrease at a time interval of 8–9 hours predicted the minimum pressure in 3 days, at an interval of 9–10 hours – in 4 days, at an interval of 11–12 hours – in 5 days and at an interval of 12–13 hours – in 6 days (Стыро 1986).

The results of the prognostic connection obtained by the deviation of HCRF values (the criterion is 10 imp/h) at an energy interval 1.2–1.6 MeV from monthly average data and atmospheric pressure decrease are presented in Table 1.

From the data presented in Table 1, it follows that the average parameter of effect realization for all the time intervals in 2002 was 58%, and in 2003 – 65%. It is possible to consider these results to be approximate and confirming the existence of required connection, as for practical application of this method, there is no information on half-month forward for definition of the monthly average value. Decrease or increase of a criterion of –10 imp/h decreases the efficiency of prognosis.

This criterion has appeared to be inefficient for the analysis of data on the difference of HCRF values between two following days in a power range of 1.2–1.6 MeV. In this case three criteria of HCRF decrease were proposed: –15, –20, –25 imp/h. As far as the average values of HCRF at an interval 1.2–1.6 MeV in 2002 and 2003 were 166 and 163 imp/h, accordingly, therefore the relative data of HCRF decrease were about 10–15 % from the absolute values. At decrease or increase of the values of criteria the correlation decrease in the efficiency was observed.

The results of analysis according to the bove proposed values of criteria of HCRF decrease between adjacent days are presented in Tables 2–4.

According to the data of Tables 2–4, the prognostic connection efficiency between HCRF decrease and the atmospheric pressure minimum in Vilnius in 2002 was 61–63%, and in 2003 – 50–59%.

It means that the above studied effect is real and can be used in practice.

Table 1. Efficiency of prognostic connection between HCRF decrease (deviation from monthly average value) at an energy interval 1.2–1.6 MeV (criterion –10 imp/h) and atmospheric pressure decrease at some intervals of time in Vilnius in 2002–2003

Time intervals, hour	2002					2003				
	Total number	Realization		Non-realization		Total number	Realization		Non-realization	
		Number	%	Number	%		Number	%	Number	%
8–9	54	30	55	24	45	56	40	71	16	29
9–10	61	33	54	28	46	58	33	57	25	43
11–12	43	37	63	16	37	53	34	64	19	36
12–13	52	31	60	21	40	57	38	67	19	33
Total	210	121	58	89	42	224	115	65	79	35

Table 2. Efficiency of prognostic connection of HCRF decrease between two adjacent days at an interval 1.2–1.6 MeV (criterion –15 imp/h) and atmospheric pressure (criterion 4 hPa) at various time intervals in Vilnius in 2002–2003

Time intervals, hour	2002					2003				
	Total number	Realization		Non-realization		Total number	Realization		Non-realization	
		Number	%	Number	%		Number	%	Number	%
8–9	88	52	59	36	41	85	48	56	37	44
9–10	82	53	65	29	35	93	54	58	39	42
11–12	78	50	64	28	36	91	56	61	35	39
12–13	90	59	65	31	36	91	56	61	35	39
Total	338	214	63	124	37	360	214	59	146	41

Table 3. Efficiency of prognostic connection of HCRF decrease between two adjacent days at an interval 1.2–1.6 MeV (criterion –20 imp/h) and atmospheric pressure (criterion 4 hPa) at various time intervals in Vilnius in 2002–2003

Time intervals, hour	2002					2003				
	Total number	Realization		Non-realization		Total number	Realization		Non-realization	
		Number	%	Number	%		Number	%	Number	%
8–9	52	29	56	23	44	65	39	60	26	40
9–10	62	39	63	23	37	63	33	52	30	48
11–12	54	32	59	22	41	55	35	64	20	36
12–13	64	42	66	22	34	61	37	61	24	39
Total	232	142	61	90	39	244	144	59	100	41

Table 4. Efficiency of prognostic connection of HCRF decrease between two adjacent days at an interval 1.2–1.6 MeV (criterion –25 imp/h) and atmospheric pressure (criterion 4 hPa) at various time intervals in Vilnius in 2002–2003

Time intervals, hour	2002					2003				
	Total number	Realization		Non-realization		Total number	Realization		Non-realization	
		Number	%	Number	%		Number	%	Number	%
8–9	38	22	58	16	42	50	28	56	22	44
9–10	47	32	68	15	32	51	25	50	26	50
11–12	31	19	61	12	39	33	20	61	13	39
12–13	42	27	64	15	36	42	26	62	16	38
Total	158	100	63	58	37	176	99	56	77	44

Table 5. Efficiency of prognostic connection of HCRF decrease (criterion –15 imp/h) and atmospheric pressure (without criterion) between two adjacent days at an interval 1.2–1.6 MeV at various time intervals in Vilnius in 2002–2003

Time intervals, hour	2002					2003				
	Total number	Realization		Non-realization		Total number	Realization		Non-realization	
		Number	%	Number	%		Number	%	Number	%
8–9	82	50	61	32	39	86	54	63	32	37
9–10	84	58	69	26	31	88	55	63	33	37
11–12	76	52	68	24	32	81	58	72	23	28
12–13	89	59	66	30	34	85	62	73	23	27
Total	331	219	66	112	34	340	229	67	111	33

However, these results (Tables 2–4) describe the correlation connection by the decrease of HCRF in one time interval only. Within 6 days before the analysed effect, the decrease of HCRF according to chosen criteria is possible at once at several time intervals that considerably increase the realization of prognostic effect. In this case the analysis of correlation between the HCRF decrease (criterion –15 imp/h) and atmospheric pressure decrease from 1005 hPa and less took place. Here the realization of effect for 2002 was 92%, and for 2003 – 82%.

In general, the prognosis of atmospheric pressure decrease by the HCRF data decrease is less than the above indicated values; this decrease also predicts the pressure decrease in anticyclones too, where the realization of positive results is lower.

Therefore, the correlation between the HCRF decrease (criterion –15 imp/h) and atmospheric pressure decrease (without a criterion) in 3–6 days according to the above presented time intervals has to be carried out. The obtained results are illustrated in Table 5.

Here the efficiency of prognostic connection realization is higher for the results of Tables 2–4.

The highest efficiency refers to time intervals 11–12 and 12–13 hours, i.e. 72 and 73 %, accordingly, in 2003. However, the present prognostic method gives negative results in 33–34 % of cases. The possible reason of its impracticability is described in the paper (Стыро 1984).

A number of examples of meteorological situations which resulted in formation of a low atmospheric pressure in Vilnius in October of 2002 and in January of 2003 at the presence of the signal HCRF are illustrated in Figs. 2–19.

Conventional signs: thin lines – isobars in hPa; **thick lines** – atmospheric fronts: warm; cold; occluded; **T** – cyclone; **H** – anticyclone; motion direction of baric formation; ★ Vilnius city.

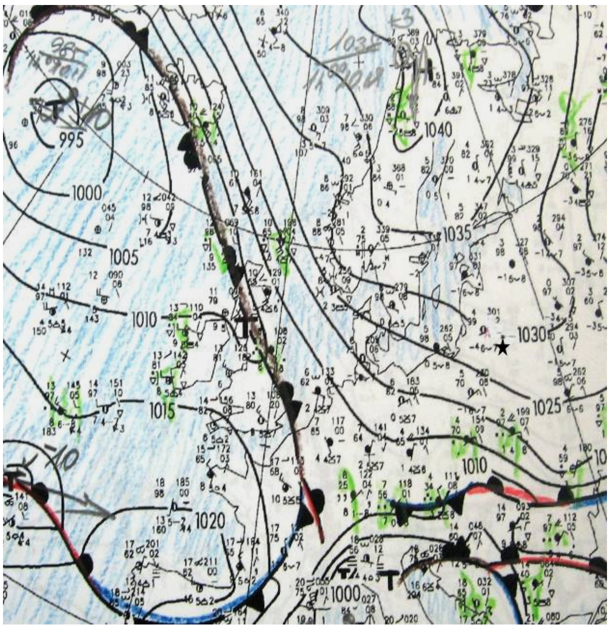

Fig. 2. 12 Oct. 2002 14 h. Time interval 12–13 hours of HCRF registration and its decrease (–44 imp/h)

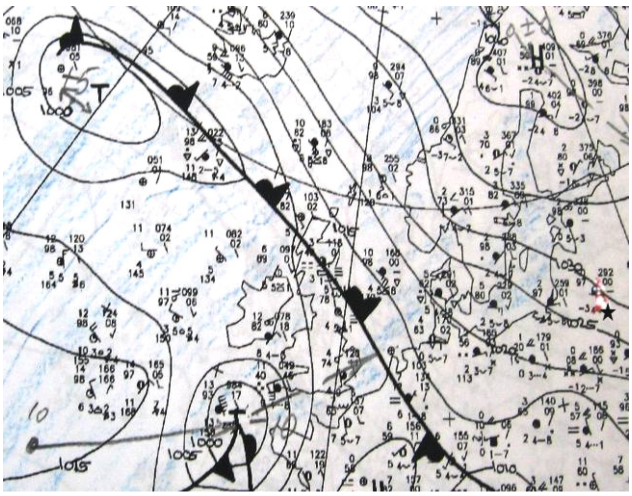

Fig. 3. 13 Oct. 2002 14 h. Time interval 11–12 hours of HCRF registration and its decrease (–16 imp/h)

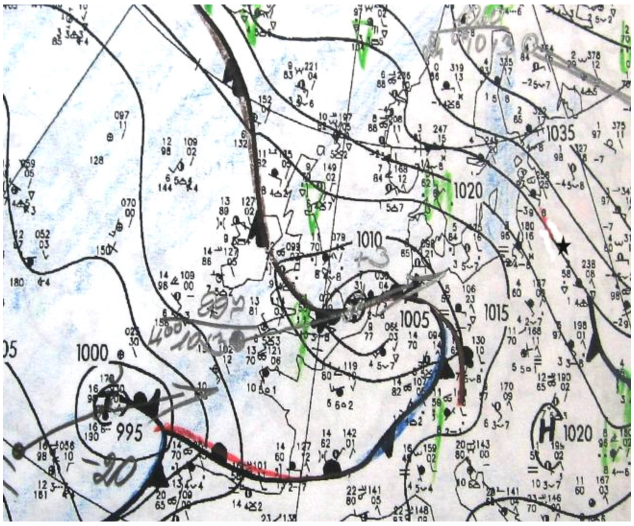

Fig. 4. 14 Oct. 2002 14 h. Time interval 9–10 hours of HCRF registration and its decrease (–23 imp/h)

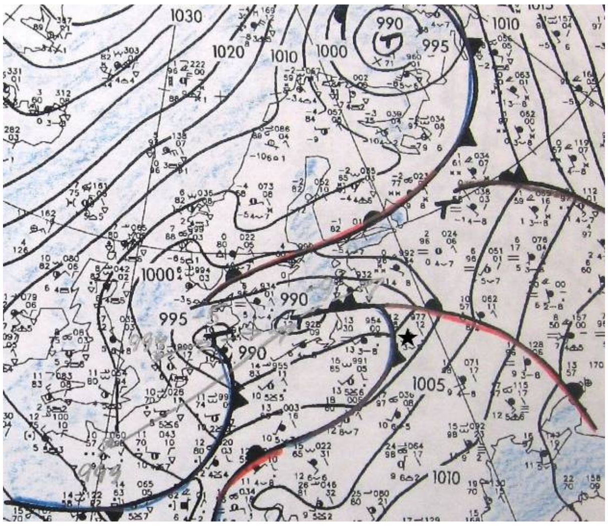

Fig. 7. 17 Oct. 2002 14 h. No HCRF decease. Cyclones approaching Vilnius

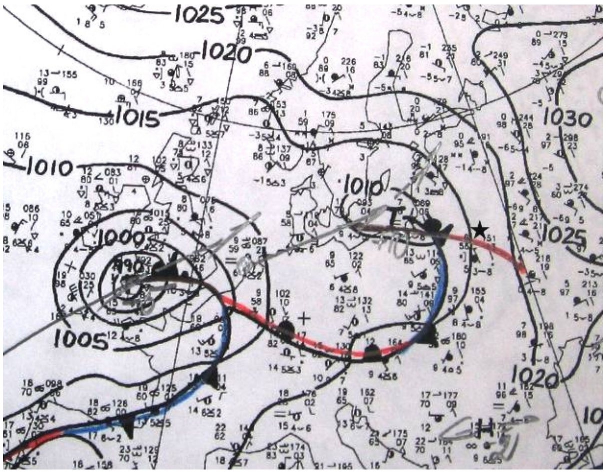

Fig. 5. 15 Oct. 2002 14 h. No HCRF decrease. Cyclone motion eastward in Vilnius direction

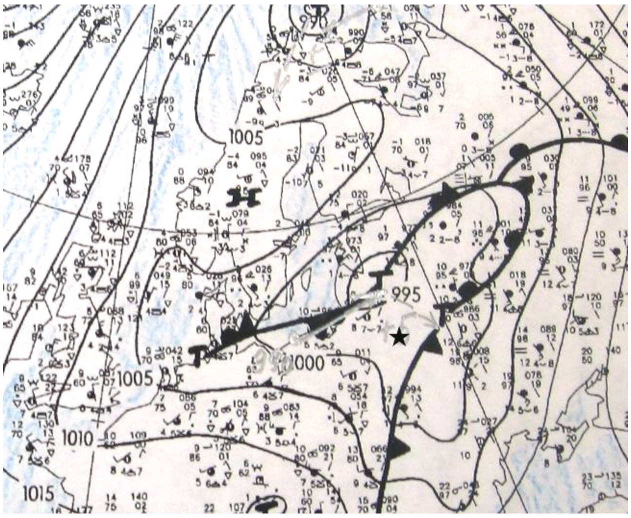

Fig. 8. 18 Oct. 2002 14 h. No HCRF decrease. Minimum atmospheric pressure formation (997 hPa) in Vilnius in six days after the first registration of HCRF decrease (Fig. 2)

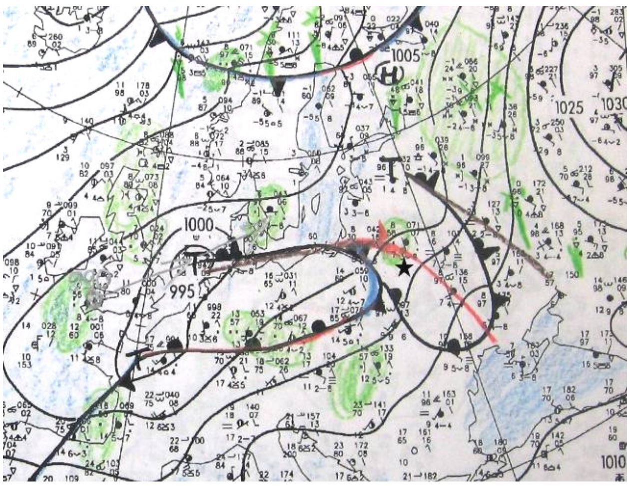

Fig. 6. 16 Oct. 2002 14 h. No HCRF decrease. Cyclone motion eastward in Vilnius direction

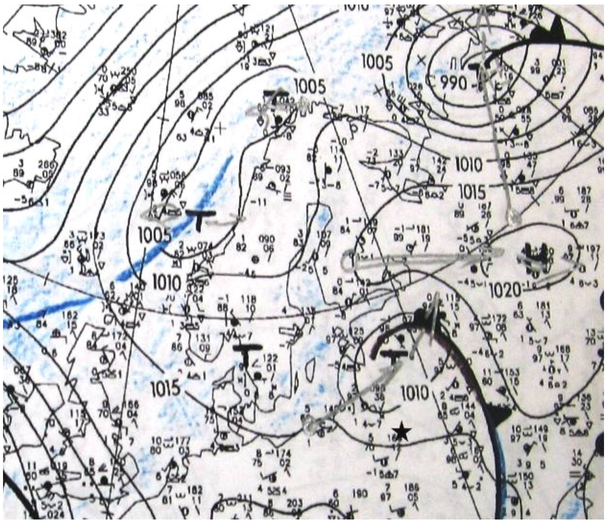

Fig. 9. 20 Oct. 2002 14 h. Time interval 9–10 hours of HCRF registration and its decrease (–48 imp/h)

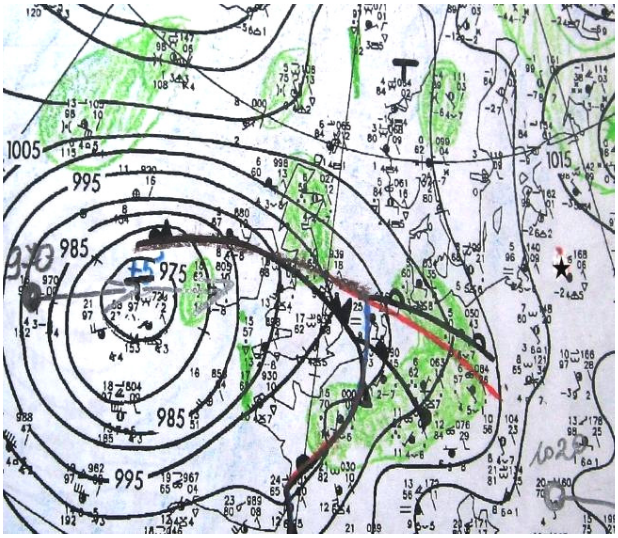

Fig. 10. 21 Oct. 2002 14 h. No HCRF decrease. Cyclone motion eastward

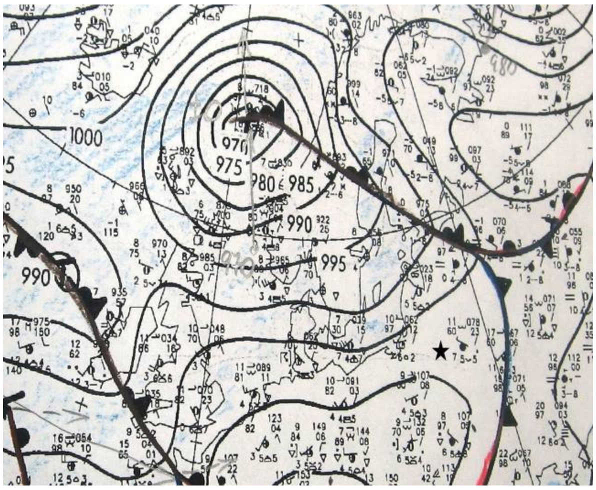

Fig. 13. 24 Oct. 2002 14 h. No HRCF decrease. Minimum atmospheric pressure formation (985 hPa) in Vilnius in 3–4 days after the first registration of HCRF decrease (Fig. 9)

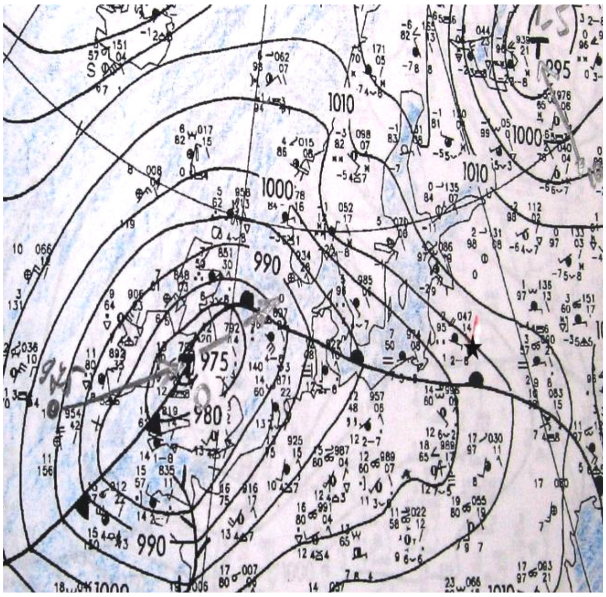

Fig. 11. 22 Oct. 2002 14 h. No HCRF decease. Cyclone motion eastward

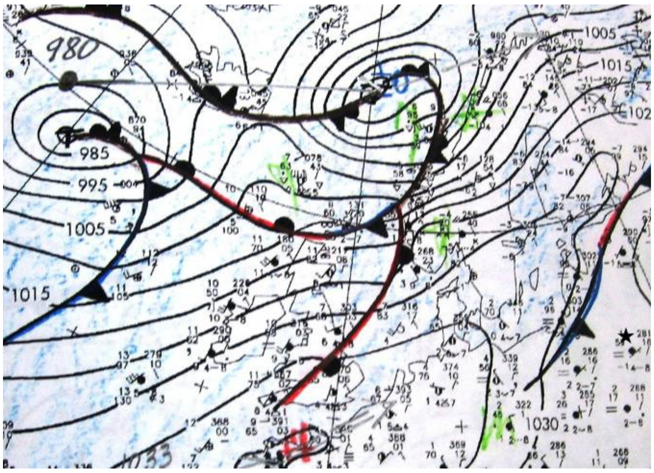

Fig. 14. 25 Jan. 2003 14 h. Time interval 12–13 hours of HCRF registration and its decease

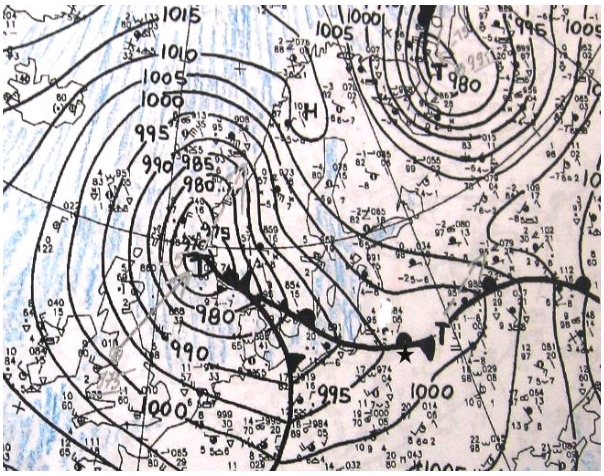

Fig. 12. 23 Oct. 2002 14 h. No HCRF decease. Cyclone motion change into east northern direction

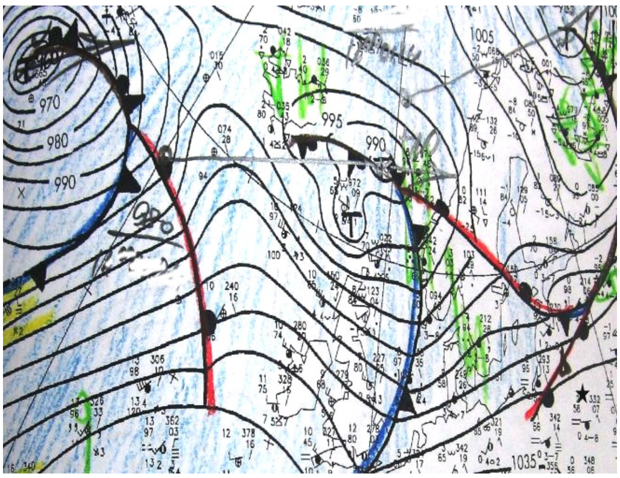

Fig. 15. 26 Jan. 2003 14 h. No HCRF decrease. Cyclone motion eastward

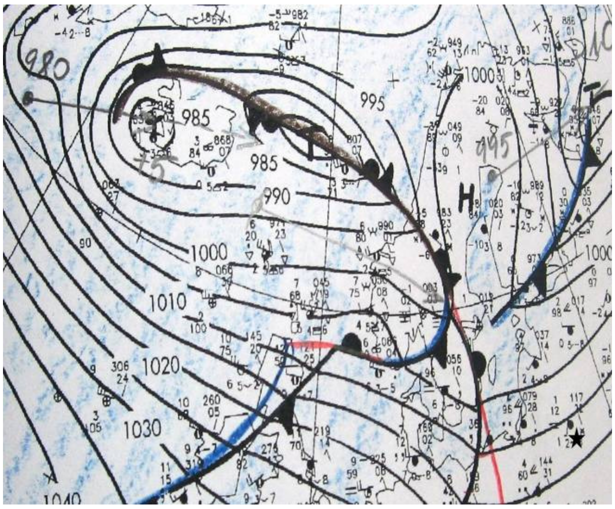

Fig. 16. 27 Jan. 2003 14 h. No HCRF decease. Cyclone motion eastward

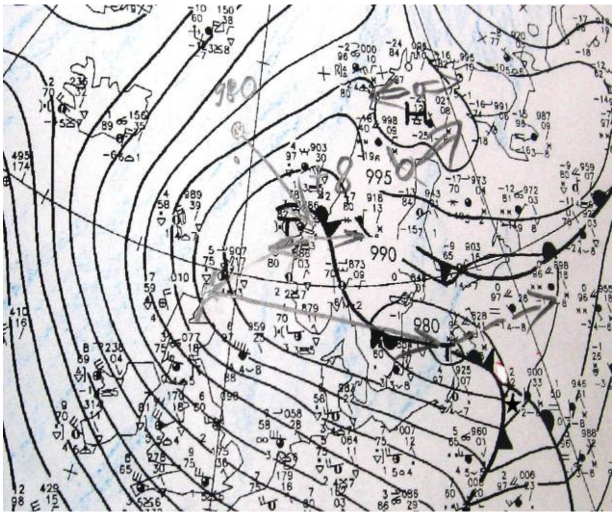

Fig. 17. 28 Jan. 2003 14 h. No HCRF decease. Cyclone motion eastward

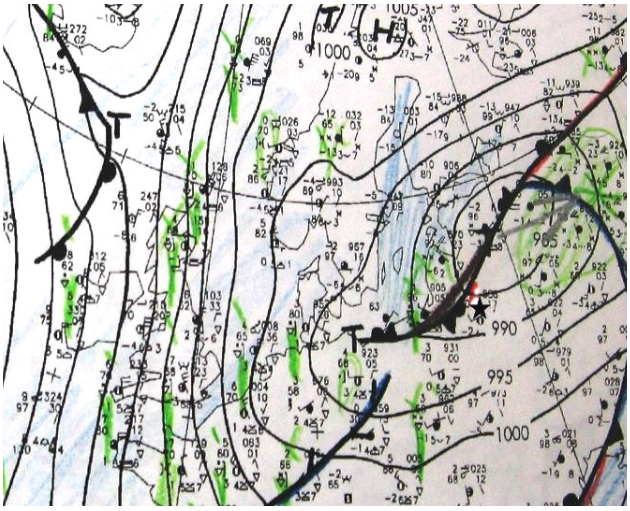

Fig. 18. 29 Jan. 2003 14 h. No HCRF decrease. Cyclone motion eastward

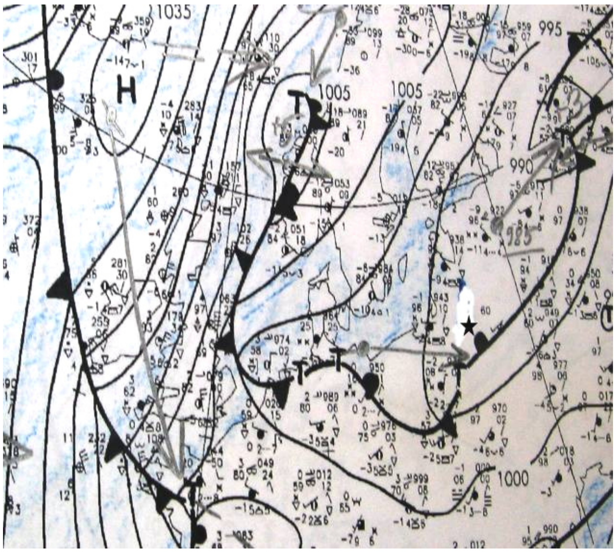

Fig. 19. 30 Jan. 2003 14 h. No HCRF decrease. Minimum atmospheric pressure formation (993 hPa) in Vilnius in 5–6 days after the first registration of HCRF decrease (Fig. 14)

A signal about HCRF decrease (–44 imp/h) was registered on October 12, 2002, when a cyclone was formed at Newfoundland (Fig. 2); on October 13 a signal of –16 imp/h was obtained at time interval 11–12 hours (Fig. 3); on October 14 a signal of –23 imp/h was registered at time interval 9–10 hours (Fig. 4). All these signals predict the minimum atmospheric pressure (997 hPa) in Vilnius in 6, 5, 4 days, accordingly, i.e. on October 18, 2002 (Figs. 2–8).

At this period of time an intensive cyclonic activity was occurring. The mentioned situation was predicted by HCRF decrease (–48 imp/h) on October 20, 2002 (Fig. 9) at time interval 9–10 hours. After this signal a minimum atmospheric pressure occurred in Vilnius on October 23–24, i.e. in 3–4 days (Figs. 9–13).

HCRF decrease (–38 imp/h) was registered on January 25, 2003 at time interval 12–13 hours, when the cyclone formation was occurring near Newfoundland (Fig. 14). Its change and transfer to the minimum atmospheric pressure (993 hPa) in Vilnius on January 30, 2003 is illustrated in Figs. 15–19.

Thus, the signals of HCRF decrease, depending on their registration, define the minimum atmospheric pressure in the observation station (Vilnius) in 6–3 days after the cyclone formation in the North Atlantic.

4. Discussion

Natural phenomena are interconnected. In any case any abnormal phenomenon can be found out beforehand. For this purpose it is necessary to understand the information, outgoing from it. In the present investigation such an information is realized by HCRF changes under appropriate conditions – at an optimum choice of the number of criteria and also from the time of their registration. Here, it is necessary to take into consideration the interval of energy, where the analysis of experimental data is carried out.

The leaps of HCRF are often registered because of geomagnetic field instability. These processes have an influence on meteorological situations such as cyclonic or anticyclonic activity.

Prognostic connection between HCRF variations and atmospheric changes in Vilnius is defined. It is found that HCRF decrease up to a certain value at a time interval 12–13 hours predicts the minimum pressure in Vilnius by a cyclone formed near Newfoundland. In spite of baric structures over the North Atlantic intensive change, the atmospheric pressure in Vilnius becomes minimum in 6 days. This regularity was often observed up to 60–70 % in 2002–2003 in a general case. If the atmospheric pressure decrease is lower than normal, the forecast realization exceeds 80 %. However, the primary information on the minimum pressure in Vilnius can be HCRF variations at other time intervals. In particular at a time interval 11–12 hours a signal from baric structure formation near Southern Greenland is registered. At time intervals 8–9 and 9–10 hours this information comes from Iceland. These situations are illustrated in Figs. 2–7.

Hence, the analysis of HCRF decrease at all time intervals increases the efficiency of prognosis. The prognosis of atmospheric pressure increase by the increase of HCRF, however, at other time intervals (Стыро 1986).

HCRF decrease at an energy interval 0.5–0.8 MeV, exceeding the value of criteria at the same time intervals 3–4 times, predicts short-term hurricanes at a distance limited by 100 km from the observation station, though the atmospheric pressure in Vilnius decreases insignificantly (Стыро 1984). The method of registration of the above mentioned abnormal phenomena is the same as for cyclonic activity prognosis which takes place in 3–6 days. To predict the location of hurricane the information of HCRF according to some observation stations is necessary. In the area of Lithuania this phenomenon is rather rare, that does not allow receive the statistical data using them to mathematical processing. On the other hand, in many cases it is impossible to confirm the fact of hurricane because of the absence of an appropriate network of meteorological observation. Therefore, it is rather problematic to coordinate in time the abnormal large decrease of HCRF at an energy interval 1.2–1.6 MeV and hurricane activity in 2002–2003. However, the territories of strong atmospheric processes and their after-effect took place at a distance of sensitivity of measuring installation.

The short-term whirlwind formation brings additional mistakes in prognosis of minimum atmospheric pressure. The sudden intensive increase of HCRF at the above mentioned time intervals predicts a thunderstorm in some hours near the observation station (Стыро 1984).

The decrease of HCRF from 50 % and more the number relative to annual data at any time of the day predicts a catastrophic phenomenon on the Earth; however, according to measurement results of the observation station it is impossible to find its location.

5. Conclusions

1. Prognostic connection between HCRF decrease at an energy interval 1.2–1.6 MeV and atmospheric pressure decrease up to a minimum value was found in Vilnius. This connection takes place at HCRF decrease according to chosen criteria only from 8 to 13 hours.

2. HCRF decrease at time intervals 8–9, 9–10, 11–12, 12–13 hours is determined by the influence of cyclones which are formed in various areas of the North Atlantic. These baric structures form a minimum atmospheric pressure decrease at an energy interval 1.2–1.6 MeV.

3. The impracticability of the prognosis of atmospheric pressure decrease depends on some external factors: thunderstorm activity, occurrence of whirlwind formations and sudden increase of anticyclonic activity in two days, etc.

4. It is necessary to consider the present investigation concerning the HCRF course at an energy interval 1.2–1.6 MeV as approximate tendency for the atmospheric pressure during 6 days.

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CIKLONŲ AKTYVUMO PASEKMIŲ TRUMPALAIKĖS PROGNOZĖS GALIMYBĖS VILNIAUS MIESTE PAGAL KIETOSIOS KOSMINĖS SPINDULIUOTĖS SRAUTO VARIACIJAS

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Santrauka

Atlikta kietosios kosminės spinduliuotės srauto variacijų analizė energijų intervale 1,2–1,6 MeV Vilniaus mieste. Nustatytas ryšis tarp kietosios kosminės spinduliuotės srauto (KKSS) sumažėjimo šiame intervale ir atmosferos slėgio kitimo, kuris įvyks per 3–4 paras. Toks ryšis registruojamas tik nuo 8 val. iki 13 val. KKSS mažėjimas Vilniaus mieste priklauso nuo laiko intervalo, pvz., nuo 8–9 ir 9–10 val. slėgis sumažėja po 3–4 dienų; 11–12 ir 12–13 val. slėgis sumažėja po 5–6 dienų. Prognozės efektyvumas viename iš laiko intervalų buvo nuo 56–67 % 2002–2003 m. atitinkamai. To paties tyrimo rezultatai, įskaitant ir atmosferos slėgio mažėjimą nuo 1005 hPa ir mažiau, parodė aukštą prognozės efektyvumą visuose laiko intervaluose per 6 dienas – 92 % ir 82 % 2002–2003 metais atitinkamai.

Reikšminiai žodžiai: kietosios kosminės spinduliuotės srautas, atmosferos slėgis, ciklonas, anticiklonas, trumpalaikė prognozė.

О ВОЗМОЖНОСТИ КРАТКОВРЕМЕННОГО ПРОГНОЗА ПОСЛЕДСТВИЙ ЦИКЛОНИЧЕСКОЙ АКТИВНОСТИ В ВИЛЬНЮСЕ ПО КОЛЕБАНИЯМ ПОТОКА ЖЕСТКОГО ИЗЛУЧЕНИЯ

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Резюме

Проведен анализ колебаний потока жесткого космического излучения (ПЖКИ) в энергетическом интервале 1,2–1,6 МэВ в г. Вильнюсе. Установлена связь между падением ПЖКИ в этом энергетическом интервале и изменением атмосферного давления, которое произойдет через 3–6 суток. Такая связь регистрируется только с 8 час. до 13 часов. В зависимости от интервала времени регистрации падения ПЖКИ, в частности, 8–9 часов, 9–10 часов – наименьшее давление в г. Вильнюсе образуется через 3–4 суток, а 11–12 часов и 12–13 часов – через 5–6 суток. Выполнимость такого прогноза по падению ПЖКИ в одном временном интервале в среднем соответствовала 56–67% в 2002–2003 гг. Результаты аналогичного исследования с учетом того, что атмосферное давление уменьшается, начиная с 1005 гПа и ниже, показали высокую эффективность прогноза формирования наименьшего давления в г. Вильнюсе по падению ПЖКИ во всех временных интервалах в течение 6 суток – 92% и 82% в 2002 и 2003 гг. соответственно.

Ключевые слова: поток жесткого космического излучения, атмосферное давление, циклон, антициклон, кратковременный прогноз.

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