Geomagnetic storms link to the mortality rate in the Smolyan region for the period 1988–2009

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Abstract. We present correlations and trends of 10 parameters of annual mortality rate (1 to common mortality rate, 5 to cardiovascular reasons and 4 to "accidental" reasons (car accidents, suicides, infections)) with respect to 6 parameters of annual solar and geomagnetic activity (Wolf index, number of geomagnetic storms, duration of the storms, amplitude of the storms). During the period of observation, characterized by a 3-4-fold decrease of the mean geomagnetic activity (in terms of the number and the duration of the storms) and with a strong variations of the amplitude of the storms (about an almost constant mean values for the period), there is a 1.3-fold decrease in the urban population, a 1.5-fold increase of the common mortality rate, a 1.8-fold increase of the cardiovascular mortality rate and a 1.1-fold decrease of the "accidental" mortality rates. During the years 2003-2005 we observe about 2-fold temporary increase in the storm amplitudes. During the years 2007-2008, characterized by extremely low geomagnetic activity, we observe a surprising temporary increase of the common and the cardiovascular mortality rates 1.1 and 1.3-fold, respectively (Figures 1-4). We point out 3 main results. (1) The available data shows notable increase in the mortality rates while there is generally a decrease of the solar or geomagnetic activity during the studied period (Figures 5-9). We explain this anti-correlation with the domination of the increasing mortality rates as an effect of the advance in the mean age of the population (due to immigration of young people and decrease of new-borns), hiding an eventual display of the solar and geomagnetic influence on the mortality rates. Using this data we can not reveal influence of the long-time (10-20 years) change of the average solar and geomagnetic activity on the mortality rate. (2) Excluding the unusual years 2007 and 2008, we establish that with respect to the years with low geomagnetic activity (1993, 1995, 1996, 1999), in the years with high geomagnetic activity (2000, 2001, 2003-2005) the common and the cardiovascular mortality rates increase by at least 20% and at least 30%, respectively (Figures 10-13). (3) The time delay of the maximum of the common and the cardiovascular mortality rates in 2007-2008, about 3 years after the sharp maximum of the strong storms in 2003-2005, lead to suggestion that the influence of the storms on the mortality rates may manifest clearly itself some years later. Generally, our data shows that the geomagnetic storms increase notable the common and the cardiovascular mortality rates.

Key words: Sun, solar activity, geomagnetic storms, human health, mortality rate

Влияние на геомагнитните бури върху смъртността в Смолянска област за периода 1988-2009 г

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Ние представяме корелации и трендове на 10 параметъра на годишна смъртност (1 за общата смъртност, 5 за сърдечно-съдова смъртност и 4 за "инцидентна" смъртност

(пътни катастрофи, самоубийства, инфекции)) спрямо 6 параметъра на годишна слънчева и геомагнитна активност (индекс на Волф, брой на геомагнитни бури, продължителност на бурите, амплитуди на бурите). В изследвания период, характеризиращ се с 3-4 пъти намаляване на средната геомагнитна активост (изразена чрез броя и продължителността на бурите) и силни вариации на годишните амплитуди на бурите (около почти постоянни за периода средни стойности), имаме 1.3 пъти намаляване на населението, 1.5 пъти увеличаване на общата смъртност, 1.8 пъти увеличаване на сърдечно-съдовата смъртност и 1.1 пъти намаляване на "инцидентната" смъртност. През 2003-2005 г се наблюдава временно увеличаване на амплитудите на бурите около 2 пъти. През 2007-2008 г, характеризиращи се с екстремално ниска геомагнитна активност, се наблюдава изненадващо временно увеличение на общата и сърдечно-съдовата смъртност, съответно 1.1 и 1.3 пъти (Фигури 1-4). Ние изтъкваме 3 главни резултати. (1) Наличните данни показват забележимо нарастване на смъртностите, докато през из-следвания период имаме общо намаление на слънчевата и геомагнитна активност (Фигури 5-9). Ние обясняваме тази антикорелация с доминиране на нарастването на смъртността като ефект от увеличаването на средната възраст на населението (поради изселване на млади хора и понижена раждаемост), скриваща евентуална проява на слънчево и геомагнитно влияние върху смъртностите. Използвайки тези данни ние не можем да изявим влияние на дълговременната (10-20 г) промяна на средната слънчева и геомагнитна активност върху смъртноста. (2) Изключвайки необикновените 2007 и 2008 г ние установяваме, че спрямо годините с ниска геомагнитна активност (1993, 1995, 1996, 1999), в годините с висока геомагнитна активност (2000, 2001, 2003-2005) общата и сърдечно-съдовата смъртност нарастват съответно с поне 20% и 30% (Фигури 10-13). (3) Времевото отместване на максимума на общата и сърдечно-съдовата смъртности през 2007-2008 г, около 3 г след максимума на силните бури през 2003-2005 г, води до предположението, че влиянието на бурите върху смъртността може да се проявява по-ясно няколко години по-късно. Изобщо, нашите данни показват, че геомагнитните бури увеличават забележимо общата и сърдечно-съдовата смъртности.

Introduction

During the last decades the link between the solar and geomagnetic activity and the biological world on the planet has been studied many fold. The Sun provokes changes in the meteorological parameters and their change can be felt in the biosphere. However, no no meteorological parameter change is global. On the contrary, a change in the solar and the geomagnetic activity can be observed at the same time all over the world, during the day and the night, in the biosphere as well as in the communication and technology world. The main factor that defies this "space weather" are the geomagnetic storms, forced by the solar flares (see http://spaceweather.com/solarflares; Georgiev et al, 2007). Many medical and biological experiments prove the sensibility of the human organism with respect to these storms.

It is known that the geomagnetic storms affect mainly people in certain risk groups, suffering from critical diseases, such as diseases of the cardiovascular and nervous system. Many scientists have been studied the impact of geomagnetic storms on the human health on the base of information taken from different hospitals and countries. For example, the rates of the brain strokes and heart attacks have been analyzed trough the information about emergency calls in Moscow for a long period of time (Vladimirski & Temur'jants

1989, Breus & Rapoport 1998, 2003, 2005; Kleimenova & Kozyreva 2008). The results show during days with strong geomagnetic disturbances the number of patients suffering a brain stroke and a heart attack grow by 7.5% and 13%, respectively.

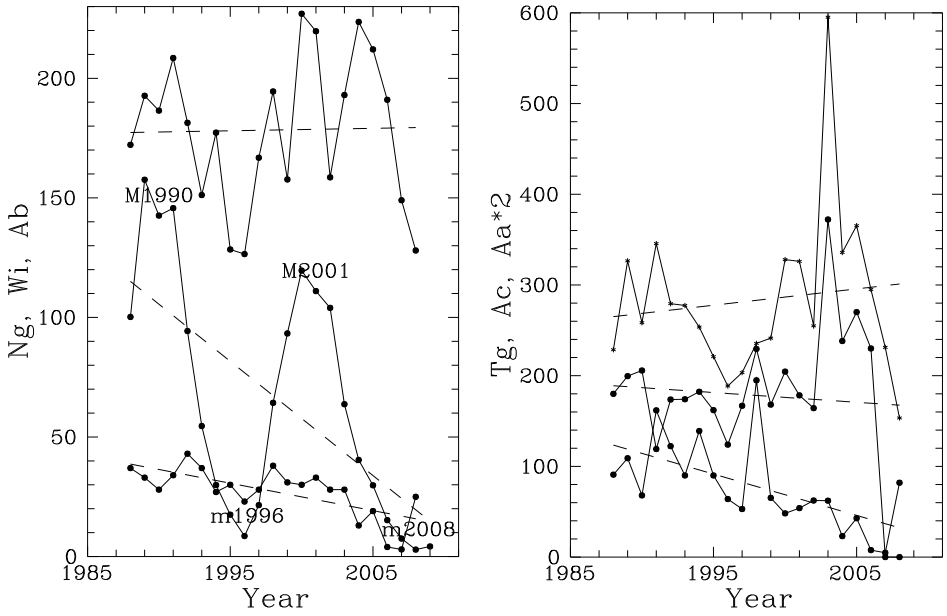

Fig. 1. Time behaviour of the solar and geomagnetic parameters. The adopted years of the solar minimums and maximums are noted by m1996 and m2008, as well as M1990 and M2001, respectively. Hereafter the regression trends are shown in the graphs by dashed lines.

There is a growth also in the number of brain strokes and heart attacks during days characterized by geomagnetic storms with electromagnetic pulsation of 0.5 - 2.0 Hz. These frequencies coincide with the heartbeat rhythm and have biological effects. Another result is that brain and heart problems are more common in winter, because then the resistance of the human body is weaker. Heat waves are also known for causing more death cases due to extreme overheating of the body.

However, the existing data and theories can not identify the specific mechanisms of the influence of the geomagnetic storms on human health. For this reason, inspire of the proofs collected so far, the wide-spread opinion is that the proofs are still insufficient. To make the problem clearer further investigation is necessary.

In 1997 the Planetarium and Astronomical Observatory of Smolyan started a research about the influence of the solar activity and geomagnetic storms on the mortality rates. The study covers ten regions within Smolyan district, situated in the central part of the Rhodope Mountains (Banite, Borino, Devin, Dospat, Zlatograd, Madan, Nedelino, Rudozem, Smolyan and Chepelare). Folowing Vladimirski (1981), Gnevyshev & Novikova (1971), Komarov et al. (1994), Shapiro (1988), Dermendzhiev (1997), etc., mortality rates due

to well-known critical diseases and accidental death rates have been selected. We used official medical statistics which has kindly been provided to us by the Regional Healthcare Centre in Smolyan. The registergram of the geomagnetic storms has kindly been provided by the Geomagnetic Observatory in the town of Panagyuriste, Bulgaria.

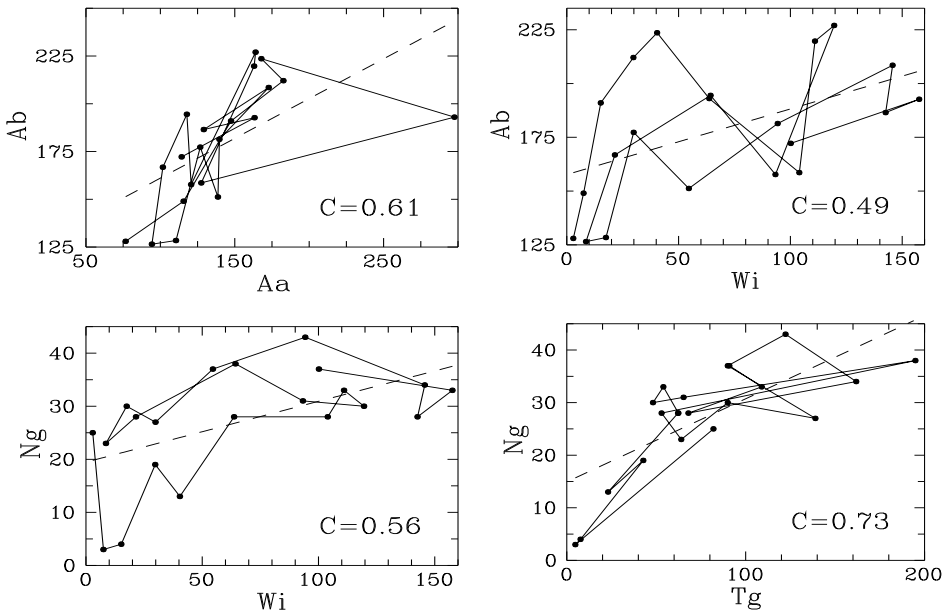

Fig. 2. Correlations between some of the activity parameters (See also Tables 3 and 4).

In the present study we describe (1) the sources of data, (2) the trends of the solar and geomagnetic activity, (3) the trends of the demographics processes, (4) the correlations of the mortality rates and the common activity parameters, (5) the correlations of the mortality rates and storm parameters, folowing by (6) conclusions.

1 Sources of data

To achieve the aims of the study we apply two preliminary data collections and reductions.

1.Processing of registergrams of the every-day geomagnetic monitoring in the Panagyurishte Geomagnetic Observatory. More than 570 registergrams of storms were processed. In the present study we classify the storm by the change of the H-amplitude (the vertical component) of the geomagnetic field as follows:

- up to 120 nT - weak storm
- from 120 to 200 nT - moderate (bland) storm
- from 200 to 320 nT (and more) - strong storm

The annotation of the annual parameters of the solar activity and the geomagnetic storms, chosen to be used here, follows:

- Wi – the international Wolf index of the solar spot formation (available via
$ftp://ftp.ngdc.noaa.gov/STP/SOLAR\_DATA$);
- Ng – the annual number of all (weak, moderate and strong) storms;
- Tg – the time duration of all storms, in days;
- Aa – the average amplitude of all storms, in nT;
- Ab – the average amplitude of the moderate and strong storms, in nT;
- Ac – average amplitude of the moderate and strong storms with sudden onset, in nT;

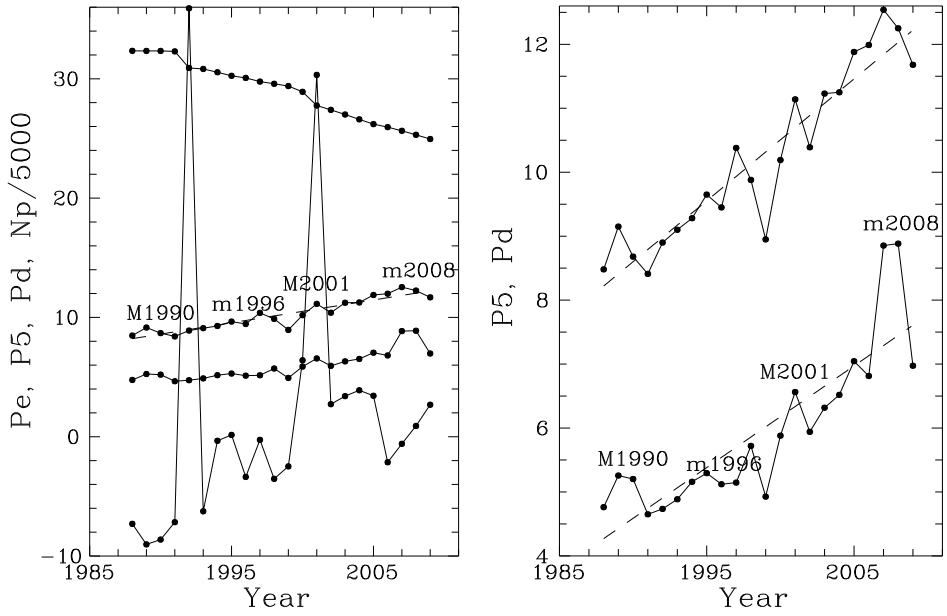

Fig. 3. Time behaviour of the human population parameters Pe, P5, Pd and Np (*left*) and mortality rate parameters P5 and Pd with vertical enlargement (*right*).

The values of the used parameters of the solar and geomagnetic activity are presented in Table 1. The values of Ng, Tg, Aa, Ab and Ac are derived for the period 1988-2008. Unfortunately, because of changes of the methods of registration in Panagyurishte Observatory, deriving just such parameters for the years before 1988 and after 2008 is impossible.

2.Processing of the official statistical material about the annual urban population and mortality rate from the Smolyan Healthcare Center. The data about the annual urban population and the mortality rate was extracted. The annotation of the annual parameters of the population and the common mortality rate, chosen to be used here for the period 1988-2009, follows:

- Np – the number of registered persons at the end of the calendar year;
- Pd – the number of all registered cases of death that occurred during the year with respect to 1000 persons;

- Pe – number of the escape persons during the year with respect to 1000 persons, including new-borns (with sign"'+"') and people who have migrated (wth sign "'-"'). (The negative values of Pe in Fig.3 correspond to addition to the population and the positive values correspond to addition to the urban population!)

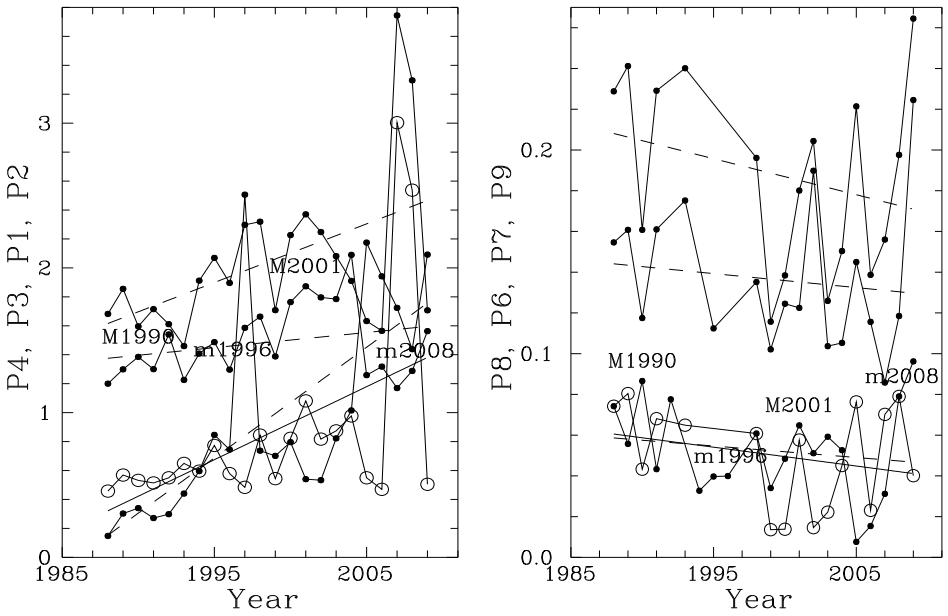

Fig. 4. Time behaviour of the mortality rate parameters P1-P4 and P6-P9. The circles and solid lines present the heart attacks P3 (left panel) and the car accidents P6 (right panel)

The annotation of the annual mortality rate, caused by critical diseases or accidents, with respect to 1000 persons, for the period 1988-2009, follows:

- P1 – the brain attack (including the most heavy manifestation: brain stroke; no separate data about brain strokes only);
- P2 – coronary artery disease (including after-effects such heart attack etc.);
- P3 – heart attack (the most heavy manifestation of the coronary artery disease);
- P4 – hypertonic disease (as general reason for the death, independent of the after-effects that leads to death);
- P5 – cardiovascular disease (generally, the values of P1, P2 and P4 present different parts of P5 and P5 > P1+P2+P4);
- P6 – the car accident;
- P7 – the suicide;
- P8 – the infection and parasite diseases with lethal end, including tuberculosis;
- P9 – the mortality rate corresponding to the sum P6 + P7

The annual values of the used parameters P1-P9 are presented in Table 2. The years with missing data have been excluded from the computations and the graphs.

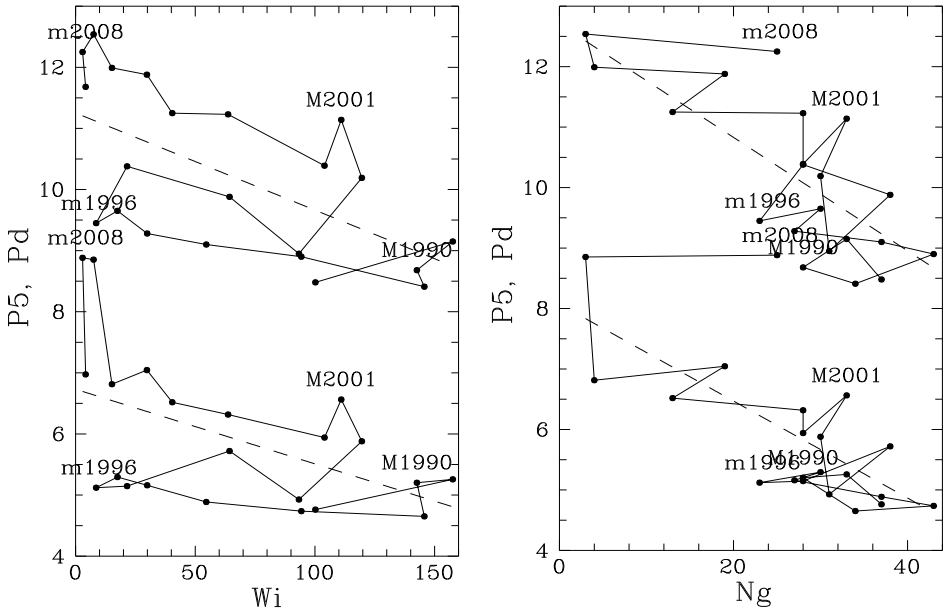

Fig. 5. Correlations of the mortality rates P5 and Pd with the parameters Wi and Ng Hereafter the regression trends are shown by dashed lines.

2 Trends of the solar and geomagnetic activity

The behaviour of the activity parameters and correlations between some them are shown in Fig.1, and Fig.2. The mutual correlation coefficients of solar and geomagnetic parameters, as well as parameters of the death rartes, are collected in Table 3.

Uniform data row, registered in the Panagyurishte Observatory, exist for the period 1988-2008. This period comprehends the Zurich cycles of the solar activity registered under No. 22 and No. 23. The chosen para meters of the geomagnetic activity Ng, Tg, Aa, Ab and Ac fluctuate strongly. They show largest variations in the frames of the Cycle No.23, which is characterized with enormous strong storms in the years 2003-2005 and extremely low levels of the storms in 2006-2009 (Fig.1).

In the Cycle No.22 the amplitudes of the storms follow roughly the Wolf numbers. However, at the beginning of the Cycle No.23, during the years 1997-2001, the amplitudes of the big storms increased significantly. Later, in the years 2003-2005 the amplitudes increased about 2-fold. A lot The coronal mass ejections and the three solar flares are the most powerful in the history of these investigations. Fast plasma streams flowing out of coronal holes were observed too.

In the autumn of the unusual year 2003 the Geomagnetic Observatory in Panagyurishte registered the two strongest storms for this twenty years period: on 29.10 - a four-day storm with an amplitude of 694 nT (!) and on 20.11 - a single-day storm with an amplitude of 557 nT. In 2004 two strong storms were registered too: on 26.07 - a single-day storm with an amplitude of 309 nT; on 07.11 - a five-day storm with an amplitude of 338 nT. In 2005 two storms with a single-day duration one were registered: on 15.05, with an amplitude of 368 nT and on 24.08, with an amplitude of 387 nT.

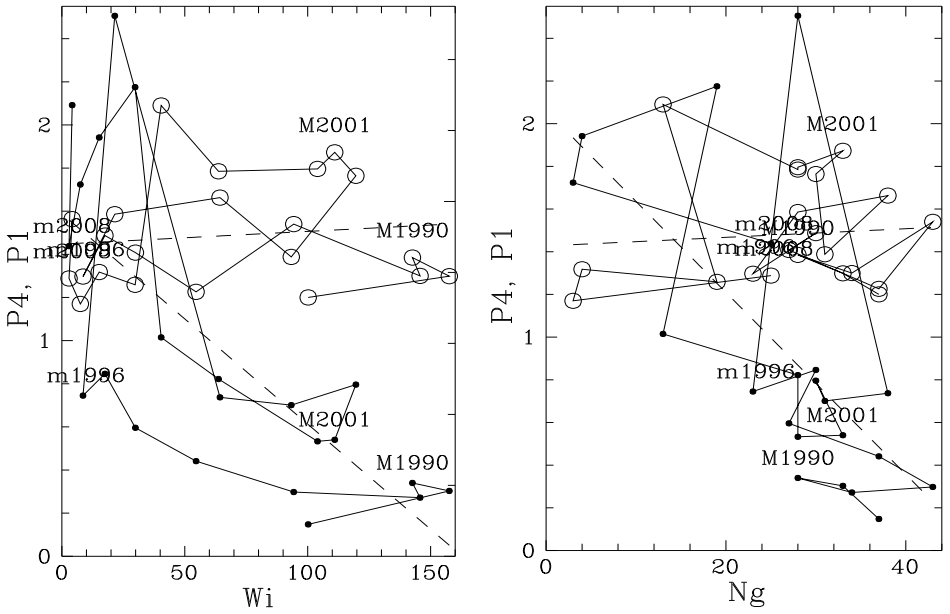

Fig. 6. Correlations of the mortality rates P4 (dots) and P1 (circles) with the parameters Wi and Ng.

Despite of the fluctuations of the activity parameters, the regression trends show significant decrease of the geomagnetic activity on average: Ng – 3-fold and Tg – 4-fold. These decreases support the opinion that the solar activity goes generally down toward a super-senturial minimum, expected in the middle part of the 21th century.

Examples of mutual correlation between activity parameters are shown in Fig.2.

Figures 1 and 2, as well as Table 3, lead to two conclusions, as follows.

First, the Wolf number Wi, having cyclic behaviour and a decrease on average, correlates moderately with the number of storms Ng (C=0.56, Fig.2, left-bottom) and weakly with the other activity parameters (C=<0.5; Fig.2, right-top). This is evidence that the solar spot formation and the solar influence on the Earth magnetosphere are different manifestations of the solar activity.

Second, the parameters Ng and Tg as well as Aa and Ab, have moderate mutual correlations (C=0.61–0.73; Fig.2, left-top and right-bottom). It is to

be expected, because they reflects different appearances of the event "geomagnetic storm". The storms with sudden onset have highest amplitudes and the number of the long-time storms is larger then the number of short-time storms.

The parameters Ng and Tg correlate notable (Fig.2, right-bottom), but Ng shows weaker fluctuations then Tg and it is used thereafter as better indicator of the mean decrease of the general solar and geomagnetic activity (Fig.5-9).

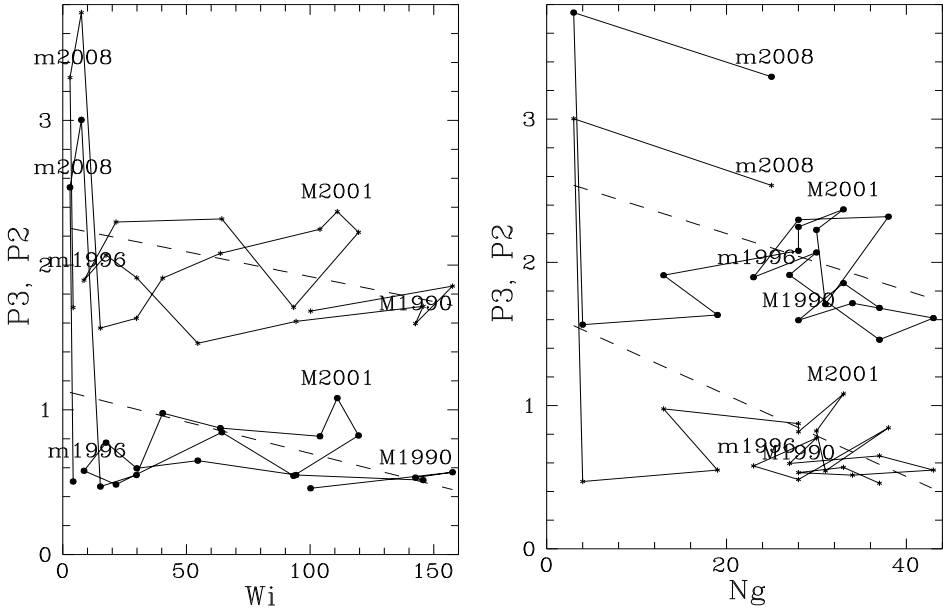

Fig. 7. Correlations of the mortality rates P3 and P2 with the parameters Wi and Ng.

3 Trends of the demography processes

The trends in the number of human population and the mortality rates are shown in Fig.3 and Fig.4.

Figure 3 shows an approximately linear decrease of the annual number of the population Np (1.3-fold), a such increase of the annual common mortality rate Pd (1.5-fold) and a such increase of the mortality rate due to cardiovascular diseases N5 (1.8-fold). In the same time the common amount of escaped persons Pe shows more complicated trend. Two its high maximums correspond to large immigrations in 1992 and 2001.

Figure 4, left panel, shows the behaviour of the mortality rates P1-P4. They fluctuate significantly but increase about 1.6, 1.2, 4 and 7-fold, respectively. Note that in the years 2007-2008, with very weak geomagnetic activity, the mortality rate due to brain attacks, P1, decreases about 1.5-fold but the parmeters P2-P4 increase sharply up some times.

Figure 4, right panel, shows the behaviour of the mortality rates P6-P9. They vary significantly and show negligible decreases (1.1-1.2-fold). However,

the parameters P6-P9 are result of a poor statistics and we do not point out sure conclusions.

Figures 3 and 4 lead to two conclusions.

First, in the studied period, when the storm activity parameters Ng and Tg decrease on average 3-4-fold, the common mortality rates Pd and P5 increase generally 1.5 and 1.8-fold, respectively. The increase of the mortality rates may be explained (1) by the advance in age of the population: adult persons die frequently of the regarded dangerous diseases or (2) by the significant decrease of the mean solar and geomagnetic activity (characterized by the parameters Ng and Tg). We consider the effect of the population aging dominates and hides the possible effect of the decrease of the mean solar and geomagnetic activity.

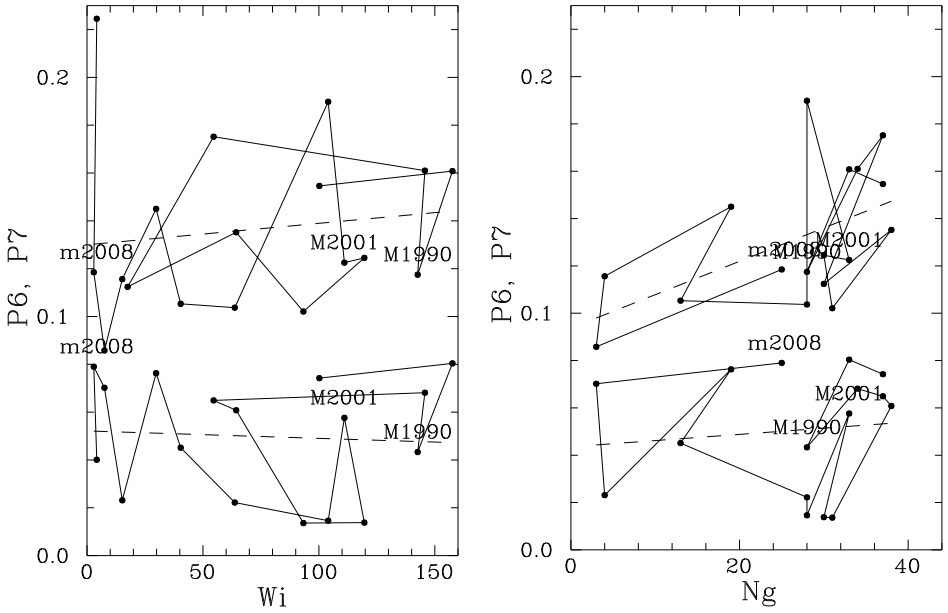

Fig. 8. Correlations of the mortality rates P6 and P7 with the parameters Wi and Ng.

Second, in the last 2-4 years of the studied period the behaviour of the mortality rate parameters P2-P5 and Pd show sharp increase and P1 show significant decrease. These facts may be explained (1) by accidental increase of the common mortality rate combined with some change of the applied diagnostic methods or (2) with the sharp decrease of the solar and geomagnetic activity or (3) as a time postponed effect of the big storm activity in the years 2003-2005. We prefer the first explanation. The second one is inconsistent with the contemporary knowledge that the high geomagnetic activity is bad for the health. The last one may be object of a future check.

4 Mortality rates and activity parameters Wi and Ng

The correlation coefficients are presented in Table 3 and Table 4. The respective trends are shown in Fig.5-9. The graphs with Tg instead Ng (not shown) are practically equivalent to these with use of Ng.

Figures 5-7 show the trends of the mortality rate parameters P1-P5 and Pd with respect to the activity parameters Wi and Ng. They confirm the already revealed important fact – the mortality rate parameters (except P1) anti-correlate with the solar and geomagnetic activity parameters Wi and Ng. With respect to Ng the decrease is about 1.7 and 1.4-fold for Pd and P5, respectively, as well as some tines for P4 (Fig.5, Fig.6). Nevertheless, the high mortality rate and the low activity in the years 2007-2008 increase significantly the observed anti-correlations with Ng (right panels). Only the mortality rate P1, corresponding to brain attacks, likely overcome this anti-correlation and shows a weak positive trend (Fig.6).

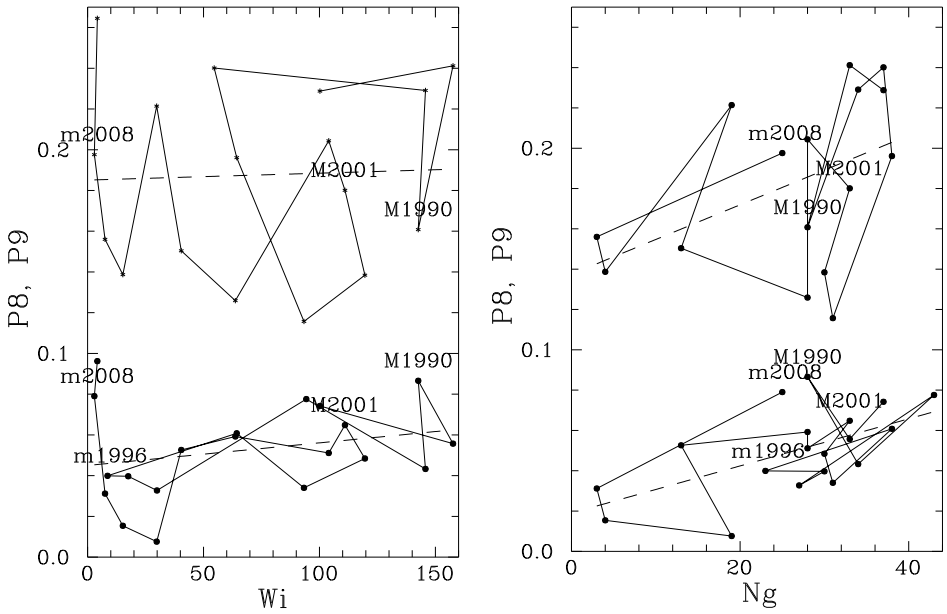

Fig. 9. Correlations of the mortality rates P8 and P9 with the parameters Ng and Wi.

Figures 8 and 9 show the behaviour of the mortality rate parameters P6-P9 with respect to the activity parameters Wi and Ng. Generally, the correlations are weak and the increase of the parameters are negligible. However, the suicides mortality rate P7 grows up about 1.5-fold with growing of Ng (Fig.8, right panel). This growing appears also in the increase of the sum of the mortality rates due to suicides and car accidents P9 (Fig.9, right panel).

Figures 5-9 lead to three conclusions.

First, the mortality rates, and especially the parameters P5 and Pd, show anti-correlations with the activity parameters Wi and Ng (Fig.5). This fact may be explaining again by a casual coincidence between the general decrease

of the solar activity and the general increase of the mean age of the observed population. We can not reveal again the influence of the solar and geomagnetic activity on the mortality rates.

Second, separating P1 and P7, we may consider, that the brain problems leading to a lethal end (1) decrease with the advance of the population age or (2) increase with the solar-geomagnetic activities. The second possibility seems to be more acceptable, however the data amount is not enough for sure conclusion.

Third, the common mortality rate parameters P5 and Pd seem to anti-correlate weakly or moderately with the parameters of the storms Aa, Ab and Ac. However, the reason of these anti-correlations is the low values of Ab and zero values of Ac in the years 2007 and 2008. By this reason the role of the parameters Ab and Ac will be regarded in Section 5 with and without data about the years 2207 and 2008.

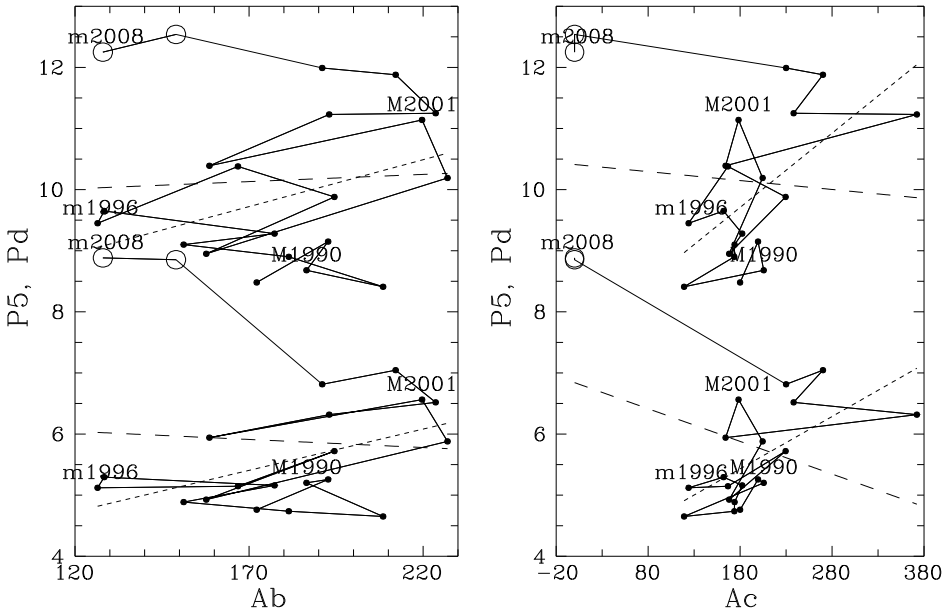

Fig. 10. Correlations of the mortality rate parameters P5 and Pd with the storm parameters Ab and Ac. Dashed lines present the regressions for all data. Dotted lines present the regressions after excluding the data from the years 2007 and 2008 (circles).

5 Mortality rates and storm parameters Ab and Ac

During the studied time period, while the mortality parameters P1-P5 and Pd increase, the activity parameters Wi and Ng fluctuate moderately and trend generally to very low levels. In the same time the storm parameters Aa, Ab and Ac fluctuate strongly, keeping an almost constant average level (Fig.1). Consequently, the connections of the mortality rate parameters with the activity parameters Aa, Ab and Ac must be object of high attention.

However, in the years 2007-2008, when the storm parameters show very low values, the available data shows surprising peaks of temporary increases: 1-1 fold for the common mortality rate Pd, 1.3-fold for the cardiovascular mortality rate P5q as well as 1.5-fold decreasing of the brain attack mortality rate P1. These circumstances dominate and produce anti-correlations between the mortality rates and the storm parameters. In this situation we regard the correlations and graphs secondary,excluding data for the years 2007 and 2008.

Table 4 presents the correlations of the storm parameters Aa, Ab and Ac with the mortality rates with and without data about the years 2007 and 2008. The anti-correlations in the top part of Table 4 become correlations in the bottom part. The respective graphs are shown in Fig.10-12. The graphs based on Aa show large scatter of data they are not shown here.

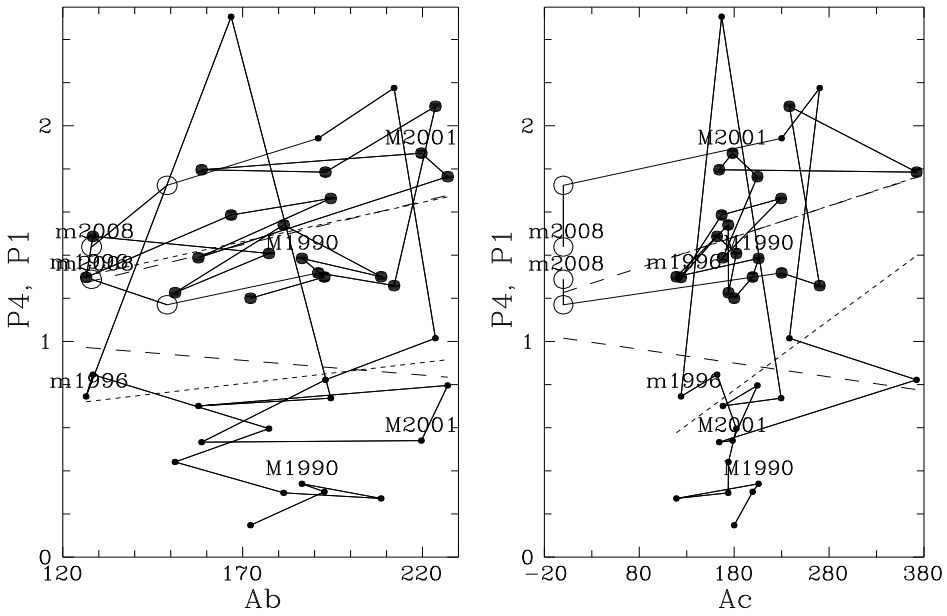

Fig. 11. Correlations of the mortality rate parameters P4 (small dots) and P1 (large dots) with the storm parameters Ab and Ac. Dashed lines present the regressions for all data. Dotted lines present the regressions after excluding the data from the years 2007 and 2008 (circles).

In Figures 10-12 the regressions, based on all data, are shown by dashed lines. The the data about the years 2007 and 2008 are shown by circles. The regressions after exclude of the data about the years 2007 and 2008 are shown by dotted lines. So, the negative trends become positive and all trends occur positive. We see also significant increasing of some parameters. The parameter P4 increases even 2.3-fold (Fig.11, right panel). Moreover, the exclude of the years 2007 and 2008 affects strongly the correlations with the parameter of the storms with sudden onset, Ac.

The accidental mortality rates P6-P9, where the statistics is poor, do not show something of interest and they are not shown here.

Figures 10-12 lead to two conclusions.

First, in spite of the poor defined trends, we may point out that in the studied range of mean annual amplitudes of storms Ab and Ac the common mortality rate Pd increases 1.2-1.3-fold and the cardiovascular mortality rate P5 increases 1.3-1.4-fold (Fig.10). This result is shown more clear in Fig.13, where the reverse regressions are shown too.

Second, one outlying point in the right parts in the graphs with abscissa axis Ac (Fig.10, Fig.13, right panel) causes significant decrease of the slope of the trend. It is possible that the true dependence of the mortality rates on the storms with sudden onset may be significantly more steep an strong.

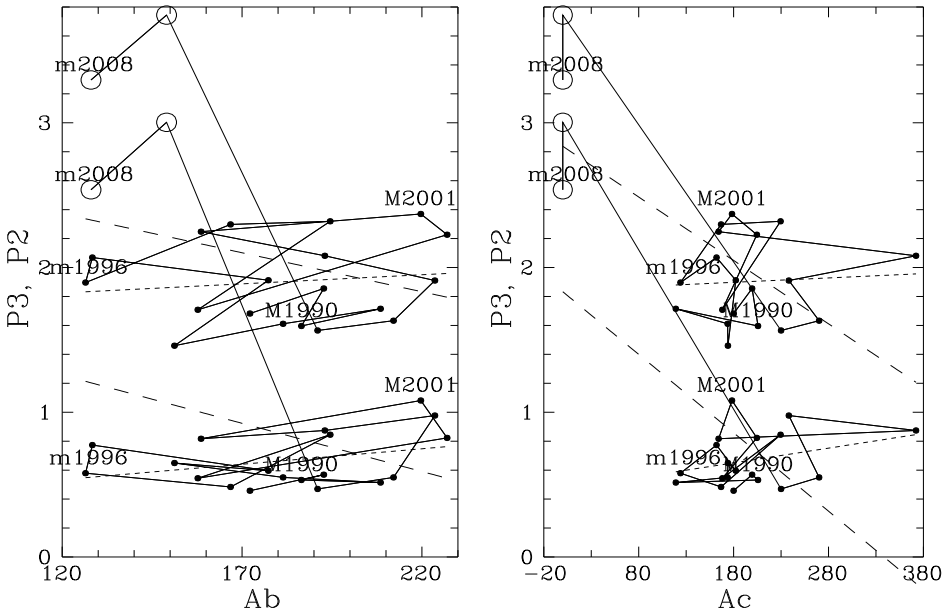

Fig. 12. Correlations of the mortality rate parameters P3 and P1 with the storm parameters Ab and Ac. Dashed lines present the regressions for all data. Dotted lines present the regressions after excluding the data from the years 2007 and 2008 (circles).

6 Conclusions

In this study we introduce, estimate and use five annual parameters of the geomagnetic storms: Ng, Tg, Aa, Ab and Ac (Section 1, Table 1). The values of the parameters of the geomagnetic activity are estimated from registergrams "by eye". We consider the relative errors of the estimated values are less than 10% and the they are generally correct.

Also we introduce, estimate and use ten annual mortality rate parameters: Pd and P1-P9 (Section 1, Table 2). Since the diagnosis about the reason of the death is given in principle without necropsy, we consider some diagnosis may be wrong. However, we believe the reason of the death, suspected in the parameters P1-P4, remains in the number of the regarded cardiovascular

diseases. We consider the cardiovascular mortality rate P5 is estimated with relative error also less then 10%.

Three main results of this study may be summarized as follows.

1. During the studied time period the mortality rates P9 and P2-P5 show anti-correlations with the activity parameters Wi and Ng. In the same time the accident mortality rates P6-P9 correlate weakly with Wi and Ng, showing poor defined increase (Fig.5-9, Table 3). However, in the same time we observe a decreasing of the human population Np about 1.3-fold, as well as an increasing of common mortality rate Pd about 1.5-fold, an increasing of the cardiovascular mortality rate P5 about 1.8-fold and a decreasing of the accidental mortality rates about 1.1-fold (Fig.3, Fig.4). Nevertheless the influence of the advance in the mean age of the human population remains unknown and the real influence of the solar and geomagnetic activity on the mortality rates remains hidden. To solve this problem we need data about population with approximately equal mean age in the whole studied period.

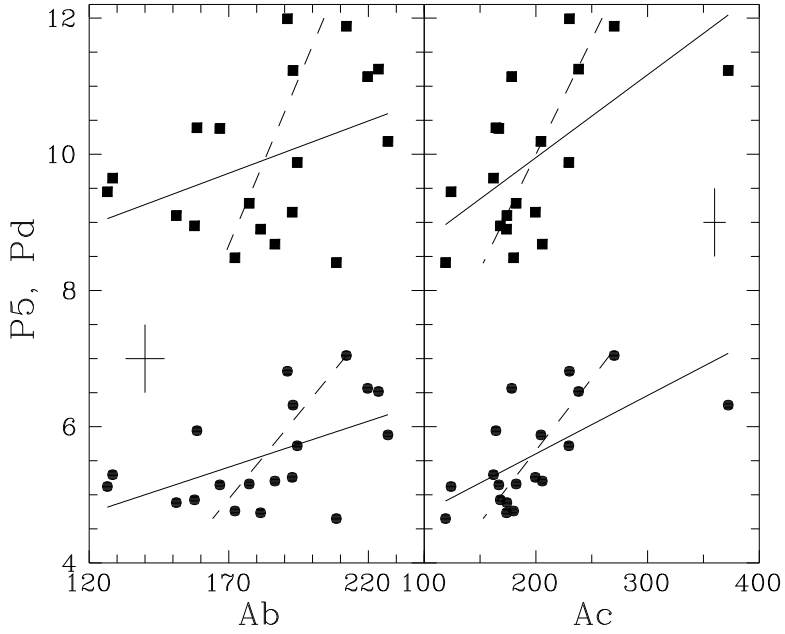

Fig. 13. Correlations of the mortality rates P5 (dots) and Pd (squares) with the storm parameters Ab and Ac for the period 1988-2006. Solid lines represent the regressions and the dashed lines present the reverse regressions. Horizontal error bar presents the estimated error in Ab and Ac. Vertical error bar presents the estimated error in P5.

2. Excluding the years 2007 and 2008, which are characterized with a very high mortality rate, we find correlations of the mortality rates with the amplitudes of the strong storms (Fig.10-12, Table 4, bottom part). However, in the studied period we find that the annual amplitudes of the strong storms Ab and Ac fluctuate around an approximately constant mean values. By this reason the increase of the mortality rates Pd and P5 in dependence of the storm amplitudes Ab or Ac seems to be real. (The statistics about the accidental

mortality rates P6-P9 is poor to be used for definite conclusions.) Generally, we establish that with respect to the years with low level of the geomagnetic storms (1993, 1995, 1996, 1999), in the years with strong geomagnetic storms (2000, 2001, 2003-2005) the common mortality rate increases with 20-30% and the cardio-vasculiar mortality rate increases with 30-40% (Fig.13)

3. The time delay of the maximum of the common and the cardiovascular mortality rates in 2007-2008, about 3 years after the sharp maximum of the strong storms in 2003-2005, lead to suggestion that the influence of the storms on the mortality rates may manifest clearly itself some years later. This suspicion must be check on more larger base of data.

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Table 1. Parameters of the urban population, solar and geomagnetic activity (see Section 1).

Year	Np	Pd	Pe	Wi	Ng	Tg	Aa	Ab	Ac
1988	161710	8.48	-7.30	100.2	37	90.9	114.3	172.2	180.0
1989	161690	9.15	-9.03	157.6	33	109.0	163.3	192.7	199.5
1990	161680	8.68	-8.62	142.6	28	68.0	129.2	186.5	205.7
1991	161478	8.41	-7.16	145.7	34	161.8	172.8	208.5	119.1
1992	154553	8.90	35.91	94.3	43	122.3	139.7	181.4	173.7
1993	154114	9.10	-6.25	54.6	37	90.0	138.7	151.2	174.0
1994	152749	9.28	-0.34	29.9	27	139.0	126.8	177.3	182.3
1995	151267	9.65	0.15	17.5	30	90.0	110.5	128.4	162.0
1996	150352	9.45	-3.37	8.6	23	64.0	94.3	126.5	124.0
1997	148845	10.38	-0.26	21.5	28	53.0	101.7	166.8	166.8
1998	147906	9.88	-3.53	64.3	38	194.9	117.8	194.5	229.5
1999	146957	8.95	-2.49	93.3	31	65.3	120.7	157.7	168.1
2000	144558	10.19	6.41	119.6	30	48.2	164.0	227.0	204.5
2001	138802	11.14	30.33	111.0	33	54.0	163.0	219.7	178.3
2002	137005	10.39	2.73	104.0	28	62.4	127.5	158.6	164.2
2003	135029	11.23	3.40	63.7	28	62.2	297.6	193.0	372.2
2004	133015	11.25	3.89	40.4	13	23.1	167.9	223.6	238.2
2005	131010	11.88	3.43	29.8	19	42.8	182.7	212.1	270.1
2006	129731	11.99	-2.14	15.2	4	7.7	147.5	191.0	230.0
2007	128200	12.54	-0.59	7.5	3	4.8	115.6	149.0	0.0
2008	126536	12.25	0.90	2.9	25	82.0	76.7	128.0	0.0
2009	124745	11.68	2.68	4.2	--	---	---	---	---

Table 2. Parameters of the mortality rate caused by the chosen diseases (see Section 1).

Year	P1	P2	P3	P4	P5	P6	P7	P8	P9
1988	1.200	1.682	0.458	0.148	4.762	0.0742	0.1546	0.0742	0.2288
1989	1.299	1.855	0.569	0.303	5.257	0.0804	0.1608	0.0557	0.2412
1990	1.385	1.596	0.532	0.340	5.202	0.0433	0.1175	0.0866	0.1608
1991	1.300	1.715	0.514	0.272	4.651	0.0681	0.1610	0.0433	0.2291
1992	1.540	1.611	0.550	0.298	4.736	-----	-----	0.0776	-----
1993	1.226	1.460	0.649	0.441	4.886	0.0649	0.1752	-----	0.2401
1994	1.408	1.912	0.596	0.596	5.159	-----	-----	0.0327	-----
1995	1.487	2.069	0.773	0.846	5.295	-----	0.1124	0.0397	-----
1996	1.297	1.896	0.579	0.745	5.121	-----	-----	0.0399	-----
1997	1.586	2.298	0.484	2.506	5.146	-----	-----	-----	-----
1998	1.663	2.319	0.845	0.737	5.720	0.0608	0.1352	0.0608	0.1961
1999	1.388	1.708	0.544	0.701	4.927	0.0136	0.1021	0.0340	0.1157
2000	1.764	2.227	0.823	0.796	5.880	0.0138	0.1245	0.0484	0.1384
2001	1.873	2.370	1.081	0.540	6.563	0.0576	0.1225	0.0648	0.1801
2002	1.796	2.248	0.817	0.533	5.941	0.0146	0.1898	0.0511	0.2044
2003	1.785	2.081	0.874	0.822	6.317	0.0222	0.1037	0.0592	0.1259
2004	2.090	1.910	0.977	1.015	6.518	0.0451	0.1053	0.0526	0.1504
2005	1.259	1.633	0.550	2.175	7.045	0.0763	0.1450	0.0076	0.2214
2006	1.318	1.565	0.470	1.942	6.814	0.0231	0.1156	0.0154	0.1387
2007	1.170	3.744	3.003	1.724	8.853	0.0702	0.0858	0.0312	0.1560
2008	1.288	3.296	2.537	1.438	8.883	0.0790	0.1185	0.0790	0.1976
2009	1.563	1.707	0.505	2.092	6.974	0.0401	0.2245	0.0962	0.2645

Table 3. Correlation coefficients with respect to activity parameters Wi, Ng and Tg; The second number is the standard deviation of the coefficient (see Section 1).

	Wi	Ng	Tg
Ng	0.56,0.10	-	-
Tg	0.33,0.17	0.73,0.05	-
Aa	0.28,0.18	-0.03,0.22	-0.10,0.21
Ab	0.49,0.13	0.26,0.23	0.00,0.22
Ac	0.22,0.20	0.15,0.21	0.01,0.22
Pd	-0.58,0.10	-0.73,0.05	-0.62,0.08
P1	0.14,0.21	0.08,0.22	-0.10,0.21
P2	-0.37,0.16	-0.36,0.16	-0.22,0.20
P3	-0.39,0.16	-0.44,0.14	-0.29,0.18
P4	-0.68,0.06	-0.66,0.07	-0.54,0.11
P5	-0.49,0.13	-0.68,0.06	-0.51,0.12
P6	-0.19,0.24	0.11,0.24	0.34,0.20
P7	0.44,0.16	0.56,0.13	0.45,0.15
P8	0.44,0.15	0.58,0.10	0.32,0.19
P9	0.04,0.24	0.45,0.16	0.53,0.13

Table 4. Correlation coefficients with respect to the activity parameters Aa, Ab and Ac. Top part – for the whole time period; Bottom part – after excluding the data from years 2007 and 2008 (See Section 5).

	Aa	Ab	Ac
Ab	0.61,0.09	-	-
Ac	0.74,0.04	0.58,0.10	-
Pd	0.15,0.21	0.06,0.22	-0.09,0.21
P1	0.37,0.16	0.49,0.13	0.44,0.14
P2	-0.26,0.19	-0.30,0.18	-0.62,0.08
P3	-0.22,0.20	-0.31,0.18	-0.66,0.07
P4	-0.09,0.21	-0.06,0.22	-0.08,0.22
P5	-0.01,0.22	-0.07,0.22	-0.35,0.17
P6	-0.28,0.21	-0.14,0.24	-0.40,0.18
P7	-0.07,0.24	0.02,0.24	0.05,0.24
P8	-0.10,0.22	-0.03,0.23	-0.09,0.26
P9	-0.24,0.22	-0.13,0.24	-0.21,0.23

	Aa	Ab	Ac
Ab	0.54,0.12	-	-
Ac	0.79,0.03	0.43,0.15	-
Pd	0.43,0.15	0.40,0.16	0.60,0.09
P1	0.31,0.19	0.40,0.16	0.32,0.18
P2	0.02,0.23	0.13,0.22	0.06,0.23
P3	0.35,0.18	0.34,0.18	0.31,0.19
P4	0.01,0.23	0.09,0.23	0.28,0.20
P5	0.48,0.14	0.52,0.12	0.64,0.08
P6	-0.13,0.26	0.13,0.26	-0.18,0.25
P7	-0.24,0.23	-0.20,0.24	-0.43,0.17
P8	-0.03,0.24	0.06,0.24	-0.04,0.24
P9	-0.27,0.23	-0.18,0.25	-0.41,0.18