

## CEREBRAL PATHOLOGY AND SOLAR ACTIVITY

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**Key words:** cerebro-vascular pathology, ischemic cerebral stroke, cerebral hemorrhages, transient cerebral cardiovascular conditions, geomagnetic activity

**Abstract:** The paper describes the strategic goals as well as first results of an ongoing project designated as "Heliobiology". The latter has started at the beginning of 2011 and will end in fall 2015. The project reflects the intense interest towards the influence of solar activity and meteorology on the activity of human brain. The project aims to study:

- The putative relationships between some solar activity indexes and meteorology factors on the one hand and the changes in several psycho-physiological parameters in healthy volunteers as well as the occurrence of cerebral pathology on the other;
- The possible lag between the time of manifestation of cerebrovascular accidents, if any, and the geomagnetic indexes;
- The relation between the cerebral vascular pathology (ischemic or hemorrhagic cerebral infarction) and the stages of magnetic storms as there are data that during geomagnetic disturbances the microcirculation parameters undergo rapid changes from increased coagulation.

## ВЛИЯНИЕТО НА СЛЪНЧЕВАТА АКТИВНОСТ НА ЧОВЕШКИЯ МОЗЪК

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**Ключови думи:** мозъчно-съдова патология, исхемичен и хеморагичен инфаркт, преходни нарушеници на мозъчното кръвообращение, геомагнитна активност

**Резюме:** Статията представя целите и първите резултати от текущ проект, с краткото название "Хелиобиология". Проектът започна през 2011 г., ще приключи в края на 2015 г. и отразява интересът към влиянието на слънчевата активност и метеорологичните фактори върху дейността на човешкия мозък. Проектът има за цел да проучи:

• Вероятната връзка между някои индекси на геомагнитната активност и метеорологични фактори, от една страна и промените в редица психо-физиологични параметри при здрави доброволци, както и поява на церебрална патология, от друга;

• Възможното забавяне между времето на проявление на мозъчно-съдови инциденти, ако има такива, и геомагнитните индекси;

• Връзката между мозъчната съдова патология (исхемичен или хеморагичен мозъчен инфаркт), както и етапите на магнитни бури, тъй като има данни, че по време геомагнитни смущения микроциркулаторните параметри биват подложени на бързи промени от увеличената коагулация.

## Introduction

Acute cerebro-vascular disease put significant pressure on society, medical systems and family budgets. This has led to the study of a broad range of possible physiological and environmental links in the hope of finding and developing better prevention measures against the disease.

It may seem rather unusual to suggest a possible links between cerebral functions and cerebral pathology at one hand and events in the heavens on the other, as for example between cerebral accidents and solar and/or geomagnetic activity, but a number of publications reveal that such link may exist although we still do not know the exact mechanisms of these relationships. One of the first known works on the topic was published in 1934 by Dull and Dull (after Mishlove, 1997). The paper showed a striking correlation between incidents of human illness and death during periods of sharp geomagnetic disturbances.

In brief, it is already accepted that extremely high as well as extremely low values of geomagnetic activity seem to have adverse health effects (Gurfinkel 2004, Persinger 1988, 2004). When brain function is concerned both animal studies and research on humans support the hypothesis for a possible correlation between mental health and solar activity. While it is easier to perform experiments on animals, observations on humans are not so many. The main reason is that in order to demonstrate the potential correlations a large scale research, including hundreds or even thousands of subjects, has to be performed. Despite of the constrictions, available data revealed that:

- A subset of the human population (10-15%) is a bona fide hypersensitive and predisposed to adverse health problems due to geomagnetic variations (Palmer et al., 2006; Lipnicki 2009; Mulligan et al. 2010; 2012) ;

- A positive correlation between days of geomagnetic intensity and the number of persons admitted to a psychiatric hospital was demonstrated based on years research at the Veterans Administration Hospital in Syracuse, New York (Friedman et al. 1963, Becker 1969);

- A 36.2% increase in the number of men admitted into hospital for depression in the second week after geomagnetic storms was revealed in another study (Royaume-Uni, 1994);

- A correlation between peaks in suicide numbers and geomagnetic activity (Ap index) was found in an Australian study. The correlation was gender dependant (Berk et al. 2006) and confirmed by a review of 13 years suicide rates in South African. The latter also suggested a link between suicides and magnetic storms (Gordon & Berk, 2006);

- Heliogeophysical factors are considered as possible triggers of suicide terroristic acts, too (Grigoryev et al. 2009);

- Larcan et al. (1982) revealed correlations between climatic parameters, the parameters of geomagnetic activity and the occurrence of acute neurological vascular accidents (thrombosis, hemorrhages);

- Several publications on a large scale studies (Stoupel et al. 1994; Mikulecky & Střeštík 2007) disclosed that the periodicities of cerebral infarction, cerebral hemorrhage and subarachnoid hemorrhage episodes, resembled the periodicities found in the solar and geomagnetic activity. The authors reported that the increased intensity of the geomagnetic parameters appeared to be significantly connected with decreased occurrence of cerebral infarctions, and vice versa.

The aim of this paper is to describe in brief the first data obtained as part of an ongoing project. The project has started in 2011 and will end in fall 2015 and reflects the intense interest towards the influence of solar activity and meteorology on human brain. The project is a continuation of previous efforts of the partners to study the relationship between geomagnetic activity and human physiology.

## The Project

The project aims to study:

- The putative relationships between some solar activity indexes (Sunspot numbers, F10.7 index, Ap index, etc) and meteorology factors and the occurrence of cerebral pathology;
- The possible lag between the time of manifestation of cerebrovascular accidents, if any, and the geomagnetic indexes;
- The relation between the cerebral vascular pathology (ischemic or hemorrhagic cerebral infarction) and the stages of magnetic storms as there are data that during geomagnetic disturbances the microcirculation parameters undergo rapid changes from increased coagulation (i.e. increased probability of thromboses) to decreased viscosity (i.e. increased probability of hemorrhages) (Gurfinkel 2004);
- The partners also plan to follow the changes in cerebro-vascular morbidity based on daily changes of solar activity and meteorology data at the time of analyses.

Project partners are:

- Space and Solar-Terrestrial Research Institute, Bulgarian Academy of Sciences, Sofia, Bulgaria;
- First Municipality Hospital, Sofia, Bulgaria;
- Space Research Institute, Russian Academy of Sciences, Moscow, Russia;
- Institute for Population and Human Studies, Bulgarian Academy of Sciences, Bulgaria and
- Central Clinical Hospital GSC Russian Railways Moscow, Russia.

### Material and Method

The focus during the first stage of the project, that is reported here, is to reveal whether there is a similarity in the pattern of changes in geomagnetic activity and cerebral vascular disturbances. If a similarity is observed any further research on the project topic will be justified. If such similarity does not exist, project goals have to be revised.

The attention of partners during the first year was on patients admitted to the neurological department of the First Municipality Hospital, Sofia. This hospital exists for more than 60 years and serves about 1/5 of the population of the capital and its surroundings.

As the aim of the project is to study at least 15 years time period, we have started the research from the beginning of year 2001. The goal for the first project period was to start creating a database describing all cerebro-vascular patients treated in the hospital. Data for a 9 year period are included in this paper.

Out of over 60000 patients admitted to the Department of Neurology of the First Municipality Hospital, for a period of 9 years, i.e. from 1.1.2001 till 31.12.2009, 18000 were hospitalized and 42000 patients were discharged for home treatment with appropriate medication. From those hospitalized only patients diagnosed for ischemic or hemorrhagic cerebral infarction, transient cerebral ischemia and dizziness were selected. The diagnosis was confirmed with up-to-date imaging procedures, such as brain computed tomography and magnetic resonance imaging. The number of patients is 6255. Collection of cases continues. The overall distribution of patients is presented in Table 1.

Table 1: Distribution of patients per year, gender and diagnosis

	Ischemic Cerebral Infarction		Hemorrhagic Cerebral Infarction		Transient Cerebral Ischemia		Dizziness	
	Men	Women	Men	Women	Men	Women	Men	Women
<b>2001-2009</b>	2253	2715	319	318	104	119	143	284

As a first step, in addition to the cases of cerebral pathology the daily sunspot number (SN) and daily F10.7 index were included in the analysis.

The daily Sunspot Number provides the longest available record of Solar activity since 1818 and is the main reference Solar index. SN represents the recurrence of intense magnetic loops visible on the Sun surface. Presently, the estimated International SN is distributed by the Solar Influences Data Center (SIDC) and is based on statistical processing of the data of a worldwide network of 86 stations from 29 countries.

The daily F10.7 index is also used to observe solar activity. This index is derived from solar radio flux at a frequency of 2800 MHz (a wavelength of 10.7 cm) and is measured in solar flux units (sfu, 1 sfu=10–22W/m<sup>2</sup>/Hz). The daily F10.7 index is observed by the Dominion Radio Astrophysical Observatory in Canada and is available for a long period dating back to the 1940s with high reliability while being nearly free of instrumental degradation (Tapping, Charrois, 1994).

### Results and Discussion

The authors have to answer of the question whether the changes of geomagnetic activity, sunspot numbers and daily F10.7 index in this specific case from one hand, and cerebral pathology, from the other, follow more or less the same pattern or are totally different. Only if the pattern is similar it is worth dedicating efforts and time in the years to come to study in details the potential correlation between human cerebral pathology and geomagnetic activity.

As our database includes such details as gender, day of admission to the hospital, precise diagnosis, it gives the possibility to compare the cerebro-vascular pathology and daily geomagnetic indexes. The results are presented graphically at Figure 1.

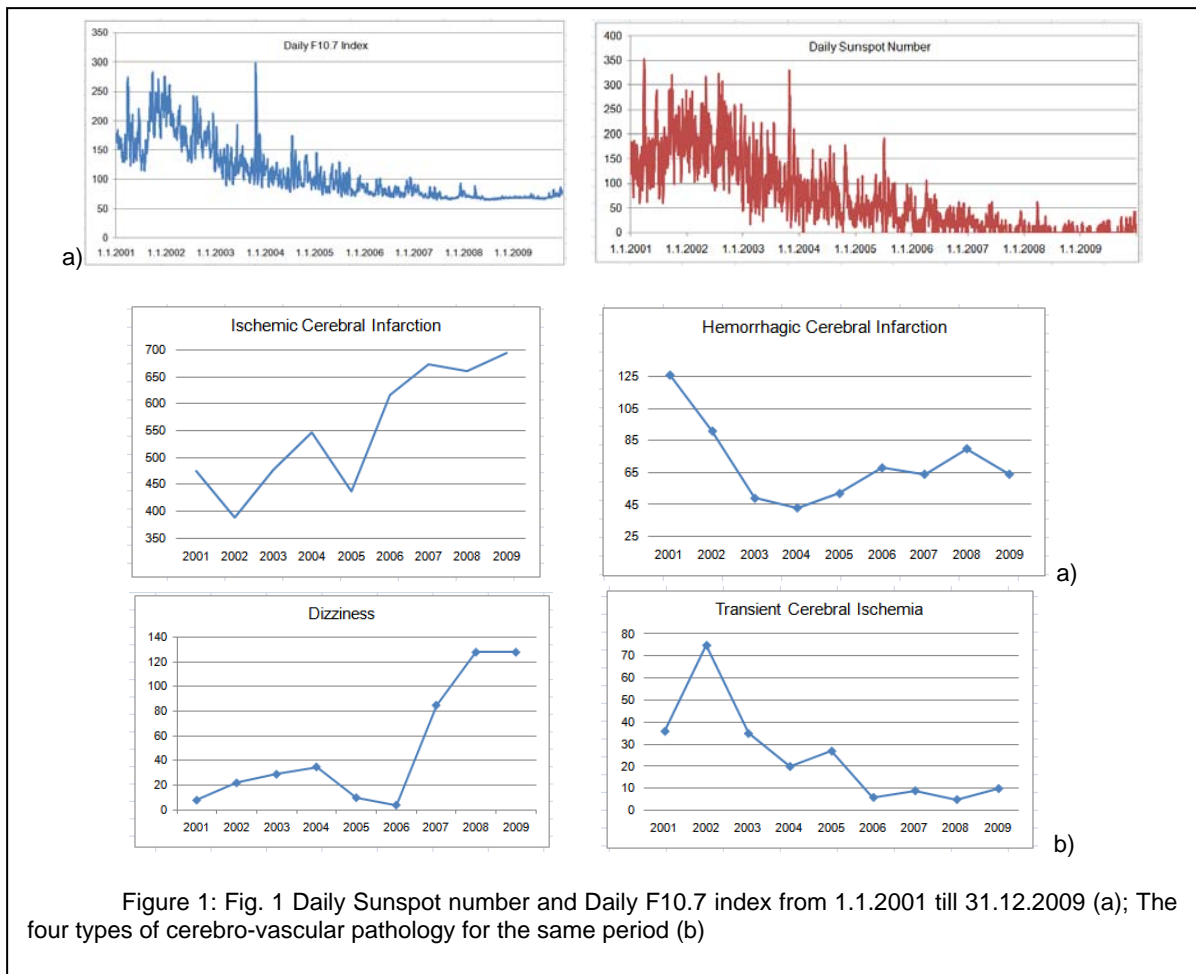


Figure 1: Fig. 1 Daily Sunspot number and Daily F10.7 index from 1.1.2001 till 31.12.2009 (a); The four types of cerebro-vascular pathology for the same period (b)

Figure 1 a) presents the daily distributions of F10.7 index and daily sunspot numbers and thus illustrates solar activity. The data used are available for free at the National Weather Service, Space Weather Prediction center website (<http://www.swpc.noaa.gov/index.html>). Figure 1 b) reveals the distribution of the four types of cerebro-vascular pathology.

Despite of the fact that the available data are not so many, i.e. covered only 9 years period, two opposite trends are revealed:

- A negative correlation is observed between the solar activity from one hand and the occurrence of ischemic cerebral infarction and dizziness, i.e. the decrease of the daily F10.7 indexes and daily sunspot numbers correspond with the increase of ischemic cerebral infarction and dizziness morbidity.
- The relationship between the geomagnetic activity and the occurrence of hemorrhagic cerebral infarctions and transient cerebral ischemia is just the opposite – with the decrease of the geomagnetic activity, the morbidity of hemorrhagic cerebral infarctions and transient cerebral ischemia also decreases.

Having in mind that these are just the first results from the project and data collection is still in progress, any firm conclusions will be preliminary. Nevertheless the partners believe that these preliminary trends will be confirmed when the data collection is finalized as the aim is to have data of cerebro-vascular morbidity for at least 15 years period.

Even at this introductory stage the partners are confident that the preliminary results will be validated. The reciprocal relationship between geomagnetic activity and cerebro-vascular morbidity has been observed in 1989–2004 by (Kováč, Mikulecký 2005). The authors revealed a significantly decreased morbidity of cerebral infarction in two periods – once in the years 1989–1992 and again in the period 2002–2003, i.e., around the peaks of the solar activity in cycles 22 and 23. Just the opposites were the results at the time of the solar minimum between cycles 22 and 23, i.e. 1996–1997 – a significant increase of cerebral infarctions was registered. Similar results were published also by Larcan et al. (1982) and Stoupeľ et al. (1994).

In sum: Based on the results presented above, it is worth continuing the research on the connections between cerebral vascular pathology and geomagnetic activity. There is no need to revise project goals.

## Conclusions

The possible connection between geomagnetic activity and cerebro-vascular pathology needs further extensive studies and verifications based on large scale samples as well as longer time of observations. As data are gradually piling up, it is rather possible that the correlations between some of the geomagnetic indexes and cerebral pathology will be confirmed, i.e. negative for such diseases as ischemic cerebral infarction and positive for others as hemorrhagic cerebral infarction. Once this is ultimately done, the mechanisms should be elucidated and should then be applied in medical practice for predicting the development of morbidity.

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