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The Impact of Solar Activity on the Greatest Forest Fires of Deliblatska peščara (Serbia)

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Abstract

The subject of research refers to potential causative-effective connection between processes on the sun and the largest forest fires in Deliblatska peščara. The four greatest forest fires in Deliblatska peščara in the period 1948-2009 were in 1973, 1990, 1996 and 2007. The analysis of solar activity, especially the solar wind data and the analysis of the fire events were used in the research of the possibility of mutual connection. There are no enough data for the fire that occurred in 1973 on the basis of which the connection with processes on the sun would be determined. The fire from 1990 developed in the conditions of intensive solar activity and it was probably caused by the solar wind. There are some indications that the solar wind from energetic region 7981 caused the largest forest fire in Deliblatska peščara in 1996. For fire that occurred in 2007, the energy source (coronary hole CH279) was determined, as well as the moving of the solar wind particles. During the investigated fires the phenomena characterising fires caused by solar wind were recorded, such as frequent wind direction changes and appearance of fire on different locations at the same time. The statistical analysis of the number of fires in Deliblatska peščara and AMO also indicated the anti-phase connection between these events. Even though the obtained results have shown the signal of the connection between charged particles and initial phase of fire, the laboratory testing is necessary to prove the mentioned hypothesis.

Key words: *forest fires, solar wind, solar activity, Deliblatska peščara*

Rezumat. Impactul activităţii solare asupra marilor incendii de pădure din Deliblatska peščara (Serbia)

Subiectul cercetării se referă la potential conexiune cauză-efect dintre procesele care se produc la nivelul Soarelui şi mariile incendii de pădure din Deliblatska peščara. Cele patru mari incendii de pădure din regiune, din perioada 1948-2009, au avut loc în 1973, 1990, 1996 şi 2007. În această cercetare, s-a avut în vedere posibila legătură dinte activitatea solară, mai ales vântul solar, şi incendiile de pădure. Nu există date suficiente despre incendiul din 1973 pe bază cărora să se determine cu exactitate conexiunea cu activitatea solară. Incendiul din 1990 s-a produs în condiţiile unei activităţi solare intense şi a fost probabil cauzat de vântul solar. Există unele indicii care arată că vântul solar din regiunea energetică 7981 a determinat cel mai mare incendiu de pădure din regiunea Deliblatska peščara din 1996. În ceea ce priveşte incendiul din 2007, a fost determinate sursa de energie (gaura coroniană CH279), precum şi deplasarea particulelor din vântul solar. În timpul incendiilor investigate au fost înregistrate fenomenele caracteristice induse de vântul solar, precum schimbări frecvente ale direcţiei vântului şi apariţia incendiilor în diferite locaţii în acelaşi timp. Analiza statistică a numărului de incendii din regiunea Deliblatska peščara şi OMA indică de asemenea conexiunea anti-fază dintre aceste evenimente. Deşi rezultatele obţinute au indicat o legătură între particulele încărcate electric şi faza initial a incendiilor, sunt necesare teste de laborator pentru a susţine ipoteza menţionată.

Cuvinte cheie: *incendii de pădure, vânt solar, activitate solară, Deliblatska peščara*

INTRODUCTION

Deliblatska peščara is situated in the south-eastern part of Vojvodina (northern province of Serbia). It is also known under the name the Banat peščara. It is elliptical in the direction NW-SE. The total area of Deliblatska peščara is about 300 square kilometres and the average altitude 138 m. The mentioned area belongs to the category of special nature reserves.

There are four types of vegetation in Deliblatska peščara: sandy, steppe, marshy and forest type. The sandy type of vegetation is characteristic for bare areas, piled up places or very rarely overgrown areas. The steppe type is the most represented and a wide diapason of floral elements can be found within this type, from semi-desert to temperate steppe or meadow-steppe ones. The marshy type is least represented in this area and can be mainly seen in peripheral parts. The forest type of vegetation is

represented by oak-linden forests (Stjepanović-Veseličić, 1979). However, the forests of Deliblatska peščara have been represented by a species used for afforestation in the last 200 years. Black locust prevails most (*Robinia pseudoacacia* L.), then Austrian pine (*Pinus nigra* Arn.) and Scotch pine (*Pinus sylvestris* L.).

Forest fires are the greatest problem for the nature protection in Deliblatska peščara. According to the evidence of the forest enterprise "Banat" from Pančevo, in the area of the forest management unit "Deliblatski pesak" (Deliblato sand), 259 forest fires were recorded in the period of 1948 to 2009 (averagely 4.18 per year). Fires occurred each year with the exception of 1980, 1992, 2004, 2006, and 2008. The total fire spread area is 11,923.5 ha in all fires in the mentioned period (averagely 192.31 ha per year), while the total fire spread area of forests 6,128.93 ha (averagely 98.85 ha per year). In this period, ground fires occurred most (88.8%), while the rest of the fires reached the canopy of pine plantations. The cause of the fires was the human factor in 64% of the cases, while the origin for 36% of the fires was not determined. At this moment, we do not have data on fires originated from arson, negligence or accident. About 86% of the fires occurred in the interval 9:00 a.m. - 18:00 p.m. The end of winter and beginning of spring, as well as summer months have been critical periods for the fires to occur in Deliblatska peščara. Almost a half of all the fires (48%) from the examined period were recorded during March and April (collectively), while about 26% of the fires occurred in the period June-September. Although most fires occurred in March and April, the fires which occurred during summer spread over larger areas and caused more damage. The largest forest fires were recorded in Deliblatska peščara in 1973, 1990, 1996 and 2007. The fire of 1973 only occurred at the beginning of spring, while others occurred in summer.

A hypothesis that the mentioned four disastrous fires occurred as the consequence of the solar activity was tried to be tested in this paper. Stevančević (2004) first indicated the possibility that the charged particles of the solar wind (SW) cause forest fires, while Todorović et al. (2005), Radovanović et al. (2007), Ducić et al. (2008), Gomes and Radovanović (2008), Radovanović and Gomes (2009), Radovanović et al. (2009), Stevančević and Todorović (2010) and Stevančević (2010) also came to significant results. According to the results of these researches, the characteristics of the forest fires caused by the SW have been the large fire spread areas and the phenomenon of hundreds and even thousands of isolated fires in some area. These fires are followed by strong winds, so that they spread very fast and they are difficult to be extinguished. Fires can be caused by the positive or negative charged particles of the SW, so that proton and electron fires can be distinguished. Generally, the mentioned results suggest the SW charged particles burn through the plant mass in certain conditions and thus cause the initial phase of the flame. The process which directly precedes the depositing of the charged particles towards the ground is in the close connection with the hydrodynamic seizing of air masses by the SW.

The existence of the connection between the atmospheric circulation and solar activity was pointed out by Radovanović et al. (2003). On the other hand, the connection between some indexes and forest fires was also determined in the USA and South-Eastern Asia. Norman and Taylor (2003) found that Pacific Decadal Oscillation (PDO) and El Niño-Southern Oscillation (ENSO) influenced fires in the pine dominated forests in the southern Cascade Mountains in north-eastern California. The fires were the most widespread when the PDO was in warm or regular phase. Schoennagel et al. (2005) ascertained that the combination of either warm or cold phases of ENSO and PDO can be brought into the connection with the increasing number of fires in the Rocky Mountains. Dixon et al. (2008) determined the existence of the significant correlation between the ENSO, PDO values and other indexes and fire variables for the state of Mississippi (USA). It is also known that the disastrous fires in Indonesia in 1997 were in connection with ENSO (Jim, 1999; Stolle and Tomich, 1999; Fuller and Murphy, 2006).

Another hypothesis in this paper has been the existence of the connection between the number of the forest fires in Deliblatska peščara and the index of the atmospheric circulation. The AMO (Atlantic Multidecadal Oscillation) index was chosen for this part of the research, for which it is supposed that could be in the statistically more significant correlation with forest fires in Europe. Having in mind the connection of the atmospheric circulation and solar activity, the eventual confirmation of this hypothesis could be considered as the evidence of the connection between the forest fires in Deliblatska peščara and the solar activity. It is emphasized in the researches that the initial phase of the fire had probably occurred due to burning of biomass by charged particles. Also, it is necessary to emphasize their assertive opinion that the simulation in laboratory conditions is needed for the

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confirmation of the mentioned hypothesis. Radovanović et al. (2005), Radovanović (2010).

DATA AND METHODS

The researches of the potential possibility that the SW is the cause of the four largest forest fires in Deliblatska peščara in the period 1948-2009 are based on the following of the solar activity in the period which preceded them. The periods of the entry of the energetic regions and coronary holes into geo-effective position were analysed. The available data of the ACE satellite were also used (structure, speed, temperature and density of the SW particles). Moreover, in the case of the fires from 2007, the satellite images were used which showed the occurrence of the forest fires in the surrounding regions (part of the Mediterranean, the Balkans).

The meteorological data were taken from the web site of the Hydro-Meteorological Office of the Republic of Serbia due to non existence of measuring station in Deliblatska peščara (Observatory Belgrade: 1973, 1996, 2007). The data for 1990 (Vršac) were taken from www.tutiempo.net. The basic data on the fire spread areas are given in the Table 1.

Table 1. Largest forest fires in Deliblatska peščara in the period 1948-2009

	March 27-29, 1973	August 30-September 9, 1990.	August 10-16, 1996.	July 24-31, 2007
Fire spread area (ha)	1,006.69	881.60	3,815.40	546.79
Fire spread area of forests (ha)	748.38	705.16	2,235.01	414.58
Fire spread area of conifers (ha)	478.05	636.11	1,557.63	333.50
Fire spread area of deciduous (ha)	270.33	69.05	677.38	81.08
Other fire spread areas (ha)	258.31	176.44	1,580.39	132.21

Source: Forest service 'Banat', Pancevo
Public enterprise 'Vojvodinasume', Novi Sad

RESULTS AND DISCUSSIONS

Before 'large' fire from 1973, nine fires were recorded in Deliblatska peščara in only six days. There were large areas under Austrian pine and Scotch pine plantations near the locality where the fire was ascertained on the 27th of March. The wind was changing direction occasionally and the fire spread towards the north and south. The fire spread over 3 km long and 2 km wide area at almost 13:00 p.m. In the meantime, large number of people came to the place of fire (employed in the forest enterprise, firemen and inhabitants of surrounding villages). In the afternoon hours, the gusts of wind called košava (it blows across Serbian plains) became stronger, seizing the fire balls and throwing them 30-50 meters ahead and thus spreading the fire more rapidly. The night was used for the fire extinguishing and on the 28th of March 1973 the fire was brought under control at 1:00. During the night smaller fires were being extinguished and unburned stumps and separate trunks throughout the following night. About 4,500 people were engaged and the machinery used in the fire extinguishing (Sekulić and Šljivovački, 1975).

According to data from the observatory Belgrade, the mean daily air temperature was 13.8°C, the maximum 19.5°C and the minimum 9.4°C on the 27th of March. At 7:00 a.m. 10.2°C was recorded and 19.0°C at 14:00 p.m.

The hypothesis that the SW charged particles caused this fire cannot be completely examined due to the lack of the corresponding satellite data. However, there are some elements which indicate that possibility. The assumptions that workers caused the fire were not proved. Therefore, the cause of the fire remained unknown. The total fire spread area was 1,006.69 ha, although 'only' 13.5 hours passed from the time when the fire was noticed until its bringing under control. The occurrence of 9 fires in six days immediately before the 27th of March points out to the SW (large number of fires in short period of time).

"Fire balls" which contributed to the fire spreading were particularly interesting. The similar phenomenon was seen in 1871 in the fire which spread over Peshtigo (USA). The case has been known by a large number of casualties in this fire (http://www.peshtigofire.info/).

Nevertheless, we are not able to make an adequate analogy between the processes on the sun and the origin of large forest fire from 1973 due to the lack of data.

The fire from 1990 was noticed on the 30th of August at 15:45 p.m. on the locality "Kajtasovački vinogradi" in the compartment 474, near the forest border. This part of Deliblatska peščara was under large areas of pine plantations. According to data from the meteorological station Banatski Karlovac, the air temperatures exceeded 33°C, while the relative air humidity was below 30%. About 20 days before the fire occurred, there had not been rainfalls. The fire became weaker during the first night, but almost around 5:00 a.m. it became again strong at several places. In the period of 8:00 to 11:00 a.m., it was extinguished by helicopters. The

wind blew 4-5 m/sec, often changing direction. The head of the fire extended in length of 2.5 km. The helicopters came back at almost 18:00 p.m. and planes also joined the fire extinguishing. The next day (the 1st of September), a large number of people were engaged in extinguishing and helicopters and airplanes were used again. Even above that, wildfires blazed up on several locations at 13:30 p.m. The fire was brought under control at late afternoon hours. The following day (the 2nd of September), the fire was brought under control at evening hours. Fires burned up to the 5th of September at some places (according: "Report and analysis on the fire in Deliblatska peščara", FE "Banat" Pančevo, October 1990).

In the period immediately before the fire, an intensive activity was recorded on the sun. The average value of solar flux at 2.8 GHz was 222.6 sfu in August, which was close to the maximum for the 22nd cycle (Stevančević, 2004). Relatively frequent changes of the wind blowing direction were also recorded in this case. Frequent intensification of the fire and breaking out of new ones in irregular intervals also indicate the pulsation of the SW. The concrete determination of the analogue connection between the charged particles ejecting from the sun towards the Earth and the time of the origin of the initial phase of the flame has been considerably impeded by the lack of adequate satellite data, as in the previous case.

In the summer 1990, almost the same time as large fire, catastrophic fires occurred on Athos peninsula in Greece, the worst ever recorded in this area. The fires burned two weeks and spread over about 1,500 ha of chestnut forests and bush vegetation. The fire spreading was also contributed by strong winds (Dimitrakopoulos and Sakelaridis, 1990). Dimitrov and Jurčec (1991) mentioned long dry period in the spring and summer of 1990 and larger forest fires which occurred on the Croatian coast. The fires were occurring in the second half of summer, while several were ascertained at the end of August and the beginning of September (e.g. the 28th of August-Trogir and the 4th of September-Brač).

The fire from 1996 was registered on the 10th of August at 10:40 a.m. in the southern part of Deliblatska peščara on the locality of Vrelo, section 54 and in pine stands. The fire spread rapidly towards north-west. It soon broke out the first line of defense which was formed on the forest road between the forestry services "Vrelo" and "Topila" line (compartments 53 and 54). The fire was decided to be extinguished by helicopters and airplanes due to large areas under pine plantations. However, extinguishing from the air started three days later. The second day of the fire (the 11th of August), the destructive power of fire spread so much that the second line of defense had to be formed. Many people were arranged along the road with fire engines and hard machinery. However, this line of defense was broken out, too. The fire spread towards north-west and north-east rapidly. It was brought under control on the 14th of August by effective extinguishing from helicopters and airplanes. It rained the next day and the day after which brought to complete fire extinguishing (Munćan et al., 2004).

Having in mind that the fire from 1996 has been the largest one ever recorded in Deliblatska peščara, a survey of air temperatures, as well as relative humidity was given in the Table 2 for the period before, throughout and after the fire. Bold values in the table refer to the period of the fire duration.

Table 2. Air temperatures (maximum, minimum and mean) and mean relative air humidity from observatory Belgrade for the period of the 3rd to 21st of August 1996

Date	Air temperature (°C)			Mean relative air humidity (%)
	max	min	mean	
3	33.7	21.0	28.2	59
4	27.4	18.6	19.8	78
5	24.8	15.2	19.8	68
6	26.3	14.8	21.4	56
7	28.3	15.7	23.0	56
8	25.6	17.7	21.7	63
9	26.9	17.4	21.7	55
10	**28.5**	**13.8**	**21.9**	**55**
11	**30.8**	**17.4**	**24.0**	**41**
12	**26.8**	**20.8**	**23.4**	**48**
13	**29.2**	**21.2**	**24.5**	**50**
14	**29.9**	**18.0**	**24.6**	**54**
15	**30.3**	**19.4**	**23.0**	**70**
16	**22.0**	**17.5**	**19.2**	**85**
17	24.2	15.4	19.2	77
18	21.1	15.9	17.9	85
19	23.9	16.9	19.1	80
20	26.8	15.0	20.5	70
21	27.1	14.1	21.0	69

Source:http://www.hidmet.gov.rs/ciril/meteorologija/klimatologija_godisnjaci.php

According to the Observatory Belgrade data for the 10th of August, the air temperature was 17.3 °C at 7:00 a.m., while 27.5 °C at 14:00 p.m. It turned out that at the time when fire was registered (10:40), the air temperature was not extreme in the surroundings. During the fire, air temperature exceeded 30°C only on the 15th of August. However, fire was not spreading that day since it was brought under control previously.

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The fire spread wood mass was 247,206 m^3 (230,895 m^3 of conifers and 16,311 m^3 of deciduous). This fire spread over the areas of all structures in Deliblatska peščara. The area of fire, observed by outer borders, was nearly 7,000 ha. However, the fire bypassed some parts within the area, and it broke off at some places.

It was determined by the analysis of the solar parameters that the energetic region 7981 was on the visible side of the sun at the beginning of August (Fig. 1).

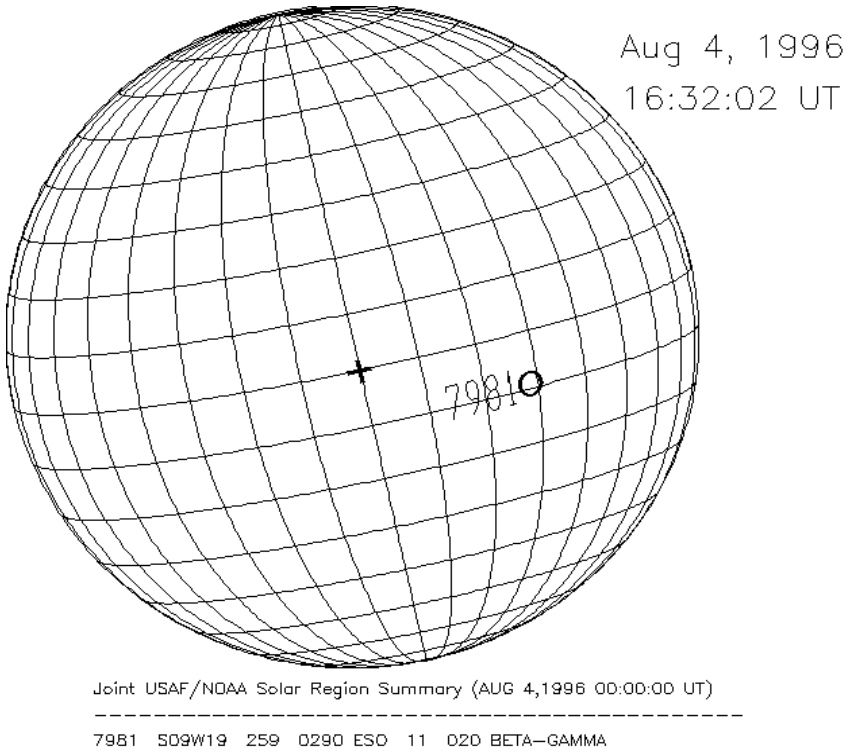

Fig. 1. Position of energetic region 7981 on the sun on August 4th 1996 (the site from which the image was taken is not in the function due to the operation stoppage of the satellite)

The region 7981 entered the geo-effective position on the 4th of August and in the following days it emitted the strong SW towards the Earth. The temperature of electrons was about 600,000 °C.

The magnetic structure of the sources of energy (beta-gamma) and the temperature of particles indicate that there is a possibility that electrons in the structure of the SW can be the cause of the largest forest fire in the recent history of Deliblatska peščara. Moreover, the fire area was elongated, which is typical for the fires caused by electrons. The length of the fire spread area was 19.5 km, while width was different, from 1 km in the north-west to 5 km in the central part. The frequent changes of the wind blowing directions were also noticed throughout the whole fire, as well as breaks out of new fire areas in irregular time intervals.

The fire from 2007 was noticed between 21:30 and 22:00 p.m. on the 24th of July in the area of Forestry Management Unit Bela Crkva (compartment 471, department a, Sokolica region) in the artificially grown stands of Scotch pine (*Pinus sylvestris* L.) of about 40 years of age. The fire first seized the tree-tops and spread over the surrounding sections, which was contributed to a great extent by strong wind of changeable direction. Problems with wind of changeable direction and intensity continued, so that fire got into the fenced area of the hunting ground (compartments 428 and 429) and spread over a lumber store, too. In the meantime, the number of people engaged in extinguishing was enlarged so that it was brought under control at around 18:00 p.m. Nevertheless, the next morning (the 26th of July) fires occurred on several locations. Further spreading was prevented by effective intervention in the lines of defense. Late in the afternoon the wind speed decreased so larger interventions were not necessary during the night. The following day (the 27th of July) fires occurred at several locations but they were brought under control. At around 15:00 p.m. fire extinguishing began by airplane, which dropped 40 tons of water on the fire spread area. During the 28th of July the number of engaged people on extinguishing gradually decreased and duty was

introduced which lasted to the 31st of July when it rained (Gomes et al., 2009).

According to data from observatory Belgrade, the maximum air temperature was 43.6 °C on the 24th of July, however the fire broke out between 21:30 and 22:00 p.m. (it was 29.8 °C at 21:00, while relative air humidity was 36%).

It can be seen from the Fig. 2 that the coronary hole CH 279 was in geo-effective position on July 21st 2007.

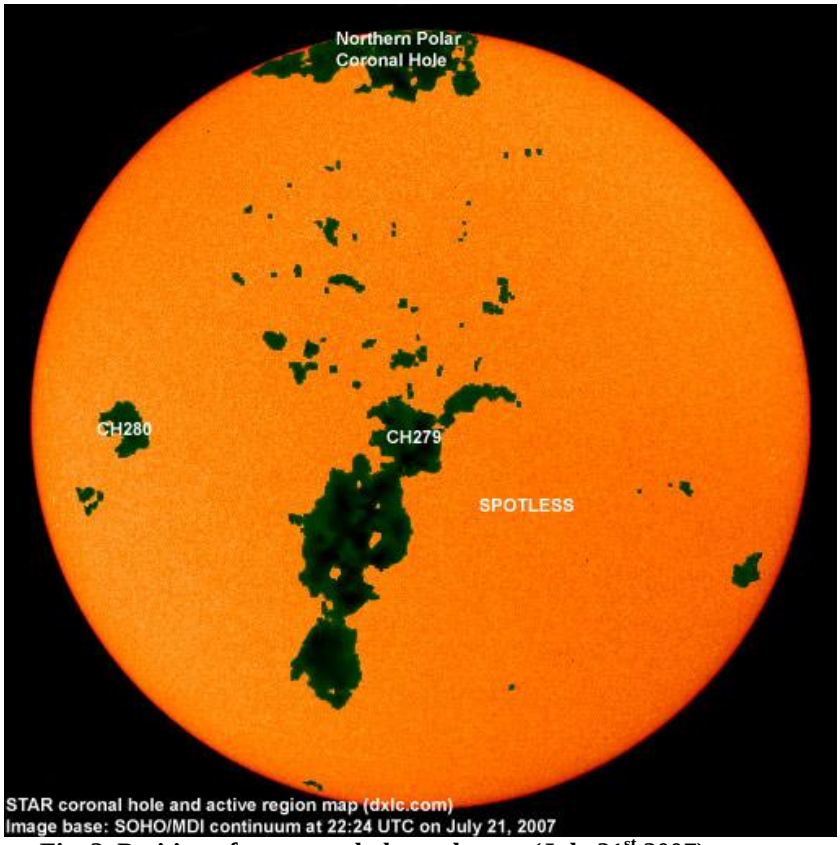

Fig. 2. Position of coronary hole on the sun (July 21st 2007) (http://www.dxlc.com/solar/index.html)

Coronary mass ejections (CMEs) from the coronary holes and /or energetic sources which are in geo-effective position are by rule followed by the striking wave of the SW particles in the interplanetary space (Fig. 3).

Instruments which measure the speed of the SW particles on the satellite detected clearly the influx of energy aimed towards the Earth. In this case, the parameters of temperatures and speeds of particles are not characterized by too high values (in comparison with cases analysed by Gomes and Radovanović, 2008) and almost do not indicate the potential danger from fires in vegetative cover.

However, this cannot be said for density of particles (90 p/cm3 approximately – Fig. 4). Moreover, it can be noticed that there is a delay in the maximum speed of the SW in relation to the maximum density of particles for about one day.

If the previous three figures are compared, the temporal coincidence of the striking wave of the SW particles and geo-magnetic disturbance on Earth can clearly be noticed (Figs. 3, 4, and 5). Simultaneously with fires in the area of the Mediterranean, the fires also occurred in the area of Manitoba (Canada). The connection between these events was explained by Radovanović et al. (2009).

While examining the connection between fires in Deliblatska peščara and AMO, Pearson's correlation coefficient was applied to annual data, as well to moving decadal values.

The statistical analysis by seasons showed the highest antiphase correlation throughout the summer months for moving decadal values ($r = -0.612$), statistically significant at $p = 0.01$ (Fig. 6).

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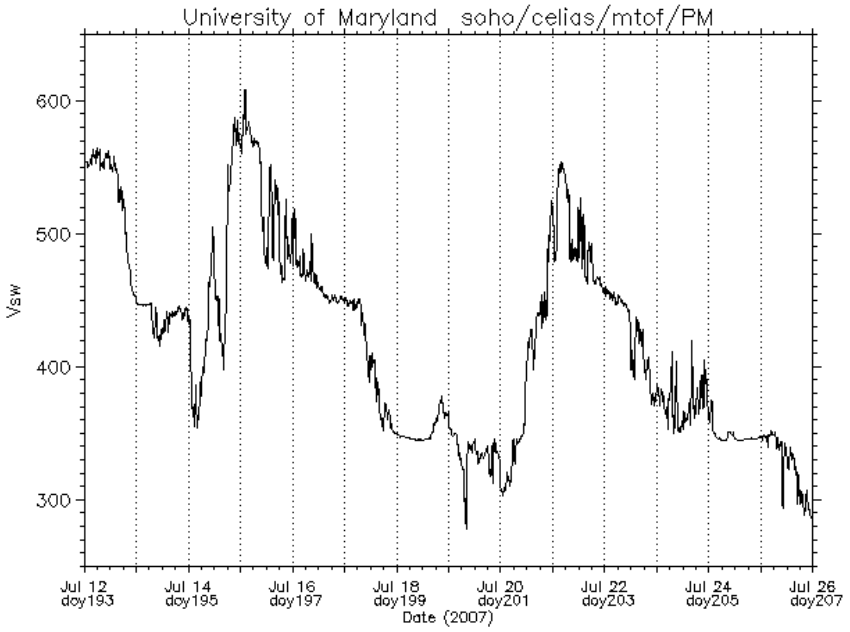

Fig. 3. Speeds of protons reached approximate values of 550 km/s at the beginning of July 21st 2007 (http://umtof.umd.edu/pm/crn/)

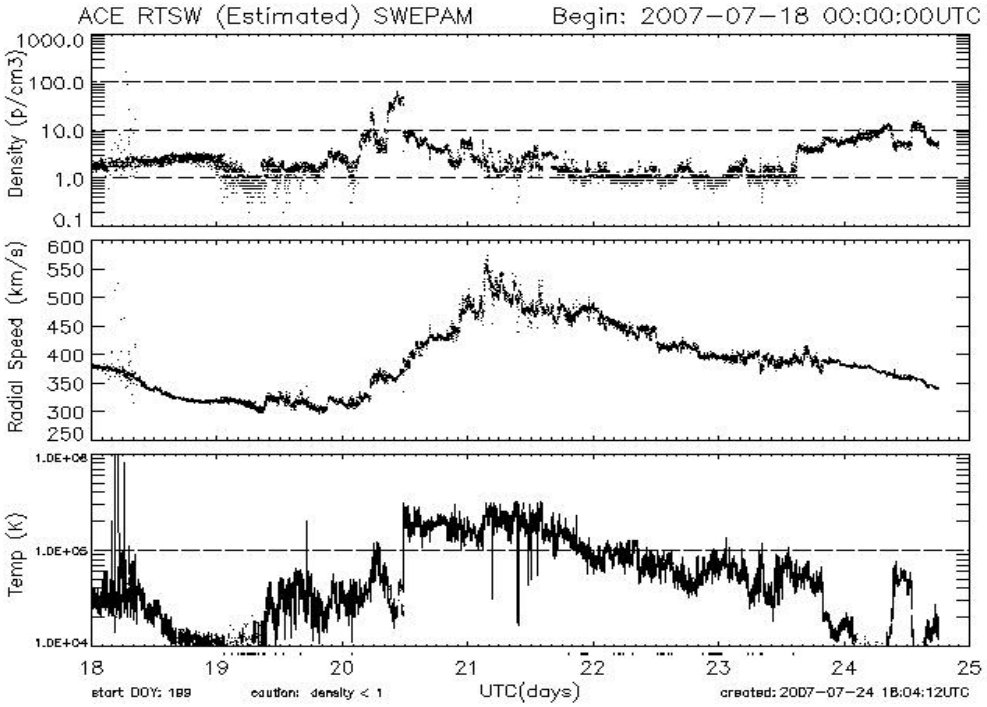

Fig. 4. SW parameters: density of particles, speed and temperature show sudden increase on July 20th 2007 (http://umtof.umd.edu/pm/crn/)

The connection is weaker in other cases: spring – 0.32, autumn –0.417. Possible connection between the mentioned processes was also noticed by other scientists. "Years of extensive fires are related to extreme drought conditions and are significantly related to the La Nina phase of ENSO, the negative (cool) phase of the PDO, and the positive (warm) phase of the AMO. The co-occurrence of the phase combination of La Nina-negative PDO-positive AMO is more important to fire occurrence than the individual influences of the climate patterns" (Sibold and Veblen, 2006). Similar thoughts had Schoennagel et al. (2007): "There is a mounting evidence that the recent shift to the positive phase of the AMO will promote higher fire frequencies in high-elevation western U.S. forests."

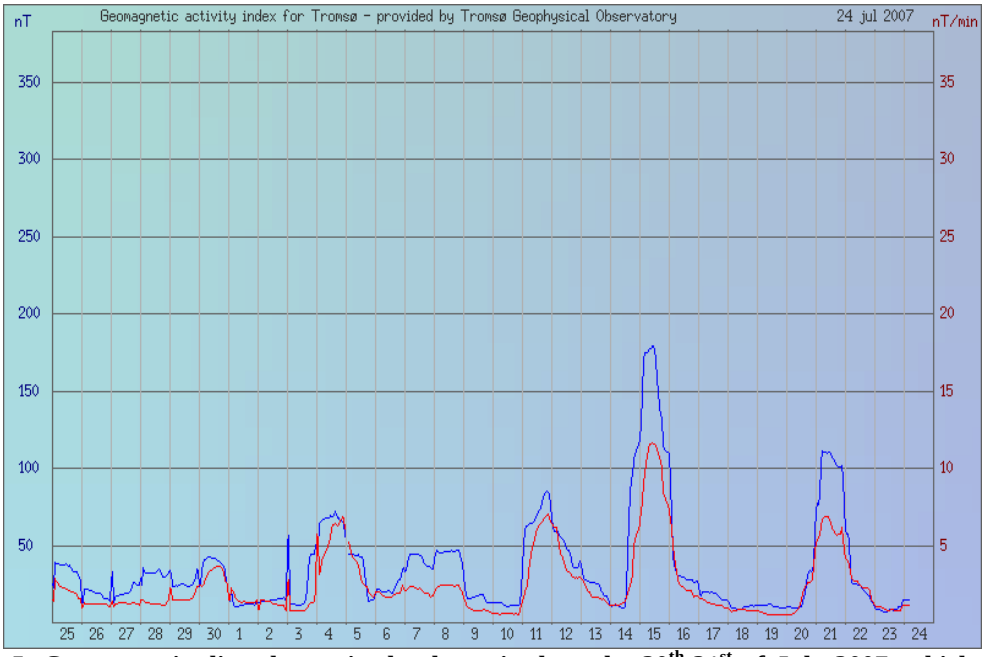

Fig. 5. Geomagnetic disturbance is clearly noticed on the 20th-21st of July 2007, which also indicates the temporal coincidence with the phenomenon of coronary hole in the geo-effective position (http://flux.phys.uit.no/ActIx/)

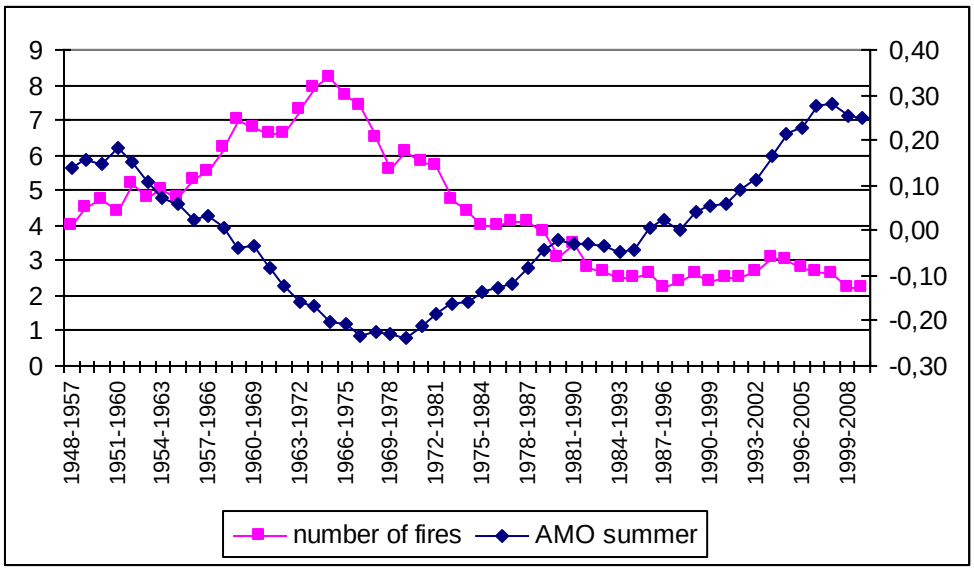

Fig. 6. Correlation of (movable decadal values) AMO (summer) – annual number of fires in Deliblatska peščara (1948-1957 to 2000-2009)

CONCLUSION

There are not enough elements, due to the lack of data, to make a clear enough conclusion that the SW caused the forest fire in Deliblatska peščara in the period of 27th-29th March 1973. However, the size of the fire spread area, strong wind of changeable direction and the phenomenon of 9 fires in six days immediately before this fire are leading to this conclusion.

The forest fire of the 30th of August to the 5th of September 1990 occurred in the period of the intensive solar activity. The average value of solar flux at 2.8 GHz was 222.6 in August, while there were 201 sunspots on the visible side of the sun. That year the largest number of strong proton winds was recorded with the temperature of over 1,000,000 ºC. The shape of the fire spread area (irregular, round) is characteristic for proton fires. Throughout this period, frequent changes of the wind blowing direction were also recorded, as well

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as breaking out of the new fire areas. The dynamics of fires, size of the fire spread surface and duration also fit in the assumption on the SW as the potential cause. Even though this fire has been the largest one ever recorded in Deliblatska peščara, in the time of its occurrence the air temperature was not extremely high.

The largest forest fire in recent history of Deliblatska peščara (August, 10^{th}-16^{th} 1996) was in the temporal analogy with the inflow of the SW energy from energy region 7981. The mentioned region entered the geo-effective position on the 4^{th} of August. The form of fire (length-19.5 km, width-1-5 km) was characteristic for fires caused by electrons. The dynamics of fire, the size of fire spread surface and its duration also fit in with the assumption on the SW as potential cause. Even though this fire has been the largest one ever recorded in Deliblatska peščara, the air temperature was not extremely high in the time of the fire occurrence.

In the case of the fire from 2007 (July 24^{th}-31^{st}), the coronary CH279 hole was the source of energy on the sun which entered the geo-effective position on the 21^{st} of July. The speed of protons was around 550 km/s, while the density of particles around 90 p/cm^3. In the time of striking of the SW particles, geo-magnetic disturbance was also recorded. Many fires were recorded in the area of the Mediterranean in the period that followed.

The statistical analysis of the number of fires and AMO also indicated the anti-phase connection between these events. Thus, the indirect indications are that the SW could be the cause of not just fire occurrence for which the causes have not been known, but hydrodynamic air mass seizing, too. On the basis of presented results we are of opinion that the future researches can be aimed at three basic directions.

- The first one is connected with the establishing of the chronological connection between forest fires and processes on the sun on statistically satisfied number of samples.

- The second one relates to experimental laboratory researches that could at least approximately simulate the conditions for which there is a conviction that can be responsible predisposition to the phenomenon of the initial phase of fire.

- The third approach is about astrophysical phenomena and processes which need a detailed parameterization as well as specific study of the particle penetration mechanism from space toward Earth's surface i.e. stand of forests.

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