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ELECTRONS OR PROTONS: WHAT IS THE CAUSE OF FOREST FIRES IN WESTERN EUROPE ON JUNE 18, 2017?

*Milan Radovanović***[1], João Fernando Pereira Gomes***, Anatoly A. Yamashkin****, Milan Milenković*, Milan Stevančević******
* Geographical Institute "Jovan Cvijić" SASA, Belgrade, Serbia
** South Ural State University, Institute of Sports, Tourism and Service, Chelyabinsk, Russia
*** Àrea Departamental de Engenharia Química do Instituto Superior de Engenharia de Lisboa (ISEL), Lisbon, Portugal
**** Faculty of Geography, N.P. Ogarev Mordovia State University, Saransk, Russia
***** ex Federal Ministry of Telecommunications, FR Yugoslavia, Belgrade, Serbia

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Abstract: Forest fires in Portugal (June 17–24, 2017) destroyed 64 lives and caused considerable material damage. The coronal hole CH807 and the energy region S5710 were in the geoeffective position on the Sun immediately before the outbreak of fires. In the period that preceded it, as well as at the time of the fires, increased values of the solar wind (SW) parameters (temperature, speed and density of particles) were recorded. In addition, a geomagnetic disorder was recorded. The shape and size of the burning areas, as well as the low air pressure over Portugal indicate the possibility of the effect of positively charged particles that came from the area south, i.e. southwest of Portugal. Nevertheless, it is a specific case that would have to be investigated in more detail.

Key words: forest fires, solar wind, solar activity, Portugal

Introduction

Catastrophic fires in the central part of Portugal occurred almost simultaneously in the afternoon on June 17, 2017. In these fires, 64 people were killed, while 204 people were injured. The largest number of dead was recorded in the area around Pedrogao Grande in the district of Leiria. The burned area was about 45,000 ha, and lightning strikes were mentioned in the media as potential causes. This series of fires lasted until 24 June[2].

According to the European Commission, Portugal is the most vulnerable country in Europe when forest fires are concerned. In the period 1980–2015 there were 656,437 fires, while the total burned area was 38,121 km^2. The largest damage

[1] Correspondence to: m.radovanovic@gi.sanu.ac.rs
[2]https://en.wikipedia.org/wiki/2017_Portugal_wildfires

was recorded in 2003 when a total of 4,257 km^2 was affected by fire (San Miguel-Ayanz et al, 2016). The main fire season in Portugal is during the summer, and catastrophic fires occur mainly during thermal waves with air temperatures over 40 °C. The relationship between the number of forest fires in Portugal and the Atlantic Multiannual Oscillations (AMO) (Milenković, Yamashkin, Ducić, Babić, & Govedar, 2017) was also established. In addition to climatic conditions, a significant presence of easily combustive species of trees - pines and eucalyptuses is also the fire risk factor. Pines (*Pinus* spp.) include about 31% of the area under the forest, while the eucalyptuses (*Eucalyptus* spp.) account for 21% (FAO, 2015). It is important to note that species of the genus Eucalyptus are allochthonous species. They have been used for afforestation since the 19th century, but today they are invasive species.

Gomes and Radovanović (2008) believe that fires in Portugal are related to the activity of the Sun, that is, the SW charged particles are the cause of the fires. According to this theory, these particles can penetrate the atmosphere, reach the surface of the Earth, and cause fires by burning the plant mass (Radovanović & Gomes, 2009). In support of this theory, there is also a statistical link between the indicators of activity of the Sun and the fires in the United States (Radovanović et al., 2013; Radovanović, Vyklyk, Milenković, Vuković & Matsiuk, 2015).

This paper analyzes the possibility that forest fires in Portugal in the period 17–24. June 2017 were the result of the activity of the Sun, that is, they were caused by charged particles.

Material and methods

The research used data related to:

- activity of the Sun,
- the SW parameters (temperature, speed and density of particles) and
- motion of charged particles in the atmosphere (Radovanović & Stevančević, 2015).

It covers a period of several days before the occurrence of fires, as well as during the fires. By analogy, i.e. by monitoring the time track of the events, we tried to determine whether in this case the occurrence of forest fires is preceded by a sudden inflow of charged particles.

Results of discussions

The intense activity of the Sun was recorded on June 14, 2017 (http://www.solen.info/solar/old_reports/2017/june/20170615.html). The coronal holes CH807 and CH808 spread over a large surface of the Sun. In addition, the presence of several active regions was also recorded, of which the S5710 was potentially the most significant due to its beta-gamma structure.

The first impact of the SW particles was registered on 16 June in the afternoon, while the other was recorded on 17 and 18 June (http://umtof.umd.edu/pm/). During these impacts, a rapid rise in temperature, speed and density of particles occurred (http://www.swpc.noaa.gov/products/ace-real-time-solar-wind).

In the interplanetary space, the current field moves along the lines of the magnetic field of the Sun, and in the free atmosphere, it moves along the lines of the resulting magnetic field of the Sun and Earth. The movement of charged particles creates a convection electric current, and the emergence of electric current causes the occurrence of a magnetic field in the form of a shell that does not allow the particles to scatter.

The current field represents the space in which the SW charged particles move. It occurs in the interplanetary space and in the free atmosphere on Earth and carries energy from the Sun. The current field in the atmosphere of the Earth has an inductor through which it is powered by energy from the interplanetary current field. It performs spatial distribution of matter and energy of the Sun in the Earth's atmosphere and moves under the action of the force of the amount of the SW particles movement (Gomes et al, 2012).

In its motion, the current field disperses electrons right of the radial direction (the positively charged particles go left). Electrons in the form of jet with a certain circulating velocity have the ability to propagate at long distances. In the northern hemisphere they create wind turbines with a counter clockwise direction. According to this hypothesis, Portugal found itself exposed to the action of several electron jets that caused fires.

Figure 1 shows the locations of the fires, and the wind direction can be seen based on smoke.

According to the figure shown, the shape and arrangement of the fires are not typical of fires caused by electrons. On the other hand, in the period in which fires occurred over Portugal, there was a low air pressure field indicating the action of protons

(http://www.wetterzentrale.de/reanalysis.php?jaar=2017&maand=6&dag=18&uur= 000 &var=45&map=1&model=nws).

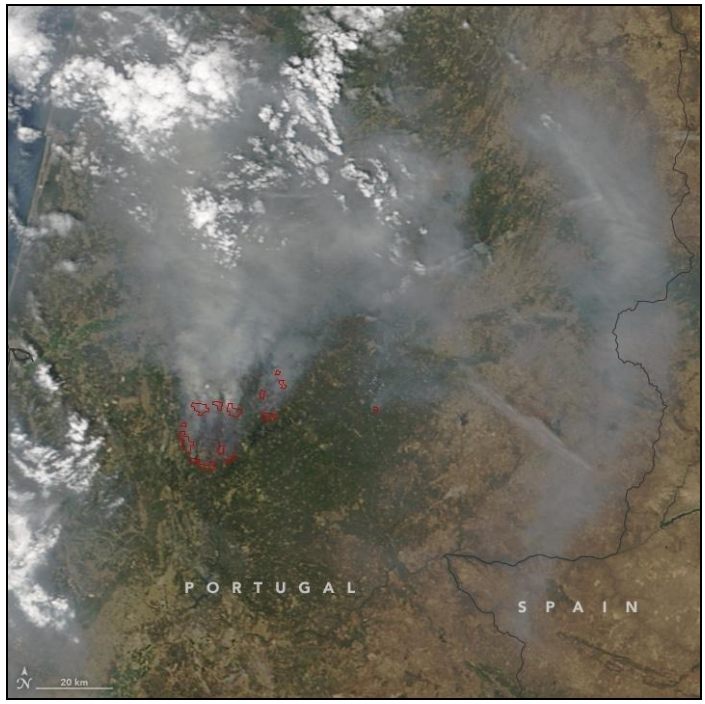

Figure 1. Satellite image of the fires in Portugal — June 18, 2017 (source: https://earthobservatory.nasa.gov/NaturalHazards/view.php?id=90423)

Nevertheless, in addition to the electrons in the investigated case, protons may also have acted. This is also indicated by the spatial grouping of sites affected by fire. Radovanović and Gomes (2009) pointed out that fires caused by protons spatially affect relatively small areas (contrary to those caused by electrons), and that in critical days such areas are under the influence of relatively low air pressure. Forest fires caused by the burning of plant mass by electrons usually include relatively large areas and relate to areas with increased air pressure. In this case, if there was a penetration of the protons to the ground, the propagation of the SW particles arrived from the area of the Atlantic geomagnetic anomaly. The investigated case is specific and it is necessary to conduct more detailed research.

Conclusion

Before the occurrence of fires in Portugal in June 2017, there were sources of energy in the form of a coronal hole CH807 and the energy region S5710 on the Sun. At the time of the fires, the SW values were increased: temperature, speed and density of particles. A geomagnetic disorder is also recorded. The time sequence of the events indicates that fires could be caused by electrons, and the electron jets came from several directions. There is also the possibility that protons may have affected in this case, which should be the subject of more detailed research.

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