UDK 504.055+ 528.8

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MONITORING OF POTENTIAL SELF-IGNITION ZONES OF THE FOREST ACCORDING TO CLOUD COVER REMOTE SENSING DATA

Abstract. *The complex analysis of the main properties of natural objects with establishment of extent of interference of their specifics and the factors causing inflaming is carried out. The dominating natural factor forming a local source of fire is revealed. Formation conditions of potential self-ignition zones are defined. The method allowing to reveal potential zones of self-ignition according to decryption of storm clouds with use of Earth sensing remote methods and to predict the probable level of a fire hazard is presented. Results of program realization of a method according to monitoring of these zones are displayed.*
Keywords: *polarization; spark discharge; organic compounds; storm clouds*

Introduction

The wildfires which are periodically passing across territories of Europe and America became an integral part of life of the population of these continents counties as of today. Fire elimination material costs are huge. As such, the fires in the State of California in 2017 put USA economies at unprecedented losses of about $27 billion. The problem of wildfires is relevant for many countries. Perfection of emergence forecasting methods and their anticipation is carried out everywhere, however, still remains the most urgent task.

The purpose of the research is the development of a prediction method for the fire hazard level of potential self-ignition zones (PZSI), earlier unknown. The PZSI is a territory of the forest where sources of fire and combustible materials are formed by exclusively natural forces.

Main content of research

It is known that for a number of the wildfires ignition sources, those sources are usually brought to the forest territory from the outside (a human factor or a natural phenomenon – a lightning). The process of emergence of such fires is well studied and known. With due approach the cause and the source of the fire are established rather precisely. Therefore, they are not considered in this work.

According to this, the main accent in this article is given to the definition of the conditions forming the fire source immediately in the territory of the probable fire.

Local source of fire

According to authors, one such source can be the spark discharge. As such, around potent clouds the electric intensity can reach $E_0 = 10^4$ V/m and more. In these conditions vegetation of the wood is polarized and the process of dispersion begins with acumination from the sharp tops of the stream of charged particles (ions). At the same time, if the local field near the edge of E_{max} reaches a value, sufficient for an electrical breakdown of air, then, factually, spark discharge occurs.

So, at field strength E_0, operating between the basis of the cloud and the plant, the size of the charge of the plant and the maximum field strength at its top are respectively equal [1]

$$Q_{max} = \pi \frac{\varepsilon_0 E_0 b^2}{lg\frac{2b}{a} - 1} \; ; \; E_{max} = \frac{\left(\frac{b}{a}\right)^2 E_0}{lg\frac{2b}{a} - 1}.$$

At the same time, the energy of a spark discharge:

$$W = Q_{max}^2 / 2\,C,$$

frequency of following spark discharges:

$$f = \frac{\gamma}{\varepsilon_0},$$

where *b* and *a* is length and width (*b* >> *a*), *C* and γ is the capacitance and conduction of a plant respectively, ε_0– permittivity of vacuum, F/m.

So, for example, at $E_0 = 10^4$ V/m, b = $5 \cdot 10^{-1}$ m, a = $5 \cdot 10^{-3}$ m we get $E_{max} = 10^7$ V/m, $Q_{max} = 7 \cdot 10^{-8}$ C, W = $2{,}5 \cdot 10^{-2}$ J, f = 10^4 Hz. Thus, the plant with a sharp, pointy top can become a source of a spark discharge with electric field of a storm cloud acting on it.

Combustible materials

One of the known natural phenomena, distinctive for vegetation of the forest is the production of organic compounds in the surrounding medium which are a very flammable mixture, as it contains carbon, hydrogen, etc. [2]. Unlike traditional solid combustible materials organic compounds can easily ignite from electric sparks which energy ($0{,}3 \div 0{,}06 \cdot 10^{-3}$) J much less than that of a spark discharge of plants (10^{-2}) J [3].

The defining properties of organic compounds are:

– drains, transfer of organic compounds from one atmosphere container to another;

– conversion of hydrocarbons in aerosols;

– dispersion of aerosol particles under the influence of an electric field on the edge of plant tops;

– cuticular layer of wax containing terpenes covering the foliage.

Thus, under the favorable conditions, especially during the vegetative period, on the forest territory there can form zones, saturated with the easily igniting mix of hydrocarbon compounds.

The choice of the dominating natural factor forming a local source of fire

The PZSI is a territory of the forest, where sources of fire are formed exclusively by forces of nature. Unlike a lightning, which is brought to the territory of future fire from the outside, a local fire source arises immediately on it. The location of the lightning is visually controlled well, whereas ignition of combustible materials with such sources of fire, according to the hidden nature of this process's development, practically can't be monitored. Therefore, it is expedient to carry out their monitoring on existence of the natural factors forming these sources. The first factor – production of the gas mixture of hydrocarbon compounds by vegetation.

The second factor – storm clouds, which form anomalously high tension of an electric field on an edge of the tops of trees, leading to a spark discharge. Thus, local places of accumulation of flammable gas mixture and the storm clouds passing over them are two factors which form the PZSI with a fire source, sufficient for the ignition of hydrocarbon compounds and the subsequent inflaming of solid (traditional) combustible materials.

It is visible that storm clouds and vegetation of the wood can be the provocative factors. But vegetation is a passive factor, though constantly present. Its action can be shown only in the presence of a storm cloud – the factor, which activates the process of a spark discharge. From this it follows that only the storm cloud bearing electric charge can be the parameter which is subject to monitoring.

Program realization of the developed method of PZSI monitoring

For the purpose of research of optical characteristics of cloud cover, the program module allowing both to analyze chromatic characteristics, and to receive their statistical values was developed. Development was done in Visual Studio in C# language. The choice of language is justified by sufficient simplicity of development of Windows Applications.

The program module allows to carry out decryption of storm clouds, on the basis of color channel (RGB) brightness distribution.

The training selection consisted of the pictures of a cloudy cover received from open sources on the Internet. All processed data was divided into 2 classes: storm clouds and others. Their classification was carried out on the basis of archived data of analyzed territories weather: wildfires in the Kherson region in May, 2018 and in Zhytomyr, Khmelnitsky, Vinnitsa regions in July, 2013. At the training stage in the interactive mode, cloud cover zones were highlighted and distribution of brightness of spectral ranges histograms were constructed.

On the basis of injected data, contrasting with use of a histogram normalization method was carried out. When normalizing the histogram on maximum interval, the change of brightness from 0 to 255 doesn't "stretch" for the full range of the current image brightness values, but only its part representing the most informative site. Thus, peaks of the histogram display those levels of brightness, which prevail in the image of the studied cloud cover. The same areas where level is low on the histogram, correspond to brightness values which occur in the image very rarely and

they can be left out of the stretching range. The essential stretching of the histogram was achieved by the exception of the 5% of extreme brightness values, i.e. increase in contrast.

From the obtained data the conclusion follows that the storm cloud of 2013 is non-uniform, because it has a set of local extremums, and the storm cloud of 2017 was homogeneous.

It is known that if the cloud is homogeneous, it tells us about a big density of charges in it, which leads to an increase in probability of emergence of fire in this territory. It is confirmed with the example of a wildfire in May, 2018. On the contrary, in 2013 the density of storm cloud charges was less and insufficient for an emergence of wildfires on the storm cloud route.

Forest PZSI monitoring method

The method is based on monitoring of the chosen meteorological parameters received from ASE (artificial satellites of the earth), differing from the known ones in that, for the purpose of fire hazard assessment, the storm clouds are diagnosed by their ability to activate the process of creation of local sources of fire.

The decision making to reference a cloud cover as a storm is carried out on the basis of existence of multiple local extremums of spectral subrange brightness histograms. Origin of local sources of fire is determined by the maximum change gradient of brightness levels. In this case the cloud is uniform and has the maximum density of charges. Formation of the PZSI can undergo starting from the beginning and after (1–2 days) the passing of cumulus clouds over the controlled territory of the forest. The period of monitoring is defined by the time of PZSI formation processes.

Conclusions

According to the research results, the relationship of storm clouds with the PZSI formation processes, where the source of the fire is formed only by forces of nature, is established. It is shown that PZSI monitoring according to remote sensing data is a basis for expeditious gathering of estimates, which involve current observation subject state and the fire hazard level prediction. Need of further collection of material and its analysis together with the poorly studied "indirect" factors causing forest sites self-ignition is obvious.

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Text of the article was accepted by Editorial Team 02.10.2018

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МОНІТОРИНГ ПОТЕНЦІЙНИХ ЗОН САМОЗАЙМАННЯ ЛІСУ ЗА ДАНИМИ ДИСТАНЦІЙНОГО ЗОНДУВАННЯ ХМАРНОГО ПОКРИВУ

Анотація. Проведено комплексний аналіз основних властивостей природних об'єктів із встановленням ступеня взаємного впливу їх специфіки та чинників, що викликають займання. Виявлено домінуючий природний фактор, який формує локальне джерело вогню. Визначено умови формування потенційних зон самозаймання. Представлений метод дозволяє виявляти потенційні зони самозаймання за даними дешифрування грозових хмар з використанням методів дистанційного зондування Землі і прогнозувати можливий рівень пожежної небезпеки. Показані результати програмної реалізації методу за даними моніторингу цих зон.

Ключові слова: поляризація; іскровий розряд; органічні сполуки; грозові хмари

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