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APPLICATION OF AEROSPACE METHODS FOR MONITORING OF FOREST FIRES AND EVALUATION OF BURNED AREA IN HASKOVO REGION IN THE SUMMER OF 2011

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Abstract

The most significant forest and field fires in Haskovo region in the summer of 2011 are looked through. Information about physico-geographic characteristics of the area, land cover, etc. are gathered and analyzed in GIS. The location and the area affected by the largest fire are being determined based on sattelite data. An analysis of the affected area is done.

Introduction

Haskovo region is situated in the East part of South Bulgaria. It has an area of 5534 km^2 that is 5% of the country area. In the region there are 261 urban places, arranged in 11 municipalities - Haskovo, Dimitrovgrad, Svilengrad, Lyubimets, Harmanli, Madzharovo, Simeonovgrad, Ivaylovgrad Topolovgrad, Mineral Baths and Stambolovo. The municipality borders are: the districts of Plovdiv, Stara Zagora, Yambol, Kardzhali. In the South-East region it borders with Greece and Turkey. The region is crossed by the railway line Sofia - Istanbul and the highway “Trakia”.

The territory of Haskovo region covers the southwestern ridges of the Sakar Mountain and the northern parts of the Eastern Rhodopes. Though the region flow the rivers Maritsa, Arda and Sazliyka. There are hot springs and balneological resorts in the area of Haskovski Mineral Baths and Merichleri, in Simeonovgrad and Dolno Botevo.

The terrain is hilly. As a northern extension of the Eastern Rhodopes the area was named the Eastern Rhodopes foothills step or Haskovo hilly area. The highest point is Mechkovets - height 860 m asl. The region offers good conditions for the development of cultural, rural and eco-tourism.

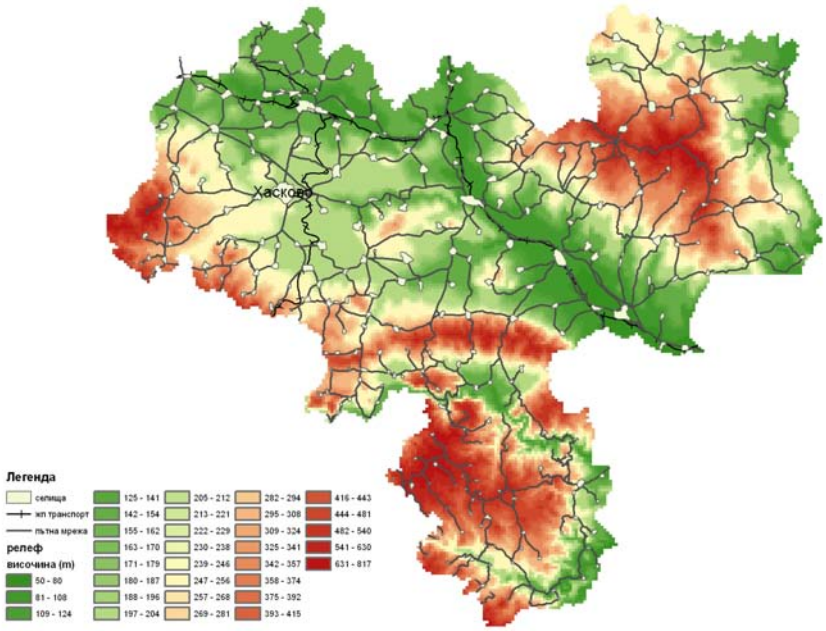

Fig. 1. Thematic map of the terrain and road network of Haskovo

The climate in the municipality is temperate continental with a strong Mediterranean influence. That influence results in higher average annual temperatures and causes a significant shift of the main precipitation minima and maxima. The absolute value of the maximum temperature is considered to be one of the most generous in the country.

The average annual temperature in the valley and lowland areas is 12 °C and in the Eastern Rhodopes is 13 °C.

The biodiversity within the region is extremely rich. The Eastern Rhodopes are notorious for many protected areas inhabited by rare animal and plant species and is recognized as an Important Bird Area and an area with the highest biodiversity (such as types and numbers) in Europe. There were registered 25 species of orchids and more than 300 species of birds.

Here is one of the three natural breeding colonies of vultures in Europe and the largest number of breeding pairs of black storks.

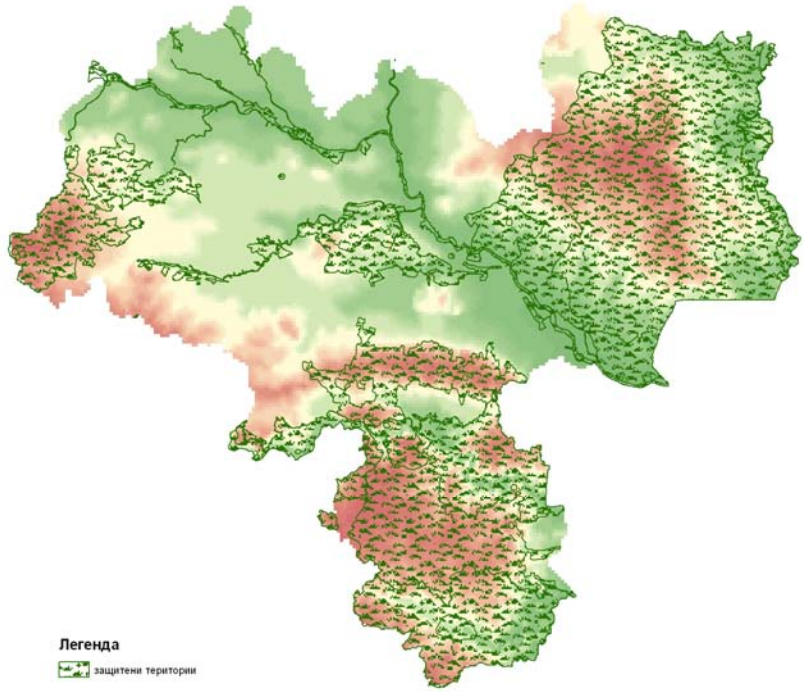

Fig. 2. Thematic map of the protected areas in Haskovo

According to the Law for the Protection of Nature in the territory of Haskovo region there are the following categories of protected natural areas: 1 reserve, 1 maintained reserve, 24 historic places, 28 natural monuments, 21 protected areas; 119 old trees.

This area includes 25 zones of the European ecological network NATURA 2000.

The number of fires and the scale of the destroyed areas in recent years have reached critical levels and have no equivalent in the history of forestry in Bulgaria. The data show that in regard to the indicators of traditional possibility of forest fires in Bulgaria the rates have reached and even exceeded many times the average level, typical for the Mediterranean region. For example, in the year 2000 the area of the burned territory is about 100 times greater than that in the early 90's.

The largest fire in recent years in Bulgaria is that on August 2007, in municipalities Topolovgrad and Svilengrad. The fire began on August 25 between the village of Srem and Ustrem and destroyed 15000 hectares of forest area. The fire passed through the villages Radovets, Prisadets, Varnik and Filipovo.

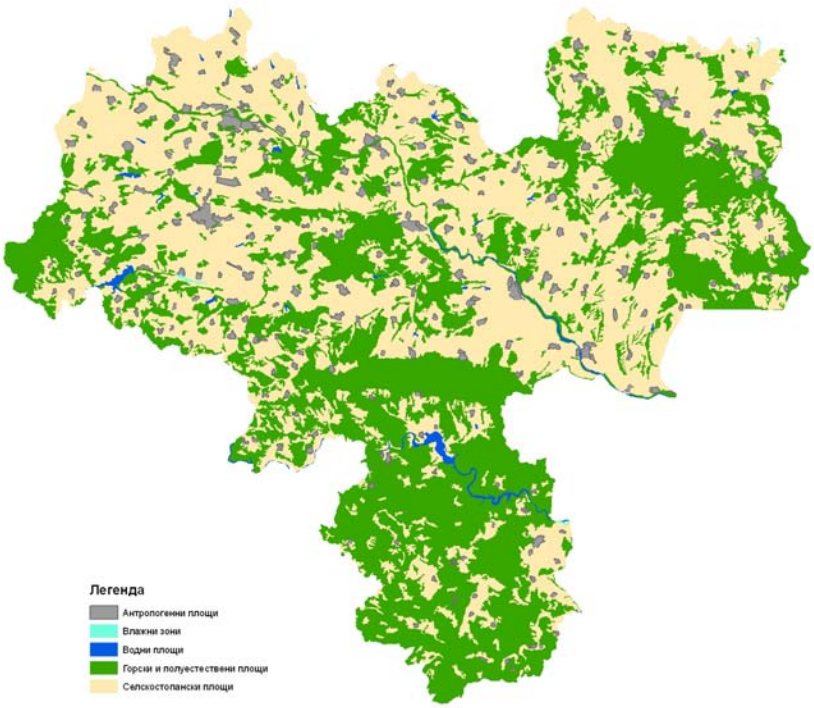

Fig. 3. Thematic map of land cover in Haskovo

Methodology for studying the dynamics of fires based on satellite data

The fire detection is performed using spectral channels of MODIS (4-11 μm) of temperature brightness. The fire detection procedure is based on absolute fire detection, if it is strong enough, or on detection of objects close to the fire, which is associated with changes in the surface temperature. To improve the visual images they are presented in pseudo colors.

Aqua and Terra satellites provide 4 images for 24 hours. Data from MODIS can be used to monitor the burning stubble, specify the type and

condition of the vegetation, the smoke aerosols, water vapor and clouds, which serves as a comprehensive monitoring of the fire development and its impact on ecosystems, the atmosphere and climate.

This information can be used to monitor the spatial and temporal distribution of the fires in different ecosystems, detect changes in their distribution and determine their new boundaries and intensity.

The described methodology is based on satellite data from the system MODIS, that have high spectral, temporal and radiometric resolution, and meet the requirements of objective and accurate assessment of fire dynamics. The satellite data parameters of MODIS system are:

- temporal resolution – 2 times in 24 hours for each satellite;
- spatial resolution – 250–2000 m;
- spectral resolution – obtaining hyperspectral data from 36 spectral ranges;
- radiometric resolution – 12 bits.

For processing of forest and field fires in Haskovo region in the summer of 2011 in GIS environment layers are created, that contain:

- Digital Elevation Model
- Urban areas
- Road Network
- River Network
- Vegetation Index
- Protected Areas
- Fires Location

Two satellite images are presented for each moment. The first image is entirely in the visible range (channels 143) and the second one is a combination of channels in the visible and infrared range (channels 721).

In the first satellite image is better to observe the area covered by the smoke and its density, and in the second image type is seen the outbreak of the fire and also the already burned areas. The spreading smoke is less visible, because in the higher atmosphere layers it cools and is not visible in the infrared channels.

The darker and in brown colored spots are already burnt areas and their size can be measured.

Forest and field fires in Haskovo region in the summer of 2011

Code red, which is the highest level of risk for the occurrence of forest and field fires was announced from 12.07.2011 in Haskovo. The decision is related to the permanent increase in the temperatures over 35 degrees.

The largest fire in the country for that summer is the one of 14 September 2011 between the villages Vaskovo, Oryahovo and Georgi Dobrevo in Haskovo region, and it was spread to over 9000 acres.

That summer from all the fires in the area were affected more than 25000 acres of forest, shrub and farmland.

Table 1 lists the ten most significant fires during the summer of 2011. Fig. 4 shows their distribution in the observed area.

Tab. 1. List of the ten most significant fires in Haskovo region in the summer of 2011

date	**Area (acres)**	**Type area affected**	**Urban Place**
16.07	1 000	Dried grasses, shrubs and deciduous forests	Podkrepa
17.07	2000	deciduous forest	Mineralni bani
20.07	1 500	grass and shrubs	Garvanovo
26.08	50	grass	Lyubimec
27.08	100	60 - deciduous forest 40 - grass and shrubs	Hlyabovo
29.08	1 000	270 - deciduous forest	Dimitrovgrad, Merichleri
15.09	3000	Not forest land	Tatarevo, Garvanovo
	5000	farmland	Vaskovo, Oryahovo, Georgi Dobrevo
	500	100 - forest	Kostilkovo, Meden buk
Общо 15.09	12 000	grasses, shrubs and forests	
18.09	70	mixed forest	Bogomil
Full affected area		**Over 25 000 acres**	

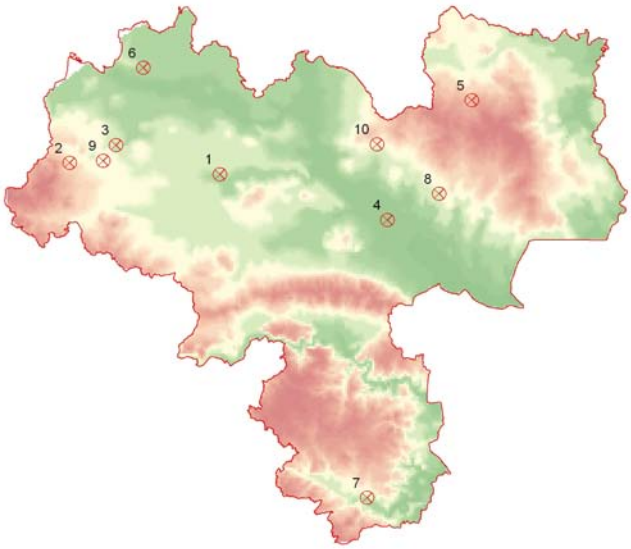

Fig. 4. Distribution of a major fire in 2011 on the territory of Haskovo

The fire from 14.09.2011 was traced through aerospace images from the satellites Terra and Aqua and they are presented in Figures 5, 6 and 7.

Figure 8 shows the completely destroyed area by the fire. Its size is shown.

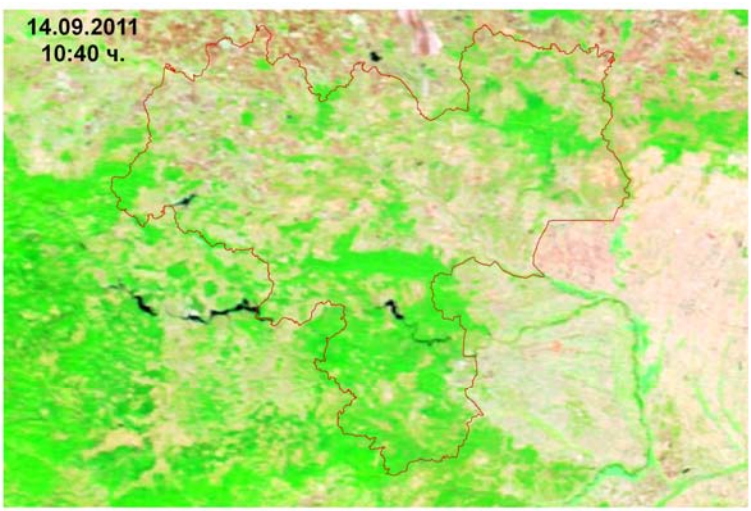

Fig. 5. Image in spectral channels 721 from Terra satellite - 14.09.2011 before the fire

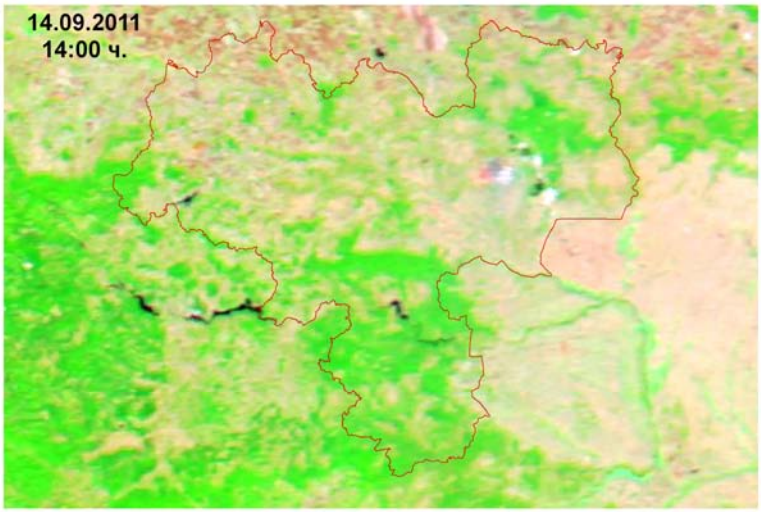

Fig. 6. Image in spectral channels 721 from Aqua satellite - 14.09.2011 before the fire

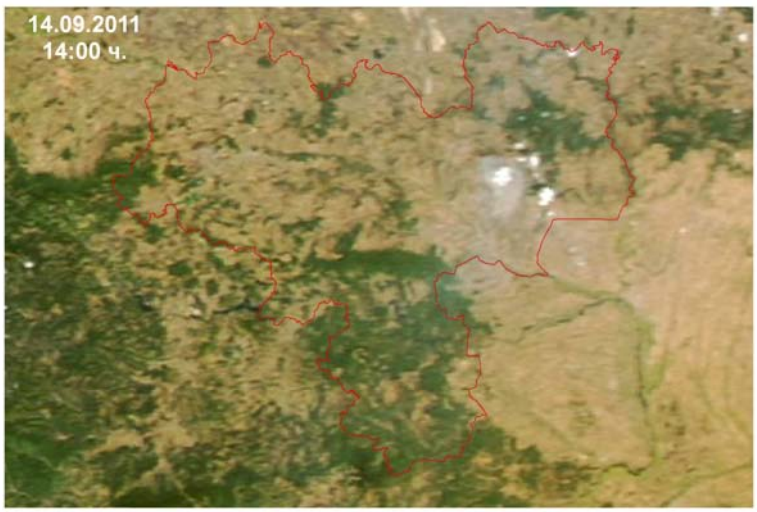

Fig 7. Image in spectral channels 143 form Terra satellite on 14.09.2011, include two existing fires

Figure 5 shows the territory of Haskovo before the fire on the day it arises – September 14, 2011. The image is in the visible range of the spectrum.

In Fig. 6 can be detected the flame of the fire, visible on the image of the spectral channels 721 of the Aqua satellite on 14.09.2011.

Fig. 8. Thematic map of the area completely burnt in the fire area of 721 spectral channels from the Aqua satellite

Fig. 7 shows an image in the visible spectrum range from the satellite Terra from 14.09.2011. The smoke from the existing fires is to be seen.

Fig. 8 shows already burnt area a day after the fire - 15.09.2011- in the spectral 721 channels from the satellite Aqua. Its size is calculated.

Analysis of the fire affected area on 14.09.2011

The fire near the village Vaskovo is a result from a thrown not doused cigarette.

The completely burnt area, determined by satellite images, is 8682 sq.km. It borders the territory of the village Vaskovo.

Mainly affected are agricultural areas, as shown in Fig. 9.

Fig. 10 presents a thematic map of protected habitats, on which territory is the burnt spot.

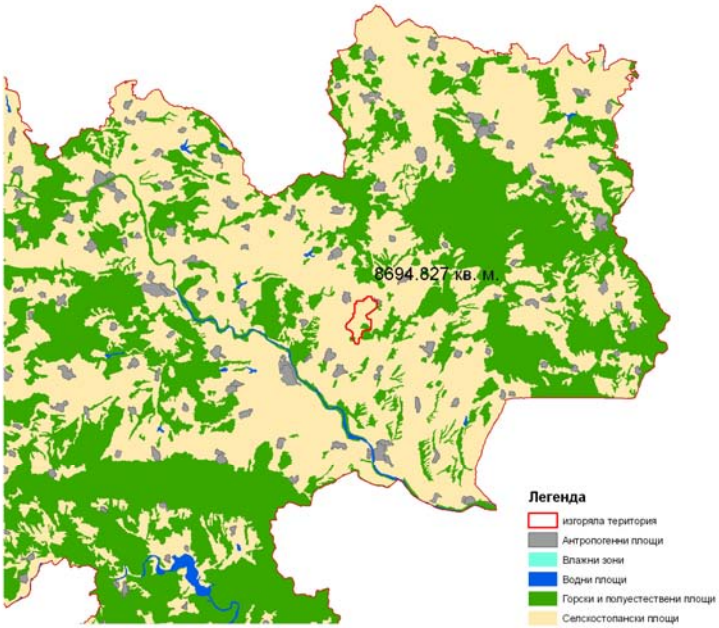

Fig. 9. Nine thematic maps of land cover affected by the fire at 14.09.2011

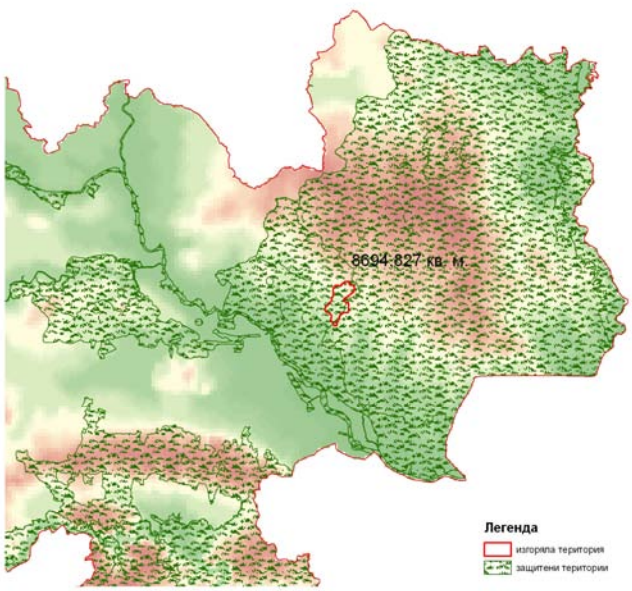

Fig. 10. Thematic map of the protected area affected by the fire at 14:09

Conclusions

Analysing the results, based on the proposed methodology for monitoring of the fire dynamics and development, the following conclusions can be made:

- The methodology used is applicable to study the dynamics of fire;
- Despite the short fire duration the induced negative effect associated with the environment is significant

Fires can cause long lasting disturbances in the ecological balance for the recovery of which decades are needed.

The problem of the occurrence of summer forest and field fires, especially due to human negligence, and their consequences should be treated with appropriate seriousness.

Due to the aerospace methods and technical equipment it is possible to trace the occurrence, development and impact of fires on the environment by making analysis and evaluation of the burnt areas and the occurred damages in time, close to real one.

References

1. Pavlova, A., R. Nedkov. Remote Sensing Based Forest Fire Monitoring In Different Seasons,WDS'06, 2006, Prague,pp 163-167
2. Nedkov, R., M.Dimitrova, M. Zaharinova, I.Ivanova. Web-based monitoring of the fires in the Balkan using satellite data during July and August 2007, vol.1/2008, Ecological Engineering and Environment Protection, pg.13-20
3. Мардиросян, Г. Природни екокатастрофи и тяхното дистанционно аерокосмическо изучаване, "Проф.М.Дринов" - БАН 2007 г.
4. Web-based monitoring of fires at the Balkans region - http://195.96.250.235/BG-Fires/index.html

ПРИЛОЖЕНИЕ НА АЕРОКОСМИЧЕСКИТЕ МЕТОДИ ЗА ПРОСЛЕДЯВАНЕ НА ГОРСКИ И ПОЛСКИ ПОЖАРИ И ОЦЕНКА НА ИЗГОРЕЛИТЕ ПЛОЩИ В ОБЛАСТ ХАСКОВО ПРЕЗ ЛЯТОТО НА 2011 г.

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Резюме

Разгледани са по-значителните горски и полски пожари в област Хасково през лятото на 2011 година. В GIS среда е събрана и анализирана информация за физикогеографските характеристики на областта, растителна покривка и др. На базата на сателитни данни са определена местоположението и площта на засегнатата от най-големия пожар територия. Направен е анализ на засегнатата от него област.