

Wildfire Optimizations in Modeling and Calibrations for Bulgarian Test Cases

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Abstract In this article we are going to present the optimizations that has been done through different types of models applied on wildland fires for Bulgarian test cases. We will present approaches where meteorological data along with terrain specific relief and vegetation coverage are modeled in a way to present credible scenarios for wildland propagation used for calibration purposes of the different cases. This work aims to prove that the used modeling tools can be used as decision support mechanism for the responsible authorities when it is combined with field observations and simulated propagation scenarios. In conclusion we will give as working example a web-based system in USA which with adaptations can be applicable for Bulgarian conditions.

1 Introduction

The work presented in this paper is a year's long efforts which have been started because of an accident that happened in Pirin Mountain near by the city of Razlok. In the year 2003 a helicopter with water tank flew very low to a running fire trying to suppress it dumping water quantities over the mountainous area. Unfortunately the engine oxygen has been vacuumed because of the flames, which caused helicopter's crash with four people crew that died that day [1]. This accident was very problematic for the Bulgarian society. That is why in the Bulgarian scientific community has been launched in the beginning of 2007 a pilot Ph.D. program dedicated to the wildland propagation and its modeling opportunities as first attempts for computer based simulations on wildland fires propagation in Bulgaria.

In 2007 small team from Bulgarian Academy of Sciences (BAS) started adaptation of a US model, which was running in parallel mode. The model was called WRF-Fire (in 2010 renamed SFIRE). The input data for the model had to be first collected for a specific test area and second preprocessed for model calibration.

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The area of interest for the BAS team at first was nearby Sofia, where idealized case has been run with the model functionalities in order to set the model parameters. No real fire has been on this area. So no calibration has been done. However the second attempt was run for a real test case wildland fire, which has occurred near by the village of Leshnikovo, region of Harmanli in the past. For the second test case we tried as much as possible to do a model set up repeating the steps of fire propagation as it was described by the forester's department in Harmanli.

In this paper we will show the basis of the mathematical calculations and optimizations outlined from the research efforts and the achieved results as final outcomes. This work is ongoing and more optimizations will occur in future.

2 WRF-Fire (SFIRE) Mathematical Basis

The mathematical background of the WRF-Fire model (SFIRE) is as position in the (x, y) plane. The model is semi-empirical and it represents the spread of the fire in direction of the fire line. This is the so called Rothermel modified formula. The burning region is represented as Ω for time t , which is represented with the point coordinates (x, y) . The formula itself is:

$$\tilde{S} = \min\{B_0, R_0 + \phi_w + \phi_s\}, \quad (1)$$

where B_0 is the fire spread against the wind direction, R_0 is the fire spread in absence of wind, $\phi_w = a(\vec{v} \cdot \vec{n})b$ is the wind correction and $\phi_s = d\nabla z \cdot \vec{n}$ is the terrain correction, $\vec{v}$ is wind, ∇z is terrain variable along the normal $\vec{n}$ of the fire line, a, b and d are constants. In this case WRF-Fire use:

$$S = \begin{cases} 0, & \text{if } \tilde{S} < 0 \\ S_{\max}, & \text{if } \tilde{S} > S_{\max} \\ \tilde{S}, & \text{if } 0 \leq \tilde{S} \leq S_{\max} \end{cases}, \quad (2)$$

where $S_{\max}$ is max fire spread. After the burning materials are burnt the model decrease them in the points (x, y) exponentially and that is represented with the formula:

$$F(x, y, t) = F_0(x, y)e^{-\frac{(t-t_i)}{W(x,y)}}, \quad (3)$$

where t is the time, t_i is the time for the burning, F_0 is the initial quantity of the burning materials (before they started to burn) and $W(x,y)$ does not depend on the time, but from the burning materials. The heat transfer released by the fire, is represented in the atmosphere model as layer above the surface, which is situated in height [2]. The burning material quantity is represented by:

$$\Phi = -A(x, y) \frac{\partial}{\partial t} F(x, y, t) . \quad (4)$$

This representation is needed because the atmosphere model WRF, does not support border values for heat transfer. The coefficients B_0 , R_0 , $S_{\max}$, a , b , d , W and A , which describe the burning materials are measured in laboratory with experiments. For every surface point in the plane the coefficients of the burning materials are represented using the 13 Anderson categories [3]. These categories are developed for US originally and they have been defined by usage of the different sea levels on the surface. WRF-Fire (SFIRE) has internally representation of every category and all additional characteristics, which gives opportunity for modifications when the fire is outside US.

WRF-Fire use also level-set functions for the spread of the fire [4]. This approach set as function $\psi = \psi(x, y, t)$, which define for Ω subregions using the rule:

$$\Omega(t) = \{(x, y) \in \Omega : \psi(x, y, t) < 0\}. \quad (5)$$

These subregions are burned and the fire line is defined as curve:

$$\Gamma(t) = \{(x, y) \in \Omega : \psi(x, y, t) = 0\}. \quad (6)$$

The function $\psi(x, y, t)$ satisfy the equation:

$$\frac{\partial \psi}{\partial t} + S(x, y)|\nabla \psi| = 0, \quad (7)$$

which can be solved numerically.

Formulas (1)–(7) are general description how mathematically the fire spread is represented inside the WRF-Fire (SFIRE) model. In the beginning the atmosphere model is interpolating the wind in order to get into the bigger domain of the atmosphere the fire changes. Afterwards is applied numerical method for the level-set function. The next step is to apply quadratic formulas for evaluation of the burnt material. In parallel it is evaluated also the released heats transfer into the atmosphere layers. The last step gives atmospheric change and that trigger the repetition of the model to starts again.

3 Experimental Results with WRF-Fire (SFIRE)

The experimental results which were obtained after evaluation of the WRF-Fire (SFIRE) model can be presented in brief summary in this section.

The first experimental run of the model was for an ideal case, nearby Sofia city using coordinates and information for the village of Leshnikovo. The used version of the model was WRF-Fire v.3.2 for the simulation. We did domain with size 4 by

4 km, with horizontal resolution of 50 m, for the atmosphere mesh, the used grid was 80 by 80 cells and with 41 vertical levels from ground surface up to 100 hPa. We didn't use nesting to keep the ideal case as basic as possible in order to evaluate the model capacity and set up the needed initial conditions for a Bulgarian runs.

The domain, was set with a location 4 km west from village Zheleznitsa in the south-east part of Sofia city region. The domain was covering the lower part of the forests of Vitosha mountain.

The ignition line was set in the center of the domain and the ignition line was 345 m long. The model at that stage of its development did not allow us to use ignition from a point, because the atmospheric model did not cover such narrow measurements. The ignition in parallel has been set to start 2 s after the simulation has begun. The results from this first simulation gave us idea how the model can be initialized and what the input data will be if we start calibration simulations with real wildland fire test case.

That is why we selected from the national data base in the ministry of forests, food and agriculture, a fire which has been burning in the period 14–17 August 2009 located near by the city of Harmanli. For the initialization of the model with the real test case we had to use algorithm for implementation of the real data in a way that WRF-Fire (SFIRE) was able to recognize it. We set for these purposes two domains: the first was covering area of 48 km² with resolution 300 m (160 × 160). This domain was producing boundary and initial meteorological conditions for the inner domain and in this domain were no fire simulations.

The inner domain was located in the middle of the coarse domain. The resolution in Domain 2 was set as 60 m and the area covered is 9.6 km² (161 × 161). Domain 2 was centered on the fire ignition line and it was covering the areas of villages Ivanovo, Leshnikovo and Cherna Mogila. This area was located in South-East Bulgaria close to the Bulgarian-Greece border nearby Harmanli city.

The first data source which was very important was the meteorological input. We used US NCEP Global Analyses data for meteorological background input: The data was with 1 × 1 degree grid resolution covering the entire globe, the time resolution was 6 h. With this data we could simulate all over the world but with resolution of around 100 km.

The next data set, which was needed for input in WPS (WRF pre-processor) was the topography data. The standard topo-data used in WPS was USGS 30 s resolution global data set (GTOPO30), but because terrain elevation is very important for correct fire behavior we used much more detailed data for the area of Harmanli (this data was available also for the whole country of Bulgaria) from USGS / SRTM 3 s data (<http://eros.usgs.gov>; Shuttle Radar Topography Mission (SRTM) Finished Grade Data) in order to be used in WPS it had to be converted in a special format. The data received from the server was through a GIS raster format (DTED format *.dt1) in Lat/Long format, datum WGS84. The open source Quantum GIS (www.qgis.org) interpolate the missing data of the raster (if any) with simple linear interpolation and then we could change the projection to the one we were going to use in WRF – Lambert

Conformal Conic (ref_lat = 41.84, ref_lon = 25.936, truelat1 = 41.82, truelat2 = 41.86, stand_lon = 25.936). After the reprojecting, we exported the raster in the new format – GeoTiff. This format was used in the WPS program “convert_geotiff”. The procedure we followed was explained in details at [5]. The resulting fails after convert_geotiff were used by WPS/geogrid. In order to have fire behavior, we needed fuel data for the simulation domain. Because there was no such data, for our test case area we had to choose information about the vegetation from the project Corine Landcover (funded by the European Environment Agency and the member states). This landcover data for Bulgaria was with 100 m resolution and 25 ha minimum mapping unit. (<http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2006-raster>). The downloaded data (it gives options for GIS vector or raster formats) was used to create fuel data, based on the land cover information. The applied classification was the 13th Anderson classes from 1982 [6]. Also orthophoto data from the geoportal of The Ministry of Regional Development and Public Works (MRDPW) of Bulgaria was used to make even more detailed the available fuel data for the domains of interest, namely Harmanli region. All rivers, lakes, villages and forest areas have been vectorized using the orthophoto images combined with CORINE2006. The resulting fail was a GIS vector shape fail with very high accuracy of representation of non burning areas like rivers and lakes, and areas with high burning fuel level, like woods.

Following the description in [5] we got the intermediate fails which WPS could use for topography and fuels. Along with the provided global datasets with WPS we placed the newly created fails in the WPS working directory. The rest of the procedures made input fails for WRF part of the model described in the WRF on-line tutorial (<http://www.mmm.ucar.edu/wrf/OnLineTutorial/index.htm>). The only difference was in the geogrid program, where the output fail had 2 extra variables – NFUEL_CAT and ZSF. NFUEL_CAT for the 13th fuel categories done based on [6] with the detailed topography. The result burnt simulated area compared to the real one can be seen on the Figs. 1 and 2.

The simulation result on Fig. 1 has been done on a supercomputer at the University of Denver by distant connection. In Table 1 the simulation outcomes were presented according to the number of the cores used.

With this simulations for the test site nearby Harmanli city has been elaborated a methodology for collection, processing and implementation of real data for test sites on Bulgarian territory. The selected model was having as input meteorological data, DEM and only 13 FBFMs (Fire Behavior Fuels Models) which led to the idea that we can experiment also with other different models like BEHAVE Plus and FARSITE for our next steps.

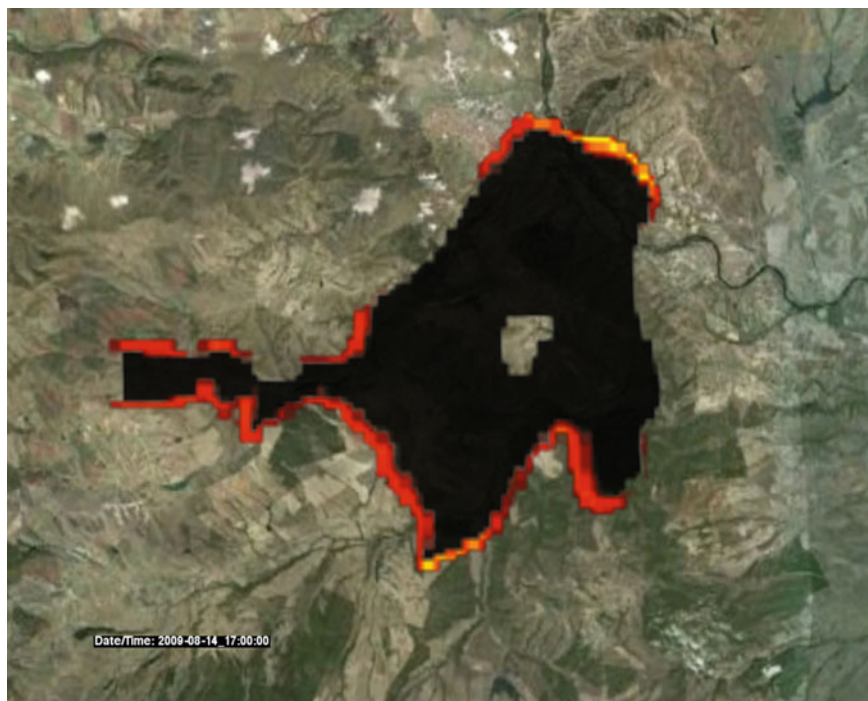


Fig. 1 The simulated burnt area

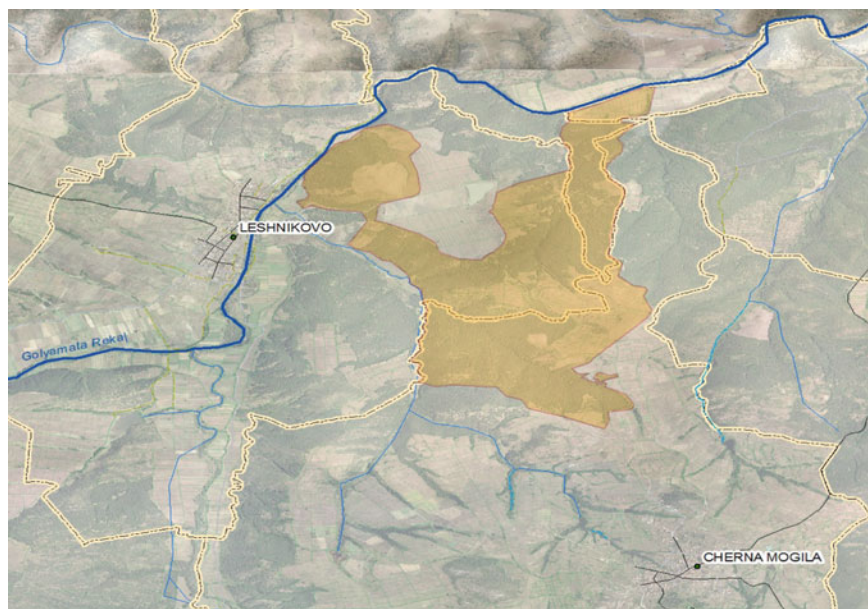


Fig. 2 The real fire burnt area

Table 1 The time required for the simulation presented in seconds depending on the number of processors running the parallel execution of processes showing that in 120 cores the simulations run as fast as real time. Everything above this cores is performing faster than real fire propagation

Cores	6	12	24	36	60	120	240	360	480	720	960	1200
Fire line propagation in km.	1.91	1.08	0.50	0.34	0.22	0.13	0.08	0.06	0.06	0.04	0.10	0.04
Region 1	6.76	7.05	2.90	2.06	1.20	0.73	0.45	0.32	0.26	0.23	0.24	0.17
Region 2	0.00	0.00	0.00	0.02	0.02	0.04	0.04	0.06	0.06	0.08	0.07	0.15
Total sec. which is the coeff. for real time	10.59	9.21	3.91	2.75	1.64	0.99	0.61	0.44	0.37	0.31	0.44	0.26

4 Experimental Implementation of BEHAVE Plus and FARSITE Simulations in the Test Cases of Zlatograd, Madan and Nedelino Municipal Areas in Bulgaria

In the framework of bilateral cooperation program between Greece and Bulgaria 2007–2013 the BAS team had the opportunity to work in the Zlatograd forestry department located on the territories of Zlatograd, Madan and Nedelino municipal areas in south – central part of Bulgaria. The study area was the territorial state-owned forestry department with its headquarters in Zlatograd. This department covers an area of 33,532 ha, where 31,856 ha are state forests. Most forests are in early to mid-serial succession stages, with only small amounts of mature to old forest. Stand age was highly variable, ranging from 20 to 80 yrs; most stands range between 35 to 50 yrs with the average being 46 yrs. Average stem stock is $140 \text{ m}^3 \text{ ha}^{-1}$. The average forest canopy cover was 81%.

In terms of climate, the region is part of the continental-Mediterranean climatic region, south-Bulgarian climatic sub-region and East Rodopi mountain low climate region. The average annual temperature for the area is 10.8°C , with a maximum temperature in July of 20.6°C and minimum temperature in January of -0.8°C , indicating moderate summers and relatively mild winters. Extreme values of annual average maximum and minimum temperatures could be respectively 17.1 and 4.9°C , the monthly maximum estimations are in the range in August (28.9°C) and in January (-3.9°C). Average annual rainfall reaches 1000 mm. Maximum precipitation amounts for the period from April to October range from 10.0 mm for 5 min to 46.3 mm for 60 min and 59.7 mm for more than 60 min. The average annual relative humidity is 75% which is an indication of good growing conditions; maximum relative humidity values of 85% which occur in November. The approximate relative humidity less than or equal to 30% was estimated about 13–15 days per year.

The data we were working on was about fifteen wildfires that occurred in 2011 to 2012 within the Zlatograd municipal territory and it was provided by the Zlatograd forestry department; this data included vegetation type, area burned (in decares where 10 decares = 1 hectare), date, and start and end hours of the fire event (Table 2). These wildfires burned in a variety of vegetation types and were more than likely started

Table 2 Wildfire for the period 2011–2012. Information provided by the Zlatograd Forestry Department

Fire No.	Vegetation type	Burned area in decarees	Date of occurrence	Hour of start	Hour of end
1	Durmast	3.0	25 March 2012	1330	1530
2	Beechwood	5.0	29 March 2012	1400	1800
3	Scotch pine	1.0	16 June 2012	1500	1700
4	Scotch pine	7.0	6Aug. 2012	1640	1950
5	Scotch pine	5.0	6 Aug. 2012	1710	2130
6	European black pine	4.0	27 Aug. 2012	1200	1600
7	Scotch pine	3.0	5 Sept. 2012	1400	2030
8	Scotch pine	6.0	6 Sept. 2012	1400	1930
9	Scotch pine	2.0	6 Oct. 2012	1600	2320
10	Scotch pine	1.0	16 March 2011	1310	1400
11	Scotch pine	1.0	5 April 2011	1715	1900
12	Scotch pine	1.0	10 April 2011	1130	1530
13	Grassland	3.0	30 Aug. 2011	1400	1800
14	Scotch pine	4.0	12 Sept. 2011	1230	1900
15	Scotch pine	1.0	15 Sept. 2011	1600	1830

by humans to clear agricultural debris or prepare fields, based on the proximity to villages. Paper maps from the forestry department identified the ignition location and final fire shape; this data was digitized in a GIS which allowed each ignition point to be viewed with background orthophotos and the spatial Zlatograd vegetation classification showing pre-fire vegetation (Table 2).

After we collected and located the forest fires we did runs with BehavePlus point based prediction system in order to analyze fire growth and behavior for homogeneous vegetation with static weather data. We used standard fuel models developed for US and we evaluated which fuel models were best able to produce estimates of fire behavior and growth in BehavePlus similar to those observed on each of the fifteen fires. In addition to fuel model, BehavePlus requires inputs for weather, fuel moisture, slope, and duration of the burning period. We obtained weather data for each fire from TV Met, a private company in Bulgaria, which provided the ability to calculate fine dead fuel moisture values. Due to the paucity of available weather data in Bulgaria, we had to assume that weather recorded for the weather station closest to each particular fire is consistent with weather experienced on the wild-fire. We estimated live herbaceous and live woody fuel moisture values based on the expected phenological stage for the time of year that the fire occurred. To estimate slope, we first acquired a 30m resolution digital elevation model (DEM) from the National Institute of Geophysics, Geodesy, and Geography in Bulgaria, then subsequently calculated the average slope for each fire using standard geospatial

processing in ArcGIS (ESRI 2010). Burn period length for each fire was obtained from the Zlatograd forestry department data (Table 2).

Based on initial BehavePlus results using standard fuel models, custom fuel models were developed for some vegetation types not well represented by the US fuel models. Custom fuel models were developed for native durmast oak and grass as well as one of the Scotch pine sites by modifying fuel loading parameters to better match local vegetation and reflect the lack of woody debris in the understory.

Following evaluation of fuel models with BehavePlus, we then performed analyses in FARSITE, a spatial fire growth system that integrates fire spread models with a suite of spatial data and tabular weather, wind and fuel moisture data to project fire growth and behavior across a landscape. We defined our test landscapes using a 500 m buffer zone around each of the fifteen Zlatograd fires.

Input for FARSITE consists of spatial topographic, vegetation, and fuels parameters compiled into a multi-layered “landscape file” format. Topographic data required to run FARSITE include elevation, slope, and aspect. Using the aforementioned 30 m DEM, we calculated an aspect layer, and then clipped elevation, aspect, and slope rasters to the extent of our fifteen test landscapes. Required vegetation data include fuel model and canopy cover. Fuel models within the 500 m buffered analysis area for each individual fire were assigned based on our BehavePlus analyses; fuel model assignments were tied to the dominant vegetation for each polygon based on the Zlatograd forestry department’s vegetation data. Canopy cover values were visually estimated from orthophoto images and verified with stand data from the Zlatograd forestry department. Additional canopy variables (canopy base height, canopy bulk density, and canopy height) that may be included in the landscape file were omitted, as these variables are most important for calculating crown fire spread or the potential for a surface fire to transition to a crown fire. None of the fifteen fires analyzed experienced crown fire.

Tabular weather and wind files for FARSITE were compiled using the weather and wind data from TV Met, Bulgarian meteorological company that included hourly records for the purposes of our research interests. Tabular fuel moisture files were created using the fine dead fuel moisture values calculated for the BehavePlus analyses for 1-h timelag fuels. The 10-h fuel moisture value was estimated by adding 1% to the 1-h fuel moisture and the 100-h fuel moisture was generally calculated by adding 3% to the 1-h fuel moisture. The live fuel moisture values previously estimated for BehavePlus analyses were used to populate live herbaceous and live woody moisture values.

All simulations performed in FARSITE used metric data for inputs and outputs. An adjustment value was not used to alter rate of spread for standard fuel models, rather custom fuel models were created. Crown fire, embers from torching trees, and growth from spot fires were not enabled.

As an example of one of our successful FARSITE runs, we present the results from a single wildfire that burned in grassland vegetation, for which we developed custom fuel models. This fire occurred on August 30, 2011, starting at 1400 and ending around 1800, and burned a total area of 0.3 ha. We used the following input parameters to model this small grassland fire in FARSITE:

Fuel moisture values: 6 (1-h), 7 (10-h), 9 (100-h), 45 (live herbaceous), and 75% (live woody);

Daily maximum temperatures: 17–21 °C;

Daily minimum relative humidity: 24–50%;

Winds: generally from the west-southwest at 1 – 2 km/h

The fire size as calculated using FARSITE was 0.5 ha, which seems reasonable considering the modeled size would not have included the suppression actions that most likely occurred given the close proximity of a village to this fire Fig. 3.

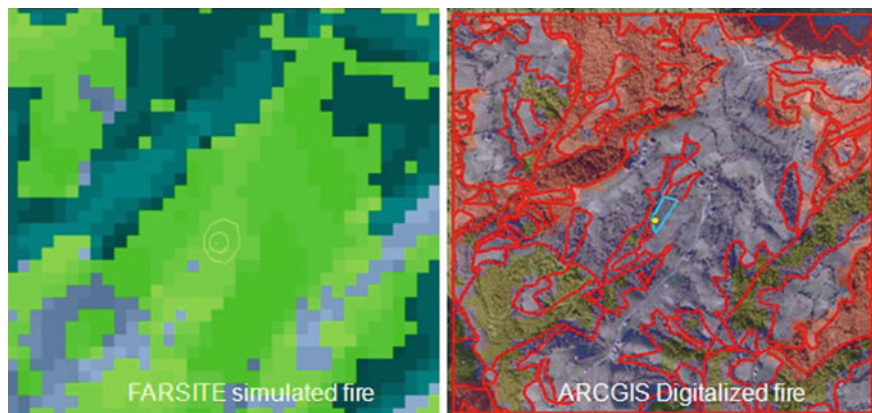


Fig. 3 FARSITE run for a grassland fire, where size of the fire is very close to the real one, but the shape is different, because of wind information discrepancies

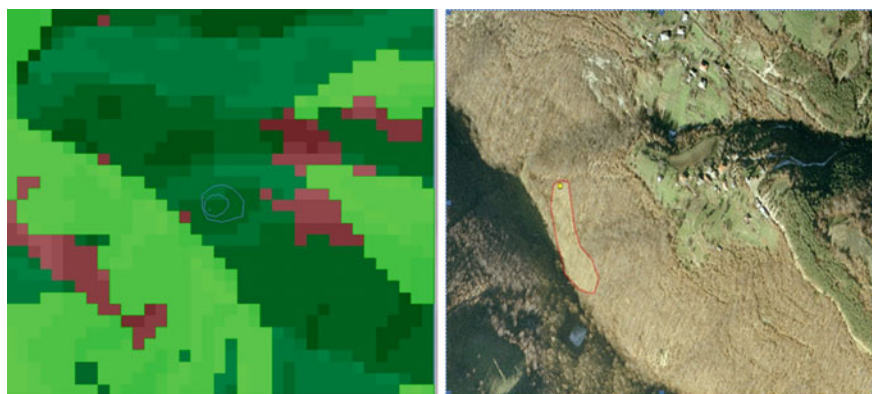


Fig. 4 FARSITE run for wildfire that burned in a beechwood forest, where size of the fire is very close to the real one, but the shape is different, because of wind information discrepancies

Table 3 Summary of the working FBFMs for the territories in Zlatograd forestry department with conclusions in which cases which type of fuel model can be applied

Vegetation type	Possible fuel models	Logic/Assumptions
Scots pine (<i>Pinus sylvestris</i>)	188 (often used for ponderosa pine) 183-modified	Ponderosa pine (<i>pinus ponderosa</i>) may be a suitable western US proxy. Otherwise, probably a modified 183 (TL3) to increase rate of spread and flame lengths.
Black pine/Acacia (<i>Pinus nigra/Acacia</i>)	161 183-probably modified	FBFM 161 works best when the understory is dominated by an herbaceous understory including forbs and grasses (it is dynamic). Creating a custom fuel model starting from FBFM 183 is another solution, to increase the rate of spread and flame lengths. Using FBFM 165 would assume ladder fuels to be present and will probably overpredict rate of spread and flame lengths.
Beechwood (<i>Fagus sylvatica</i>)	182/186 (dormant season fire) 161 (growing season fire)	FBFM 182 or 186 (or a custom FBFM) may be used when a fire is mostly burning through hardwood (round leaf) litter. FBFM 186 tends to have much higher rate of spread and flame lengths than 182. FBFM 161 is dynamic and may be used during the growing season when a fire would be expected to burn through the understory vegetation.
Durmast (<i>Quercus dalechampii</i>)	182/186 (dormant season fire) 161 (growing season fire)	FBFM 182 or 186 (or a custom FBFM) may be used when a fire is mostly burning through hardwood (round leaf) litter. FBFM 186 tends to have much higher rate of spread and flame lengths than 182. FBFM 161 is dynamic and may be used during the growing season when a fire would be expected to burn through the understory vegetation.
Grasslands	101 (may be best for grazed pasture) 102 (ungrazed pasture) Custom FBFM (lower ROS and FL than FBFM 101)	Assumes no irrigation. Rate of spread and flame length drastically change depending on chosen FBFM.

An example of another fire we modeled in FARSITE using standard fuel models was a fire that occurred on March 29, 2012 in a beechwood forest. This fire burned for a total of four hours, starting at 1400 and ending around 1800, and burned a total area of 0.5 ha. Wind speeds were variable throughout the burning period as they were quite high during the early afternoon but tapered off throughout the day. In this case we used the following input parameters in FARSITE:

Fuel moisture values: 3 (1-h), 4 (10-h), 5 (100-h), 40 (live herbaceous) and 70% (live woody);

Daily maximum temperatures: 7–10 °C;

Daily minimum relative humidity: 36–40%;

Winds: generally from the north-northeast at 10–20 km/h

The projected fire size from FARSITE was 0.9 ha. Based on the close proximity of a village to the fire location (Fig. 4) it is quite reasonable to assume that local residents responded to the fire in a volunteer capacity; these suppression actions could not be accounted for in the FARSITE analysis. Decreasing winds through the afternoon may have significantly helped suppression activities.

From this two modeled fires we were able to estimate that the standard fuel models established for US can be run also for Bulgarian cases, but only after a good calibration with real case studies where vegetation and past events are well observed. However FARSITE and BehavePlus provided reasonable outputs for future work in the field of fire behavior fuel modeling on the Bulgarian territory. As a result of the calculations with the simulations of the Fire Behavior Fuel Models we can have as summary Table 3 with the used custom and non custom FBFMs working as calibrated values for Bulgarian wildfire test cases.

The work performed with the FBFMs on the territory of Zlatograd forestry department has been published in details in the articles [7–10] where more information can be seen.

5 Potential for Implementation of the Simulated Results in Web-Based ICT Application

Natural disasters and in particular wildfires are a major problem for many European societies threatening human lives and properties, often with disastrous impacts, particularly at the wildland-urban interface. The reduction of wildfire hazard, but mainly the reduction of damages and impacts induced by wildfires, requires integrated approaches and new practices in wildland fire management, such as prescribed burning and suppression fire, together with increasing the awareness and preparedness through knowledge (education/training) and technology transfers.

In Europe the management of natural disasters is mostly within the Public Administration sector with a very small contribution from the private sector. In particular the management of forest fires is under the responsibility and within the competences of specially qualified and organized state agencies and bodies such as the Fire Departments, Forest Fires' Fighting Corps and in some cases the Forest Service itself.

To fulfill their mission, the personnel of these organizations have the necessary education and training (Formal Training). They are the professionals of forest fire fighting. In the management of natural disasters and in particular forest fires, a network of volunteers in the framework of Civil Protection Agencies is also involved, having different theoretical background and operational training levels (Informal Training). The training of these groups is often general information around the mech-

anisms and behavior of forest fires, or demonstrations of the use of the equipment used for the management of forest fires.

In most cases, volunteers and the professionals limit their action to logistical tasks or even spontaneous and often not well planned actions that sometimes could cause serious issues on personal safety.

That is why it becomes evident the need of creation of a system for a continuous training targeted towards the volunteer's groups and all involved professionals in wildfire suppression activities, in accordance to their needs. The most effective way to create such a system in rich forest vegetation areas and frequent episodes of forest fires, is to exchange experiences and good practices on the subject with more developed groups.

For example in Bulgaria, according to the Act of the Minister of the Interior (2009), the Civil Protection Directorate-General (DG Civil Protection) became part of the Ministry of the Interior of the Republic of Bulgaria and is responsible for performing tasks related to prevention and preparedness, management, reaction and recovery in case of natural and man-made disasters. Volunteers can participate in intervention operations together with professional firefighters, under the decision of the municipal council, and after training.

Quite the same is the situation in Greece the other south-east member state of EU affected often by wildfires as Bulgaria. According to the Act of Civil Protection (Act 3013/2003) in Greece, the General Secretariat for Civil Protection (GSCP), under the Ministry of Citizen Protection is tasked to work out prevention plans and programmes for all kinds of risks (natural and technological (CBRN included), in cooperation with all the relevant authorities at national, regional and local levels. GSCP is the authority to register Voluntary Organisations, while the National Register is listing today 240 Volunteers' Organizations.

That is why the management of natural disasters and in particular wildfires need a network of volunteers and professional firefighters to be involved, at the Local Authorities' level, having different theoretical background and operational training levels. There is a need to create a continuous and open system for the training of the volunteers and professionals, so that their participation in wildfire suppression activities to be as effective and safe as possible.

A framework for vocational training and preparedness of the volunteers and the professionals who operate within the civil protection mechanisms in general need support also from the nowadays ICT tools. Such tools already operate on the territory of USA [11], where the main idea is to have web-based decision support tools for the fire analysts who navigate the volunteer groups and the professional firefighters on the fields. In general the main idea of the so called Wildfire Decision Support System (WFDSS) is to collect information from the field by any type of observers, which is transmitted to the Fire analysts. These analysts have on their disposal information about the terrain in GIS formats (Geographical Information Systems Layers), meteorological conditions in the area and the predefined burning materials - fuel models represented by the available 13 or 40 FBFMs [6, 12] or Custom Fuel models if no available fuels from the standard ones is not suitable.

All that information than can be calculated by a model which has in its origin mathematical, physical and chemical representation of the different fire spread rate depending on the type of the fire e.g. surface, crown, fire acceleration or spotting, which is included in the crown fires models.

In Fig. 5 is presented a general structure how the information in cases of wildfires can be collected, processed and then returned back with respective scenarios of fire spread to the people on the field. However this kind of decision support systems is not well developed outside US.

There are attempts for children education on how natural disasters can affect everyday life of people and such initiatives are described in [13, 14].

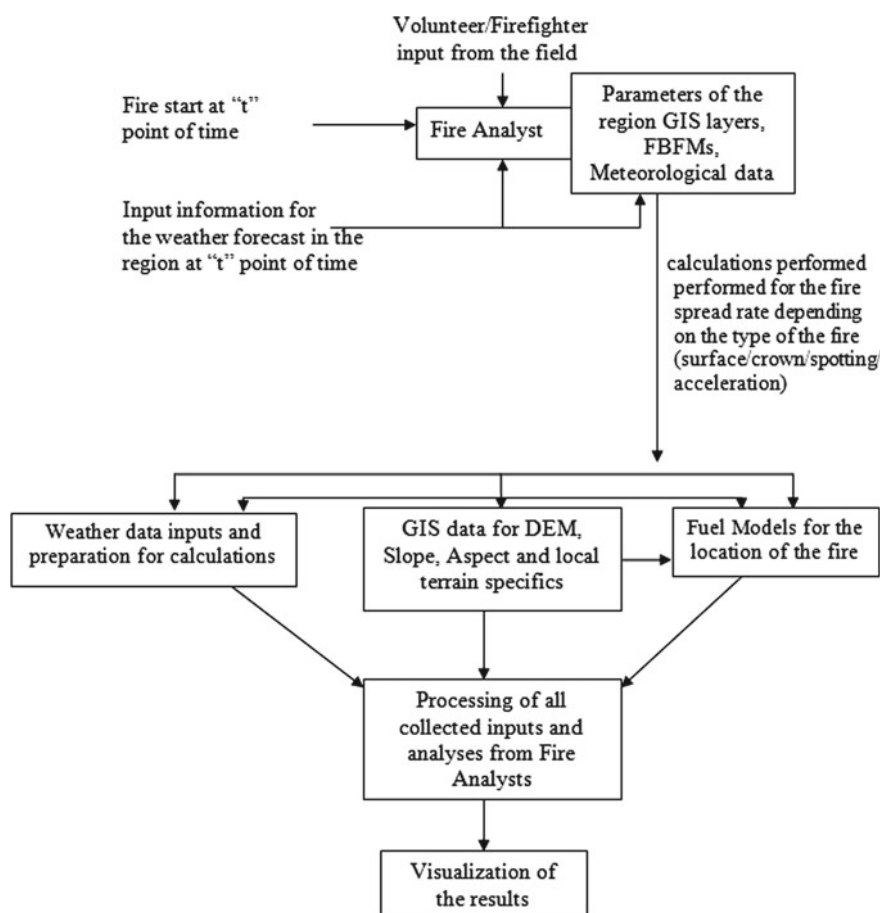


Fig. 5 General scheme of receiving information from the field by person who spot a wildfire and its process of getting supported through web-based Decision support tools such as WFDSS [11]

6 Conclusion

The presented paper was having as main aim to provide a broader view on the tested modeling options for the Bulgarian wild land fires and the achieved results. There are still a lot of issues to be solved in the data collection and processing phase. The accuracy of the meteorological inputs is still not that well developed as a network in the test areas. However the achieved results after all computations give promising options for future implementation of this modeling tools for more operational use as described the web-based decision support tool which is nowadays available in USA. Such tools and information is crucial when it comes to big wildfire events and volunteer groups work together with professionals on the field.

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