A web service for the assessment of the behavior and the spread of a forest fire

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Fires in forests and forested areas in South Europe, North America and Australia constitute a diachronic threat with critical ecological, economic and social impacts. Over the last decade the frequency, the size and the intensity of fires have increased even more as a consequence of climate change. An effective response to such disasters requires an effective planning, with emphasis on the early detection of the ignition area and the accurate assessment of the fire propagation to support the fire fighting mechanism. For this reason, an information system with the ability to simulate, using near real-time meteorological information and visualize the growth and behavior of the fire could be an efficient fire management tool. If such system has also the capability to perform simulations in order to evaluate scenarios, based on alternative weather conditions, it becomes a valuable tool for supporting decisions associated to fire prevention and mitigation plans. In the context of FLIRE (floods and fire risk assessment and management) project, a web-based information system of this type has been developed and presented in this study.

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1. Introduction

Forest fires are considered one of the most important natural hazards globally. South Europe, North America, Central Asia and Australia are the main areas of the planet that are affected annually with very large variations in the fire seasons (IUCN, 2000). This natural hazard is a permanent threat for the natural resources with critical ecological, economic and social impact, including loss of lives and goods, damages to wildlife habitats, soil erosion and degradation of the watersheds which are effects of the fire occurrence interlinked to each other. The latter two effects are responsible for catastrophic flash flood events that may happen during the winter time following large summer fires. Even if fire is a natural phenomenon, during the last decade, the frequency, the size and the intensity of the fires in forests and forested areas has increased greatly as a consequence of the global warming and the degradation of natural resources (Flannigan et al. 2005) in the "altar" of human's need for material possession. In South Europe, every year, wildland fires reduce the forested areas at a remarkable rate (Eurostat 2011). Despite the fact that the forest management authorities and Regional Civil Protection agencies increase continuously their efforts in forest fire fighting, thousands of hectares of forests are lost every year. In order to prevent the impair of forest ecosystems, forest managers and civil protection agencies have to make efficient use of modern technology for addressing fire management problems. New technologies like geoinformatics (GPS systems, digital cartography, GIS systems), sensor networks (automatic remote weather stations, smoke detection sensors, 3G/4G mobile network, smartphones, tablet pc with 3G network) and Earth Observation products can have a strong potential to contribute to a more effective organization for the environmental protection (Noonan - Wright et al. 2011). The efficient management of the fires is crucial in the early stage of fire ignition. The civil protection mechanisms need information on time concerning the potential spread of the fire in order to plan for an effective control and containment. Such information requires the efficient combination of interdisciplinary research, technology, innovation and the development of a consistent approach for assessing fire risk and hazard (fire hazard is the potential of injury or damage from fire while fire risk is the product of the probability of occurrence of a fire and the consequence of its occurrence (e.g. financial loss or death/injury), along with prompt and reliable fire management information system. New technologies of geoinformatics and electronic data capture and transmission of information from remote areas have a strong potential to contribute to more effective organization for environmental protection. Based on the above rational and in order to fill the gap in the era of new technology and the easy access of the internet facilities from a variety of hardware sources, the objective of this study is to discuss the role of the web-based information provision for an efficient prevention planning and forest fire management. A web-based Decision Support System (DSS) developed in the framework of FLIRE (floods and fire risk assessment and management), a LIFE+ co-funded by the European Commission research project, is presented in this study. The innovation of this application is the possibility to remotely access the fire management information services, by means of laptops, tablets and smart-phones that the end users can use even in the field during the early stages of a fire incident. This approach is important either to support fire mitigation planning, or control of the fire during the very first steps.

2. Data and methodology

The study area covers the catchment of Rafina Municipality, an area of 123 km^2, located in Attika region, Greece.

2.1. FLIRE DSS System architecture

The FLIRE DSS system for fires consists of two different subsystems which are connected by a unified server. The system has a distributed structure as shown in Figure 1. The DSS server employs FTP tools and web services technologies, whereas a Graphical User Interface (GUI) has been also developed. The DSS contains the following modules, described in more detail below: a Weather Information Management Tool (WIMT); an Early Fire Warning System (EFiWS) and a DSS server with a GUI.

Fig. 1. The distributed architecture. Each component is used via ftp or web service.

2.2. Weather information management tool (WIMT)

WIMT has been designed in order to retrieve, handle, manage and utilize the available weather data (both in-situ measurements at weather stations in the broader study area and weather forecasts). The stations measurements are provided every 10 min, whereas the weather forecasts every day, for the same day and for the following, at 1-h interval (Kotroni et al. 2004). The produced forecast is stored in the form of hourly text files in the server of the National Observatory of Athens (NOA) and can be retrieved using the FTP protocol. The forecast data are handled using the *NoaForecastData* tool, an internal module operating in the DSS server that was developed by the Foundation for Research and Technology – Hellas (FORTH) for this purpose. It is executed automatically as a "*Scheduled Task*" at specific times (when forecast data are available) while all parameters (urls, folder names etc.) needed by the program are stored once in *NoaForecastData.ini* file. Data from the meteorological stations are provided by both NOA and NTUA (National Technical University of Athens) infrastructures. This data are retrieved by the system via FTP in XML format, for further use in the EFiWS system.

2.3. Early Fire Warning System (EFiWS) - Geographic Fire Management Information System (GFMIS) - KBDI Index

EFiWS is comprised by two operational relative fire management components, G-FMIS (fire propagation) (Eftichidis et al. 1998) and KBDI (fire risk assessment) (Burgan 1988) subsystems. G-FMIS web service is used through the FLIRE DSS for providing fire risk assessment and fire propagation data. The fire risk assessment service operates on a daily base pulling meteorological data from the WIMT module. KBDI is a cumulative index which provides indication concerning the conditions contributing to the flammability of the vegetation and its daily variation due to meteorological conditions. A daily risk map is published on the web using the system's web facility and the DSS platform. The DSS communicates appropriately stored messages to different group of stakeholders when the index exceeds a predefined level. For the FLIRE project, KBDI index has been selected as the index for fire risk assessment since it is related with soil moisture and conditions related to drought. Soil moisture is also related to floods which is the other side of the FLIRE project and therefore KBDI is a risk index that allows the estimation of eventual interaction between fire and flood. While normally KBDI is used every year from March till October (extended fire season) in fire management for assessing soil drought status and therefore fire occurrence risk level, in the case of FLIRE, the calculation of the index during the rainy period can be also used for supporting flood risk assessment.

2.4. DSS Server - GUI

All the above mentioned systems are accessible from the FLIRE web site (www.flire.eu) for authorizes users. Having as backbone a windows-based server, DSS application has four tabs, each one having a different role in the system. These are the following: (A) *Map*, (B) *Weather Forecast Data*, (C) *Weather Stations* & (D) *Fire Management System*. Tab (A) has the role of the GIS platform (Figure 2). Here the user can visualize the results of the fire modeling, the weather forecast grid for selected dates, the weather stations, as well as other available spatial data like Landcover, Landuse datasets, Polygon with the area of the project, satellite images, flood risk maps. Tabs (B) and (C) provide the weather forecast data, in both XML and KML format as well as the weather stations data for the time the user access them. Tab (D) provides options for G-FMIS parameterization. Options are related to three elements: (a) the ignition point of the fire accessed in tab A, (b) the updated weather observation data in tab C and (c) the capability to use forecast data for the model of the fire. The last is necessary when the user wants to explore what would happen in a specific area, at a specific time and weather conditions, in case of a fire (what-if analysis).

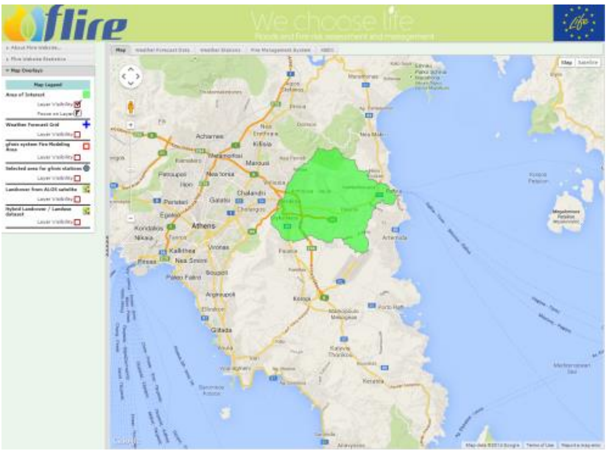

Fig. 2. The Map of the FLIRE - DSS system.

3. Results

Each user, by providing on-line all the necessary inputs for the fire model, sends a request to the G-FMIS server and within two minutes, runs and returns simulation on the spread of the fire for the next 3 hours as shown in Figure 3. KBDI values are presented in the locations of weather stations. For testing the DSS system, a series of 100 ignition point scenarios using real time weather data were used to evaluate the response time of the model and thus to be considered as a real time DSS. G-FMIS model has a response after a cold start in about 27 sec. (mean value) with maximum at 61 sec. and minimum at 23 sec. Only in a few cases the return of the results exceeds 35 seconds. Similar performance is also achieved by using the weather forecast data that are stored in server.

Fig.3. The spread of the fire for the next 3 hours in a given location.

4. Conclusions

The FLIRE DSS has been built as a web-based application that incorporates all the new available tools and approaches, like the open geospatial platforms, the transformation of the models into web services, the use of ftp tools and the implementation of the distributed architecture. The FLIRE DSS can be therefore used as either a real-time information system to support fire mitigation, or as a planning tool to support fire prevention. 60% of the requests in the G-FMIS model return the data of the spread of the fire in less than 30. Such a response gives to the FLIRE DSS the potential to be used as a valuable tool in the early depression of a fire in an area that fuel maps and weather data are available. Such information will become vital for both Forest Management Departments and the Regional Civil Protection Agencies during the fire season. Moreover, similar tools need also to be developed for other natural disasters such as floods, earthquakes and tsunamis to provide the information on time and therefore to prevent the loss of natural heritage values, properties and human lives. Finally, such tools have the potential to support the combined assessments of different hazards (like floods and fires), which is the ultimate goal of the FLIRE project.

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