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A web based DSS for the management of floods and wildfires (FLIRE) in urban and periurban areas

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ABSTRACT

The FLIRE DSS is a web-based Decision Support System for the combined forest and flood risk management and planning. State of the art tools and models have been used in order to enable Civil Protection agencies and local stakeholders to take advantage of web based DSS with no need of local complex infrastructure and maintenance. Civil protection agencies can predict the behavior of a fire event using real time data and in that way to plan its efficient elimination. Also, they can implement "*what-if*" scenarios for areas prone to fire and thus develop plans for forest fire management. Flood services include flood maps and flood-related warnings; these become available to relevant authorities for visualization and further analysis on a daily basis. Real time weather data from ground stations provide the necessary inputs for the calculation of the fire model in real time and a high resolution weather forecast grid support flood modeling and "*what-if*" scenarios for the fire modeling. The innovations of the FLIRE DSS are the use of common Earth Observation (EO) data as the backbone of the system to produce data for the support of fire and flood models, the common use of weather related information, the distributed architecture of the system and the web-based access of it with no need for installation of dedicated software. All these can be accessed by all means of computer sources like PC, laptop, Smartphone and tablet either by normal network connection or by using 3G and 4G cellular network. The latter is important for the accessibility of the FLIRE DSS during firefighting or rescue operations during flood events. FLIRE DSS can be easily transferred to other areas with similar characteristics due to its robust architecture and its flexibility.

1. Introduction

Decision Support System (DSS) is a computer-based information system which has the efficiency to support business or organizational decision-making activities. Such systems can provide services for the planning, operation and management of an organization in order to support make decisions. DSS introduce multiple interdisciplinary aspects into the planning process in complex decision environments by adding the geospatial domain (Chrysoulakis et al., 2010). DSS are popular in several fields like water resources management (Koutsoyiannis et al., 2003), environmental management (McIntosh et al., 2011), fire management (Kalabokidis et al., 2013; Noonan-Wright et al., 2011) and flood management (Honghai and Altinakar, 2011).

The application of a DSS is considered vital in the areas of fire and flood management where the early detection of the ignition of the fire or the early warning on the flood event are crucial for the protection of human lives, properties and assets.

Forest fires and flash floods are among the most destructive

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natural disasters, the occurrence of which is related with severe socioeconomic impacts, including loss of human lives, health and quality of life degradation, loss of private and public property and destruction of economic activities. The occurrence and the extent of both natural disasters strongly depend not only on the existing weather conditions in an area, but also on human intervention, which is particularly pronounced in peri-urban areas and can increase the environmental impact. These phenomena have typically been investigated separately, with different systems collecting information and modeling the resulting risk.

This approach overlooks two significant facts:

- The input data (field and remote sensing) required in both cases are essentially the same, and hence a "*collect once – use for many purposes*" paradigm can be adopted resulting in increased accuracy and economies and,
- The phenomena are tightly interrelated, with forest fires exacerbating the risk of flooding and preceding floods drastically reducing the risk of fires.

A combined approach to manage flood and fire risk would achieve better, more realistic results at a decreased cost and thus have considerable added value beyond current practice. The fact that end-users, in the form of emergency services (civil protection) are more often the recipients of both warnings only strengthens the case for a combined risk assessment and management.

The aim of the FLIRE DSS is to change the paradigm for the coupled, effectual and strong risk assessment and management of both flash floods and forest fires. This has been achieved by using state of art tools, technologies and methods and taking into account prevention, adjustments and interaction issues.

The innovations of the FLIRE DSS are: (a) The use of Earth Observation data, in a periodical basis (hypertemporal Earth Observation data analysis), mainly from Copernicus Sentinel missions in order to parametrize the models of the fire behavior (fuel map design) and the flood assessment (landcover map – curved number analysis), (b) The use of same weather information data (in situ and forecasts) for the models; both the collected and analyzed data are collected once (reducing the required recourse) and used for many purposes (same Earth Observation data for both models, same weather information data for both models) and (c) FLIRE DSS has a distributed architecture, and in case of failures, the system will continue to work as backup systems exits in geographical isolated areas.

2. FLIRE DSS structure

FLIRE DSS is the web based decision support system for integrated weather information management, forest fire management and floods information management. It uses service-orientation architecture (SOA) and is based on IT sources (Information Technology) and Geoinformation (GI). Innovative components of the DSS, acting as backbones, is the extensive use of EO data for modeling support, the shared weather information as input to the models as well as the web-based technology; this allows the end user to have unrestricted access by any computer means with no need of installation of software application.

Fire propagation modeling and floods case scenarios based on weather forecasts are used as web services. The components of the system are used as web services via a Graphical User Interface (GUI). The FLIRE DSS is consists of three different modules and several components (Fig. 1) under the FLIRE Server. The server uses *ftp* and *http* communication protocols as well as web service technologies. The GUI has been designed and developed based on the user's requirements consulted in a Community of Practice approach. The FLIRE DSS consists of the following components:

1) Weather Information Management Tool (**WIMT**): It handles, manages and provides the available weather information data.
2) Storms Early Warning System: It serves information about storms in the study area. Is part of the WIMT tool.
3) Early Fire Warning System (**EFiWS**): It provides control of the Fire Management System and the Fire Index.
4) Flood Risk Assessment System (**FLORAS**): It provides the user with flood maps based on weather forecasts and flood maps for different rainfall scenarios. Also include smart alerts and scenarios for future planning.
5) **FLIRE server**: Unify the aforementioned modules.
6) **GUI** – Web browser: The user interface.

3. Software availability

FLIRE DSS is accessible from the web (www.flire-dss.eu) with no prior installation of any add on software for support on the browser. It is a password protected system, in which only authorized users can have access for security reasons. The user's manual is available from here: http://goo.gl/lkWUgM. A free version (http://goo.gl/kWW8nK) is available for any user want to understand the functionalities and the innovations of the system. It has demo data for fire and flood models but provide live access to the weather data (stations and forecast). In Table 1, the technical characteristics of the application are provided.

4. Discussion

4.1. DSS innovation

The innovation of the FLIRE DSS are: (a) the use of hypertemporal Earth Observation from Copernicus Sentinels in order to parametrize the models of the fire behavior and the flood assessment, (b) the use of same weather information data (in situ and forecast) for the models; both the collected and analyzed data are collected once (reducing the required recourse) and used for many purposes (same Earth Observation data for both models, same weather information data for both models) and (c) FLIRE DSS has a distributed architecture, thus in case of failure of a component, the system will continue to work as backup systems exits. JavaScript web application is used for the frontend while the support data are organized in *xml*, *kml* and raster data files. The developed web services provide the web application with both real and non-real time data and data dictionaries.

4.2. User involvement, acceptance and use

During the design phase, Community of Practice (CoP) has been implemented in order to have the user's needs and requirements on such a system. The FLIRE DSS has been demonstrated to the Civil Protection, the Fire Brigade agencies and the Local stakeholders in order to have an interplay for improvements on the design and the presented tools. FLIRE DSS is a promising tool for these key components of the local administration. It provides the natural disaster management departments with the advantages of the GIS abilities without the challenge of the installation of complicated and expensive software. The DSS provides the users with real time information on the current weather conditions in the area as well as high resolution imageries which support the identification of the shortest paths to reach the areas of fire or flood and other important information for the surrounding terrain. An Important component of the FLIRE DSS is the potential of the users to use