THE DEVELOPMENT OF A FIRE VULNERABILITY INDEX FOR THE MEDITERRANEAN REGION

LANEVE Giovanni\textsuperscript{a}, JAHJAH Munzer\textsuperscript{a}, FERRUCCI Fabrizio\textsuperscript{b}, BATTAZZA Fabrizio\textsuperscript{c}
\textsuperscript{a}Università di Roma “La Sapienza” – CRPSM, Rome, Italy – laneve@psm.uniroma1.it
\textsuperscript{b}Università della Calabria, Department of Earth Sciences, Rends (CS), Italy
\textsuperscript{c}Agenzia Spaziale Italiana, Rome, Italy

1. INTRODUCTION

The SIGRI (Sistema Integrato per la Gestione del Rischio Incendi) pilot project, funded by ASI (the Italian Space Agency), aims at developing an Integrated System for the Management of the Wild Fire Events. The system should provide satellite based products capable to help fire contrasting activities during all the phases: prevision, detection, and damage assessment/recovering. In particular, the paper concerns the development of a Fire Risk Index to be produced daily with the objective of showing the total level of risk for the area of interest and the zones of major concern within such area.

The idea to develop maps able to show the fire risk is based on the observation that there is a tight relationship between the fire and the characteristics of the fuel (vegetation type, density, humidity content), of the topography (slope, altitude, solar aspect angle) and the meteorological conditions (rainfall, wind direction and speed, air humidity, surface and air temperature). These parameters directly impact the proneness of a given area to the fire ignition and propagation. Since these quantities can be measured, notwithstanding the cause of the fire ignition, mainly due, in Italy, to human actions (more than 90% of the ignitions is intentional or accidental), could be unpredictable the behaviour of the fire can be considered strictly dependent from those and then it can be foreseen when such parameters are known.

According to the model, the methods of fire risk estimate exploit different information and can be distinguished as follow [6]:

Statistical Methods or Structural (long-term fire risk index) defining forecast models based on the utilization of slowly changing parameters like topography or other variables that can be considered constant along the year and statistical information on the frequency of the phenomenon.

Dynamical Methods (short-term fire risk index) based on data measured continuously (i. e. daily), on characteristics territorial data (orography and vegetation) and on forecast models of the meteorological parameters.

The short-term fire indices are, in general, able to provide information on the danger of the event defining: areas of possible ignition, propagation direction and speed, irradiated energy, etc. In other words, such index represents the probability of the ignition and propagation of the forest fire and defines a daily level of risk. By combining this
daily fire risk index with the information typical of the Likely Probability Index (infrastructures, protected areas, etc.) we can compute the Fire Vulnerability Index that would be one of the products provided by the SIGRI project.

2. FIRE RISK INDICES

The European Commission funded the development of the EFFIS (European Forest Fires Information System) system [9]. This system, developed by JRC (Joint Research Centre), provides, apart from a structural risk index, a seven days forecast based on a daily updated fire risk index. For several years the forecast has been based on 7 different indices: the Portuguese index, the ICONA Method, the numerical risk Drouet-Sol, the Italian index of risk, the Canadian Fire Weather Index, the BEHAVE Model, the Fire Potential Index (FPI). Satellite data are used for the computation of only one of these 7 indices, namely the FPI. After this test period, the JRC has selected, as index useful for describing the fire risk for the European region, the FWI (Canadian Fire Weather Index).

The present paper aims at presenting the results obtained by applying at the Italian territory and more specifically to the three test areas of the SIGRI project (namely: Calabria, Liguria and Sardinia) a modified version of the FPI. The FPI consists in the estimate of the fuel conditions by means of a separation of the dead and green vegetation. This estimate is carried out by using maps of the vegetation index NDVI (Normalized Digital Vegetation Index) obtained with space-borne sensor like, for instance, MODIS. To carry out the computation, a map of the fuel distribution on the area of interest is needed. Other needed quantities are the air temperature and humidity, cloudiness and rainfall. This index is based on the FPI derived by Burgan [3] for U.S. and successfully validated in California. Its validation in the European context has not yet completed [6]. The model requires the NDVI for computing the Relative Greenness, meteorological data (air temperature, relative humidity, cloudiness and rainfall) for estimating the Ten Hours Time Lag Fuel Moisture (FM10hr) and a fuel map to estimate the percentage of dead vegetation. The relative greenness (RG) or vegetation stress index represents how much green is a pixel, with reference to the range of historical observation of the NDVI used [2]. The FM10hr has been selected as the quantity representative of the humidity available in the dead vegetation [8]. Such a quantity can be computed by using the meteorological parameters and the relationship described by Lopez [7].

The classic definition of FPI doesn’t allow to take into account the effect of solar illumination conditions in determining the humidity present in the dead vegetation therefore its proneness to burn. In order to introduce such parameter we estimate the vegetation evapotranspiration rate, ET₀, and use the computed values as a weight for obtaining the FM10hr term for similar vegetation types characterized by a different solar aspect angle. ET₀ has been computed by using the Penman-Monteith formula, modified according with FAO. However, the whole process to obtain the quantities needed can be found in [10]. Anyway others relationship, like these of Hargreaves [5] and Thornthwaite [11], can be used for computing the same quantity.

Since also the presence of water in the alive vegetation can be considering relevant in determining the fire regime, the problem of estimating the vegetation water content, by using satellite images, has been dealt with. This
estimate is made through an index called the \textit{Equivalent Water Thickness} (EWT). We adopted the expression given by Ceccato [4]. It should be noted that the EWT parameter is not related to the Fuel Moisture Content (FMC) that is commonly used in the derivation of indices of risk of fire. This index, however, is not easily estimated from satellite, unlike what happens for the EWT index. A preliminary analysis of the capability of this MFPI (Modified FPI) to capture the actual spatial and temporal behaviour of the fire risk has been presented in a previous paper. In such paper, due to the limited availability of needed meteorological data the evaluation of the performances of the index have been restricted to the year 2007 summer fire season.

The historical minimum and maximum values of the NDVI have been computed by using the NDVI averaged values provided by the MODIS sensor image for the years 2006 to 2010. The daily NDVI values, used to estimate the RG has been computed by using MODIS images and the IMAPP software. The fuel maps have been constructed by using the 2006 CLC maps, the forest maps of Europe, the Forest information for the Sardinia region available from the Regione Sardegna website and visually comparing the photos showing examples of the NDFRS fuel types [1] with these representing the CORINE classes. The 90 m spatial resolution SRTM-DEM has been used for computing the solar illumination conditions and the evapotranspiration rates. The fires data, used for validating the FPI maps, have been obtained by using MODIS and SEVIRI/MSG satellite sensors based hot spots. The analysis covers the period 2007 - 2010. The atmospheric data will be provided by the Italian DPC.

The usefulness of including in the computation of the modified FPI the solar illumination/evapotranspiration effect has been demonstrated in a previous paper, where the behavior of the evapotranspiration index has been compared with the fire events distribution. In that case it has been observed as, even if most of the fires (more than 90%) are due to the human intervention (intentional or accidental), their daily distribution clearly follows the evapotranspiration behavior. The number of fire events, obtained by the MODIS Fire Mapper website, on the Calabria region for the year 2007 have been 1080. In such a paper it has been also observed as the 13% of such events are, apparently, involving areas not classified as vegetation fuel in accordance with the available NFDRS fuel models. Of course, this result arises some concern on the possible presence of false alarms among the hot spots detected by using the MODIS sensor. This problem will be solved by improving the information on the hot spots by using data based on the SEVIRI images and the ground data provided by DPC.

3. CONCLUSIONS

In the paper the results of the performances of the MFPI will be described. The analysis covers the time period 2007 - 2010. The additional information (evapotranspiration and EWT) used to compute the new index with respect to these involved in the computation of the FPI index seems to be able to capture other terms relevant in determining the proneness of the vegetation to burn. Such index has been developed in the framework of the
SIGRI project and aims at producing daily maps of the spatial distribution of the fire risk to be used for prevision and resources management purposes.

4. REFERENCES