A methodology for assessing the spatial distribution of static wildfire risk over wide areas: the case studies of Liguria and Sardinia (Italy)[1]

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Abstract: In Mediterranean areas, some studies suggest universal increases in fire frequency due to climatic warming. However, some authors point out that the universality of these results is questionable. In this study, we try to go beyond the simple analysis of statistical data related with the number of fires and the total burned area, which can be misleading in the context of climate change. The fire perimeters have been used to inquire spatialized climate indexes and the vegetation cover. A statistical analysis of climate indexes has been conducted and a certain number of Type of Homogeneous Areas (THA) defined by introducing information on vegetation cover. The comparison of THA and climatic indexes allowed the definition of an index of risk. Maps of this index highlight risky areas in Liguria and Sardinia (Italy).

Keywords: climate change, climate indexes, static wildfire risk, vegetation cover.

1. Introduction

In Mediterranean area, some studies in the later ’90 (Piñol *et al*. 1998) predicted a continue increase of the number of days of very high fire risk, and more frequent catastrophic wildfires. Some studies, in the same period, suggested universal increases in fire frequency with climatic warming (Overpeck *et al*. 1990). However, Flannigan *et al*. (2000) point out that “the universality of these results is questionable because an individual fire is a result of the complex set of interactions that include ignition agents, fuel conditions, topography and weather including temperature, relative humidity, wind velocity and the amount and frequency of precipitation. Increasing temperature alone does not necessarily guarantee greater fire disturbance.”.

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In this study, we try to go beyond the simple analysis of statistical data related with the number of fires and the total burned area which can be misleading in the context of climate change. The availability of a long data series of fire perimeters combined with a detailed knowledge of topography and land cover allow to understand which are the main features involved in forest fire occurrences and their behaviour. In addition, the analysis of climate indexes allows to understand the role of climate on fire regime, both in terms of direct effects on fire behaviour and the effect on vegetation cover.

2. Materials and Methods

Study areas. Liguria (Italy) is a region of 5400 km^2 lying on the northwest coast of the Tyrrhenian Sea. For this Mediterranean region, wildfires are recurrent phenomena both in summer and winter: an average of 365 wildfires of size > 0.01 km^2 burns an area of 55 km^2 per year.
Sardinia (Italy) is the second-largest island in the Mediterranean Sea. Wildfires represent a severe threaten to life and goods during summer. On average, between May and October more than 2500 fires burn more than 310 km^2 of shrubland, grassland and forests per year.
Data. As far as fire perimeters are concerned, the data set used in Liguria references the period from 1997 to 2009 and reports 7390 wildland fires that overall burnt 510 km^2 of forests and shrubland. The dataset used in Sardinia references the period from 2006 to 2008 and reports more than 4850 fires that overall burnt 480 km^2. The available regional vegetation cover maps are different in the two regions, then preventing a homogeneous classification. Daily rainfall and temperature data referring to the period 1951-2008 have been analyzed using time series a) with more than 30 years of complete records for trend analysis, and b) with more than 20 years of complete records in the standard period 1971-2000, for climate analysis.
Method. Climate indexes have been analyzed at the seasonal and annual temporal scale. In particular, the maximum number of consecutive dry days (CDD) and the heat wave duration index (HWDI) suggested by Frich *et al*. (2002) for monitoring change in climatic extremes world-wide have been considered. Interpolated maps of the normal values have been obtained by either kriging or multiple regression. For each climate index, a finite number of classes has been defined on the basis of a preliminary analysis of the fire perimeters. These classes have been compared to land cover classes to derive the possible Types of Homogeneous Areas (THA). The index:

$$\mathbf{H_i} = \frac{1}{\Delta T} \frac{\sum_{k=1}^{N_i} \mathbf{B_{ik}}}{\mathbf{A_i^{tot}}}$$

has been defined to measure the risk associated to the *i*-th THA, where ΔT is the length of data series (years), N_i the number of fires occurred in THA *i*-th, $\mathbf{B}_{ik}$ is the burned area in THA *i*-th by fire *k*-th, $\mathbf{A}_i^{tot}$ is the total cover area by THA *i*-th.

3. Results

In general, trend analysis does not show clear patterns of climate change at the annual time-scale. As far as extreme events in Sardinia are concerned, CDD shows decreasing trend in the Central-South part, where consecutive dry days periods are longer. Similar results are not obtained in Liguria, where, on the contrary, 3 stations show increasing CDD.
In Liguria, the actual number of THA is 906 in winter and 865 in summer, while in Sardinia the number of actual THA is 395. Figure 1 shows the obtained maps of index **H** and highlights the areas at the highest risk (red).

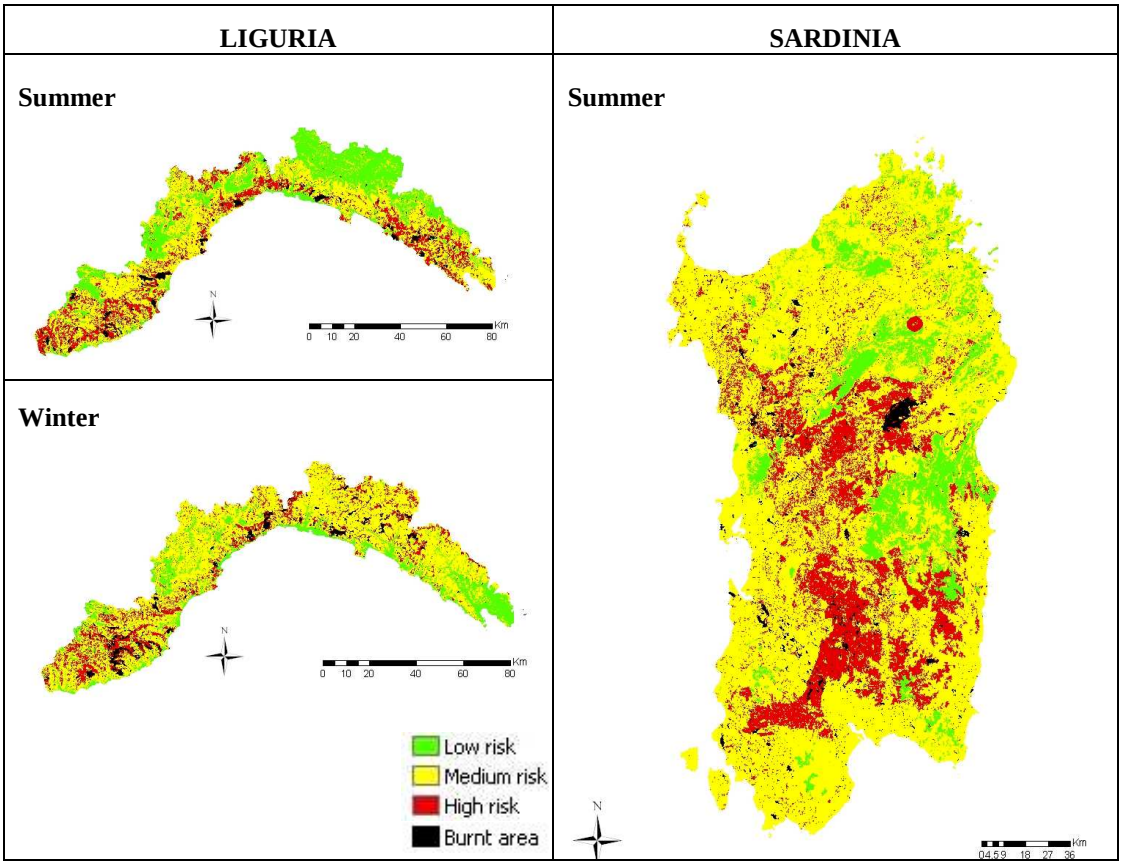

Figure 1: Risk maps in Liguria (left) and Sardinia (right). In black, the burned areas are shown.

4. Concluding remarks

In this work, an index of static fire risk has been introduced that takes into account both the climate and the vegetation cover. Two different case studies are presented, Regione Liguria and Regione Sardegna (Italy). Both regions are in the center of the Mediterranean and are characterized by a high number of fires and burned area. However, the two regions have very different fire regimes. Sardinia is affected by the

fire phenomenon only in summer whilst Liguria is affected by fires also in winter, with higher number of fires and larger burned area. In addition, the two region are very different in vegetation cover.
Concerning Liguria, the proposed methodology is able to put in evidence the different seasonal fire regimes, and provides useful information about regional fire risk management. Shrublands, in Liguria, represent the first stage of the succession dynamics in abandoned agriculture areas and it is the most flammable kind of vegetation mainly involved in large fires both in summer and in winter season. Conifer plantations near the coastline mainly constituted by *Pinus Pinaster* heavily degraded by Matsucossus represent the most high intensity and frequent fires in summer which provide the major risk for the Wildland-Urban Interface. On the contrary, in Sardinia, shrubs represent less that 10% of the vegetation cover contained in the higher risk areas and conifers are not present at all. Here, the vegetation cover characterizing the higher risk areas is mainly composed by *Quercus Suber* and mixed forests.
Concerning the climate influence on fire risk, in summer season the highest risk areas are characterized in both regions by high air temperature. Only in Sardinia the HWDI seems to play a key role. The influence of rainfall regime on fire risk in the summer season (Sardinia is affected by fires only in summer) puts in evidence, in both regions, that the higher risk areas are characterized by a significant amount of total precipitation and by a significant number of rainy days. However, the same areas are characterized by a significant number of cumulative dry days especially in Sardinia. This result shows that fire ignition is mainly favorite by the presence of annual herbaceous species which accumulate biomass in the wet season and represent almost a completely dry fuel in the summer season.
The obtained results are certainly satisfying, however suggest further improvements. The role of HWDI has to be discussed, and a seasonal definition introduced. Indeed, the relevant role of this index in Sardinia only can be due to the higher temperatures of the island. Further insight into the role of HWDI and CDD has been obtained by comparing the dates of fires and the corresponding indexes values. We obtained a strong relationship between higher HWDI values and long dry periods in spring. This result open the doors to further development of the analysis.

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