High resolution fire risk mapping in Italy

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Introduction

The high topographic and vegetation heterogeneity makes Italy vulnerable to forest fires both in the summer and in winter. In particular, northern regions are predominantly characterized by a winter fire regime, mainly due to frequent extremely dry winds from the north, while southern and central regions and the large islands are characterized by a severe summer fire regime, because of the higher temperatures and prolonged lack of precipitation. In view of the limited availability of fire risk management resources, most of which are used in the management of national and regional air services, it is necessary to precisely identify the areas most vulnerable to fire risk. The few resources available can thus be used on a yearly basis to mitigate problems in the areas at highest risk by defining a program of forest management interventions, which is expected to make a significant contribution to the problem in a few years' time. The goal of such detailed planning is to dramatically reduce the costs associated with water bombers fleet management and fire extinguishing actions, leaving more resources to improve safety in areas at risk. With the availability of fire perimeters mapped over a period spanning from 5 to 10 years, depending by the region, a procedure was defined in order to assess areas at risk with high spatial resolution (900 m2) based on objective criteria by observing past fire events. The availability of fire perimeters combined with a detailed knowledge of topography and land cover allowed to understand which are the main features involved in forest fire occurrences and their behavior. The seasonality of the fire regime was also considered, partitioning the analysis in two macro season (November-April and May-October).
About 48000 fire perimeters which burnt about 5500 km2 were considered in the analysis, that was carried out at 30 m spatial resolution. Some important considerations relating to climate and the territorial features that characterize the fire regime at national level contribute to better understand the forest fire phenomena. These results allow to define new strategies for forest fire prevention and management extensible to other geographical areas. In this first work a map of fire hazard was produced for Liguria region, in Northern Italy.

Methodology

The analysis was based on the historical wildifre dataset occurred in the territory of the Liguria Region (Northern Italy, Figure 1) and on the dependence on the geomorphological characteristics of the territory, namely height above the sea level, slope and aspect.
The risk was assessed as the fraction of cells interested by fire on the total number of cells for each class of geomorphology in which the territory was subdivided. In order to assure a constant statistical significance in the estimatation of the fraction of burned cells (used as measure of the fire hazard) and, at the same time, maintain a classification based on the three variable above-cited, the following statistical algorithm was followed:

1)The samples of the 3 variables (height, slope and aspect) are subdivided in equally numbered intervals (with sample percentiles)
2)For each interval of each variable the percentage of burned cells is computed
3)The Spearman Correlation coefficient (that accounts also for nonlinear dependences) is computed and the variables are ordered in decreasing correlation order
4)Chosen a number n of classes for each variable, and starting from the first variable, the territory of the analysis domain is subdivided in n subsets (intervals of the given variable), each one having the same number of cells. This is obtained by using the appropriate sample percentiles of the distribution of the given variable.
5)For each one of these intervals, or territory portions, the same intervals subdivison is performed for the second variables, again using the sample percentiles.
6)Again, for each of the n x n subset in which the territory was subdived in step 5), a further subdivision in n equally-numbered intervals is performed.

The variables were used in order of decreasing correlation resulting as: aspect, slope, height. From the probabilistic point of view, the iterative subdivision is equivalent to consider the conditional estimation of the fire hazard given the fact that the previous considered variables lay in the given intervals. In symbols: P(F | (Px1i < X1 < Px1i+1) U (Px2i < X2 < Px2i+1) U …..)
In Figure 2 it is represented the Conditional Distribution Density of the Fire Hazard given that the single cell is contained in a given territory class, where the classes are defined as described above.

Figure 1. Liguria region in Italy.

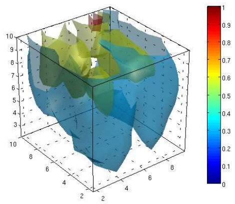

Figure 2. Conditional Probability Distribution Density for the fire hazard.

Previous maps

The previous analysis followed tea same criteria exposed above, but using, as classes for the subdivison of the territory, simple cartesian products of equal-spaced classes for each variables, not assuring the same sample size for each class. In Figures 3a and 3b the resulting maps of Fire hazard for Liguria are shown.

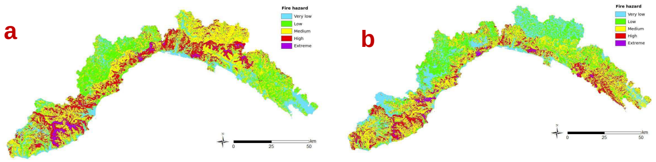

Figure 3. Fire hazard, old methodology: a) winter, b) summer.

Fire Hazard Maps

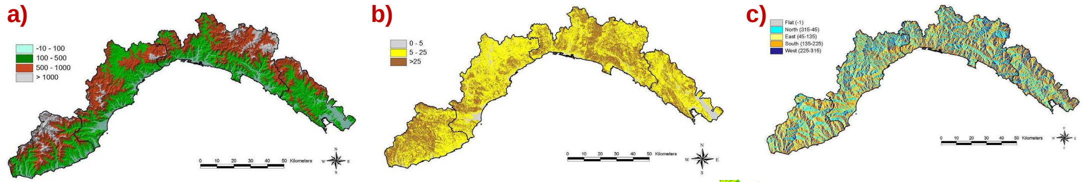

Figure 4. Geomorphological characteristics of Liguria:
a) Height above sea level
b) Slope
c) Aspect

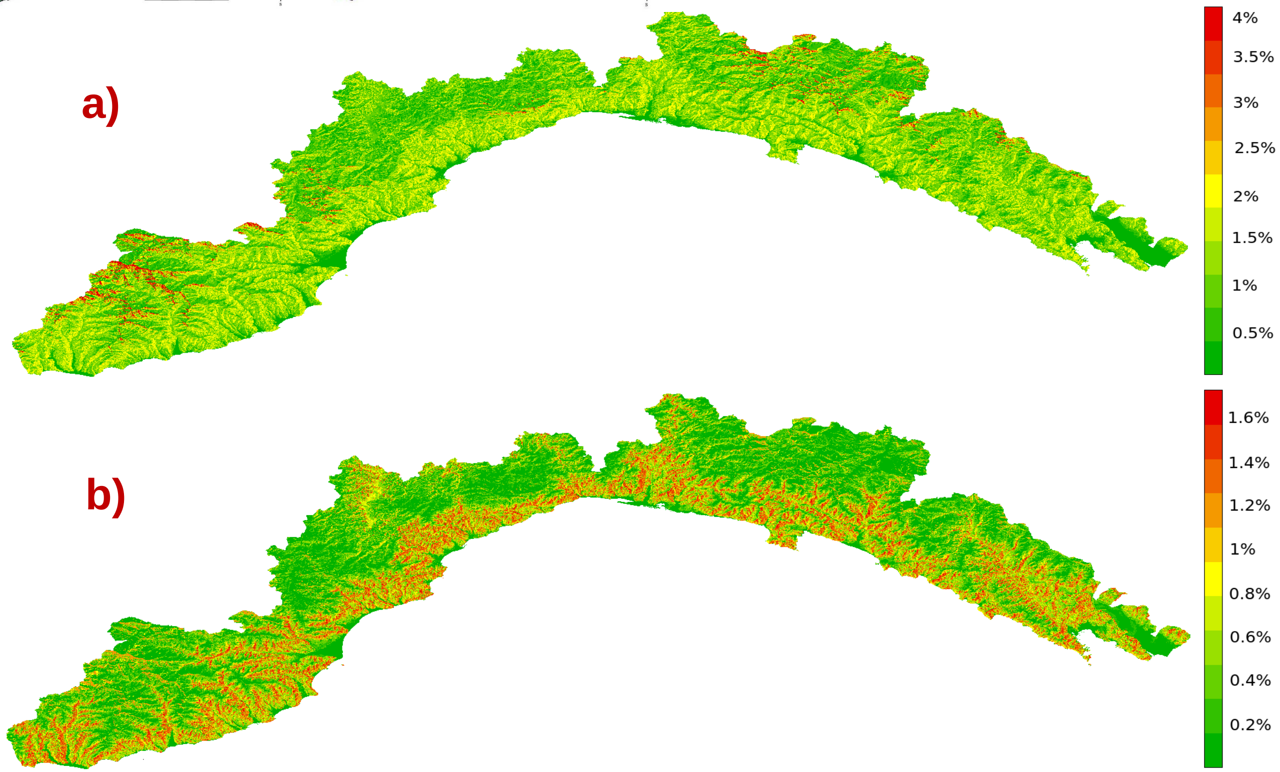

Figure 5. Fire hazard, new methodology: a) winter, b) summer.