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Analysis of burnt areas and number of forest fires in the Iberian Peninsula

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Abstract

The Iberian peninsula has suffered for many years from large scale forest fires, which in the past decades have been devastating for all components of the environment: destruction of biological systems, loss of organic matter from soils and alteration of atmospheric and climatic processes.
In this study we analyse the variation in number and burnt areas in the Iberian Peninsula (Portugal and Spain), using mathematical functions. The results obtained are compared with other European Mediterranean countries such as France, Italy and Greece. More than 1.5 million fires were recorded in the Mediterranean countries between 1980 and 2011, involving a burnt area of approximately 15 million hectares, where 67% of the fires and 60% of the burnt area lay in the Iberian Peninsula. Upon using the adjustment functions, the evolution of the number of fires in the Iberian Peninsula shows a growth rate between 1980 and 2000, while a decline in fires was observed after 2001. There is a continuous decrease in burnt area throughout these years.
The evolution of the number of fires in Spain and Portugal presents a behaviour that is quite similar to that in the Mediterranean countries. However, this is not true for the burnt areas, where an increase in Spain from 1980 to1985 was observed, and this decreased after 1986. Portugal on the other hand presents an increase in burnt areas from 1985 to 2003.

Keywords*: Iberian peninsula, burnt areas, number of forest fire, mathematical function*

1. Introduction

Spain like Portugal and other Mediterranean countries are suffering the dramatic consequences of the forest fires, which in the last years have produced a big deforestation that provokes degradation of the environment and important socio-economical losses. Their direct destructive effects are manifested in all components of the environment: the vast forest area burnt (forest and scrub); the destruction of the fauna; the loss of soil organic matter, with the consequent variation of all its properties and the loss of soil quality; and altering atmospheric and climatic processes due to particles and smoke released by the fire, which also contains hydrocarbons, greenhouse gases and toxic substances for humans and animals In addition, there are indirect effects caused by the destruction of the vegetation cover, which leaves the soil unprotected against the impact of the rain, and subsequent post-fire erosion, producing the drag of the finest components of topsoil (seeds, organic and inorganic substances) necessary for normal development of the vegetation, and in extreme conditions, the irreversible loss of soil and even the rock outcrop. The drag of water and sediments caused by the erosion and deposition away from the fire epicenter will alter aquatic and marine ecosystems and habitat for fish, shellfish, etc. This has

negative social and economic impacts. Consequently, it is of paramount importance to develop efficient tools for the integral forest fire fighting.
Most of the total burned area and the largest numbers of fires in Europe are found in southern European countries, namely in Portugal, Spain, France, Italy and Greece. The characteristics that define the fire events have been characterised using qualitative or quantitative methods, from local to regional or global scales. For example, San-Miguel-Ayanz *et al*. (2013) published an analysis of trends in the number of forest fires and burnt areas in the Mediterranean region (Galicia-Spain, Portugal and Greece). Pereira *et al.* (2011) studied the number of fires per year and burnt area per year for five Mediterranean countries (Portugal, Spain, France, Italy and Greece). Sarris and Koutsias (2014) investigated correlations between climate, vegetation and fire statistics in four Mediterranean countries (Spain, France, Italy and Greece). Oliveira *et al*. (2012) identified the main structural factors that explain the likelihood of fire occurrence at Europan scale (Portugal, Spain, France, Italy, Greece). The factors influencing fire occurrence, fire risk, or fire statistics in Mediterranean countries, have been investigated at local or regional level by several authors who have focused on Portugal (Viegas *et al*. 1992; Moreira *et al*. 2001), Spain (Chuvieco *et al.* 2009; Fuentes-Santos *et al*. 2013; Moreno and Chuvieco 2013; Martínez-Fernández *et al*. 2013; Turco *et al.* 2013; Martin-Martin *et al*. 2013), France (Ganteaume and Jappiot 2013; Sarris and Koutsias 2014), Italy (Salis *et al.* 2014), Croatia (Jurjevic *et al.* 2009) and Greece (Koutsias *et al*. 2012; Koutsias *et al*. 2013; Sarris and Koutsias 2014; Polychronaki and Gitas 2012).
The principal aim of this paper is to analyse the variation in number of fires and burnt areas in the Iberian Peninsula (Portugal and Spain), using mathematical functions.

2. **Methods**

2.1. **Study area and fire databases**

The study area for this investigation is the entire Iberian Peninsula (figure 1). This region is located in south-western Europe (western Mediterranean Basin), and includes two countries: Portugal and Spain. The results obtained are compared with other European Mediterranean countries such as France, Italy and Greece.

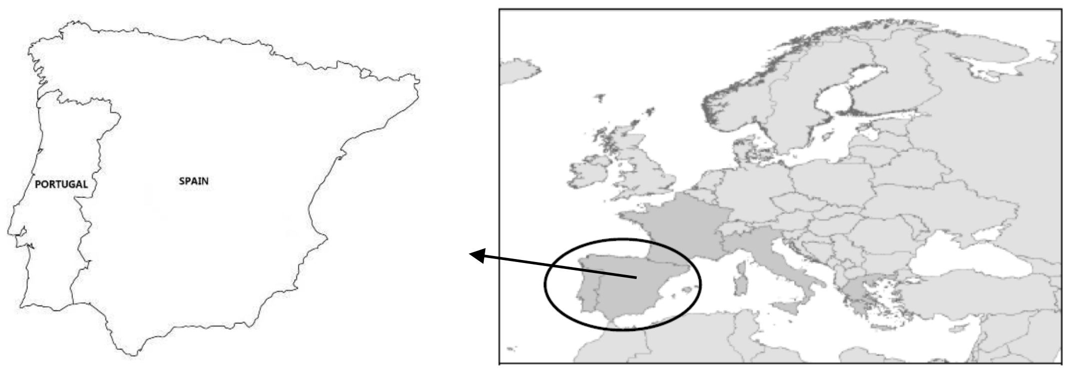

Figure 1. Study area.

In order to compile the required information for the temporal analysis on the variation in number of fires and burnt area in the Iberian Peninsula, a fire database for the Iberian Peninsula was developed from the information contained in both national official databases. The Spanish Forest Fire Prevention Service compiles a fire database based on the forest fire reports by the autonomous regions and provinces, since 1968. Data of fire occurrence and burned area in Portugal and Southern most affected European Countries (Spain, Portugal, France, Italy and Greece) were obtained from the Autoridade

Florestal Nacional (AFN) and from Join Research Center (JRC Tecnical Reports, Forest Fires in Europe Middle East and North Africa 2011), respectively. The data series from 1980 to 2011 was used in the present study.
More than 1.5 million fires were recorded in the Mediterranean countries between 1980 and 2011, involving a burnt area of approximately 15 million hectares, where 67% of the fires and 60% of the burnt area lay in the Iberian Peninsula and 31% of the fires and 36% of the burnt area corresponding to Spain.

2.2. **Equations**

In this study, data of the number of forest fires and burnt area in the Spain, Portugal, Iberian Peninsula and European Mediterranean countries (Portugal, Spain, France, Italy and Greece) from 1980 to 2011 were fitted to variable-degree polynomials such as:

$$f(x) = \sum_{i=1}^{n} A_i \cdot x^{i-1} \qquad (1)$$

where $x = x' - x_o$, x' is the year of study, $x_o = 1979$ is the year zero, f(x) is the number of fires or the burn area in the study interval. The fitting parameters A_i were computed from the unweighed least-squares method using a non-linear optimization algorithm.

In addition, the burned area and the number of fires have been considered to assess the evolution of forest fires in the different temporal periods. Then, mean number of fires and mean area burned are studied in periods of two years, three years, four years, and so on.

3. **Results**

Trends in number of fires and burnt areas in the Iberian Peninsula, Spain and Portugal was analysed. The results obtained in this study were compared with the trends followed by the set of several Mediterranean countries. Figure 2 shows the annual series of burned area and number of fires in the Iberian Peninsula, in España and Portugal, and in the set of Mediterranean countries (España, Portugal, France, Italy and Greece).

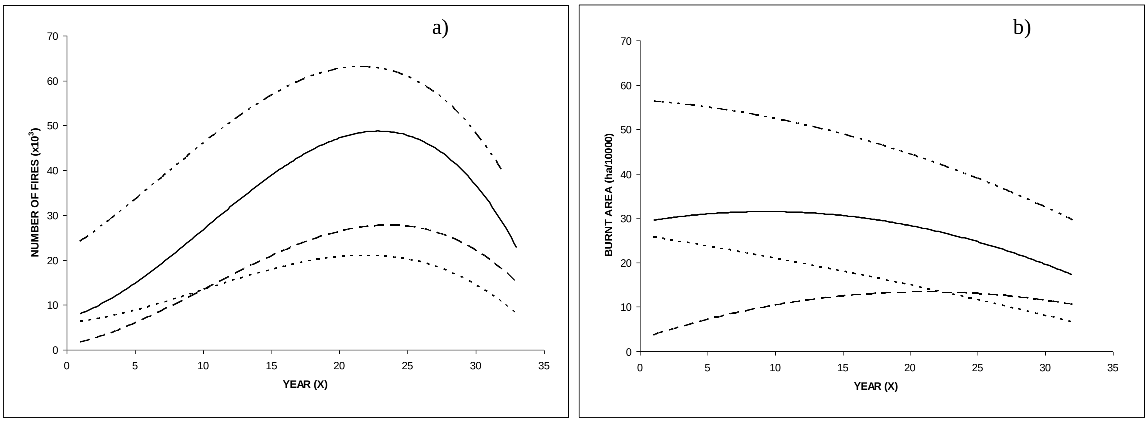

Figure 2. a) Evolution of the forest fire number registered between 1980 and 2011, b) Evolution of the burned area between 1980 and 2011. — · · — Set of the mediterranean countries, ——Iberian peninsula, – – – – Portugal, ······Spain

It can be seen that the evolution of the number of fires in the Iberian Peninsula shows a growth rate between 1980 and 2000, while a decrease of fires is observed after 2001. The number of fires in Spain and Portugal has a very similar trend. Moreover, there is a continuing decline in the area burned along these years in Spain, Iberia Peninsula and in the set of Mediterranean countries studied. However, it is noted that in Portugal the area burned increases smoothly along these years.

The functions obtained for annual data shown in Figure 2 are compared with the obtained functions for the mean data in several time intervals, of between 2 and 5 years, presented in Figure 3. The best correlations were obtained with polynomials of degree three for the number of fires and polynomials of degree two for area burned. The coefficients of correlation obtained from the fitting curves of degree three for the mean number of fires are shown in Table 1.

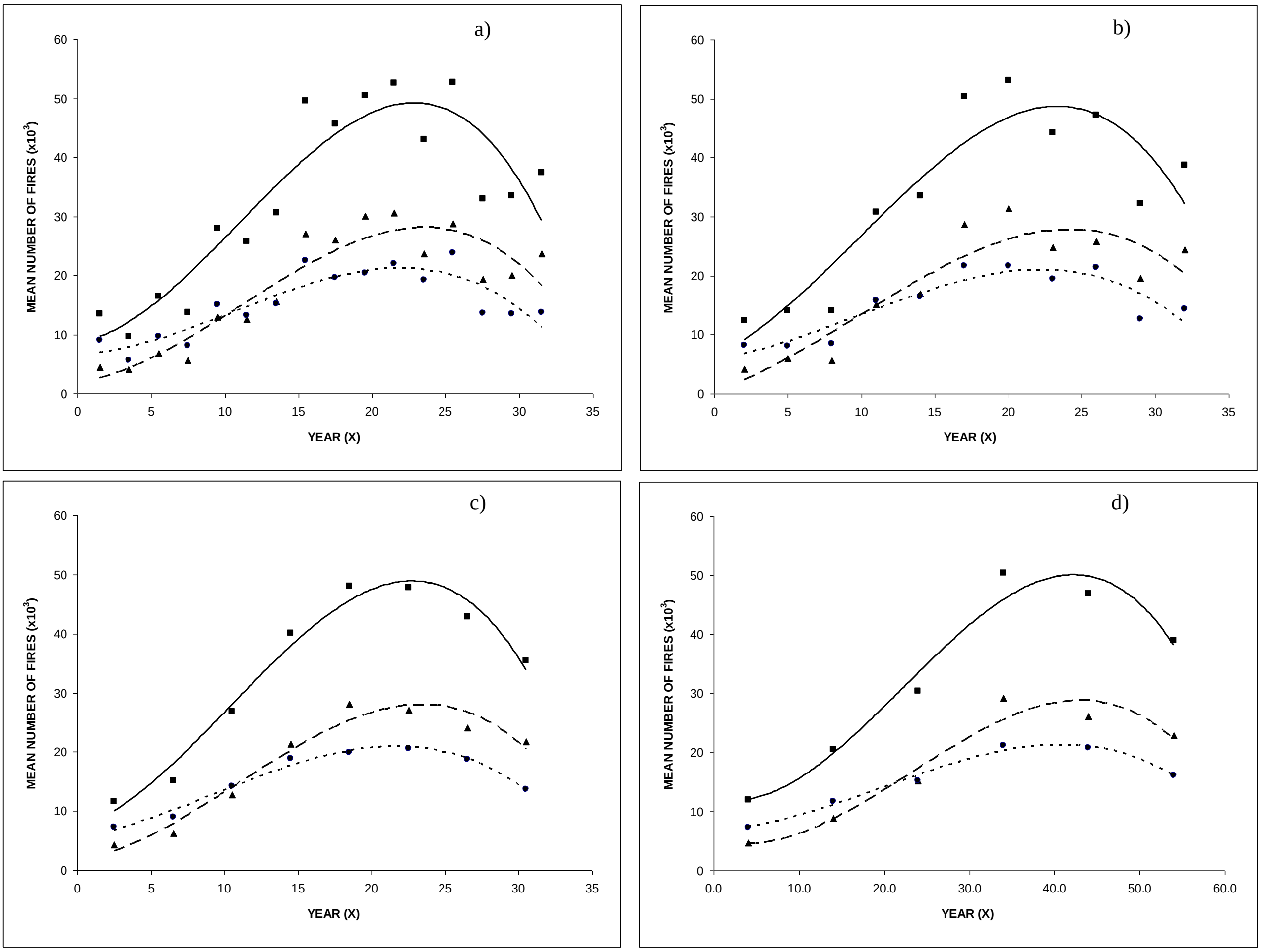

Figure 3- Evolution in several time intervals of the forest fire number registered between 1980 and 2011. a) 2 years, b) 3 years, c) 4 years, d) 5 years. Fitting curves: —— Iberian peninsula, – – – – Portugal, ······Spain. Mean number of fires: ■ Iberian Peninsula, ▲ Portugal, ● Spain.

Table 1. The correlation coefficients, R^2, of the fitting curves of degree three for the number of fires.

	1 year	2 years	3 years	4 years	5 years
Iberian Peninsula	0.7163	0.8453	0.8433	0.9752	0.9647
Portugal	0.7709	0.8568	0.8411	0.9606	0.9466
Spain	0.6591	0.7967	0.8302	0.9815	0.9849

A similar study to that presented in Table 1 for the number of fires was performed to analize the area burned. The best results were obtained with a time interval of 4 years, for both the number of fires as for the burned area.

From the fitting curves, the maximum value for the mean number of fires in the Iberian Peninsula is about 47 000 fires in 2002, around 28 000 fires in Portugal for 2002, and 22 000 fires in Spain for 2001. In accordance with real data.

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