Advances in Forest Fire Research

2018

EDITED BY

DOMINGOS XAVIER VIEGAS

ADAI/CEIF, UNIVERSITY OF COIMBRA, PORTUGAL

Short contribution – Decision Support Systems and Tools

Analysis of the temporal behaviour of the number of forest fires in some countries of Europe

J.L. Legido[3]*, M.M. Mato[4], S. García-Garabal[5], T. Carballas[2], M.I. Paz Andrade[1]

[1]*Department of Applied Physics, Microcalorimetry, Faculty of Physics, University of Santiago de Compostela. Campus Universitario Sur, E-15782 Santiago de Compostela, Spain, {inmaculada.paz.andrade@usc.es}*

[2] *Agrobiological Research Institute of Galicia (IIAG-CSIC), Campus Universitario Sur, Section 122, E-15780 Santiago de Compostela, Spain, {tcf@iiag.csic.es}*

[3]* *Department of Applied Physics, University of Vigo. Campus Lagoas-Marcosende. 36310 Vigo, Spain, {xllegido@uvigo.es*}*

[4] *Department of Applied Physics (FCCED), University of Vigo. Campus de Pontevedra. 36005 Pontevedra, Spain, {fammmc@uvigo.es}*

[5] *Department of Physics, University of A Coruña, A Coruña, Spain, {Sandra.garcia-garabal@udc.es}*

Abstract

This paper presents a temporal analysis of the number of forest fires that occurred in different European countries between 1990 and 2016. The countries studied were Bulgaria, Croatia, France, Finland, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Norway, Poland, Portugal, Romania, Slovakia, Spain, Sweden, Switzerland and Turkey.

In these countries, the data from the studied time interval indicated an annual average of 74000 forest fires where more than 75% occurred in countries of southern Europe, such as Portugal, Spain, France, Italy, Greece, Croatia and Turkey. In addition, most of them occurred in Portugal (30%) and Spain (23%) which indicates that the fires occurred in the Iberian Peninsula exceeded 50 %.

On the other hand, Portugal had the highest rate of number of fires per area and population with 0.24 annual fires per km^2 and 2.04 annual fires per thousand inhabitants, whereas Germany has a rate of 0.0031 annual fires per km^2 and 0.014 annual fires per thousand inhabitants.

Clustering data of annual number of fires for the studied countries were fitted to a variable degree polynomial function. According to this fitting, the number of fires increased up to the year 2000 and decreased afterwards.

Keywords: forest fires, number, europe, mathematical functions

1. Introduction

European countries, as well as other countries in the world, are suffering the tremendous scourge of forest fires, which were devastating in recent decades. Their direct destructive effects are the main cause of the enviroment degradation and the destruction of the forest ecosystem and provoke important socio-economic losses. The use of mathematical models and systems based on knowledge is of paramount importance to develop efficient tools for the forest fire fighting.

2. Methods

This paper presents a temporal study of forest fires that occurred in different European countries between 1990 and 2016 (Forest Fires in Europe, Middle East and North Africa 2016 (JRC, 2016)). The countries studied, shown in figure 1, are: Bulgaria, Croatia, France, Finland, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Norway, Poland, Portugal, Romania, Slovakia, Spain, Sweden, Switzerland and Turkey.

An analysis of the number of forest fires with the area or the population for each studied country was made.

Figure 1 - Studied area

2.1. Mathematical functions

In this work, data on the number of annual forest fires registered in the studied countries were normalized [2] to weighted functions ($g(x)$) between 0 and 1.

$$g(x) = (f(x) - f_{min}) / (f_{max} - f_{min})$$

1

where $f(x)$ is the number of annual forest fires, f_{min} the minimum of fires and f_{max} the maximum in the interval of the study and where $x=y-y_0+1$ (y is the year and y_0.the initial year of the study).

The clustering function ($h(x)$) was determined [3]

$$h(z_k) = (\sum_{j=1}^{m} g(x_j)) / m \qquad z_k = (\sum_{j=1}^{m} x_j) / m$$

2

where m is the clustering coefficient (number of years grouped).

The clustering functions were fitted to polynomials of the form:

$$h(z) = \sum_{i=0}^{n} A_i(z)^i$$

3

where A_i are the regression coefficients and n the degree of the polynomials.

3. Results

Figure 1 shows the fittting functions, h (z), for all studied countries compared with those of Portugal and Germany and in figure 2 Spain, France and Finland are compared. The best correlations for the functions h(z) were obtained for cubic functions (n = 3).

Portugal shows an increase in the evolution of the number of fires (by means the proposed functions) until 2000, while in Germany decreased throughout the studied time interval. The set of countries Europe shows a growth rate in the number of fires between 1990 and 1998.

In figure 2 it can be seen that Spain presents a behavior very similar to that of Portugal. The maximum number of fires in Spain occurred in 1999 while in Finland it was in 2006.

The data from the studied time interval indicated an annual average of 74000 forest fires where more than 75% occurred in countries of southern Europe, such as Portugal, Spain, France, Italy, Greece, Croatia and Turkey. In addition, of all the studied countries, Portugal had the highest annual average of forest fires, with 30% of the total as well as Spain reached 23% of the total, which indicates that the fires occurred in the Iberian Peninsula exceeded 50%.
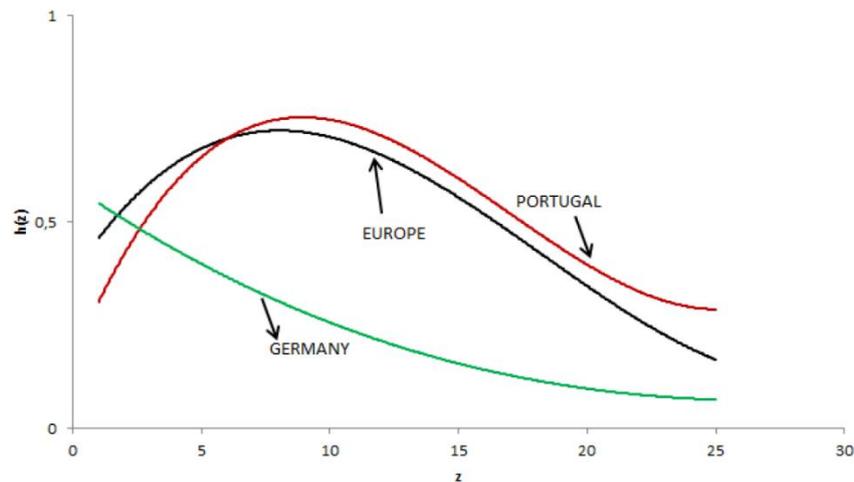

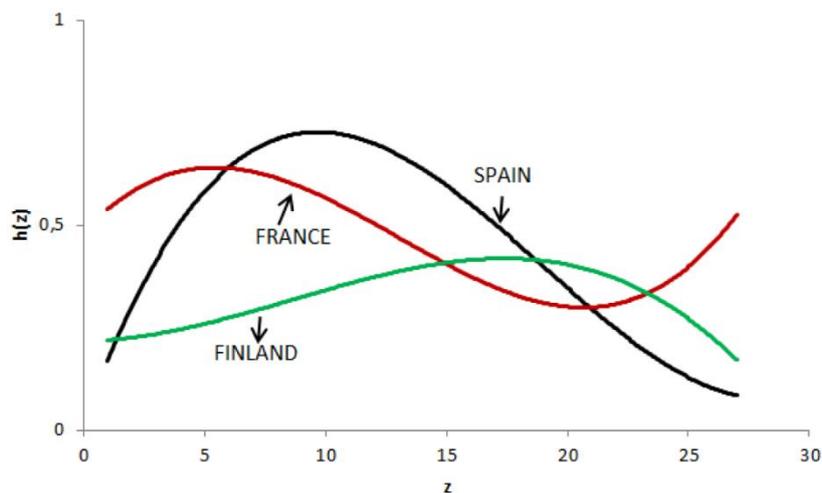*Figure 2 - Functions h (z) for all the studied countries compared with those of Portugal and Germany*

Figure 3 - Comparison of the h(z) functions for Spain, France and Finland.

Table 1 shows the results obtained, using the equations 2 and 3, for all the countries studied in this work. The values of the clustering coefficients, m, vary between 3 and 5.

The annual average data from Bulgaria, Finland, Germany, Latvia, Lithuania, Slovakia, Sweden, Switzerland, France, Spain, and Greece were clustered each five years (m=5). The value m=4 was used for the data from Croatia, Hungary, Lithuania, Norway, Romania, Turkey, and Italy. Finally, the fire data from Poland were clustered with m = 3.

The countries that obtain correlation coefficients higher than 0.9 were Germany, Italy and Spain. On the other hand, poor correlations, with correlation coefficients below 0.7, were obtained, for Italy, Croatia and Denmark.

Table 1 - Clustering coefficients, m, from eq. 2, regression coefficients, A_i, from eq. 3 and the correlation coefficients, R^2, of the fitting curves, h(z), for all estudied countries.

COUNTRIES	m	A_0	A_1	A_2	A_3	R^2
BULGARIA	5	0.4724	-0.0985	0.0103	-0.00028	0.5624
CROATIA	4	0.4212	-0.0140	0.0018	0.000067	0.4788
FINLAND	5	0.2835	-0.0272	0.0047	-0.00015	0.9471
GERMANY	5	0.6808	-0.0481	0.0012	-0.0000094	0.9922
HUNGARY	4	0.1820	-0.0406	0.0035	0.000065	0.6066
LATIVIA	5	0.4668	-0.0488	0.0060	-0.00020	0.9998
LITHUANIA	4	0.5310	-0.0376	0.0035	-0.00011	0.7765
POLAND	3	0.0352	0.0402	-0.00041	-0.000016	0.8252
NORWAY	4	0.2239	0.0199	0.00055	-0.00054	0.6028
ROMANIA	4	0.1289	-0.0208	0.0034	-0.000099	0.4500
SLOVKIA	5	0.30594	0.21517	-0.01709	0.00037	0.9862
SWEDEN	5	0.0749	-0.0040	0.0052	-0.00021	0.6939
SWITZERLAND	5	0.2826	0.01585	-0.0020	0.000042	0.8239
TURKEY	4	0.2168	0.0261	-0.0029	-0.000098	0.8008
PORTUGAL	4	-0.1791	0.2081	-0.0138	0.00025	0.8682
SPAIN	5	0.1435	0.2120	-0.0155	0.00030	0.9954
FRANCE	5	0.1644	0.1764	-0.0176	0.00045	0.7547
ITALY	4	1.201	-0.1430	0.0085	-0.00018	0.9924
GREECE	5	0.6110	0.0050	0.0013	-0.000076	0.9195

Table 2 shows the annual average number of fires per unit area and the annual average number of fires per thousand inhabitants. The average number of annual fires per unit area in Europe was 0.022 fires/km^2, obtaining the highest value Portugal with a rate of 0.24 fires/ km^2. Related to the average annual number of fires per thousand inhabitants, the European average was 0.32 fires per thousand inhabitants and the average of Portugal was 2.04 fires per thousand inhabitants. Germany, in contrast, reached a rate of 0.003 annual fires per km^2 and 0.014 annual fires per thousand inhabitants.

Once again, Portugal has the highest rate of annual average fires per km^2, reaching 58% of the total and the highest rate of annual average fires per thousand inhabitants, about 33% of total.

Table 2 - Annual average number of fires per unit area and annual average number of fires per thousand inhabitants from each one studied countries, from the sum of all of them (almost all of Europe[1]) and from average of them[2]

COUNTRIES	BULGARIA	CROATIA	FINLAND	GERMANY	HUNGARY	LATIVIA	LITHUANIA
Fires/km^2	0.0047	0.0048	0.0037	0.0031	0.0060	0.0115	0.0084
Fires/1000 inh.	0.069	0.059	0.23	0.014	0.056	0.31	0.16

COUNTRIES	POLAND	NORWAY	ROMANIA	SLOVKIA	SWEDEN	SWITZERLAND	TURKEY
Fires/km^2	0.0013	0.0263	0.00087	0.0079	0.0090	0.0026	0.0028
Fires/1000 inh.	0.010	1.7	0.0097	0.071	0.43	0.014	0.20
COUNTRIES	PORTUGAL	SPAIN	FRANCE	ITALY	GREECE	EUROPE[1]	Avg. EUROPE[2]
Fires/km^2	0.24	0.033	0.0078	0.028	0.012	0.41	0.022
Fires/1000 inh.	2.04	0.36	0.067	0.14	0.13	6.1	0.32

4. Conclusions

The annual average data of the studied countries were clustering with m = 3 to 5.

The best correlations for the functions h(z) were obtained for n = 3.

The average number of annual fires per unit area in Europe is 0.022 fires / km^2, obtaining the highest value Portugal with a rate of 0.24 fires / km^2.

Europe shows a growth rate in the number of fires between 1990 and 1998, which decreases from 2001.

5. References

Forest Fires in Europe, Middle East and North Africa 2016. Joint report of JRC. European commission. Luxembourg. doi:10.2760/17690 ISBN 978-92-79-71292-0 (2017)

J.L. Legido, M.M. Mato, E. Miguez, V. Caselles, E. Jiménez, T. Carballas, M.I. Paz Andrade. II International Conference on Fire Behaviour and Risk. Alghero, Sardinia, Italy, 26-29 May (2015)

M.M. Mato, J L Legido, E. Miguez, V. Caselles, E. Jiménez, T. Carballas, M.I. Paz Andrade. Advances in Forest Fire Research editor Domingos Xabier Viegas. Chapter 6 - Forest Management. 1628-1633. http://dx.doi.org/10.14195/978-989-26-0884-6_179 (2014)