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Brief communication
Decreasing fires in a Mediterranean region (1970–2010, NE Spain)

M. Turco[1,2], **M. C. Llasat**[2], **A. Tudela**[3], **X. Castro**[3], **and A. Provenzale**[4]

[1]CMCC (Euro-Mediterranean Centre on Climate Change), Impact on soil and coast Division, Via Augusto Imperatore 16, 73100, Lecce, Italy
[2]University of Barcelona, Av. Diagonal 647, Barcelona, 08028, Spain
[3]SPIF (Servicio de Prevenciòn de Incendios Forestales de la Generalitat de Catalunya), Barcelona, 08028, Spain
[4]ISAC-CNR, Corso Fiume 4, 10133 Torino, Italy

Correspondence to: M. Turco (marco.turco@cmcc.it)

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Abstract. We analyse the recent evolution of fires in Catalonia (north-eastern Iberian Peninsula), a typical Mediterranean region. We examine a homogeneous series of forest fires in the period 1970–2010. During this period, more than 9000 fire events greater than 0.5 ha were recorded, and the total burned area was more than 400 kha. Our analysis shows that both the burned area and number of fire series display a decreasing trend. Superposed onto this general decrease, strong oscillations on shorter time scales are evident. After the large fires of 1986 and 1994, the increased effort in fire prevention and suppression could explain part of the decreasing trend. Although it is often stated that fires have increased in Mediterranean regions, the higher efficiency in fire detection could have led to spurious trends and misleading conclusions.

1 Introduction

Most of the total burned area in Europe is found in Mediterranean regions (about 500 000 hectares burned every year), with most fires occurring in summer (EEA, 2008). The type of vegetation and the specific climatic conditions of these areas (dry and hot summers and severe local wind events) play an essential role in increasing fire occurrence. However, forest fires are a complex phenomenon which can be modified by several factors (Bowman et al., 2009). Changes in vegetation, land use and human activities (such as fire prevention and mitigation measures) can generate either slow or abrupt changes in fire occurrence. This poses significant challenges to the determination of forest fire evolution under climate change (Bonan, 2008).

Catalonia (NE Spain) is a typical Mediterranean environment and one of the most vulnerable regions to wildfires in Europe (EEA, 2008). Of its total area of 36 000 km^2, about 60 % is covered by shrubland and forest, owing to the abandonment of cultivations during the last century (Hill et al., 2008). In this region, a long historical forest fire database including more than 20 000 fire events from 1970 is available. This is the one of the longest continuous and homogeneous series on forest fires in a Mediterranean region (the European record of fire records comes from Portugal, with 450 000 wildfires over the period 1980–2005; Pereira et al., 2011).

It is often stated that fire occurrence and intensity have increased in the Mediterranean region (Parry et al., 2007). However, the limits of the available fire databases (e.g. length and homogeneity of the records) could lead to misleading results. In particular, the homogeneity of the data could be hampered by the minimum burned area for which a fire is recorded. Similarly, the increased efficiency in fire detection and/or recording can generate spurious trends.

A recent study (Turco et al., 2013) has related climate variability and forest fires over the period 1983–2007 in Catalonia. The study highlighted the importance of concurrent climate conditions, which determine fire ignition probability, and of antecedent climate, which regulates fine fuel availability. This brief communication focuses on the analysis of the Catalan Forest Fires Database (CFFD), with an updated fire database covering the period 1970–2010. The aim of the study is to assess the trends of past fire variability and discuss

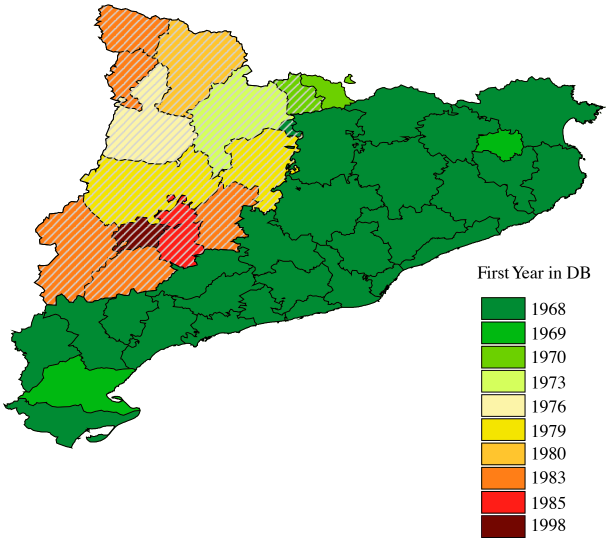

Fig. 1. Map of Catalonia and start year of the fire database for each local administrative division. The two domains of our study are (i) the whole of Catalonia (without the red and brown divisions) in the period 1983–2010, (ii) the eastern part of Catalonia (in green; i.e. excluding the Lleida province), which has a homogeneous fire database for the period 1970–2010.

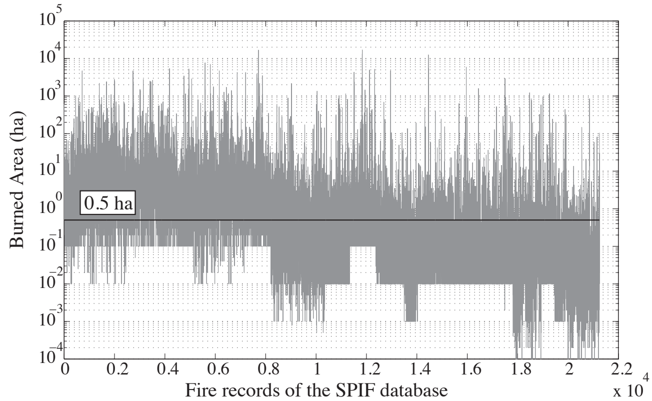

Fig. 2. Burned area (BA) in each record of the SPIF database in chronological order (BA in logarithmic scale, $\log_{10}$).

the potential regulating factors, to set up a framework for developing impact scenarios based on updated and homogeneous fire records.

2 Fire data and quality control

Accurate ground measurements of fire occurrence and burned area in Catalonia are obtained from the Forest Fire Prevention Service of the Generalitat de Catalunya (SPIF) for the period 1968–2010. However, due to changes in the administrations responsible for data collection, significant variations in the criteria for fire recording have occurred. These and other changes may affect the homogeneity of the database and interfere with the trend analysis of fire series.

The data from 1968 to 1970 have several missing values and prior to 1983 there are no complete records for the Province of Lleida (which covers an area of about 38 % of Catalonia, Fig. 1). For these reasons, two domains have been considered in the analysis presented here.

The first includes the whole of Catalonia in the period 1983–2010, excluding two local divisions (highlighted in red and brown colours in Fig. 1), for which the starting year of the fire database is posterior to 1983. The second domain includes the eastern part of Catalonia, which is characterised by a homogeneous fire data record for the period 1970–2010. This region does experience the majority (around 75 %) of forest fires in Catalonia.

An aspect that can affect the homogeneity of the data is the minimum burned area for which a fire is recorded. Figure 2 shows all the fire records in the database, in chronological order. It indicates that the minimum fire area is not constant over time: for example, the first part of the database has no records with area smaller than 0.01 ha. This inhomogeneity can significantly affect the record of the annual number of fires. To obtain a homogeneous series, it is necessary to retain only those fires whose area is above a fixed threshold which is kept constant over the years (Malamud et al., 2005; Pereira et al., 2011). Note that, from a methodological point of view, the simple use of a plot in logarithmic scale, such as that of Fig. 2, can help to immediately identify a possible inhomogeneity.

In the following, we restrict the analysis to fires with burned area of at least 0.5 ha; this is a safe minimum value which was detectable over the whole period considered. Note that the burned area is almost unaffected by this threshold, since it is largely determined by a few large fires: around 70 % of the burned area is associated with fires with a burned area above 500 ha. The difference between the total burned area considering all fires and that for the fires with burned area larger than 0.5 ha is less than 0.5 %.

3 Trend analysis

We analysed the annually burned area (hereafter, BA) and the number of fires (hereafter, NF). In addition, also BA and NF at monthly scale have been considered to assess the past evolution of forest fires in the different periods of the year.

Figure 3 shows the annual series of BA and NF. Already by visual inspection of Fig. 3, we observe that the BA series show a slight decreasing trend with two peaks in 1986 and 1994, when a total annual burned area of 70 000 ha was recorded, while the NF series shows an overall decreasing trend. The trend significance is estimated with the Monte-Carlo test implemented by Turco and Llasat (2011). This method firstly decomposes the fire series into a linear trend line and a time series of residuals, then the residuals are

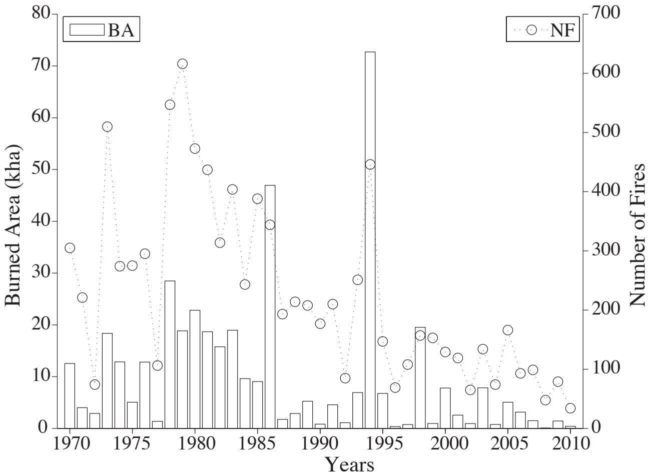

Fig. 3. Total annual burned area (BA) and number of fires (NF) with area larger than 0.5 ha in eastern Catalonia.

Table 1. Trends for annual BA and NF, over the period 1970–2010 for eastern Catalonia and over 1983–2010 for all Catalonia. Units are trend decade^{-1}. The trend significance is assessed by the Monte-Carlo test implemented by Turco and Llasat (2011).

Domain	BA (kha 10 yr^{-1})	NF (num 10 yr^{-1})
East Catalonia	−3.0*	−79**
Whole Catalonia	−7.3*	−108**

* $P > 95\,\%$, ** $P > 99\,\%$

resampled 1000 times and added back to the best fit line obtaining 1000 new plausible trend estimations, and finally, the original trend significance is estimated considering if the zero-trend falls outside the distribution of these 1000 plausible trend values. Repeating the analysis with the standard Mann–Kendall test we obtained qualitatively similar results. These tests confirm a significant downward trend in all cases, for both BA and NF, for eastern Catalonia (1970–2010) and for all Catalonia (1983–2010), as shown in Table 1. Finally, we have repeated the trend analysis on the non-homogenised database, to assess the mistake that would be made in that case. Considering eastern Catalonia in the period 1970–2010, for the non-homogeneous dataset the NF trend changes sign (+44 fires 10 yr^{-1}, $P > 95\,\%$, instead of −79 fire 10 yr^{-1}, Table 1) while the BA trend maintains the same trend. These results suggest that the often-reported increase in NF in the Mediterranean area could mix an actual trend with the trend generated by increased efficiency in fire detection.

To assess whether fire occurrences have changed in other periods of the year, we have estimated the trends of the BA and NF series also on monthly scale, as reported in Table 2. Both the BA and NF series display a significant decreasing trend over most part of the year.

Table 2. Trends for BA and NF in eastern Catalonia at monthly scale, for the period 1970–2010. Units are trend decade^{-1}. The trend significance is assessed by the Monte-Carlo test implemented by Turco and Llasat (2011).

Month	Trend for BA (kha 10 yr^{-1})	Trend for NF (num 10 yr^{-1})
1	−0.05	−0.5
2	−0.07*	−2.0**
3	−0.15**	−4.9***
4	−0.08	−4.6***
5	−0.03**	−1.5**
6	+0.02	−2.3
7	−0.75	−20.4***
8	−0.95**	−26.6***
9	−0.20	−8.3***
10	−0.55**	−3.9**
11	−0.04**	−2.3**
12	−0.18	−1.6

* $P > 90\%$, * $P > 95\%$, *** $P > 99\%$.

4 Discussion

In summary, the analysis discussed here shows that BA and NF in Catalonia are both decreasing. This result suggests that the often-reported (see Parry et al., 2007, and references therein) increase in fires in last decades in Mediterranean regions, could be at least partially caused by improved detection rather than by an actual increase in fire occurrence.

The fire trend could be driven by a complex interaction of several factors, such as human activities, climate, and vegetation evolution (Bowman et al., 2009). The Mediterranean basin is marked by a strong role of human actions on fires: ignition, fire-fighting and the change of land use are examples of crucial anthropogenic factors affecting fires. Some authors have suggested a possible increase in fire hazard owing to agricultural land abandonment (Moreira et al., 2011). Catalonia, like most Mediterranean areas, has experienced what is called the “rural exodus syndrome” (Hill et al., 2008). Our results suggest that such an increase in fire instances is not observed. Similarly, Ricotta et al. (2012), analysing fire events in another Mediterranean region (Sardinia, Italy), found that agricultural land abandonment could have indeed decreased human impact on fire ignition probability.

Among the potential drivers of forest fire evolution, the increasing effort towards fire management (including both fire prevention and fire extinction) could explain at least part of the decreasing trend detected here. Indeed, after the big fires of 1986 and 1994, policy of risk awareness and risk mitigation was improved. In particular, after the exceptional summer of 1994 (Llasat, 1997), a specific civil protection plan for preventing and limiting forest fires (INFOCAT, see http://www.gencat.cat/) has been launched. Besides, there has been an increase in legislation measures supporting fire prevention policies.

Another potential driver of the fire trend is climate change. In Catalonia, and generally in southern Europe, a transition towards warmer and drier conditions is observed (Turco and Llasat, 2011; Turco et al., 2012; Lionello, 2012). An overall increasing risk of (large) fires is associated with these scenarios (Parry et al., 2007). However, quantitatively assessing the possible fire impacts of a changing climate is not trivial (Hessl, 2011). For instance, a warmer and drier climate can affect wildfire activity not only by increasing flammability, but also by limiting the favourable condition for vegetation growth (fine-fuel production) and reducing fuel connectivity. In addition, other drivers and feedbacks could become relevant. Further research is thus necessary to investigate the impacts of climate change on fires and to explore the fire response to different regional climate change scenarios.

5 Summary and conclusions

To better understand forest fire evolution and devise proper impact scenarios and future trends, the long-term statistical properties of fire events must be estimated from homogeneous data. By quality checking the available data and considering only fires with burned area of at least 0.5 ha, in this study we analysed homogeneous series of the number of fires and burned area in two different domains. The first case considered is eastern Catalonia in the period 1970–2010, with 9284 fire events for a total burned area of 417 kha. The second case is the whole of Catalonia in the period 1983–2010, with 6385 fire events for a total burned area of 286 kha.

Both the annually burned area (BA) and the number of fires (NF) series display high interannual variability, with two peaks in 1986 and 1994. Superposed onto this variability, the data clearly show that BA and NF in Catalonia are both decreasing. After the big fires of 1986 and 1994, prevention measures have been improved, and the increased effort on fire management (including fire prevention and suppression) could explain at least part of the observed decrease in fires.

We conclude by stressing the importance of analysing homogeneous data. The increasing number of fires reported for the Mediterranean region in recent decades could indeed mix an actual trend with a growing fire detection ability. Clearly, the decreasing trend found here opens issues that need further analysis. Future works will consider the application of the model developed by Turco et al. (2013) to study the link between the observed climate and fire trends and explore the impact of the expected climate changes on fire occurrences.

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