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Discussions

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Precipitation dominates fire occurrence in Greece (1900–2010): its dual role in fuel build-up and dryness

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Abstract

Historical fire records and meteorological observations spanning over one century (1894–2010), were assembled in a database to collect long-term fire and weather data in Greece. Positive/negative events of fire occurrence on an annual basis were considered the years where the annual values of the examined parameters were above (positive values) or below (negative values) the 95 % confidence limits around the trend line of the corresponding parameter. To analyze the association of positive/negative events of fire occurrence and meteorological extremes, we proceeded with a cross-tabulation analysis based on a Monte Carlo randomization.

Positive/negative values of total annual precipitation were randomly associated with the corresponding values of burned areas, and significant associations were observed for seasonal precipitation totals (spring and fire season). Fire season precipitation is the dominant factor coinciding with negative values of area burned, while years with high spring precipitation coincide with large burnt area burned. These results demonstrate the dual role of precipitation in controlling a fire's extent through fuel build-up and dryness. Additionally, there is a clear outperformance of precipitation-related against temperature-related weather variables revealing that, at least in Greece, fire spread is controlled by precipitation totals rather than air temperature.

1 Introduction

Wildfires are considered one of the major forces shaping Mediterranean landscape and controlling vegetation communities' succession and structure (Serra et al., 2008; Millington et al., 2009). Wildfires also contribute to the development of the pattern of vegetation succession, the rate of which largely depends on the prevailing plant traits (Mouillot et al., 2003). Fire frequency, seasonality, intensity and extent are variables that are more likely to control forest distribution (Foster et al., 1998) and reshape and form Mediterranean landscape patterns and the distribution of vegetation communities

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(Pausas and Vallejo, 1999; Lloret et al., 2003; Pausas et al., 2008). It is argued that the distribution of shrublands in Mediterranean ecosystems does not solely depend on summer drought and winter precipitation patterns, but there can be a distinguished mosaic of fire-maintained and climate-maintained shrublands (Bond et al., 2005). That is because frequent and intense wildland fires tend to homogenize landscapes towards shrub-dominated cover types (Moreira et al., 2011) and can restrict the regeneration potential of various plants, such as seeders, increasing the possibility of their distinction at landscape level (Lloret et al., 2003). Climate (along with soil features) controls primary productivity which, in turn, determines fuel availability. Weather plays an important role in fire ignition and propagation (Vázquez et al., 2002).

The role of weather is complex and varies over spatio-temporal resolutions with short-term variation affecting local fire behaviour, and seasonal and inter-annual variations affecting fuel production and flammability over large areas as well as habitat type richness (Trouet et al., 2009; Falk et al., 2007; Drakou et al., 2011). The investigation of the role of either fuel or climate on the occurrence of large wildland fires has been mainly based on the assumption that these are either limited by (a) climate or (b) fuel accumulation (Meyn et al., 2007). In biomass-poor/seasonally dry ecosystems large wildland fires are mainly limited by fuel quantity, and an above average moisture availability during the vegetation growth period at lag(0) or lag(t) increases the possibility of wildland fire occurrence (Meyn et al., 2007; Pausas, 2004). Moreover, various studies have shown that weather conditions are prime drivers of large regional fires (Bowman et al., 2009) and a number of weather variables has been identified as being significantly correlated with annual area burned and number of fires (Good et al., 2008; Pausas, 2004; Littell et al., 2009). The relative importance of weather variables differ among different studies, but the most often examined are the length and intensity of dry spells (Beverly and Martell, 2005), various weather indices (Carvalho et al., 2008; Trouet et al., 2009), or simple weather variables such as mean air temperature and wind speed (Moritz et al., 2010; Flannigan et al., 2005). These findings can be combined into a generalised framework of synergy between weather and fuel (Koutsias

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et al., 2012), relating large fires with lag(0) weather features that provide suitable conditions for fire initiation and spread, and with lag(0) to lag(t) favourable moisture conditions during the vegetation growth period that increase fuel availability (Veblen et al., 2000; Zumbrunnen et al., 2009).

Concerning extreme large fire events, it has been demonstrated that extreme fire weather results in large and intense fires (Beverly and Martell, 2005) and that the area burned progressively increases with extreme weather variables (Bessie and Johnson, 1995; Moritz et al., 2010). Moreover, under extreme weather conditions, modelling approaches predict that stands will exhibit crown fires, regardless of their fuel conditions (Bessie and Johnson, 1995). Extreme fire weather is tightly related to large and intense fires at least in boreal (Hély et al., 2001) and temperate ecosystems (Gedalof et al., 2005). Similar results have been also reported for Mediterranean type ecosystems where extreme weather becomes an increasingly important forcing mechanism for large fires (Moritz, 1997) and area burned by large fires (> 100 ha) is positively correlated with summer dryness and negatively correlated with summer wetness (Ganteaume and Jappiot, 2013). Weather extremes at the 90th percentile have been identified as important variables when modelling number of fires and burned area (Carvalho et al., 2008). Striking examples are the extensive fires in Greece during the exceptionally hot and dry summer of 2007 (Founda and Giannakopoulos, 2009) when 190 836 ha were burned and 67 people died (Koutsias et al., 2012), the extreme fire events during the 2003 summer drought in Europe (European Commission, 2004), the extreme 1994 fires in Spain where extremely large burned area (430 000 ha) combined with extreme values of meteorological variables (Piñol et al., 1998), and the extreme drought and high winds that were primarily responsible for the extensive area burned during 1988 in Yellowstone National Park, USA (Turner et al., 2003).

Although a thorough analysis of fire history patterns and their correlation with climate should include additional fire regimes components such as socio-economic factors and related land-use land-cover changes (Piñol et al., 1998; Serra et al., 2008; Ganteaume and Jappiot, 2013), an important part of variability in total burned area can be attributed

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to inter-annual climatic variability (Pausas, 2004; Moritz, 1997). Weather is considered more important than fuel in fire behaviour, and extreme weather-related variables outperform fuel-related variables in variance explanation of fire intensity of various types of conifer forests (Bessie and Johnson, 1995) or shrublands (Baeza et al., 2002), at least in homogenous landscapes or when fire frequency is low (Hély et al., 2001).

In this paper we analyze the relationships between weather and fire by examining if years with values of area burnt exceeding the 95 % confidence intervals (upper and lower) of the estimated trend line coincide with respective observations above or below the 95 % confidence intervals of various weather variables. This analysis improves our understanding of the underlying mechanisms behind fire regimes and provides valuable information concerning the development of forecasting models (Moritz et al., 2010). Such models are essential when facing a changing climate that may be associated with shifts in various aspects of the typical fire regimes of ecosystems. These shifts include the increase of length of seasons with fire risk as a result of increasing fire weather extremes (Moriondo et al., 2006), or the "movement" of fires towards non-fire prone ecosystems of higher elevations (Koutsias et al., 2012). This is of major importance in Greece, where such analyses are presently lacking or abstract in this fire-prone Mediterranean country that, according to data on the average area burnt per fire, has the most severe forest fire problems of the European Union countries (Moriondo et al., 2006).

2 Materials and methods

2.1 Wildfire time-series data

Statistics on the total yearly area burned at national level were gathered from different fire data providers including the National Statistical Service of Greece (NSSG), the Hellenic Forest Service (HFS), the Hellenic Fire Brigade (HFB), and Kailidis and Karanikola (2004). These data were then assembled in a long-term time-series

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extending back to 1894 (Fig. 1). Two data gaps, the first during 1908–1921 and the second during 1939–1954 (excluding 1945 where some observations were taken), and two missing years in 1896 and 1897, are responsible for the missing time-series that account for 86 of the 117 yr between 1894 and 2010.

Since the total annual area burned from 1894–1912 referred to the country's surface area during this period in history (63 211 km^2), these values were adjusted to the country's current surface area (132 000 km^2) by multiplying with 2.088 (=132 000 km^2/63 211 km^2) so the values of total area burned are directly comparable throughout the examined period.

2.2 Meteorological time-series data

Time-series of meteorological data extending to the end of the 19th century were acquired from the historical meteorological station of the National Observatory of Athens (NOA). The mean, mean minimum, mean maximum, absolute minimum and absolute maximum air temperature, as well as precipitation totals, were provided originally on a monthly or annual basis for the period 1897–2010. The monthly precipitation values were then aggregated to seasonal values for the statistical analyses performed here (Fig. 2).

2.3 Statistical analyses

From the time-series data of both fire occurrence observations and meteorological parameters we estimated the trend lines and the 95 % confidence intervals of the model around the trend line. Time-series severely deviating from normal distribution were log transformed and the linear model was applied to the transformed values. Years during which the values of the examined variables were above the 95 % confidence limits of the trend line were marked as "strongly positive values" (noted with "+1"), while years during which the values of the examined variables were below the 95 % confidence limits of the trend line were marked as "strongly negative values" (noted

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with "−1"). Finally, years during which the values of the examined variables fell within the 95 % confidence limits were considered as "close-to-predicted values" (noted with "0"). Although this classification does not reveal the extreme values *sensus stricto*, it does allow for the cross-comparison of highly influential values of fire occurrence and meteorological variables.

To analyze how the positive or negative values of fire occurrence and meteorological parameters coincide in time on an annual basis we performed a cross-tabulation analysis within the time window between 1990 and 2010 in which 81 cases (years) are observed after excluding the missing years from both time-series. Additionally, we used a Monte Carlo randomization test to examine whether the observed frequencies are statistically different from random coincidence. In each year, and for each variable we randomly assigned one of the three values (1, 0, −1), keeping the frequency distribution of each variable constant. For each pair of variables we then measured the frequency of each combination of values (−1−1, −10, −11, 0−1, 00, 01, 1−1, 10, 11). The process was repeated 1000 times. Finally, for each pair of variables we compared the observed frequency of each combination with the results of the 1000 randomizations.

3 Results

3.1 Assessment of the extremes

Figure 3 shows the time-series data of total burned area (ln transformation) together with the model fitted to the time-series observations and the 95 % confidence intervals of the model around the trend line. The strongly positive (+1) or strongly negative (−1) values, as well as close-to-predicted values within the 95 % confidence intervals (0) are also depicted in Fig. 3. Of the 81 yr considered in the analysis (only those with full data), 30 strongly positive, 34 strongly negative and 17 close-to-predicted values

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were recorded. It is worth noting that of the 30 positive values of area burned, 19 were observed after 1974.

Figure 4 shows the time-series data of selected meteorological parameters concerning air temperature (absolute maximum, mean maximum and mean air temperature) together with the linear model fitted to the time-series observations and the 95 % confidence intervals of the model around the trend line for each parameter. Of the 81 yr analysed, 36 strongly negative, 28 strongly positive and 17 close-to-predicted values of absolute maximum air temperature were recorded. For mean maximum air temperature, 27 strongly negative, 36 strongly positive and 18 close-to-predicted values were observed, while for the mean air temperature, 34 strongly negative, 32 strongly positive and 15 close-to-predicted values were observed. During the last 15 yr, only one negative value of temperature-related variables was recorded and that is the mean maximum air temperature of 2006 (Fig. 4). In contrast, during the same period, several years are above the 95 % confidence interval.

Figure 5 shows the time-series data of selected precipitation-related variables (total, spring and fire season's precipitation) together with the line fitted to the time-series observations and the 95 % confidence intervals of the model around the trend line for each variable. Of the 81 yr studied, 35 strongly positive, 26 strongly negative and 20 close-to-predicted values were observed for the total precipitation. For fire season precipitation, 43 strongly negative, 18 strongly positive and 20 close-to-predicted values were observed. Finally, for spring precipitation, 37 strongly negative, 25 strongly positive and 19 close-to-predicted values were observed. Unlike air temperature, strongly positive and negative values of total and spring precipitation are evenly distributed within the time window. However, regarding fire season precipitation, there is one period between 1979 and 1998 where no strongly positive values are observed. Additionally, the summer of 2002 was exceptionally wet.

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3.2 Cross-tabulation analysis

The results of the cross-tabulation analysis together with the Monte Carlo randomization test are summarized in Tables 1–6.

The cross-tabulation analysis shows that of the 30 strongly positive values of area burned, 16 (53.33 %) coincide with strongly positive values of absolute maximum air temperature. On the other hand, of the 28 strongly positive values of absolute maximum air temperature, 16 (57.14 %) coincide with strongly positive values of area burned. This means that the majority of strongly positive values of area burned were also years with strongly positive values of absolute maximum air temperature and vice versa. Additionally, it can be argued that strongly positive values of area burned are limited by absolute maximum air temperature since strongly negative values of the latter result in significantly fewer positive values of area burned (22.22 %) than those expected under a random process according to the Monte Carlo randomization test.

Similar results were recorded for mean maximum air temperature. Of the 30 strongly positive values of area burned, 20 (66.67 %) correspond with strongly positive values of mean maximum air temperature. Analogously, of the 36 strongly positive values of mean maximum air temperature, 20 (55.56 %) coincide with strongly positive values of area burned. The right-above indicate that years of extensive burned areas strongly correspond with years of high mean maximum air temperature and vice versa, years with high mean maximum air temperature are expected to coincide with years of increased burned area. However, years with strongly negative values of mean maximum air temperature result in significantly fewer strongly positive values of burned area than those expected under a random process according to the Monte Carlo randomization test, thus indicating an inverse relationship between low mean maximum air temperature and extensive area burned.

The cross-tabulation of the strongly positive and negative values of area burned against the respective values of mean air temperature did not reveal any statistical

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significant differences compared to random coincidence based on the Monte Carlo randomization test.

Concerning precipitation-related variables, of the 30 strongly positive values of area burned, 8 (26.67 %) coincide with strongly positive and 16 (53.33 %) with strongly negative values of total annual precipitation. Yet, these frequencies do not differ significantly from random coincidence. From this analysis it can be argued that strongly negative values of precipitation might be associated with dry fuel conditions, while strongly positive values of precipitation may be associated with fuel built up. Therefore further analysis is required to explore the distribution of total precipitation throughout the year (spring fuel build-up and fire season-dry conditions).

The effect of fire season's precipitation was more interesting and provided argumentation in favour of its strong and straightforward association with the total annual area burned. Of the 30 strongly positive values of area burned, only two (6.67 %) coincide with strongly positive values of fire season's precipitation, while 25 (83.33 %) coincide with strongly negative values. However, of the 18 positive values of fire season precipitation, 13 (72.22 %) coincide with strongly negative and only two (11.11 %) coincide with strongly positive values of area burned. This means that, in most of cases (83.33 %), a year with increased area burned was also a year with low fire season precipitation. Additionally, years characterized by high fire season precipitation were unlikely to be characterised by extensive burned areas. That is due to the direct control that fire season precipitation exhibits on fuel moisture, an important factor that controls fire ignition and spread.

The effect of spring precipitation was also apparent but contradictive. Of the 30 strongly positive values of area burned, 15 (50.00 %) coincide with positive and 11 (36.67 %) with strongly negative values of spring precipitation. Of the 25 strongly positive values of spring precipitation, 15 (60.00 %) coincide with strongly positive and six (24.00 %) with strongly negative values of area burned. Spring precipitation is probably associated with annual area burned by fuel build up resulting from wet conditions during the growth season.

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4 Discussion

Of the 30 yr recorded with strongly positive values of burned area, 19 of these were observed after 1974. This period (1974–2010) commences in 1974 when the country's seven-year dictatorship ended and the third Hellenic democratic period began. As noted by Koutsias et al. (2013), the Greece's development in this period brought significant socioeconomic changes (an increase in personal income, rural abandonment and urbanization, development of wildland-urban interface areas, etc.). Therefore, the occurrence of most years with large burned areas is linked to, among other factors, increased fuel accumulation by land abandonment and afforestation of former agricultural land (Pausas and Fernández-Muñoz, 2012). A general increasing trend in area burned in Greece during the last decades was also reported by Dimitrakopoulos et al. (2011b) and Koutsias et al. (2013), although no significant trend was found in the total annual burned area during 1974–2010 (Koutsias et al., 2013).

Concerning the meteorological parameters, fire season precipitation is the dominant factor coinciding with area burned. The tight relation between fire-season precipitation and area burned is also revealed in similar studies, as for example in Portugal (Viegas and Viegas, 1994), Spain (Pausas, 2004), western United States (Westerling et al., 2003) and Greece (Dimitrakopoulos et al., 2011b). Although strongly positive or negative values of total annual precipitation are randomly cross-tabulated with strongly positive or negative values of area burned, significant cross tabulations appear when seasonal precipitation totals (spring and fire season) are considered. Strongly positive values of spring precipitation coincide significantly with strongly positive values of area burned and, more strikingly, strongly negative values of fire-season precipitation coincide with strongly positive values in area burned, while strongly positive values in fire-season precipitation restrict the occurrence of large burned areas. There is a strong indication therefore that on the one hand increased antecedent spring precipitation reflects a positive association with area burned due to fuel build-up, while on the other, increased fire-season precipitation is negatively correlated with area burned due to

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wet conditions during the fire season, a finding similar to those of Littell et al. (2009) and Koutsias et al. (2013). Seasonal precipitation assists in controlling the counterbalance effects that precipitation during different seasons has on fire extent, while annual aggregation could obscure such significant associations. A similar argumentation can be supported for the air temperature variables. Mean air temperature does not reflect any significant deviation from randomness in cross-tabulation because this variable is highly dependent on winter months. On the other hand, mean max and absolute max air temperature are variables dominated by summer-period values, therefore their significant coincidence with area burned is an indirect indication of the effect of seasonal aggregation.

Additionally, there is a clear outperformance of precipitation-related against temperature-related weather variables. This outperformance reveals that, at least in Greece, extreme fires are controlled by precipitation rather than air temperature. This is contrary to the findings in other regions, where air temperature was among the most important fire drivers and conditionally outperformed precipitation variables (Turetsky et al., 2004; Vázquez and Moreno, 1993). However, similar to our results, maximum air temperature outperformed mean air temperature in correlating with area burned (Vázquez and Moreno, 1993). In Portugal, monthly means (mean and maximum) of the daily maximum air temperatures together with the mean fire weather index managed to summarize a fairly large part of variation of annual area burned, while total precipitation did not enter the regression model (Carvalho et al., 2008). In Greece, it has been shown that precipitation is well correlated with area burned (Dimitrakopoulos et al., 2011b) or that air temperature has a low direct influence on extreme fire risk (Good et al., 2008). Yet, Dimitrakopoulos et al. (2011a) showed that during the period 1990–2003 the vast majority of large wildfires occur during heat waves, however although the research team considered air humidity (%), they did not examine possible effects of precipitation totals.

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5 Conclusions

A variety of meteorological parameters that could coincide with strongly positive or negative values of area burned are not considered in this paper. Additional information concerning air humidity or wind speed could help reveal further aspects of the correlation between fire and weather extremes (Dimitrakopoulos et al., 2011a), nevertheless, our results are comparable with other studies that discuss the effect of weather conditions on fire characteristics (Carvalho et al., 2008; Littell et al., 2009).

Our results could allow fire managers to more easily incorporate the effect of weather conditions into long-term planning strategies. They contribute to fire-climate forecasting and may become more important if climate change scenarios are used to predict the occurrence of future extreme weather (Trouet et al., 2009), because climate change is discussed on the basis of changes of extremes rather that changes in means (Field et al., 2012). Furthermore, most discussion on climate change is focused on the effect of increasing temperature trends, but our findings highlight the importance of precipitation and especially the need to predict changes in seasonal precipitation more accurately.

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Table 1. Cross-tabulation results between burned area and absolute maximum air temperature. Monte Carlo randomization confidence limits are in parenthesis. Values in bold are statistically significant.

		Total Area Burned						
		−1	0	1	Sum	−1	0	1
Absolute Maximum Temperature	−1	18 (11–19)	10 (4–11)	**8 (9–18)**	36	50.00 %	27.78 %	22.22 %
	0	8 (4–11)	3 (1–6)	6 (3–10)	17	47.06 %	17.65 %	35.29 %
	1	8 (8–16)	4 (3–9)	**16 (6–15)**	28	28.57 %	14.29 %	57.14 %
	Sum	34	17	30	81	41.98 %	20.99 %	37.04 %
	−1	52.94 %	58.82 %	26.67 %	44.44 %			
	0	23.53 %	17.65 %	20.00 %	20.99 %			
	1	23.53 %	23.53 %	53.33 %	34.57 %			

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Table 2. Cross-tabulation results between burned area and mean maximum air temperature. Monte Carlo randomization confidence limits are noted in parenthesis. Values in bold are statistically significant.

Mean Maximum Temperature	Total Area Burned							
		−1	0	1	Sum	−1	0	1
	−1	15 (7–15)	7 (2–9)	**5 (6–14)**	27	55.56 %	25.93 %	18.52 %
	0	7 (4–11)	6 (1–7)	5 (3–10)	18	38.89 %	33.33 %	27.78 %
	1	12 (11–19)	4 (4–11)	**20 (9–18)**	36	33.33 %	11.11 %	55.56 %
	Sum	34	17	30	81	41.98 %	20.99 %	37.04 %
	−1	44.12 %	41.18 %	16.67 %	33.33 %			
	0	20.59 %	35.29 %	16.67 %	22.22 %			
	1	35.29 %	23.53 %	66.67 %	44.44 %			

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Table 3. Cross-tabulation results between area burned area and mean air temperature. The Monte Carlo randomization confidence limits are in parenthesis.

		Total Area Burned						
		−1	0	1	Sum	−1	0	1
Mean Temperature	−1	15 (10–19)	9 (4–11)	10 (8–17)	34	44.12 %	26.47 %	29.41 %
	0	6 (3–10)	4 (1–6)	5 (2–9)	15	40.00 %	26.67 %	33.33 %
	1	13 (9–17)	4 (3–10)	15 (8–16)	32	40.63 %	12.50 %	46.88 %
	Sum	34	17	30	81	41.98 %	20.99 %	37.04 %
	−1	44.12 %	52.94 %	33.33 %	41.98 %			
	0	17.65 %	23.53 %	16.67 %	18.52 %			
	1	38.24 %	23.53 %	50.00 %	39.51 %			

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Table 4. Cross-tabulation results between area burned and total annual precipitation. The Monte Carlo randomization confidence limits are in parenthesis.

		Total Area Burned						
		−1	0	1	Sum	−1	0	1
Total Precipitation	−1	10 (10–19)	9 (4–11)	16 (9–17)	35	28.57 %	25.71 %	45.71 %
	0	9 (5–12)	5 (1–8)	6 (4–11)	20	45.00 %	25.00 %	30.00 %
	1	15 (7–15)	3 (2–9)	8 (6–13)	26	57.69 %	11.54 %	30.77 %
	Sum	34	17	30	81	41.98 %	20.99 %	37.04 %
	−1	29.41 %	52.94 %	53.33 %	43.21 %			
	0	26.47 %	29.41 %	20.00 %	24.69 %			
	1	44.12 %	17.65 %	26.67 %	32.10 %			

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Table 5. Cross-tabulation results between area burned and fire season precipitation. The Monte Carlo randomization confidence limits are in parenthesis. Values in bold are statistically significant.

		Total Area Burned						
		−1	0	1	Sum	−1	0	1
Fire Season Precipitation	−1	**11 (14–22)**	7 (6–13)	**25 (12–20)**	43	25.58 %	16.28 %	58.14 %
	0	10 (5–12)	7 (1–7)	**3 (4–11)**	20	50.00 %	35.00 %	15.00 %
	1	**13 (4–11)**	3 (1–7)	**2 (3–10)**	18	72.22 %	16.67 %	11.11 %
	Sum	34	17	30	81	41.98 %	20.99 %	37.04 %
	−1	32.35 %	41.18 %	83.33 %	53.09 %			
	0	29.41 %	41.18 %	10.00 %	24.69 %			
	1	38.24 %	17.65 %	6.67 %	22.22 %			

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Table 6. Cross-tabulation results between the total area burned and spring precipitation. The Monte Carlo randomization confidence limits are noted in parenthesis. Values in bold are statistically significant.

		Total Area Burned						
		−1	0	1	Sum	−1	0	1
Spring Precipitation	−1	17 (11–19)	9 (4–11)	11 (10–18)	37	45.95 %	24.32 %	29.73 %
	0	11 (4–12)	4 (1–7)	4 (4–10)	19	57.89 %	21.05 %	21.05 %
	1	**6 (7–14)**	4 (2–9)	**15 (6–13)**	25	24.00 %	16.00 %	60.00 %
	Sum	34	17	30	81	41.98 %	20.99 %	37.04 %
	−1	50.00 %	52.94 %	36.67 %	45.68 %			
	0	32.35 %	23.53 %	13.33 %	23.46 %			
	1	17.65 %	23.53 %	50.00 %	30.86 %			

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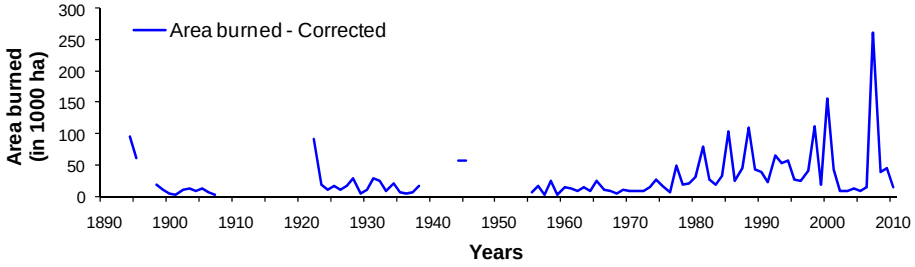

Fig. 1. Historical time-series of area burned in Greece from 1894 to 2010.

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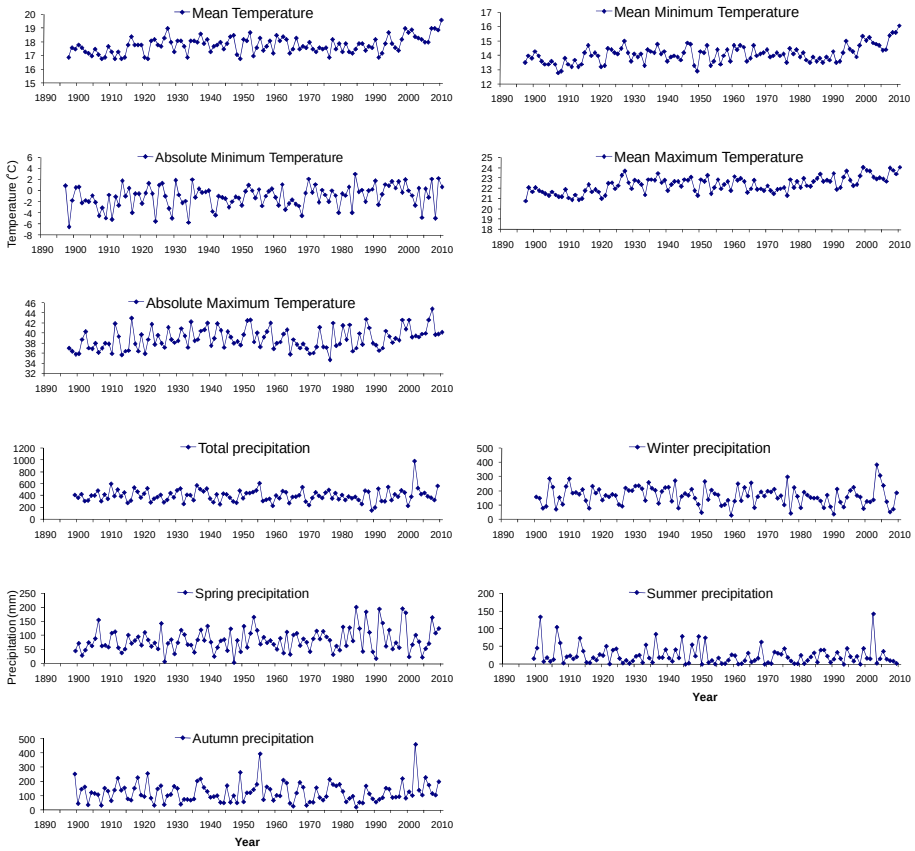

Fig. 2. Time-series of historical temperature and precipitation data as acquired from the National Observatory of Athens (NOA).

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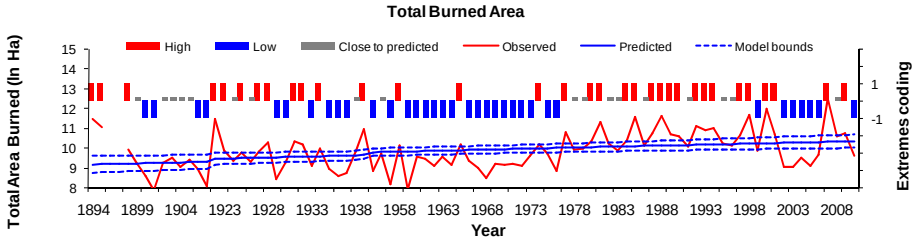

Fig. 3. Trend lines and the 95 % confidence intervals of the trend line of fire occurrence statistics (burned area). These are used as bounds to define strongly positive (red columns), strongly negative (blue columns), and close-to-predicted (grey columns) values of fire occurrence.

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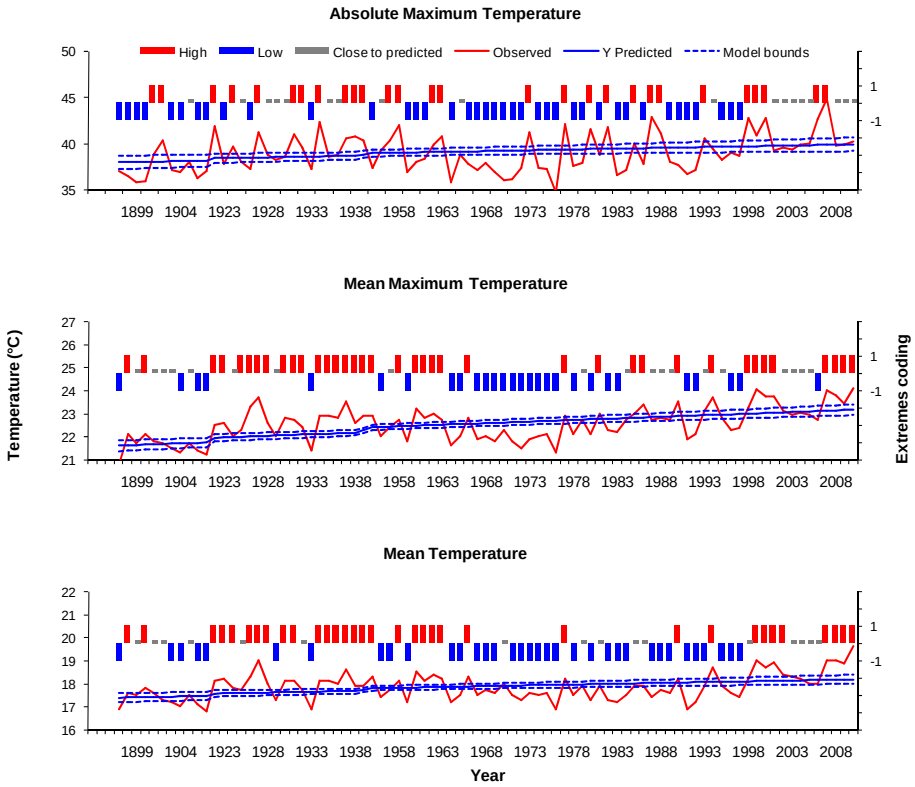

Fig. 4. Trend lines and the 95 % confidence intervals of the model around the trend line of air temperature related meteorological parameters (absolute maximum, mean maximum and mean air temperature). These are used as bounds to define strongly positive (red columns), strongly negative (blue columns), and close-to-predicted (grey columns) values of fire occurrence.

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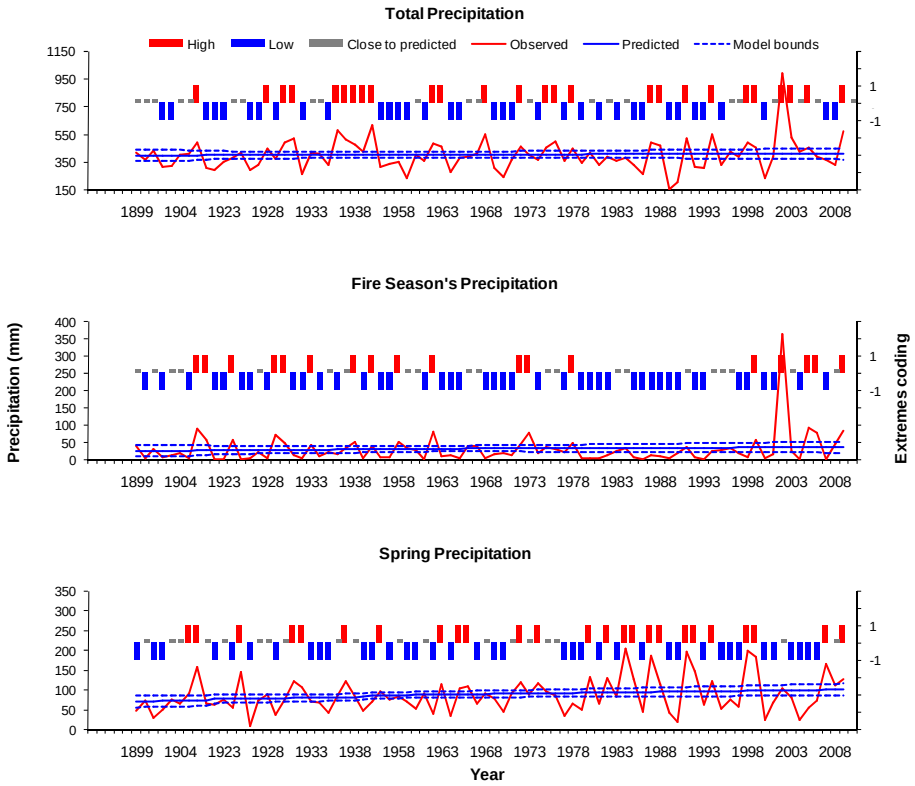

Fig. 5. Trend lines and the 95 % confidence intervals of the model around the trend line of precipitation related meteorological parameters (total, spring and fire season precipitation). These are used as bounds to define strongly positive (red columns), strongly negative (blue columns), and close-to-predicted (grey columns) values of fire occurrence.

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