Integrating past variability in climate-driven Mediterranean fire hazard assessments for 2020-2100

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Abstract

In the Mediterranean basin, Corsica (French island) harbours among the best-preserved Mediterranean forest ecosystems and its high biodiversity could be threatened by the climate and disturbance-regime changes due to the global warming. This study aims i) to estimate the future climate-related fire hazard in Corsica for the current century (2020–2100) based on two RCP scenarios (RCP4.5 and RCP8.5), and ii) to compare the predicted trends with the entire Holocene period for which fire hazard has previously been assessed. An ensemble of future climate simulations from two IPCC RCP scenarios has been used to compute the Monthly Drought Code (MDC) and the Fire Season Length (FSL) and to assess the level of fire hazard assessment. Here, we show that the MDC and the FSL would both strongly increase over the next decades due to the combined effect of temperature increase and precipitation decrease in the Corsica region. Moreover, the maximum Holocene FLS (7000 to 9000 years ago), will be reached (and even exceeded depending upon the scenario) after 2040. For the first time in the Holocene, we may be confronted to an increase in the number of fire-prone months driven by climate combined with many human-caused ignitions. This combination should increase the burned area from 15–140%. For the next 30 years, the game seems to be already played as both RCP scenarios resulted in similar increase in fire hazard intensity and duration. It is thus mandatory to reconsider fire-management and fire-prevention policy to mitigate the future fire risk, and its catastrophic consequences for ecosystems, population, and economy.

1. Introduction

Over the past decades, a surge in the number of large and uncontrolled wildfires has occurred on all terrestrial ecosystems, and this can be observed irrespectively of national fire-fighting capacities or management tactics (Westerling et al. 2006; Lohman et al. 2007; Forsyth and Van Wilgen 2008; Bowman et al. 2009). The global warming predicted by climate models for the 21st century and beyond may amplify this trend, and threat most ecosystems worldwide (Giannakopoulos et al. 2005; Pachauri and Reisinger 2007; Varela et al. 2019).

Located on a latitudinal gradient at the interface between temperate Europe and subarid North-Africa within the Mediterranean basin, the French island of Corsica has a climate characterized by a seasonal alternation between a warm and dry summer season with a marked drought period, and a cool season with high rainfall (Pausas 2004; Sá et al. 2017). This, together with the traditional use of pastoral fire, makes Corsica a fire hotspot (Keeley 2009; Leys et al. 2014). Along the last decades (1973–2019), 2 369 fires larger than 10 ha have occurred in Corsica and 305 063 ha (~ 67 779 ha.yr^{-1}) have been burned (http://www.promethee.com/). Corsica harbours a high biodiversity, many endemic species (Médail and Verlaque 1997; Médail 2017), and preserved Mediterranean forest ecosystems (Medail and Quezel 1997; Vogiatzakis et al. 2016). However, this renders Corsica vulnerable to climate and disturbance-regime changes as shown its past environmental history and the predictions for the future (Giannakopoulos et al. 2005; Giorgi 2006; Vogiatzakis et al. 2016; Varela et al. 2019; Lestienne et al. 2020b; Fargeon et al. 2020). Recent studies have suggested that the fire danger could be three times higher when summer temperature anomaly exceeds + 2°C (Fargeon et al. 2020) and that the fire danger could be doubled in Corsica (Varela et al. 2019).

In this context, it is of importance to assess the future climate-related fire hazard in Corsica for the current century (2020–2100). To do this, we use 5 climate models with two RCP scenarios (4.5 and 8.5, respectively) and we compare these results to recent studies (Varela et al. 2019; Fargeon et al. 2020). Then, we compare the future trends in fire activity to those for the entire Holocene period based on our previous works (Lestienne et al. 2020a). Indeed, values of the past fire hazard provide a valuable historical baseline and give valuable insights about thresholds and shifts in ecosystems responses related to past fire regime changes.

Several climate-related indexes of fire-danger have been tested for the Mediterranean region among which the Fire Weather Index (FWI) (Wagner et al. 1987) and its sub-indexes, which all have overall showed their efficiency on current climate conditions (Aguado et al. 2003; Moriondo et al. 2006; Carvalho et al. 2008; Varela et al. 2019; Fargeon et al. 2020). However, most of these fire-danger indexes require daily weather forecast data to be computed, which can limit their use for past assessment and future prediction. The Monthly Drought Code (MDC), whose computation is derived from the computation of the Drought Code, i.e. a sub-index of the FWI, has also been created first in Canada (Girardin and Wotton 2009) and recently tested over Corsica (Lestienne et al. 2020a). Its computation uses monthly means of maximum temperature and monthly precipitation, therefore providing an assessment of climate-related fire hazard without the constraint of daily data requirement.

2. Materials And Methods

2.1. Study area

Corsica is a mountainous French island located in the western Mediterranean basin (Fig. 1). In spite of high mountains, there are no glaciers and no permanent snow on the island (Conchon 1986). During the early Holocene (i.e. 11,000 years ago), the vegetation was mainly composed by pinewood and heather. During the Neolithic (around 6000 years ago), a significant change occurred in land cover with the expansion of oak forests, which have dominated the island during most of the Holocene thereafter (Reille 1992; Reille et al. 1999; Lestienne et al. 2020b). Nowadays, the ecological value of the region, the high population and settlement density on the island and the abandonment of traditional land uses (i.e. the subsequent fuel accumulation) represent important stakes that, combined with climate warming (Fig. 1) (NOAA 2011), induce an exponential increase in fire risk (Keeley 2009; Leys et al. 2014) in this fire-prone region (Appendix A).

Figure 1 - Geographical context of Corsica, a French European island and changes in rainfall around the Mediterranean Basin between 1971–2010 and the comparison period 1902–2010 (NOAA, 2011). Figure adapted from NOAA/Earth System Research Laboratory.

2.2. Climate datasets for climate changes scenarios

Refer to Fig. 2 for a summary diagram.

Figure 2 - Synthesis of the climatic datasets extraction methodology.

Current climate dataset was extracted from ERA-Interim (https://www.ecmwf.int/). It is a daily global atmospheric reanalysis continuously updated in real time and allowing to obtain daily temperature and precipitation data since 1979. The spatial resolution is approximately 60 x 80 km (Corsica being covered by a total of five pixels) (Dee et al. 2011).

Paleoclimate simulated datasets were extracted from simulations provided by HadCM3BL-M1, this model being a variant of the fully complex Hadley Centre climate model HadCM3, usually involved in IPCC assessment reports, and belonging to the HadCM3 family of climate models (Valdes et al. 2017). Based on orbital forcing parameters and some other prescribed variables for the ocean compartment, this intermediate-complexity model version performed a snapshot equilibrium simulation of the atmospheric compartment per millennium, from which climate normals (monthly means) for main climate variables (*i.e.* air temperature and precipitation used here) are available. We therefore used these datasets of climate normals for the last eleven millennia (centered at changeovers 11, 10, …, 2, and 1 kilo years calibrated Before Present i.e. before 1950 – abbreviated thereafter ky cal BP), as well as for the control run representative of the pre-industrial period (AD 1750, considered as equivalent to 0 BP). Then, temperature and precipitation anomalies (*i.e.* difference and rate of change for temperature and precipitation, respectively) have been computed and downscaled for each millennium changeover based on Ramstein et al. (2007). Using an inverse-distance weighting approach on the four closest HadCM3BL-M1 pixels from those covering Corsica, we downscaled these anomalies by applying them to the current period climate normal that we computed from the ERA-Interim dataset to reconstruct past climate for each Holocene millennium changeover at the whole island scale (Ramstein et al. 2007; Hély et al. 2010). As Holocene climate changes were mainly due to insolation changes, we also retrieved insolation values for the entire Holocene period using the “palinsol” R package (Crucifix 2016) which includes data from Berger and Loutre (1991).

Future climate datasets are monthly means projections from simulations of five CMIP5 coupled models (Table 1) (Pachauri et al. 2015) under two RCP scenarios (4.5 and 8.5, respectively). In a preliminary step (Appendix B), we first compared them to the overall range of historical variability (1979–2016) in order to test their representativeness and to take into account the variability induced by models (Fargeon et al. 2020).

Table 1
Summary of the climate models used in this study (based on the IPCC Fifth Assessment Report AR5 (Pachauri et al., 2015).

	Model	Resolution		References
		Atmospheric	Oceanic	
Past	HadCM3BL-M1	3,75° x 2,5°	3,75° x 2,5°	Valdes et al. (2017)
Future	FGOALS_S2	1,65° x 2,8°	1° x 1°	*Bao et al. (2013)*
	CanESM2	2,8° x 2,8°	1° x 1,4°	Chylek et al. (2011)
	MIROC_ESM_CHEM	2,8° x 2,8°	1° x 1,4°	Watanabe et al. (2011)
	MIROC5	1,4° x 1,4°	0,5° x 1,5°	Watanabe et al. (2010)
	MRI_CGM3	1,1° x 1,1°	0,5° x 1°	*Yukimoto et al. (2012)*

2.3. Climate fire hazard assessment

The MDC (Girardin and Wotton, 2009) is unitless and captures the moisture content of deep and compact organic layers. As for the DC, the MDC indicates the effects of seasonal drought on forest fuels and the probability of smouldering in deep duff layers and in large logs, but they differ in their computation requirements. Although these indices were initiated in Canada, we showed in a previous study that the DC was efficient to discriminate fire days and no-fire days in Corsica for the period 1979–2016 and that the MDC was an efficient tool to reconstruct the Holocene climate-related fire hazard (Lestienne et al. 2020a). The great advantage of the DC and the MDC is that they only require precipitation and temperature data (Wagner et al. 1987). Moreover, while the DC needs daily data, the MDC has been created to be directly computed from monthly means of precipitation and maximum temperatures, which makes it very powerful for simulated past and future datasets (Lestienne et al. 2020a). The MDC has been computed at each millennium changeover for the entire Holocene (from 11 to 0 K years cal. BP) in order to compare with the coeval charcoal-inferred fire history reconstructed from lacustrine sediments by Lestienne et al. (2020a). The 280-unit threshold in the DC appears meaningful to characterize extreme drought and a high probability of fire hazard in boreal forests (Girardin and Wotton 2009). In Corsica, we previously showed that this DC threshold is about 300 units (Lestienne et al. 2020a).

2.4. Fire-Season Length assessment

Based on the Holocene analysis of MDC values, and according to the method originally developed by Hély et al. (2010) for the DC and adapted to the MDC (Lestienne et al. 2020a), the threshold value of 300 units was used to calculate the Fire-Season Length (FSL) for the past 11 millennia and for the future decades until 2100. Basically, for all months with MDC values above the 300-unit threshold, we considered the full month length (30 or 31 days) as part of the FSL. To define the starting (and ending) month of the FSL and to add the related number of starting (ending) days (*i.e.* <30 or 31 for each month), we used a basic linear interpolation between months, reporting a MDC value lower than the 300-unit MDC, and the following (preceding) month with above-threshold MDC value (Lestienne et al. 2020a). On the expected starting (ending) month, we associated the lower-than-threshold MDC value to the first (last) day and the above-threshold value to the last (first) day of this month to perform the computation.

3. Results

3.1. estimation of future fire hazard in a multi-millennial context

In terms of fire hazard, the results showed that, by the end of the 21st century, the MDC will increase by 7.5% and up to 21% in Corsica, respectively for the RCP4.5 and RCP8.5 scenarii as compared to the 1979–2016 period reference (Fig. 3, Appendix C). Such future fire hazard values will be similar to those estimated for 7 ky cal BP, but they will not exceed the maximum Holocene MDC values. The duration of periods with high fire hazard (FSL), will increase higher (up to 25% i.e. 35 days for RCP4.5 and 32% i.e. 51 days for RCP8.5 by the end of the 21st century), and will exceed the Holocene maximum FSL value after 2040 from both RCP scenarii. Indeed, after 2040, FSL will stabilize around 130 days per a year (i.e. more than 4 months) for the RCP4.5 scenario, while it will exceed 150 days (i.e. more than 5 months) with the RCP8.5 scenario.

Figure 3 - MDC (Monthly Drought Code) and FSL (Fire Season Length) changes in Corsica during the Holocene and future decades. All computations were performed on the 5 ERA-interim pixels delimitating Corsica. MDC computation was performed from May to October, and the FSL subsequently estimated based on the 300-unit MDC threshold (see Sect. 2.3). References to fires and human intensity of activities at the figure's bottom come from a previous study based on microcharcoal, pollen and non-pollen palynomorphs analysis (Arborean/non-arborean pollen ratio for land openness; crop, ruderal pollen and dung fungal spores percentages for agropastoral activities) from the Bastani Lake in Corsica (Lestienne et al., 2020b). Past insolation has been calculated using the "palinsol" R package (Crucifix 2016) which includes data from Berger and Loutre (1991).

For comparison, the Holocene estimation of MDC and FSL values highlighted five periods (Fig. 3). Between 11 to 9 ky cal BP, the fire hazard index was relatively high, with MDC and FSL values above 600 units and 100 days, respectively. Afterwards, i.e. between 9 and 7 ky cal BP, the FSL values remained high with a peak of 126 days at 9 ky cal BP, while MDC values progressively decreased below 500 units. After 7 ky cal BP, FSL felt below 80 days, while MDC continued to decrease until 5 ky cal BP. After 5 ky cal BP, low fire hazard indexes lasted 4 millennia, characterized by minima values: below 400 units for MDC and between 54 et 77 days for FSL. Finally, between 1 and 0 ky cal BP the fire hazard switched back toward increasing trend due to both a slight increase in the MDC values, passing above 400 units, and a sharp increase in FSL values above 100 days, attesting change in fire-related climate conditions.

3.2. Intra-season variability

The fact that the 21st century FSL curve follows also an increasing but amplified trend compared to the MDC curve (Fig. 3) is related to the different trends of monthly drought intensity, especially after 2050.

Indeed, beyond the overall increase in monthly values of fire hazard intensity (MDC) for both RCP scenarii, fire-season months can be splitted in three groups (Fig. 4). The early fire-season (i.e. May and June) will have a higher fire hazard intensity than the Holocene maximum for both RCP scenarii, while it will be within (respectively higher than) the range of the reference period variability for the RCP4.5 (respectively RCP8.5 after 2050). Therefore, such drought intensity will induce at least a similar or an earlier onset of the fire-season (Appendix C). For the mid fire-season (i.e. July and August), only the RCP8.5 scenario will induce higher fire hazard intensity than the Holocene maximum after 2050, while both RCP scenarii will induce higher fire hazard intensity after 2050 than during the reference period. Such increase in mid fire-season hazard intensity would indirectly lead to an extension of the FSL if humidity of late summer and fall months would not compensate enough for the drought. This is the trend shown in the climate forecast (Appendix B), and that explains at least partially the extended fire-season end (Appendix C). Indeed, the late fire-season (i.e. September and October) is also extended, up to an extra month (i.e. November) towards the end of the 21st century in both RCP scenarii (Appendix C) due to on going temperature increase and still no extra rainfall (Appendix B).

Figure 4 - MDC (Monthly Drought Code) distributions for each fire-season month over the next decades computed using the IPCC CMIP5 RCP scenarios. Red lines represent the 1979–2016 MDC distribution (modern reference period) from ERA-interim dataset with the plain line being the median and the dotted lines being the first and third quartiles values. Blue line represents the maximum MDC Holocene value estimated for Corsica over the last 11000 years BP using the HadCM3BL-M1 model.

4. Discussion

4.1. fire hazard changes for the next decades

We showed that the MDC and the FSL will increase until *ca.* 2050 for both RCP scenarii. Then, these increases will slow down or stabilize with the RCP4.5 scenario, while they will continue their ascents with the RCP8.5 scenario.

Such overall trends agree with those found from previous studies that used the FWI or one of its sub-indexes to analyse future changes in fire hazard in the Mediterranean basin. For instance, Moriondo et al. (2006), dealing with future trend in FSL in the Mediterranean basin but based on previous generation of IPCC scenarii showed that FSL will increase by *ca.* 40 and *ca.* 32 days for the scenario SRES A2 (close to RCP8.5) and the scenario SRES B2 (no RCP equivalent), respectively. These FSL values are in line with ours (from + 48 days or 50% to + 24 days or 25% for RCP8.5 and RCP4.5, respectively) despite different IPCC scenario generations, different current reference periods and extents (1961–1990 versus 1979–2016 for this study), different temporal projections (only one period for the future (2071–2100) for their study versus all decades until 2100 in this study), and differences in the mode of computation of FSL. Moreover, Moriondo et al. (2006) worked on six Mediterranean countries (i.e. Portugal, Spain, Greece, Italy, France, and Balkan), while ours focuses on Corsica, geographically located at the centre of the

Mediterranean region covered in Moriondo et al. (2006). Our approach uses the most updated IPCC scenarii and the best temporal resolution allows better highlighting of changes in the next decades.

The review of Giorgi and Lionello (2008), based on an ensemble of global and regional climate change simulations, showed that the next decades (2071–2100) will be characterized by a decrease in precipitation and an increase in temperature, and that these changes will mostly occur in summer. This is in line with our results showing a drought increase over the next decades, especially in summer (Fig. 4, Appendix B). The causes for this large summer drying signal have been previously investigated by Rowell and Jones (2006), who examined four possible and non-exclusive mechanisms: i) the low spring soil moisture conditions leading to reduced summer convection; ii) the large land-sea contrast in warming condition leading to reduced relative humidity and precipitation over the continent; iii) the positive summer soil moisture precipitation feedback; iv) the remote influences (e.g. descending motions induced by the strengthening of the Asian monsoon). According to these authors, these changes will be similar among the RCP scenarii until 2050 and will therefore depend on the political and economic choices after 2050 (Pachauri and Reisinger 2007; Cuttelod et al. 2009; Planton et al. 2012). Such changes have been reported in most projections from both global and regional models and most IPCC scenarii (Kittel et al. 1997; Giorgi and Francisco 2000; Giorgi et al. 2001).

More recent studies (Faggian 2018; Varela et al. 2019; Fargeon et al. 2020), using the same two RCP scenarii as ours, but based on the FWI (alone or in combination with ISI and DC indexes) showed that the fire danger will increase from 24 to 67% depending on the RCP scenario. It is worth noting that ISI and FWI require more inputs (i.e. wind speed and relative humidity) and therefore likely more uncertainties, and that authors did not systematically discriminated changes in fire danger intensity from changes in the fire-season length.

4.2. How much future fire hazard will depart from past?

By comparing our Anthropocene future predictions with the Holocene values, we can see that the FSL will exceed the maximum values at Holocene from 2040, while MDC will reach in 2100 values never observed since 6 k years cal. BP. From these results, we can expect an increase in fire occurrences in the next decades, but the climatic conditions and the vegetation will differ in the future fire-prone periods as compared to the first half of the Holocene period and could also affect the fire occurrence. Indeed, the current insolation is lower than in the early Holocene (11 – 7 k years cal. BP), which corresponded to the maximum Holocene insolation (Berger and Loutre 1991) as shown in Fig. 3, especially for the months of June, July and August at 45°N latitude (Hély et al. 2010; Renssen et al. 2012). This high insolation in early Holocene induced a strong seasonality, with the highest temperature and lowest precipitation in summer, and inversely for winter as reconstructed by Dormoy et al. (2009) from Mediterranean marine pollen records. Here we showed that the FSL will increase in the future, due to both the increase in temperature as a response of increasing concentrations in Greenhouse Gas and the decrease in precipitation as a response of atmospheric dynamics over the Mediterranean region that will occur for every month (Appendix C), with most aridity in summer months. This difference in seasonality origin between early Holocene with high insolation and the 21st century with low insolation but high concentrations of Greenhouse Gas could explain the differences between the early-Holocene and the future fire hazard predictions in terms of intensity (MDC) and duration (FSL). Indeed, the MDC calculation needs monthly maximal temperatures and monthly precipitations data (Girardin and Wotton 2009). Because the early Holocene summer conditions was warmer and dryer, the MDC was high, but the strong seasonality with cooler and wetter conditions in both spring and autumn induced relatively short FSL. In the future, the climatic conditions in summer will not reach the maximal Holocene values, but the global aridification occurring for every month will extend the FSL much longer. Contrary to the early Holocene when insolation was the main climate driver, the global increase in aridity will be mainly due to the strong increase in greenhouse gas emissions and responsible for global change (Pachauri and Reisinger 2007; Thomson et al. 2011; Meinshausen et al. 2011; Riahi et al. 2011).

In addition, we have to consider that fires have not always been the sole result of arid periods. Indeed, while dry and warm climate promoted fires between 11 and 7 ky cal BP, humans have been the main driver after 5 ky cal BP with slash-and-burn activities for agro-pastoral activities (Vannière et al. 2016; Lestienne et al. 2020b). Beside this, differences in vegetation composition must also be considered. Indeed, the early Holocene vegetation in Corsica was mostly composed by pinewoods with low diversity (Reille 1992; Reille et al. 1999; Lestienne et al. 2020b), while the current vegetation is more diversified, with grasslands and low shrubby formations at high elevation, and with oakwood and sclerophyll vegetation in lower elevation (PNRC 1983; Reille et al. 1997, 1999). However, climatic changes will impact significantly the future vegetation dynamics by changing the dominant species and by conducing to a possible desertification (Gao and Giorgi 2008; Anav et al. 2011) while during the early Holocene, the strong seasonality favoured vegetation growing during wet springs. DGVM models based on these changes estimate that the fire danger (combining climate fire hazard and environment vulnerability) could increase from 2 to 4% and the amount of carbon burned could be 25% higher than today (based on the RCP6.0 scenario) (Anav et al. 2011; Dupuy et al. 2020).

In the early Holocene, the dry and warm climatic conditions have promoted fires (Vannière et al. 2008, 2011), which have in turn opened the landscape and promoted more diversified vegetation with the development of shrublands in spite of pinewoods (Beffa et al. 2016; Lestienne et al. 2020b). Nowadays, fire ignitions are mostly due to humans activities (i.e. accidental or intentional ignitions) (Curt et al. 2016; Costafreda-Aumedes et al. 2018). Associated to the warmer and dryer climate, these conditions will strongly contribute to increase wildfire frequency and intensity in the Mediterranean region, and likely the occurrence of large fires and megafires (Mouillot et al. 2002; Pausas 2004; Giannakopoulos et al. 2005; Tedim et al. 2013; Batllori et al. 2013; Lahaye et al. 2018; Lestienne et al. 2020b). In terms of burned area, the increase would reach 15–140% by the end of the 21th century, depending upon the RCP scenario (Amatulli et al. 2013; Dupuy et al. 2020).

4.3. Advantages and limits of the method

Few studies have tried to predict the future fire hazard or fire danger in the Mediterranean Basin. Most of them used a very short historical reference period (Varela et al. 2019) and just one period for the future (Faggian 2018; Varela et al. 2019). The most recent and complete study has been done by Fargeon et al.

(2020) at high spatial resolution (8 km). However, the historical depth is short (i.e. 20 years) as compared to more than 30 years in our study.

Moreover, the MDC is an efficient and really simple index to assess the fire hazard (Bürger 2013; Lestienne et al. 2020a). The few inputs needed (only precipitation and maximum temperature) make it adaptable for a wide temporal range (Wagner et al. 1987; Girardin and Wotton 2009).

However, the quality of the MDC signal (and so the quality of the FSL estimation too) strongly depends on the climate models used. Five climate models, among the most used (Watanabe et al. 2010, 2011; Chylek et al. 2011; YiMin et al. 2018), have been used to computed the fire hazard forecasts, giving confidence to our results (Shiogama et al. 2007; Ahlström et al. 2012). Such confidence is further reinforced by the strong similarities between our results and those from other studies (Giorgi et al. 1992; Pachauri and Reisinger 2007; Cuttelod et al. 2009; Planton et al. 2012).

Past climate simulations over several millennia from full climate models are scarce. Fortunately, HadCM3BL-M1, being an intermediate complexity model version from the full Hadley Center Model is one of those that covered the Holocene and beyond (ref Valdes 2017). Its efficiency has previously been compared with full complexity climate models for the Canadian boreal region with satisfaction (Hély et al. 2010). These Holocene climate simulations were also used to assess the role of climate and vegetation changes on boreal forest fire size during the Holocene (Hély et al. 2020). However, we still face to a strong lack of knowledge and we urgently need to have access to other climate simulations for the Holocene (snapshot periods as for the HadCM3BL-M1 version, or ideally transient (i.e. continuous) simulations).

5. Conclusion

In this study, we highlighted the increase in fire hazard intensity (MDC) and duration (FSL) for the next decades (at least until 2100). Even though the MDC will not reach the maximum Holocene values, the FSL will reach (for RCP4.5) or even exceed (for RCP8.5) the maximum Holocene FSL from 2050. These increases are mainly attributed to the global warming and to the increase in summer aridity that goes with in the Mediterranean region.

Early Holocene fires have been driven by climate due to high solar insolation, whereas from 6 ky cal BP, fires have been driven by human activities (pastoral activities, slash and burn cultivation…). Currently, and for the first time in the Holocene, we are confronted to an increase in both drought and human influences, and this combination will probably promote frequent and extreme fires. Such increase, associated with the increase in wildland/urban interface due to the urban sprawl could threat the population, houses and structures. Moreover, it could also lead to a biodiversity loss. In France, fire policy established after the devastating wildfires of 1990 has been very effective under normal weather conditions. However, this capacity could be undermined under more extreme weather condition, and the devastating fires of 2003, 2016 or 2019 have already showed that our capacity to control fires is limited.

For the next 30 years, the game seems to be played already because both studied RCP scenarii showed the same fire hazard trends. However, our current policies will also influence the climate response at a longer time-scale and we need to reconsider our political choices to avoid catastrophic consequences in term of ecology and/or economy (e.g. extremes wildfires close to the cities, biodiversity losses, etc.).

Declarations

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Figures

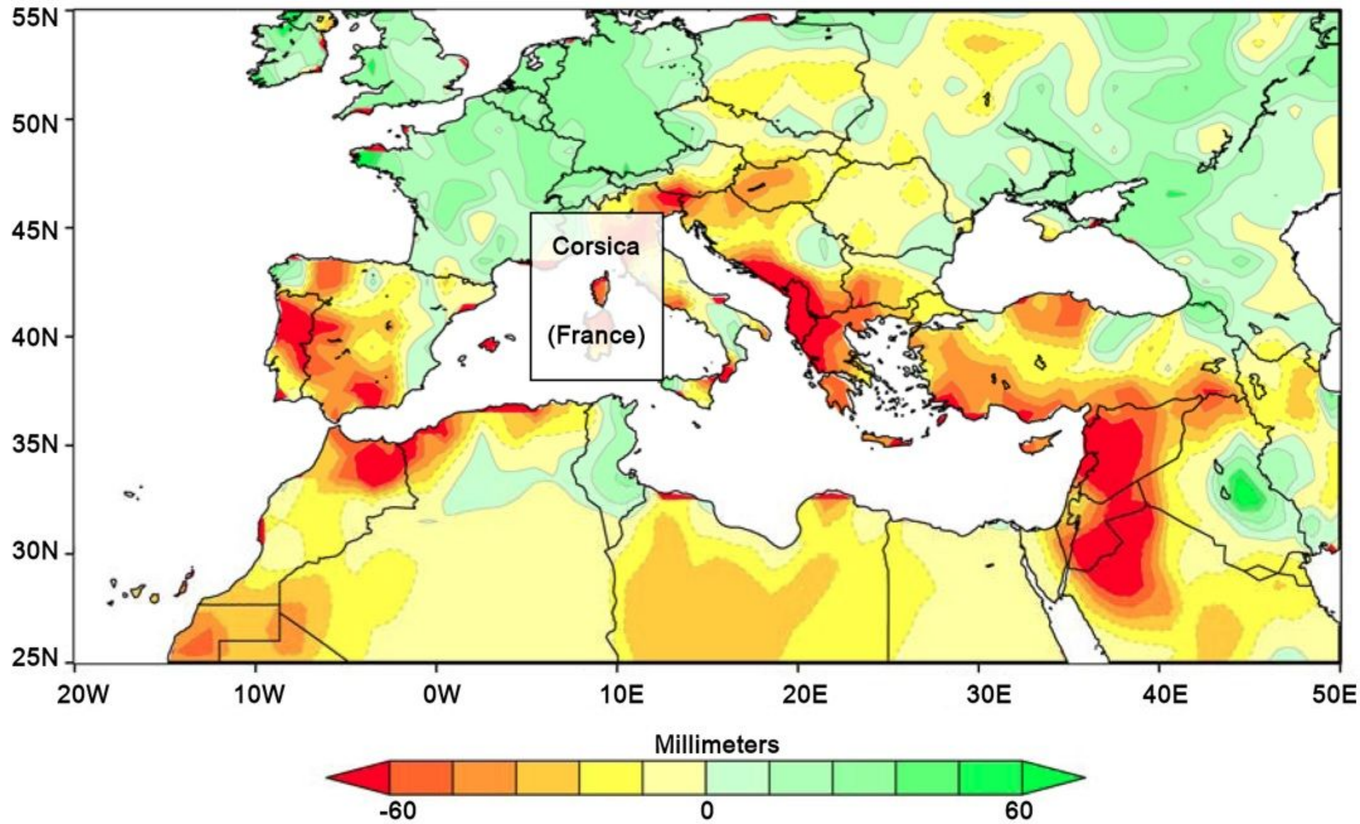

Figure 1

Geographical context of Corsica, a French European island and changes in rainfall around the Mediterranean Basin between 1971-2010 and the comparison period 1902-2010 (NOAA, 2011). Figure adapted from NOAA/Earth System Research Laboratory.

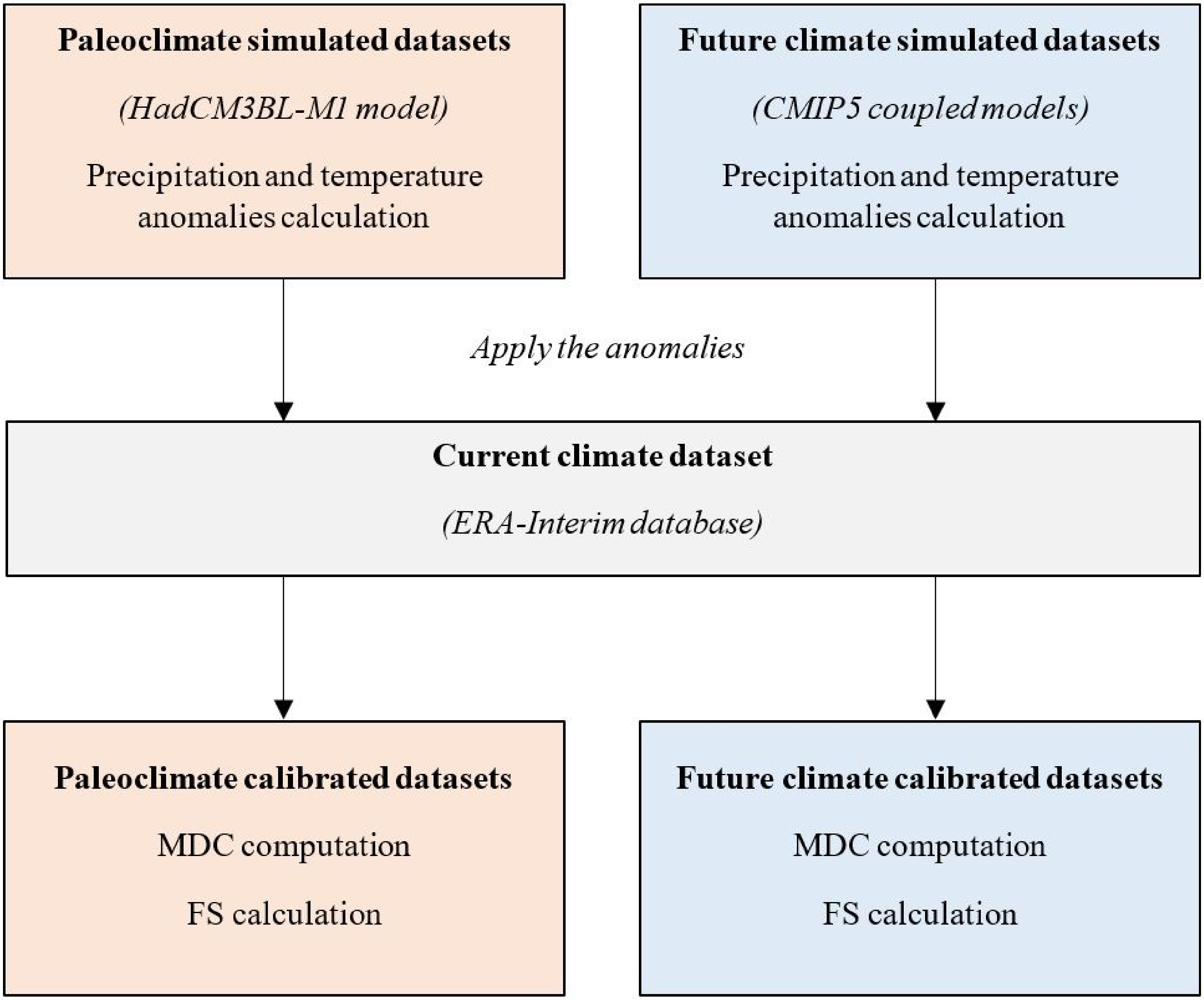

Figure 2

Synthesis of the climatic datasets extraction methodology.

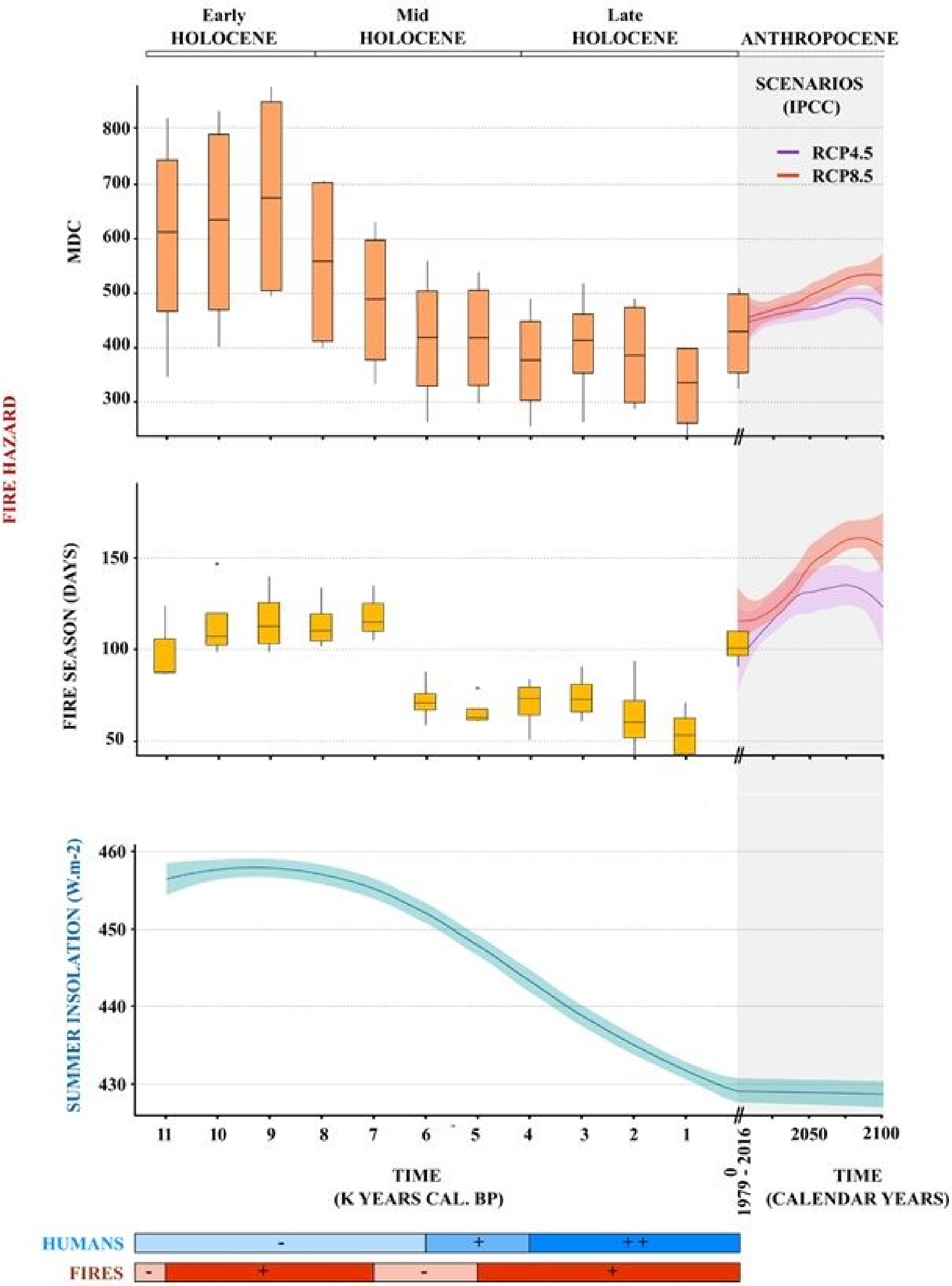

Figure 3

MDC (Monthly Drought Code) and FSL (Fire Season Length) changes in Corsica during the Holocene and future decades. All computations were performed on the 5 ERA-interim pixels delimitating Corsica. MDC computation was performed from May to October, and the FSL subsequently estimated based on the 300-unit MDC threshold (see section 2.3). References to fires and human intensity of activities at the figure's bottom come from a previous study based on microcharcoal, pollen and non-pollen palynomorphs analysis (Arborean/non-arborean pollen ratio for land openness; crop, ruderal pollen and dung fungal spores percentages for agropastoral activities) from the Bastani Lake in Corsica (Lestienne et al., 2020b). Past insolation has been calculated using the “palinsol” R package (Crucifix 2016) which includes data from Berger and Loutre (1991).

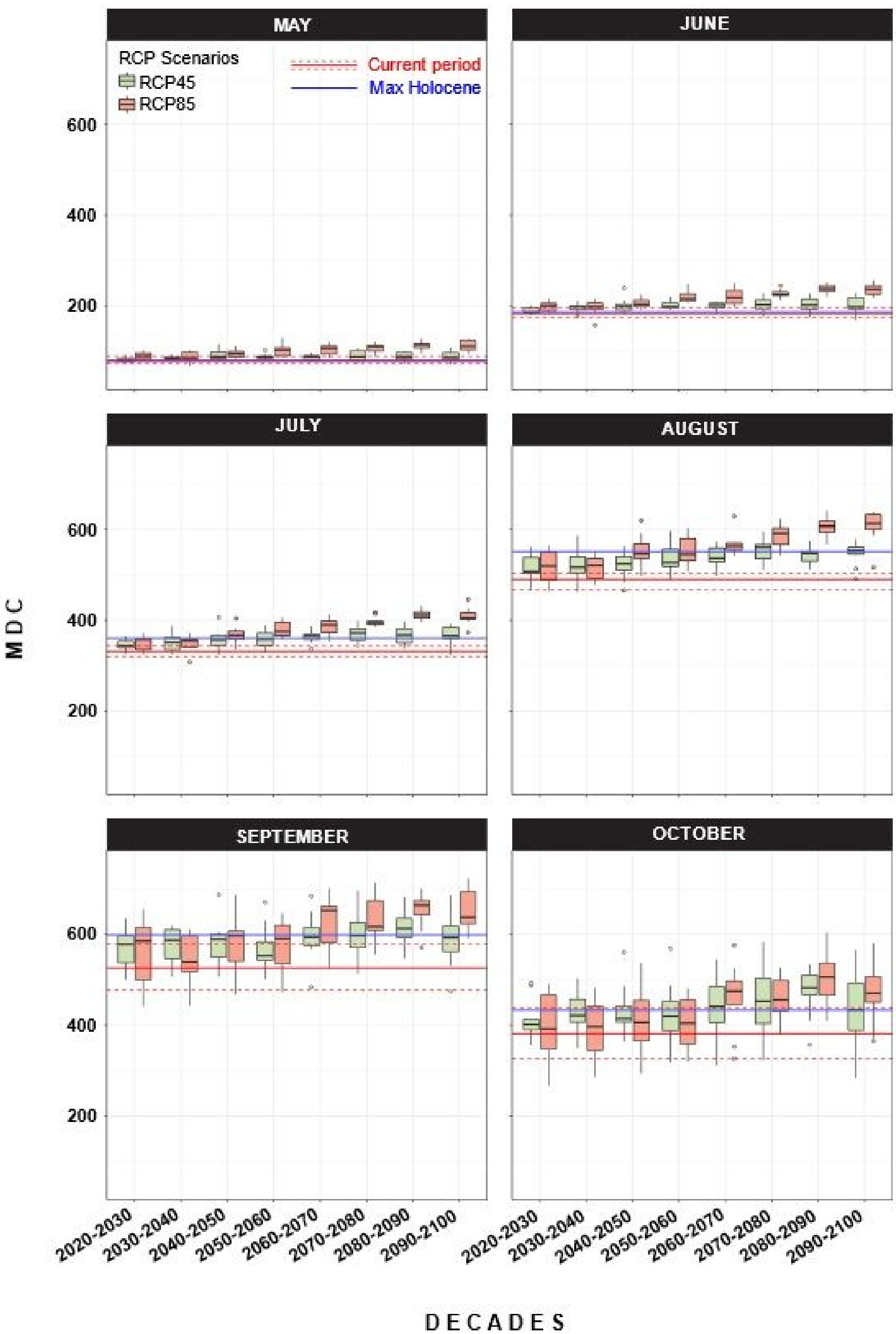

Figure 4

MDC (Monthly Drought Code) distributions for each fire-season month over the next decades computed using the IPCC CMIP5 RCP scenarios. Red lines represent the 1979-2016 MDC distribution (modern reference period) from ERA-interim dataset with the plain line being the median and the dotted lines being the first and third quartiles values. Blue line represents the maximum MDC Holocene value estimated for Corsica over the last 11000 years BP using the HadCM3BL-M1 model.

Supplementary Files

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