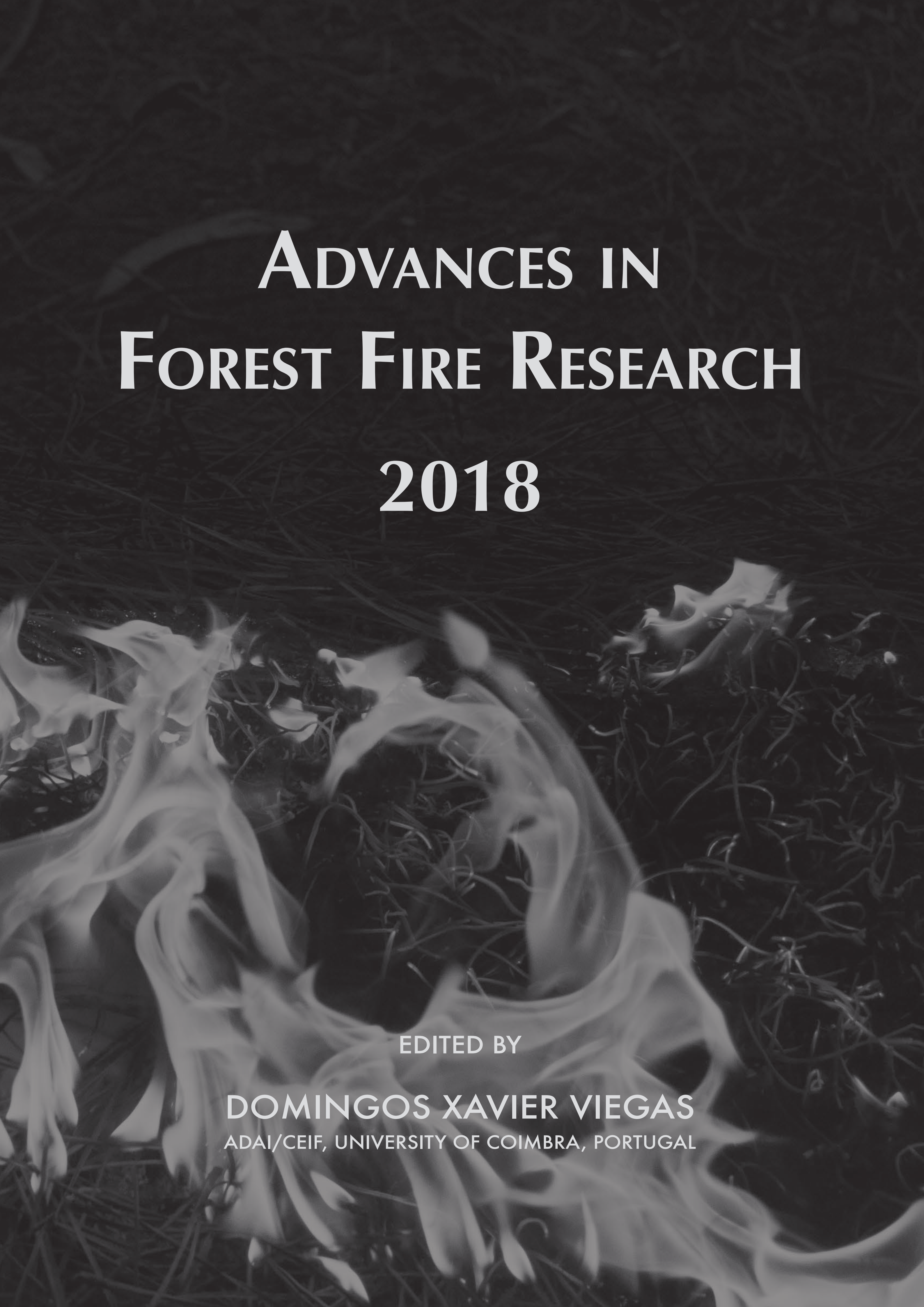

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Short contribution – Fire Risk Management

Extreme weather conditions: The role of an heat wave on wildfires in Portugal

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Abstract

Heat waves (HW) combined with periods of drought, as the one of 2017, may have a significant impact on the occurrence of extreme wildfires (EW) which, in turn, can have devastating social, economic and environmental consequences. EWs may modify (i) vegetation structure and dynamics; (ii) water quantity and quality; (iii) air quality; (iv) human health, loss of life, damage to property and infrastructures. On last decades, EWs in Continental Portugal increased in frequency and impacts. The main focus of this study is to assess the influence of HWs on the occurrence of EWs in mainland Portugal. In this study, EWs will be considered as wildfires with burnt area ≥ 5000 ha. In a first stage, HW occurrence was assessed on the basis of Fischer and Schär (2010) definition for a recent past and different future climate scenarios. In the second stage, spatial and temporal distributions of EWs were related to the occurrence and characteristics of HWs in the recent past. Finally, projections of EWs for the future are inferred from the potential changes in the characteristics of HWs for different future climate scenarios. This study benefits from the existence of reliable fire datasets, with accurate and detailed information on the date/time of ignition/extinction, the location, the shape and the size of the burnt area, as well as consistent high resolution of meteorological datasets for recent past and future climate scenarios. Results disclose: (i) almost all EWs were active during an HW; (ii) the vast majority of total EWs days were also HW days; (iii) 4/5 of the EWs had duration completely contained in the duration of an HW; and, (iv) the same amount of the EWs occurred during and in the area affected by HW. This study aims to help the definition of strategies for adaptation and mitigation of climate change to HW as well as for fire risk management.

Keywords: Heat wave, Extreme wildfire, Extreme conditions, Climate change, Portugal

1. Introduction

In last decades, EWs in Continental Portugal increased in frequency and impacts which attracted the attention of researchers for these fires and their drivers. In Portugal, extreme wildfires (EW) tend to occur in association with extreme weather conditions, namely heat waves (HW) during the summer fire season and drought in the previous months. Therefore, the main aim of this study is to assess the influence of HWs on the occurrence of EWs in mainland Portugal as well as to assess the potential changes in the characteristics of the HW for future climate scenarios and periods. As an example, the results obtained for 2003 will be presented, which was one of the years with the highest annual burnt area in Portugal.

2. Data and Methodology

2.1. Study Area

Mainland of Portugal has an area of 90,000 km^2, is located between Spain and Atlantic Ocean and has a temperate or Mediterranean climate. The Tagus River divides territory into two regions with different sub-types of climate: the north region, characterized by dry and warm summers; and, the south with dry and hot summers (Rubel and Kottek 2010). Along with other environmental characteristics (e.g., topography, land use land cover) these climatic conditions combined with extreme hot spells promote the occurrence of EWs.

2.2. Meteorological datasets

The meteorological datasets used in this study comprises daily maximum temperature (T_{max}) from: (i) ERA-Interim dataset (Dee *et al.* 2011) for a spatial domain (10°W – 6°E, 36.5°N – 42.5°N) centred in Continental Portugal for control period (1981 – 2010), with a spatial resolution of 0.125º × 0.125º latitude/longitude; (ii) CORDEX (Coordinated Regional Climate Downscaling Experiment) Adjust project dataset (http://cordex.org/data-access/bias-adjusted-rcm-data/) with 12 km (EUR-11) resolution for control and 5 consecutive 30-year future climatological periods (2021-2050, 2031-2060, 2041-2070, 2051-2080 and 2061-2090), for 4.5 and 8.5 representative concentration pathways (RCP), and for 3 pairs of General Circulation Model/Regional Climate Model, namely, MOHC-HadGEM2-ES/RACMO22E, MOHC-HadGEM2-ES/CCLM4-8-17 and MPI-M-MPI-ESM-LR/REMO2009.

2.3. Fire datasets

Information from the two official fire datasets provided by the Portuguese Institute for the Conservation of Nature and Forests (www.icnf.pt), were combined to obtain an EW dataset with detailed temporal (ignition and extinction date and time) and spatial (burnt area, BA, polygon) data. In this study, EWs are defined as very large wildfires (BA ≥ 5 000 ha). In the control period a total of 62 EWs occurred in Portugal, which corresponds to 0.02% of total number of wildfires but to almost 19% of total BA. These events tend to occur more in central and south-eastern regions of Portugal (Figure 1).

2.4. Methodology

The Fischer and Schär (2010) definition of HW was adopted in this study for being especially suitable to capture absolute (summer) extreme events of T_{max}. An HW is defined as a period of at least six consecutive days with $T_{max} > P90$. HWs occurrence in control period and for future projections were characterized by their number (HWN90), duration (HWD90), frequency (HWF90) and amplitude (HWA90). Robustness of the climate change assessment was based on Jacob *et al.* (2014) and Pfeifer *et al*. (2015). To understand the impact of HWs in EWs, spatial distribution and temporal evolution of HWD90 and HWA90 were compared with the spatial-temporal distribution of wildfire events.

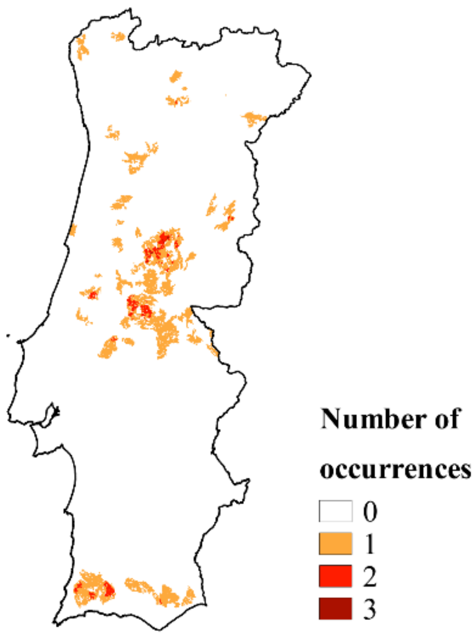

Figure 1 – Number of extreme wildfire occurrences taking in account the 62 extreme wildfires (very large wildfires with burnt area ≥ 5 000 ha) define between 1981 and 2010.

3. Results

3.1. HWs occurrence characterization

The intra- and inter-annual variability of HWs characteristics, namely, HWN90, HWD90, and HWA90 (Figure 2) unveil: (i) that HWs tend to occur between May and October; (ii) HWD90 and HWA90 present two significant increasing trends in the 1981 – 1992 and 1993 – 2010 periods; (iii) that HWN90 present a decreasing followed by a decreasing trend in the same periods; (iv) 1981 – 2010 annual HWD90 and HWA90 peak is in 1990; (v) more HWA90 doesn't mean more HWD90 or more HWN90 in every case; and, (vi) 1981 and 2009 were the years with more HWN90.

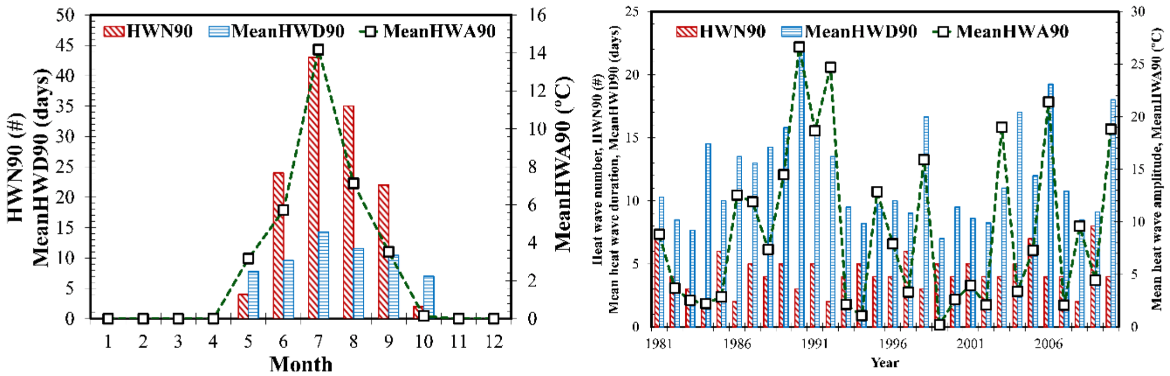

Figure 2 - Monthly and annual distributions of heat wave number (HWN90), mean heat wave duration (MeanHWD90) and mean heat wave amplitude (MeanHWA90) for control period (1981 – 2010).

Spatial distribution of annual HWN90 and HWD90 (Figure 3) reveal higher values in the northeast and in the south region with emphasis near the Spain border. In contrast, the annual spatial distribution of HWA90 is more homogeneous with high values in central region. Future projections of HWs shows that: (i) HWN, HWD and HWF are expected to increase in future for both RCP's; and, (ii) HWA is expected to decrease for both RCP's, with the exception after the second future period of RCP 8.5 where its start to gradually increase. Spatial future projections unveil that HWN for RCP 4.5 are higher in central north region, while for RCP 8.5 are higher in the interior and central north regions.

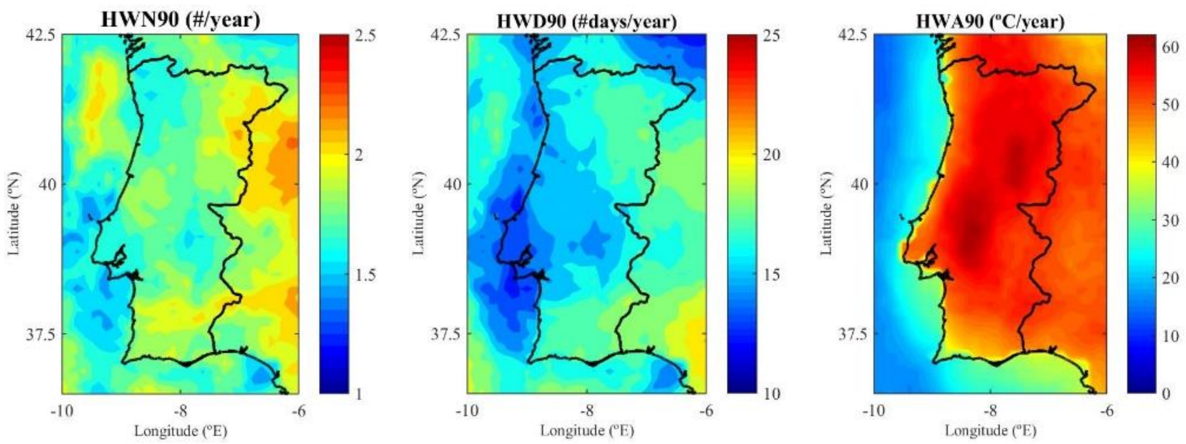

Figure 3 - Spatial distribution of annual heat wave number (HWN90), duration (HWD90) and amplitude (HWA90) for control period (1981 – 2010).

3.2. The influence of HWs on EWs occurrence

The analysis of spatial and temporal distributions of EWs, HWD90 and HWA90 (Figure 1 and Figure 3) disclose: (i) 3% of EWs were not active during an HW; (ii) only 10% of total EW days were not also HW days; (iii) more than 18% of the EWs had duration completely contained in the duration of an HW; and, (iv) 18% of EWs occurred during and in the area affected by HW. For example, Figure 4 unveils that 2003 EWs occurred on the most affected areas by 2003 HWs, even the ones on the south-eastern region.

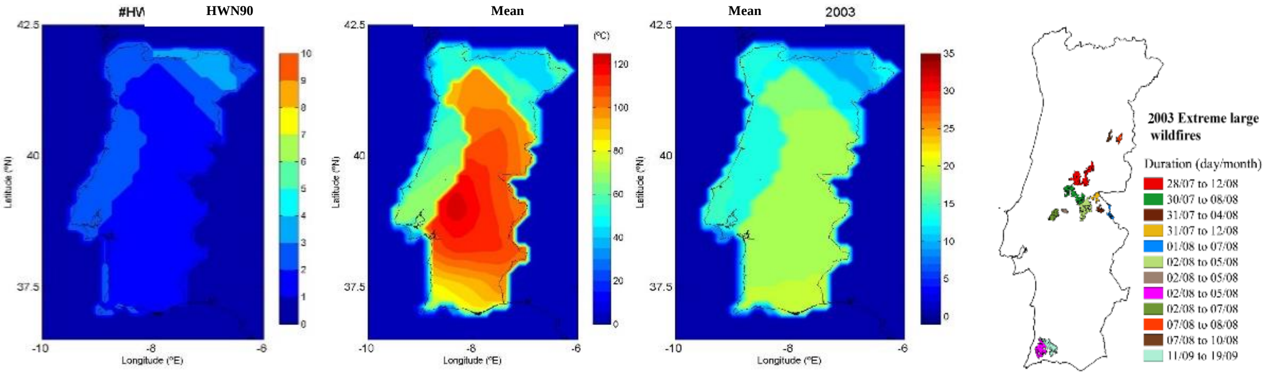

Figure 4 - Burnt area polygons of 2003 extreme large wildfires and heat wave 2003 statistics.

4. Conclusions

Due to the adopted definition of heat waves, this study is focused on summer extreme events of surface air temperature. This is particularly evident in the intra-annual variability of the heat wave descriptor of number, duration and amplitude. This study also disclose a high inter-annual variability of those features, with a sequence of low and high values, superimposed by increasing trends in two sub periods (1981 – 1992 and 1993 – 2010), except HWN90 which present a decreasing trend in the first sub period. The spatial distribution of the heat wave descriptors reveal the NE and south as the most affect regions, in terms of number and duration, the central region is the most affected in terms of the amplitude. Central Portugal is also the region most affected by the extreme wildfires as was clear in 2003, one of the most extreme years in terms of burnt area. Temporal and spatial analysis disclose that all the extreme wildfire events occurred during or immediately after several long intense heat waves. This study aimed to help decision makers and practitioners on the definition of strategies for fire risk management and adaptation to climate change to HW since our results suggest the HW should increase in number, duration and amplitude for different future scenarios of climate change.

5. Acknowledgements

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