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Modeling and forecasting extreme hot events in the central Ebro valley, a continental-Mediterranean area

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Abstract

This work has three objectives, first, to analyze the observed change in the summer maximum daily temperature during the period 1951–2004, in the centre of the Ebro river basin, a region situated in the NE of the Iberian Peninsula. Secondly, to characterize the extreme hot event behaviour by means of a statistical model consisting of a non-homogeneous Poisson process, to represent the occurrence, and three regression models, each with an adequate non-Normal error distribution, to model its severity. The model parameters are allowed to depend on temperature covariates, to take into account the influence of global warming in hot event generating process. Finally, using the fitted model and different outputs from a GCM, we obtain a medium term projection, up to 2050, of the expected behaviour of these extreme events.

Keywords: Ebro valley; heat waves; marked Poisson model; future climate projections

1. Introduction

The global warming undergone by mean surface air temperature values during the 20th century and, particularly, in its last decade, will probably continue, associated to the climate change induced by the increasing concentration of greenhouse gases in the composition of the atmosphere (Houghton et al., 2001). This likely scenario, together with the increasing occurrence of extremely hot events (EHE) and, particularly, the exceptionally long heat wave observed in Europe in August 2003, leaded to the publication of many studies dealing with climatic analyses of these events, such as Beniston and Stephenson (2004) and Schär et al. (2004).

According to the IPCC TAR (Houghton et al., 2001), the observed warming during the 20th century in land-surface air temperature signals mainly occurred during 1910–45 and 1976–2000, whereas the intermediate period, 1946–75, did not show any significant increase. In Europe, spring and winter mean temperatures followed this pattern, with winters between 1973 and 2002 being, very likely, the warmest of the last half-millennium (Luterbacher et al., 2004). Regarding the summer season, the averaged European temperature anomaly series for the period 1977–2003, shows a linear trend whose slope is 0.7 °C/decade and an exceptionally strong, unprecedented, warming in the 1994–2003 decade. Autumn is the only season where a decrease of temperature is observed in extensive areas of Europe during the 1976–99 period (Klein Tank et al., 2005).

For the European territory, the European Climate Assessment (ECA) project is carrying out a study about the evolution of many signals related to mean values, variability and extreme indices of precipitation and temperature, particularly, for 1946–75 and 1976–2004 periods (Klein Tank et al., 2002; Klein Tank and

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Können, 2003). In the ECA approach, the results for a region are obtained from point results of selected observatories situated in the corresponding area or close to it, when they show coherent evolutions. This can pose serious difficulties: the number of observatories in the Iberian Peninsula for the period 1946–75 is small, 5, and they are concentrated in the West, in Portugal or close to it.

According to the ECA results regarding the Ebro basin, the mean value of maximum daily temperature during 1976–2004 was stable in autumn and increased in the other seasons; this increment was statistically significant in spring and summer and more intense in spring. In a previous work, Abaurrea et al. (2001) analyzed the evolution of maximum and minimum daily temperatures, denoted Tx and Tn respectively, at the centre of the Ebro basin during the period 1938–97, obtaining similar conclusions to the ECA project but more precise results. We emphasize that: (i) the Tx and Tn evolution is non-homogeneous in the different seasons; during the period 1976–97, for example, the Tx mean value increases 1.43 °C/decade in spring, 0.96 °C/dec. in summer and 0.51 °C/dec. in winter, being stable in autumn; (ii) for the same time period, a generalized decrease of interannual variability, except in autumn, is observed, which is statistically significant for winter and spring Tx series and only in spring for Tn. Our results agree with those obtained by Brunet et al. (2001) for the Catalonian region, also situated in the NE of Spain.

The aim of this work is to study the extreme hot events observed during the summer season at the centre of the Ebro valley, an area represented by Zaragoza and Huesca observatories. In spite of the small size of the territory, the study is interesting because of the climatic conditions of this region, which undergoes a dry and extreme climate, influenced by the Mediterranean sea, situated to the East, and the continental conditions of the Iberian central plateau to the WSW, and also due to the shortage of studies for this type of climate. We aim to characterize the EHE generating process by fitting a statistical model relating the EHE behaviour and the temperature evolution. We also show the use of this model for providing possible trajectories of the EHE process in a medium term horizon, 2050, as an alternative to regional climate models (RCM), Beniston and Diaz (2004), Schär et al. (2004), Sánchez et al. (2004).

In next section we analyze the observed change in the summer maximum daily temperature during the period 1951–2004 and describe the occurrence rate and severity of the observed hot events. In Section 3 a statistical model able to characterize the EHE generating process is developed. In Section 4 we use the fitted model to obtain a scenario for the EHE process in the interval 2005–2050.

Fig. 1. Map locating Zaragoza, Huesca and HadCM3 grid points (in black).