CHANGES IN EUROPE’S TEMPERATURE EXTREME VALUES

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ABSTRACT. - Changes in Europe’s Temperature Extreme Values. In environmental researches several concerns on the evolution of temperatures. However, in the last decade we can observe intensification of extreme events, including that of temperatures. The present research investigates the evolution of extreme temperature values scaled at annual scale using frequency analysis on historical data. Three types of extreme temperatures were analyzed: annual minimum and maximum, and highest daily temperature fluctuation on annual scale. The results show both the dynamics of changes and probabilistic laws describing the extreme values, obtaining hazard related to these phenomena. We found risky evolutions in case of maximum annual temperatures, when in 55% of locations the associated hazard value was increasing for long or short time period, and in case of highest daily temperature fluctuation, when in 71% of cases the associated hazard value was increasing for long or short time period.

Keywords: extreme values, frequency analysis, hazard evolution, distribution laws

1. INTRODUCTION

In our society the search for security has become a very important. This is because the mentality changed over the centuries (material goods and social relations have taken a major role), the number of elements that induce uncertainty (technical and financial elements) have a growing number both in frequency and amplitude. In environmental researches several concerns on the evolution of temperatures. However, in the last decade we can observe intensification of extreme events, including that of temperatures. The present research investigates the evolution of extreme temperature values scaled at annual scale using frequency analysis on historical data.

The increasing uncertain, with the development of technology, allows but also forces the study of risk phenomena, which are reported directly or indirectly to the component elements of society to people.

Currently, in the study of the risk phenomena there are three different approaches:

- descriptive analysis: identification, description, location
- comparative analysis: numerical subjective evaluation

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- quantitative analysis: statistical analysis, frequency analysis, spatial analysis

Risk analysis regarding extreme temperatures can be found in many scientific publications, most of them using descriptive and comparative analysis based on some classic statistical indicators (Liu et al., 2003; Richards and Baumgarten, 2003; Povară, 2000). Probability analysis is also present in studies for Brasil (Astophollo et al., 2005) Switzerland (Appenzeller and Eckert, 2000), Romania (Croitoru et al., 2002).

Fell and Hartford (1997) considers that descriptive and comparative study of risk is approachable, but it cannot be used in risk estimation. It is noteworthy that in the quantitative study of the risk the phenomena is not always explored using the physical laws that defines them, but is often used a stochastic, probabilistic approach, governed by statistical laws, eventually particularized for the studied phenomena.

The present research investigates the evolution of extreme temperature values scaled at annual scale using frequency analysis on historical data for Europe. Three types of extreme temperatures were analyzed: annual minimum and maximum, and highest daily temperature fluctuation on annual scale.

2. DATA AND METHODS

In the research we want to include all land stations from across Europe which have long periods with full records. The most comprehensive data source we found was the National Climatic Data Center (NCDC) from which we requested all data. To fulfill a successful frequency analysis we need full year daily records to select the annual extreme values. It's desirable but not compulsory to have continuous years. For this we developed a minimal schema for data requests as presented in table1. For all stations 2015 years' data should be included.

Table 1. ***Minimal schema for candidate stations***

Records starting year	1840	1850	1860	1870	1880	1890	1900	1910	1920	1930	1940
Minimum coverage [%]	80%	82%	84%	86%	88%	90%	92%	94%	96%	98%	100%

In all cases just those years data were included where we had 100% coverage, but due to the fact that the coverage percent for the whole period could be under 100% several years may be missing. A number of 73 stations from different European countries respected the minimal schema.

The analysis steps were:

- Data request and download
    - the candidate stations were selected on NCDC online interface, based on metadata shown there regarding the starting year and time coverage

- Data validation, extraction and filtering
    - a proper software application were developed in C++ to verify the coverage of all years and selecting the yearly minimum, maximum and the highest daily temperature fluctuations
- Data validation
    - outliers detection based on Turkey's method was used, as this method has no distributional assumptions (Turkey, 1977), which was important as we deal with annual extreme values, which in most cases doesn't have a normal distributions
- Frequency analysis of extreme values
    - Frequency analysis is a statistical prediction method consisting in the study of past events, characteristic of a given phenomenon, in order to define the probability of occurrence of data values (Meylan and Mussy, 1999). In frequency analyses to an extreme valuean exceeding probability can associated which can be turned into a certain return period, based on equation 1:

$$T = \frac{1}{p} \quad [1]$$

where,

T – return period
p – exceeding probability

Return period doesn't identifies the moment of reoccurrence or excess but characterizes the phenomena's hazard (Haidu, 2002). For selecting the most suitable distribution law Anderson-Darling criteria was used, because grants higher importance to tails which represents the extreme values

To assess the dynamics of extreme values hazard for each station its historical value was used. The extreme values exceeding probability was determined for three scenarios: for full historical record period ($P_{A)}$, for the last 30 years (P_{30}) and for the last 15 years (P_{15}). Based on the calculated probabilities four evolution category was defined: 1 (long time decrease) – $P_{15}<P_{30}$& $P_{15}<P_A$; 2 (stable) – all unspecified cases; 3 (short time increase) – $P_{15}>P_{30}$; 4 (long time increase) – $P_{15}>P_{30}$& $P_{15}>P_A$.

3. RESULTS AND DISCUSSION

The analysis was carried out for three types of extreme values: annual minimum and maximum temperatures, and highest daily temperature fluctuation at annual scale.

After data extraction and validation we found that two land based stations from Norway have only 4 respectively 7 years with full coverage, so they were excluded from all further analysis. In case of other stations they have an average of 103 years' full coverage with minimum of 58 years and maximum 181 years of historical data records. From a total of remaining 71 land stations only 16 in case of minimum temperatures, 18 in case of maximum temperatures and 14 in case of highest daily temperature fluctuation have passed all three statistical tests (stationarity, independency and homogeneity) to be included in frequency analysis.

3.1. Annual minimum temperatures

The annual minimum temperatures for the past period doesn’t show unusual values, only at Zugspitze the value fall below -35^{0}C. Analyzing the return periods for local historical minimum there are no important threats as in only two cases (Eelde and Zamora) their value is below 100 years.

Looking at the evolution of hazard for the last 30 and 15 years against full period (fig. 1), in case of three locations we found a continuously increasing hazard value (Schwerin, Oberstdorf and De Bilt 1) and for an additional 4 locations a short time increase (Perpignan, Lindenberg, Bucureşti-Băneasa and Zamora).

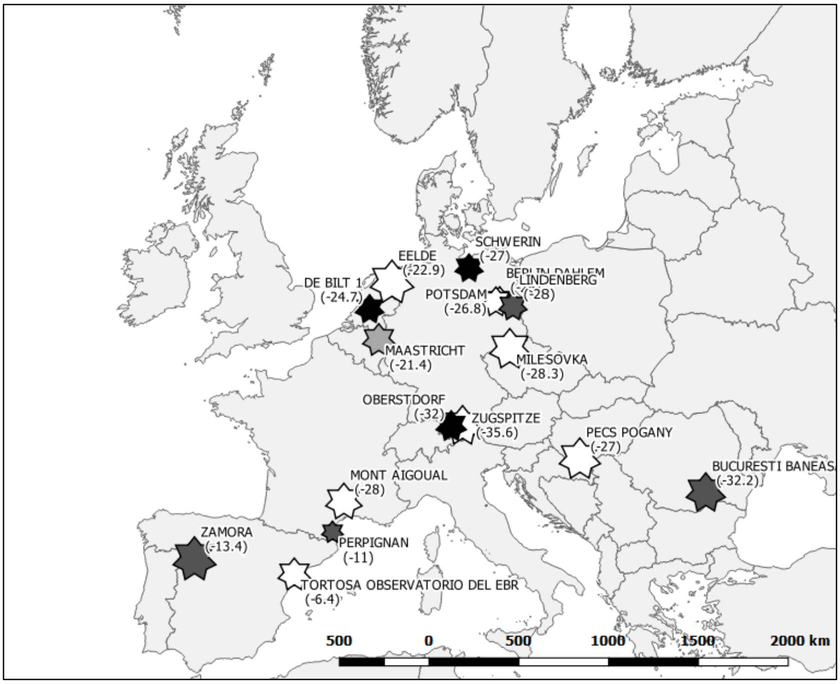

Fig. 1. ***Hazard of annual local minimum temperature (in brackets) based on historical records (bigger symbol – higher hazard; darker symbol – more risky evolution)***

Regarding the general suitability of best fitting hazard functions (fig. 2), for all time period General Logistic and Johnson SB are the most important which has changed to Wakeby and Johnson SB for the last 30 year period. For the last 15 year Johnson SB proved to be the most important, having a 44% share.

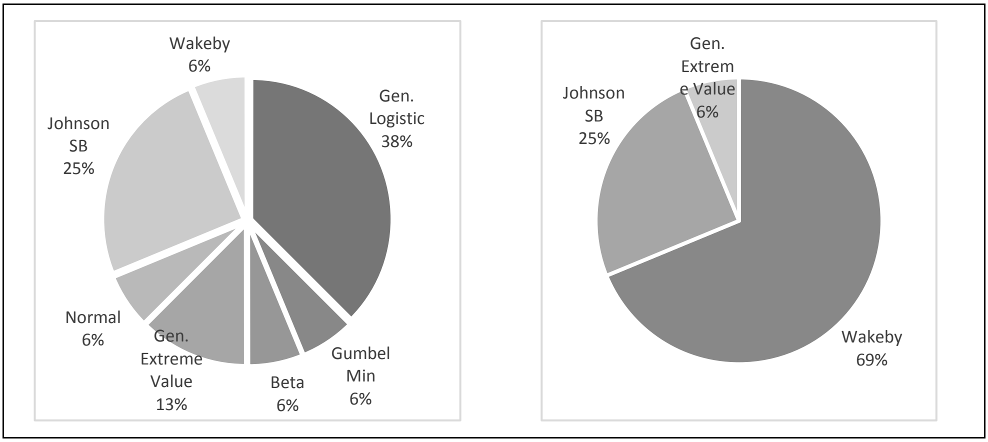

Fig. 2. ***Best fitting distributions share for minimum temperatures for all time historical records (left) and for the last 30 years records (right)***

3.2. Annual maximum temperatures

The annual maximum temperatures for the past periods doesn't shows unusual values. In seven locations the maximum rises above 40^{0}C, the highest value has Granada, slightly below 45^{0}C. Analyzing the return periods for local historical maximum in two cases (Bron Lyon Airport and Kjobli I Snaasa) the value is below 50 years (38 and 25 years respectively).

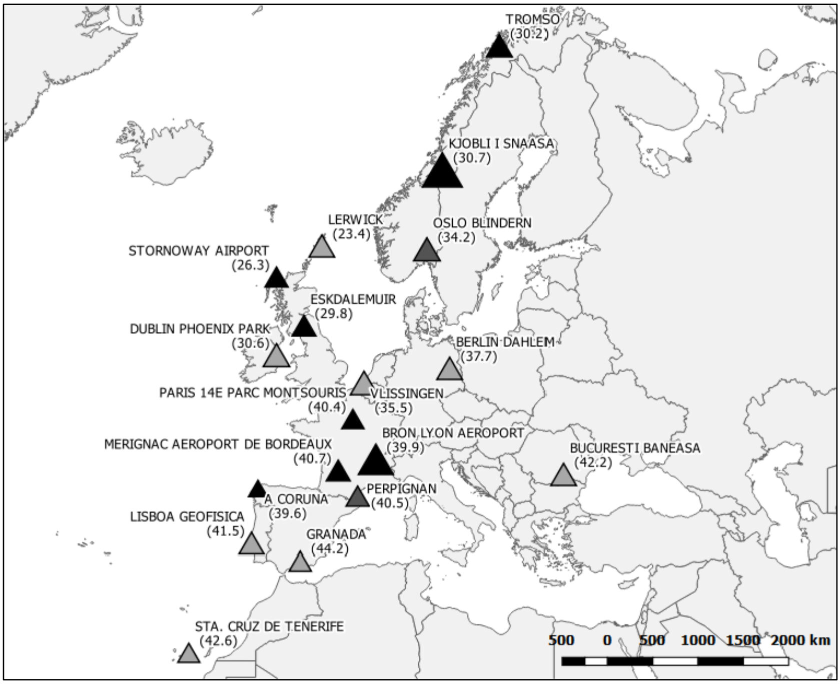

Fig. 3. ***Hazard of annual local maximum temperature (in brackets) based on historical records (bigger symbol – higher hazard; darker symbol – more risky evolution)***

Looking at the evolution of hazard for the last 30 and 15 years against full period (fig. 3) at 44% of analyzed locations we found a continuously increasing hazard value and for an additional 2 locations a short time increase, which means that over 50% of the locations have risky evolution of maximum temperatures hazard.

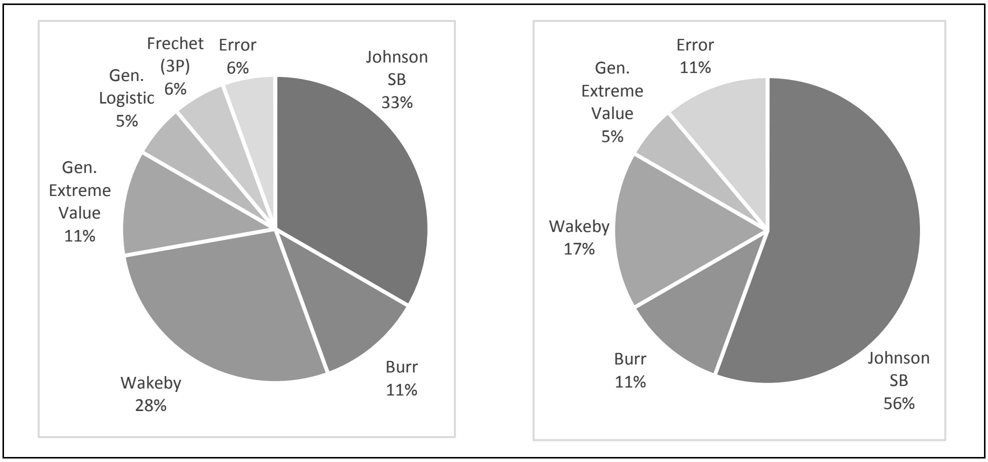

Fig. 4. ***Best fitting distributions share for maximum temperatures for all last 30 year records (left) and for the last 15 year records (right)***

Regarding the suitability of best fitting hazard functions (fig. 4), for all time period no overwhelming function appears, although Wakeby is the most frequent (22%). For the last 30 year period Johnson SB and Wakeby are the most suitable, Johnson SB remains also for the last 15 year, having a 56% percent share.

3.3. Highest daily temperature fluctuations

We can notice the relative high number of stations where the highest daily fluctuations excess 25^0C (Oberstdorf, Ljubljana Bezigrad, Valladolid Villanubla, Zamora and Daroca).

Looking at the evolution of hazard for the last 30 and 15 years against full period (fig. 5) at 35% of analyzed locations we found a continuously increasing hazard value and for an additional 5 locations a short time increase, which means that over 70% of the locations we found a risky evolution of highest daily temperature fluctuation hazard.

Regarding the suitability of best fitting hazard functions, for all time period no overwhelming function appears, although General Extreme Value is the most frequent (21%). For the last 30 year period Wakeby is the most suitable in 35% of cases. For the last 15 year again no overwhelming function appears, although Wakeby and Burr are the most frequent having a 21% share each.

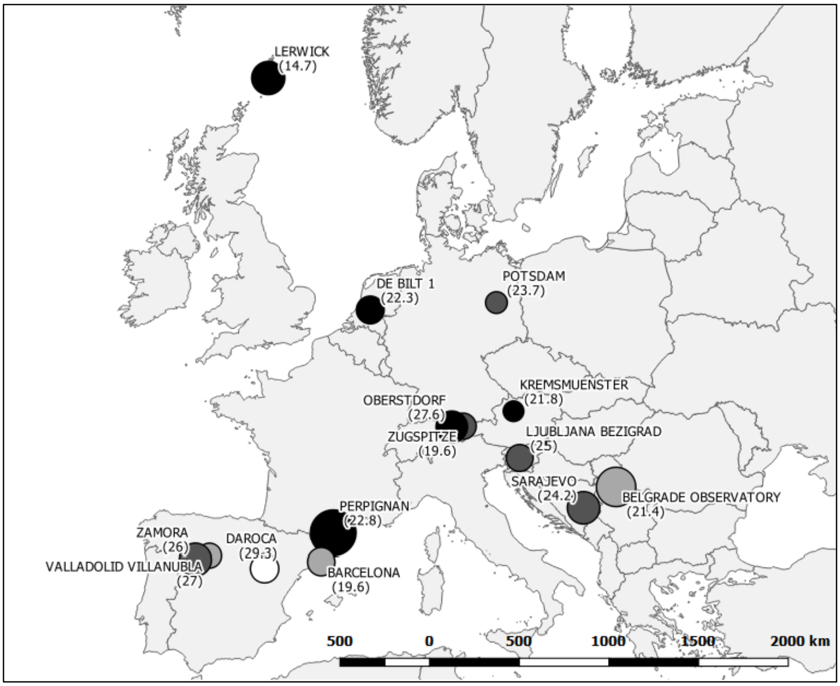

Fig. 5. ***Hazard of highest daily temperature fluctuation (in brackets) based on historical records (bigger symbol – higher hazard; darker symbol – more risky evolution)***

4. CONCLUSIONS

This research tried to make some characterizations of extreme temperatures hazard evolutions based on three measurable values which has historical data: annual minimum and maximum temperatures, and daily maximum temperatures fluctuations at annual scale. We have considered only those locations where the historical data were homogenous, with no trend and independent, so the criteria for frequency analysis were met. We found risky evolutions in case of maximum annual temperatures, when in 55% of locations the associated hazard value was increasing for long or short time period, and in case of highest daily temperature fluctuation, when in 71% of cases the associated hazard value was increasing for long or short time period. As in many cases for the same locations not all three mentioned extreme temperatures could be analyzed, we have calculated the average hazard class value, as shown in figure 6. As its observable high values appears almost everywhere on the continent (fig. 6) maybe with the exception of southern region, which means that we face an increasing hazard regarding the annual maximum and highest daily temperatures fluctuation.

The best fitting distribution function for all types of analyzed extreme values was Johnson SB with a 17% share for all-time records and a 38% share for the last 15 year records. The presence of dominant distribution laws fitting the annual maximum temperatures confirms an existing course in extreme value’s dynamics.

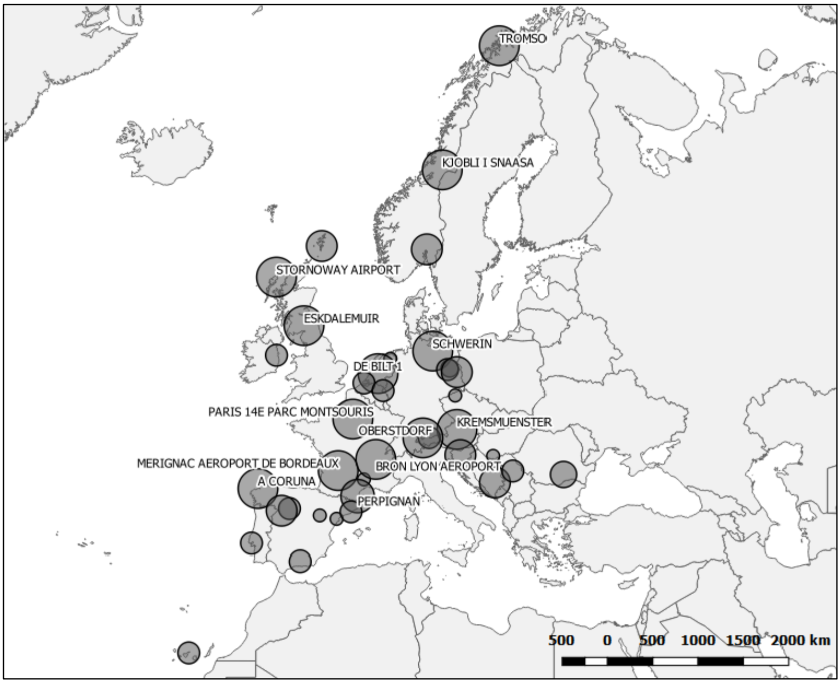

Fig. 6. ***Average value of hazard categories***

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