Global Changes in Heat Wave Duration Index from 1950 until 2100

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Calculation and non-parametric trend estimation of Heat Wave Duration Index using a method based on the exceedence of a fixed percentile (98th) of a standard normal transformation of daily maximum temperature data within the reference period 1961-1990. The standard normal transformation has been defined using Johnson's method of translation (Johnson 1949)

1. Introduction

Future climate change is generally believed to lead to an increase in climate variability and in the frequency and duration of extreme events. The definition of an extreme is not very simple, especially if we want to define an extreme coherently over the entire Globe. A 17-member ensemble simulation of climate change in response to the SRES A1b scenario, carried out using the ECHAM5/MPIOM climate model (Sterl et al. 2008), was used to define and calculate a Heat Wave Duration Index (HWDI). The simulation period is 1950-2100. To study the trend of the HWDI we used a non parametric Kendall-Tau estimator.

2. Index Definition

The HWDI is defined as the maximum period in a year with more than 5 consecutive days above a threshold. The Heat Wave Duration Index (HWDI) defined by Frich et al. [2002] has been found not to be statistically robust as it had a tendency to have too many zero values. This is because Frich et al. used a fixed threshold of 5°C above climatology to compute the index (Alexander et al., 2006).

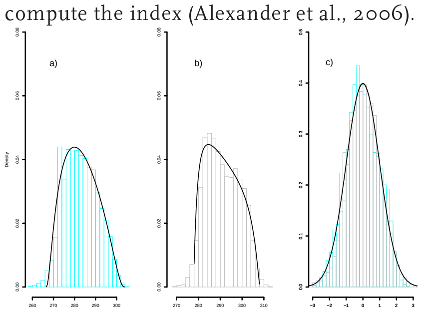

Figure A. *Bounded Johnson's Curves for two different locations: a) Switzerland; b) Southern France; c) Standard normal curve (black line) and histograms of transformed data. (number of events=10950)*

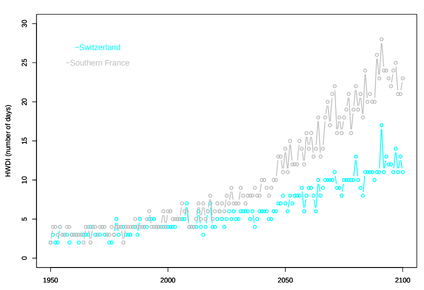

Figure B. *HWDI time series*

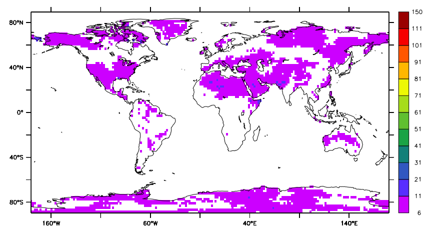

Figure C. *Maximum value of HWDI for period 1990-2000*

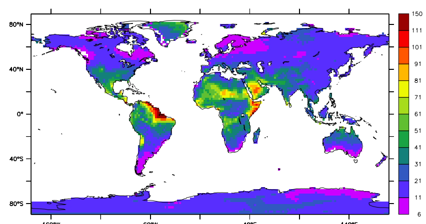

Figure D. *Maximum value of HWDI for period 2090-2100*

To overcome this we studied the distribution of daily maximum temperature data for the reference period 1961-1990 using the translation method of Johnson (1949). It classifies sample distributions according to four families of frequency curves of class C^1. Curves of Johnson, if they exist, give a one-to-one mapping between data and the standard normal curve. By using this mapping the threshold in each grid point is defined as the temperature value corresponding to the 98th standard normal value. Figure A shows histograms and superimposed pdf for two locations in Switzerland and France before (a-b) and after (c) normalization using Johnson's method. In Figure B the time series of HWDI for the studied period are plotted. Figure C and D show the maximum values of HWDI for the periods 1990-2000 and 2090-2100.

3. Mann-Kendall Trend Analysis

The HWDI data do not have a Gaussian distribution, so a simple linear least square estimation would not be correct to detect a trend. To overcome this problem we used the Mann-Kendal non-parametric slope estimator, which does not assume a distribution for the residuals. Looking at figure B, after year 2000 the change in the HWDI data does not seem to be linear, so we decide to separate the data into three different sets of 50 years. In this way we are sure that linear trend estimation was appropriate. Fig.C shows the values of the Mann-Kendall slope for period 2051-2100. The white points represent areas where the trend is not significant at the 5% level.

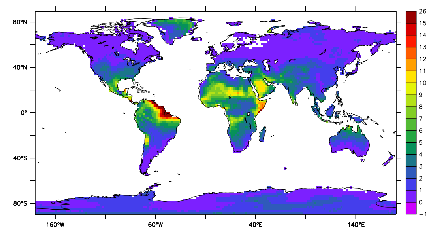

Figure E. *Mann-Kendal decadal trend in number of days for period 2051-2100*

4. Conclusion

The trend of the HWDI is increasing over the entire Globe. The increasing order in the last two studied periods is higher over the tropical area than the extratropical where the trend is costant for the entire period 1951-2100 and around 1-2 days every ten years. It should be related to different variation between maximum and minimum daily temperature (Fig.F).

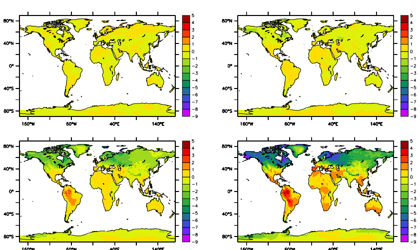

Figure F. *Differences between ten year means of yearly maximum and minimum temperature (17 samples set), color scale units are delta-temperature degrees. The 10-year mean shift has been subtracted prior to calculate the difference. Positive (negative) values represent how much maximum (minimum) are increasing more than minimum (maximum). Upper Left (1960-1970), Upper Right (1990-2000), Lower Left (2040-2050), Lower Right (2090-2100). The different variability of maximum with respect to the minimum are related to the changing in scale and shape parameters of the daily temperature distribution.*

References

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