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Trend of temperatures in Cotonou between 1970 and 2008 in the context of climate change

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ABSTRACT: The West Africa is one of the most vulnerable regions to climate change on our planet. This study specifically in Benin in Cotonou, aims to analyze the evolution of minimum and maximum temperatures recorded and homogenized for 1970 - 2008 obtained from the Agency for Safety and Air Navigation. Statistical techniques such as correlation analysis and statistical tests break detection and trend were used for analysis. The results reveal a polyphase increase, but significant in the average temperature during this period. The year 1986 appears as a date of rupture between two trends. Before 1986, the average temperature has dropped to 0.20 ° C per decade and increased in the same way between 1986 and 2008. The increase in average temperatures in Cotonou since 1987 is largely conditioned by the increase in maximum temperatures.

KEYWORDS: Global warming, temperature, trends, rupture, Cotonou.

1 INTRODUCTION

Global surface temperature has increased by about 0.3 to 0.6°C since the late-19th century, and by about 0.2 to 0.3 °C over the last 40 years [1]. The warming has not been uniform globally and some areas have cooled. The need to understand climate change has never been so urgent and important that in the 21st century, especially in tropical areas where deforestation and species extinction are relatively more important and living conditions more precarious [2]. These phenomena are even more pronounced in Africa where human pressure and especially deforestation, are very important. The importance of temporal variability in Africa is that the climatic parameters, expected vary over time due to global seasonal cycle of the planet, also exhibit different trends by region [3]. This study falls within the framework of efforts to understand climate variability West - African, marked by a significant rise in temperature during the last decades. To better characterize the evolution of temperatures in this period in Cotonou, the moment of trend reversal, which is called rupture date is determined. Here we have used in order to determine the rupture date in annual average temperature series in Cotonou between 1970 and 2008, statistical tests of Mann-Kendall and Pettitt.

2 DATA AND METHODS

Tests out of date detection statistics are made from the deviation from the mean average annual temperatures between 1970 and 2008 at the meteorological station of Cotonou (alt. 005m, lat. 06 ° 21Nord, long.: 02 ° 26 East). Annual averages are obtained by the average minimum and maximum daily temperatures. Potential rupture dates can be natural (climate change) or an origin related to the change (technical and / or geographical) measurement conditions and the local environment.

To ensure the quality of results, three statistical tests were applied to detect a rupture date: Student's test, the test of Pettit and Man-Kendall test (detailed in annex), mainly due of their power and strength demonstrated [4]. The calculations were performed with the Matlab software (Matrix Laboratory).

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3 RESULTS AND DISCUSSION

Comparing the evolution of minimum and maximum temperatures is an interesting element in the study of long runs [6],[9]. We note that the evolution of temperatures in Cotonou polyphase over the study period.

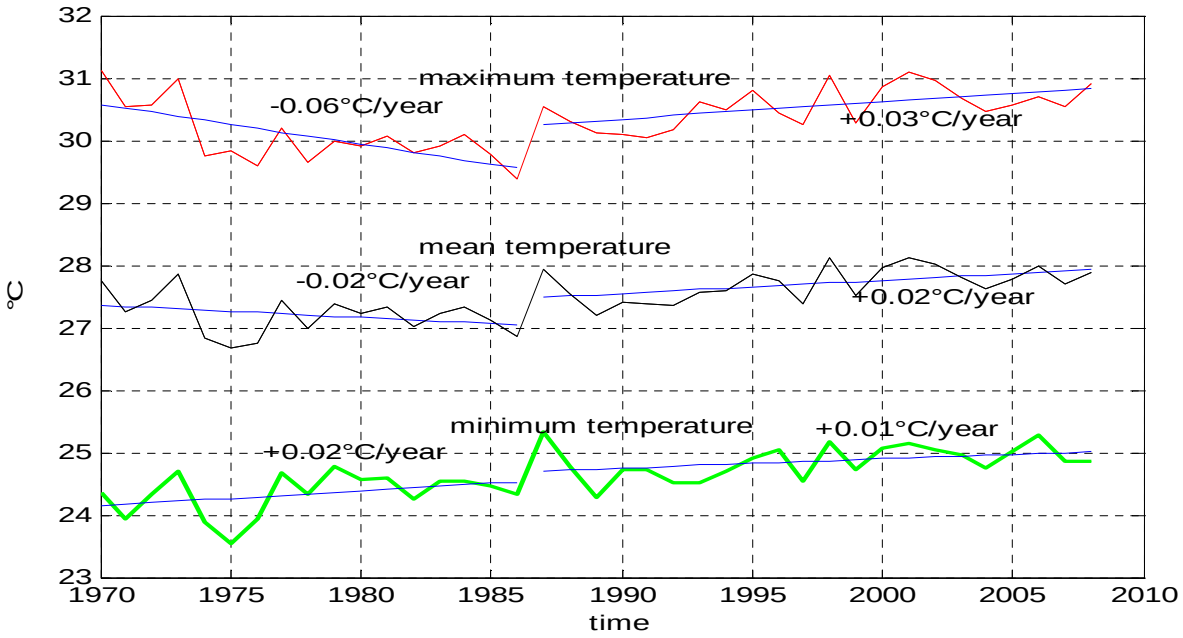

Fig. 1. Evolution of maximum and minimum temperatures in Cotonou

Minimum temperatures rose steadily between 1970 and 2008, first strongly until 1986 (+ 0.02°C per year), then slightly until 2008 (+ 0.01°C per year). As to the maximum, they have however declined quite sharply from 1970 to 1986 (-0.06°C per year) before resuming growth of 0.03°C per year thereafter (fig.1). Mann-Kendall trend detection test (see details in appendix) confirms the distribution of temperatures for the period.

Between 1970 and 1986, mean temperatures in Cotonou exhibit a downward trend. The cooling is estimated from the linear regression equation at -0.02°C per year. The 1987-2008 period was marked by a sharp upward trend in temperatures, estimated at + 0.02°C per year namely + 0.20°C per decade.

Most regions of the world experienced two periods the opposite trends: a post-war period characterized by a cooling followed by warming period (excluding Australia and some parts of South America) [5].

Estimates of temperature changes also seem quite similar. We note at United States, a decline in the temperature of -0.12°C per decade between 1940 and 1969 and an increase of + 0.19°C per decade between 1970 and 1997 [6]. In the Pyrenees-Atlantique (Pau station) in France, there was a decrease of 0.07°C per decade between 1946 and 1980 and an increase of + 0.35°C per decade between 1981 and 2000. At scale of the northern hemisphere, it is estimated a decrease of -0,040°C per decade between 1939 and 1976, followed by a rise of 0.25°C per decade between 1977 and 2000 [7]. These figures are logically approaching our own results. Temperature changes therefore seem to agree. The main point of disagreement in the literature concerning the precise date of rupture. In North America, the rupture seems premature: 1965 Alaska and eastern North America. In East Africa, the date is also estimated to 1965 [5]. Northern Europe knows this break in the early 1980s [8].

The evolution of the annual average temperature in Cotonou is represented as deviation from the average of the period 1970-2008 (fig.2).

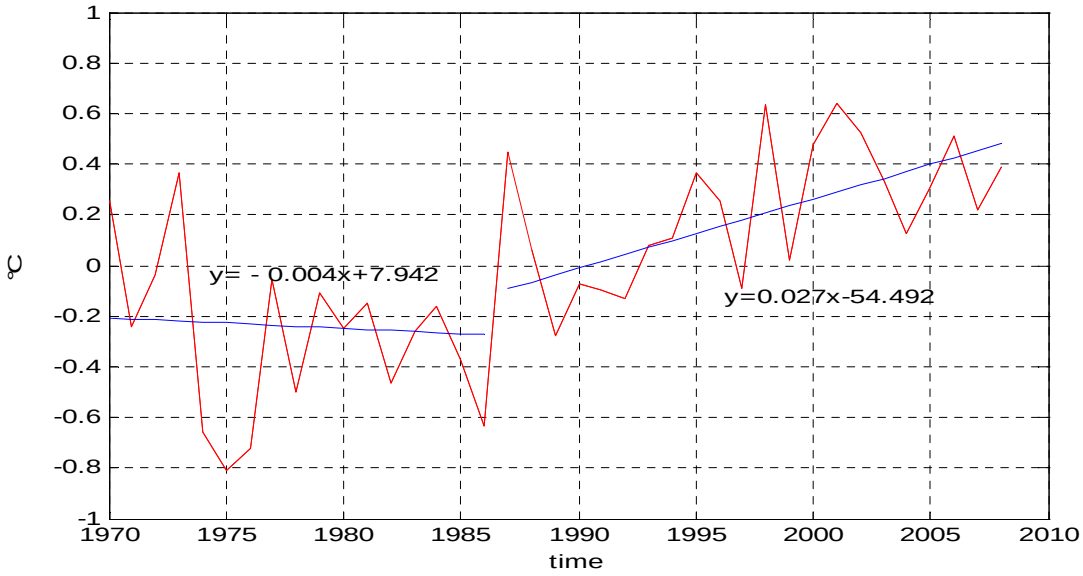

Fig. 2. Change in average annual temperatures and their linear trends in Cotonou between 1970 and 2008

We find the same characteristics as the global changing: warming average temperatures is very clear. Until the mid-1980s, the gap is mostly negative: the annual average temperature is usually lower than the average of the study period. From the late 1980s, annual average temperatures are increasing rapidly and the gap is consistently positive. The tests prove it. The years 1998 and 2001, with a gap of about 0.63°C compared to the average from 1970 to 2008 are the hottest of the series.

Pettitt test admits (fig. 3) a rupture at 1986 with 99% confidence level. Its parabolic shape clarifies which is confirmed by the Mann-Kendall: the series is increasing along its length, stable for a given period, for our case, from 1970 to 1986 and increase in the second period (1987 -2008). The curve in the direct sense of the Mann-Kendall test (solid line in Fig.4) shows more or less stable part from 1970 to 1986 and an unstable part between 1986 and 2008. This is positive not stable part reflecting an increase trend of the series. This confirms that the series is almost stable between 1970 and 1986 and then increased for the period 1987-2008.

The consistency of these results makes it possible to divide the series of average temperatures in Cotonou in two sub-series: 1970-1986 and 1987-2008. Application of Student test to these two newly defined series confirms that they have significantly different average at 95% threshold. A rupture therefore has been statistically determined to characterize the two phases of temperature changes.

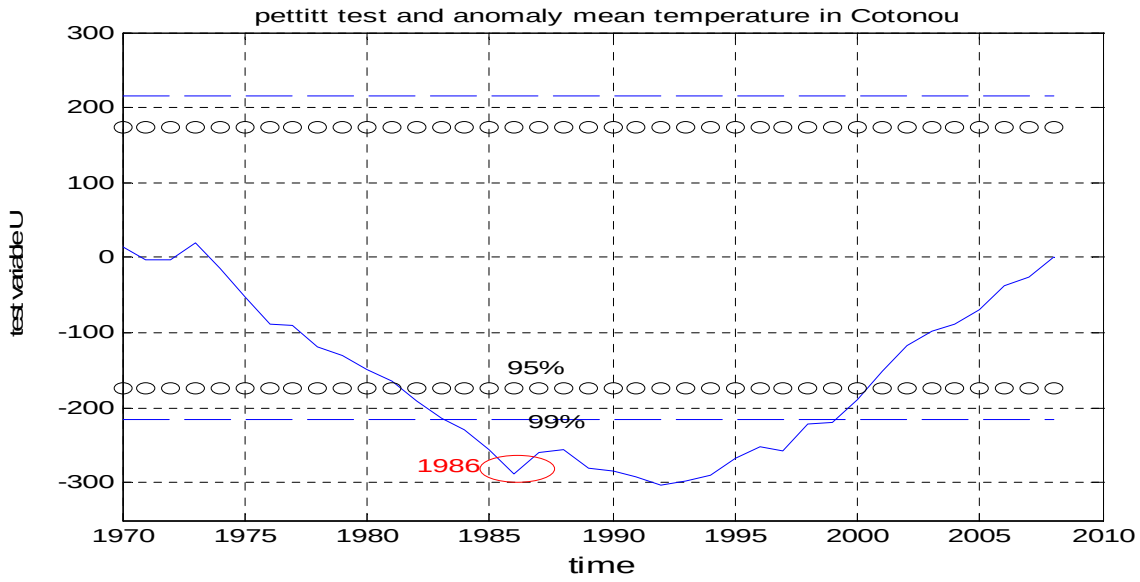

Fig. 3. Curve Pettitt to determine the date of termination

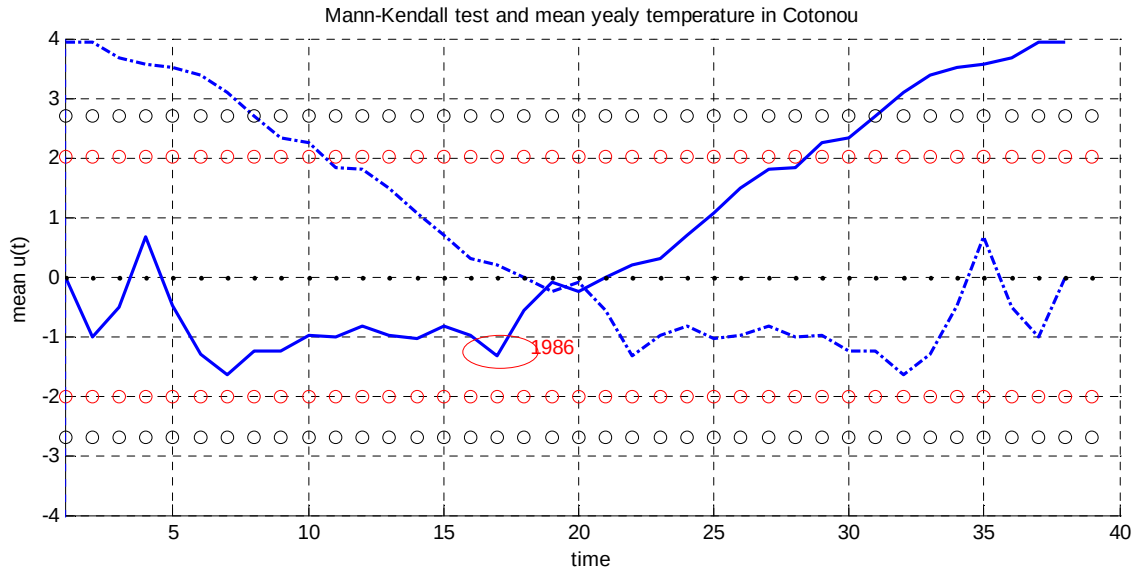

Fig. 4. The Kendall curves to determine trends

The difference between minimum and maximum temperatures is also studied (figure5).

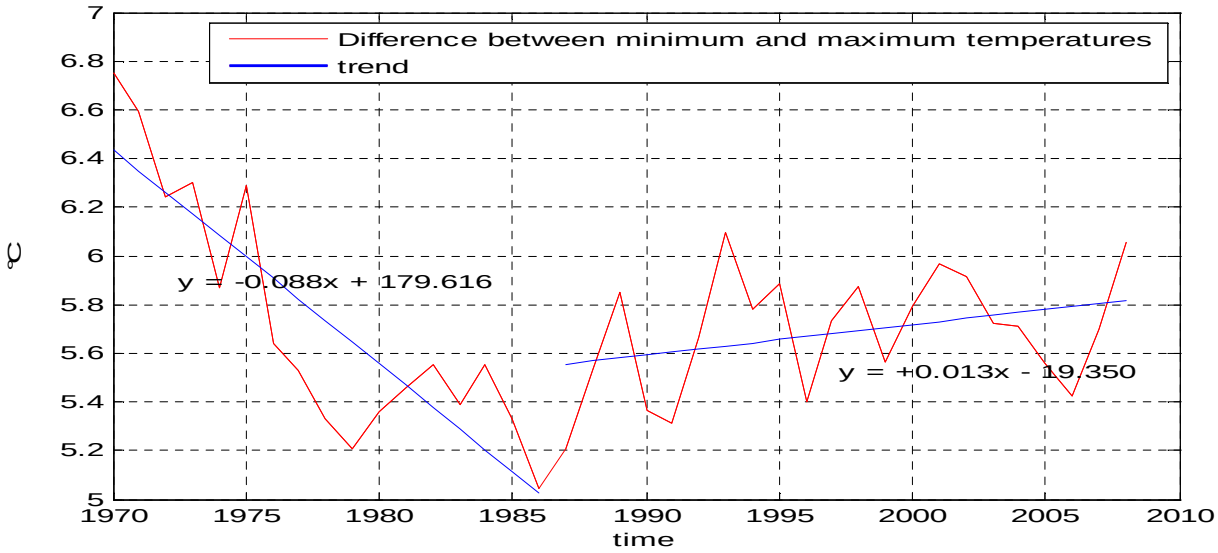

Fig. 5. Evolution of differences between minimum and maximum temperatures in Cotonou: from 1970 to 2008.

We keep firstly that the gap between the minimum temperatures and maximum constantly decreased until 1986 (-0.088°C per year) while it increased steadily from + 0.013°C per year over the rest of the period, and secondly that the strong warming that we know since the late 1980s is largely conditioned by the increase in maximum temperatures (fig.5).

4 CONCLUSION

The analysis of temperature trends in Cotonou, shows consistent results through statistical tests break detection and trend used. Two opposite trends in Cotonou a period of moderate cooling between 1970 and 1986 (down 0.20°C per decade), followed by a sharp increase between 1987 and 2008 (an increase of 0.20°C per decade). These results support the observations in other parts of the world. We also showed that during this period, maximum temperatures have risen steadily since 1987, while the minimum temperatures have increased steadily since the beginning of the study period (+ 0.015 ° C per year). The strong warming that we know since the late 1980s is exclusively linked to higher maximum temperatures. The year 1987 proved to be the date of trend rupture in Cotonou in Benin.

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