

EXTREME RAINFALL AND CLIMATIC CHANGE STUDIED AT REDEYEF REGION IN SOUTHERN TUNISIA

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ABSTRACT

In September 2009, Redeyef region was submitted to extremely stormy downpour weather (90 mm in 24 hours) and caused a flood of great importance. Therefore, in the present study, we tried to investigate “PMP”, fixing the upper limit of likely maximum rain in order to settle the general trend of the rainfall evolution in this region during the observation period. The PMP is generally used to evaluate runoff and consequently the probable maximum flow (PMF). It is useful for sizing hydraulic structures on rivers (spillway, etc.). The PMP is the highest precipitation in a given period. In this context, using the maximum rainfall observed (24 hours) at Redeyef station over a long period of 88 years, we have evaluated the probable maximum rainfall. Adjusted at empirical frequency, the lognormal law (three parameters) is satisfactory. Over the period of observation; the maximum registered rainfall in 24 hours is 90 mm. It will have a return period of 154 years. This value is widely greater than maximum rain average. In 24 hours interval time, the PMP is estimated; using the frequency factor K_m , as shown by Hershfield (1961). The PMP will be approximately 250 mm/24hours. PMP estimations are useful even if they remain dependent of observed data quantitatively and qualitatively. Furthermore, we noticed that the rainfall variability is very important. The most extreme and violent rainfall is more frequent at the end of observation period than the beginning. After 1960, there was an increase in frequency and intensity of occurrence of extreme rainfalls. It seems that the general trend of extreme rainfall is upward. Considering annual scale, we noticed a decrease in rainfall and a number of rainy days. The average behaviour of annual rainfall series over observation period, suggests that there was a climatic change upward. The application of the tests of segmentation of rainfall data shows that 1989 is exceptional ($P_{jmax} = 90$ mm). The series has two segments and averages are significantly different but not stationary.

1 INTRODUCTION

Tunisia has known a very variable and irregular precipitation cycle. It's possible to observe a very intense precipitation of strong intensity and short duration, able of reaching more than 100 mm in twenty four hours.

In September 2009 in the region of Redeyef in the South of Tunisia, we observed a heavy rain provoking an important rise in the water level (flood) and having caused human and materiel damages. The most intense rainy episodes or extreme rainfalls occur generally in autumn. Indeed, in the southern Mediterranean basin, the contrast, in

term of temperature level, is important. Stormy rains are due to a hot and humid air. These stormy rains is worthy studied in order to know further frequencies and intensities.

2 OBJECTIVES

The objective of our study is:

- To know the frequencies of rare quintiles, extreme rains, and to quantify the risks of flooding.
- To make an analysis of the evolution and the detection of tendencies in the series of maximal daily precipitations at Redeyef region in southern of Tunisia.

3 STUDY ZONE

The zone concerned by this study is Redeyef located in the South of Tunisia (Figure 1). The altitude is about 586 m. The climate is a Sahara type characterized by a soft winter and a hot summer. Redeyef is an arid region.

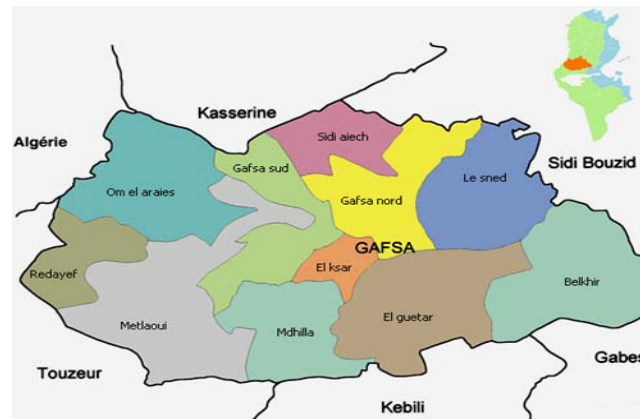


Figure 1: Redeyef region concerned by this study (left; grey colour)

4 DATA

We have a great rainy precipitation series, from 1911 to 2009, collected by hydrologic services and published by the General Direction of Water Resources (DGRE). Following the task of counting observations, we determined the set of the maximal daily rains and the number of rainy days superior to a doorstep (0 mm, 0.5 mm, and 10 mm).

The choice of 20mm doorstep corresponds to normal rains and not extreme events in other regions but is important rains in the case of our study zone. The missing data in the observed series is less than 1 %. They are replaced by those observed at Metlaoui rain gauge (see Figure 2). Observation started from 1914-1915, 1977 to 1980 and 1994.

The climatic changes have been verified by the application of Pettit tests (1978) and Huber segmentation (1989). These last tests permit to detect tendencies of the studied series, as indicated by Lubes (1994) .

5 METHODOLOGIES

In a first time, an exploratory analysis of the series of data at a daily scale (P_{jmax}) and yearly (P_{an}) is carried out. It's about determining the parameters of tendency power station (average, median and mode) and of dispersion (variance, standard deviation) and extended as well as Variance coefficient (C_v), Skewness coefficient (C_s) and Kurtosis coefficient (C_a) . Therefore, on the series of maximal daily rainfalls, we adjusted on the empirical frequencies no overrun, the probability that will determined frequencies of rare quintiles and the intervals of confidences (Bergaoui, 2010). In addition, we applied the tests of weather change and rupture of constancy, stationarity of precipitation series.

6 EXPLORATORY ANALYSIS OF THE DATA

Adjustment of empirical frequencies no overrun of the law “Log-Normal” to three parameters, permitted to determine the quintile of rare frequencies. Indeed, the rain of 90 to a probability no overrun of 99 ,4 % that corresponds to one return period in 154 years. The statistical parameters are carried in the table 1.

Table I: Statistical parameters of maximal daily rainfalls.

Parameters	
Size	96
Minimum (mm)	8.10
Maximum (mm)	90.00
Average (mm)	30.16
Standard error	1.58
Median	25.05
Standard déviation (mm)	15.50
Variation coefficient (C_v)	0.51
Skewness coefficient(C_s)	1.61

The descriptive features of the data are summarized below in table 2.

Table 2: Features of data: rainfalls and durations

	NBJ1(>0mm)	NBJ2(>=0.5mm)	NBJ3(>=10mm)	$P_{jmax}(mm)$	$P_{an}(mm)$
Mean	20.44	19.05	4.41	30.16	136.65
Max.	45	45	15	90	434
Min.	2	2	0	8.1	20
Standard deviations	8.05	7.60	2.71	15.50	70.93
C_v	0.39	0.40	0.62	0.51	0.52

We notice that the variability of the precipitation is very important, the coefficient of variation (C_v) is about 0.5 .This deviation of annual rainfall is very important. During

observation period, we notice that the number of daily maximum rainfall more than 50 mm does not exceed 9% (see table 3).

Table 3: Values of occurrences

Threshold	>50 mm	>=30 and <50	>=20 and < 30	>=10 and < 20
Occurrence	9	33	32	22
Fr %	9.38	34.38	33.33	22.92

The occurrence of rainfall, in threshold, is defined as a number of the rainfall observed in this station is upper or equal to the threshold. According to the table 3, it clears at self that more than 50 % of the maximal daily rainfall doesn't pass 30 mm in 24 hours. The graphic #2 of the evolution of maximal daily rainfalls evolution (Figure 2) shows that the most violent extreme rainfall events are more frequent at the end of the period of observation than to the beginning.

Indeed, before the sixties, the daily rainfall was over 50 mm for only one time; that was in Redeyef in 1920 (52 mm/24 h.). After the sixties, we observe an increase in the frequency of extreme rainfalls as well as in their intensities.

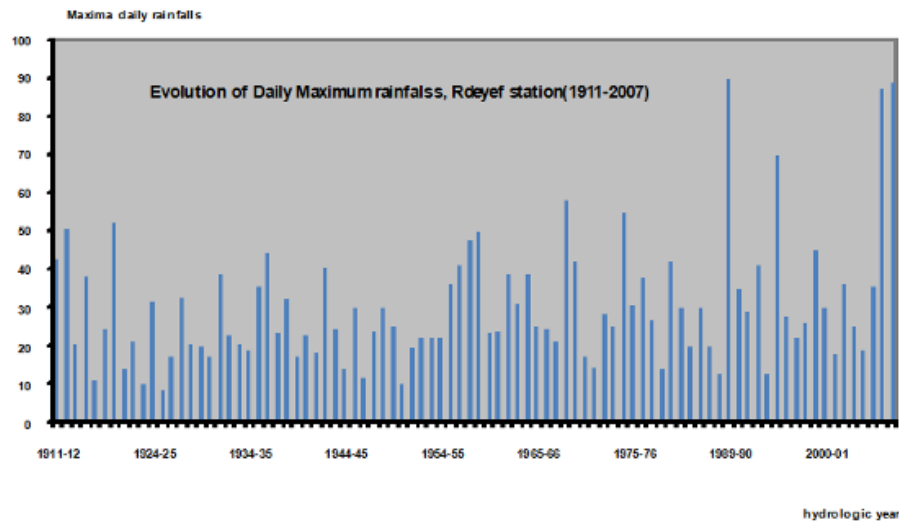


Figure 2 : Daily maxima rainfall evolution in Redeyef region (1911 – 2008)

It seems that the general trend of rainfall extremes is upward. However, the number of rainy days per year is not changed. The number of extreme events is increased toward the end of the observation period. The same report has been verified on the yearly rainfall (figure 3). Before the Sixties, the yearly rainfall is rarely over the value of 200 mm. On the other hand, it was often superior to this threshold after the hydrologic year

(1959-1960). The middle behaviour of the series during the observation period seems to indicate that there was a change, toward the rise, in the yearly rainfalls series.

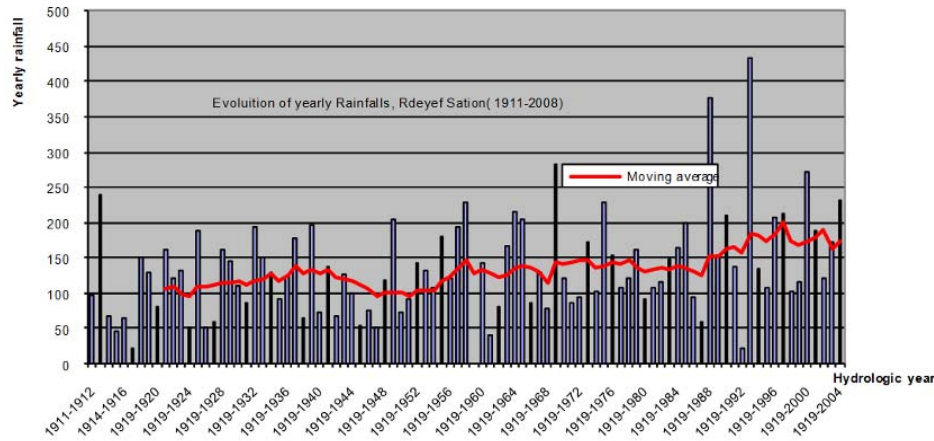


Figure 3: Evolution of yearly rainfalls; Redeyef station.

7 SEGMENTATION TESTS

Assignment applied the test here high cities, we noted that the test of Pettit (1978) is rejected. The hypothesis represents the absence of rupture in series. The test is based on an analysis of two coins samples. The statistics is founded on the sum of the ranks of sample coins. Indeed, to the threshold confidence of 90 % and 95 %, the rupture of series is signalled. The critical value seems to appear in 1954. The overtaking probability of the critical value in 1954 is equal to 0.015. Thus, for a threshold α equal to 5 % and 10 %, the probability is lower than the values of α . The research of multiple changes of average can also be achieved by the procedure of series segmentation presented by Hubert (1989). The principle of this method is developed by Sen (1975). The application of this test on our series shows that 1989 year is exceptional. The maximum daily rainfall is equal to 90 mm. Series show two segments of averages meaningfully different. The first segment, from 1912 to 1989, is of 28.36 mm average and a standard deviation of 12,7 mm. The second segment, from 1990 to 2008, is of 3.51 mm average and of 19.4mm Standard Deviation. Thus, we can conclude that observed series is not stationary.

8 PROBABLE MAXIMUM PRECIPITATION "PMP"

The statistic method of Hirschfield (1961;1965) is applied in order to determine the probable maximum precipitation "PMP" for a period of twenty four hours. This PMP is given by:

$$PMP = Pm.max + Km * \sigma \quad (1)$$

Where Pm.max is the maximal daily rainfall average and Km is a frequencies factor.

For our series, an application of this method gives a value of PMP equal to 247,6 mm / 24 hours. This value represents nearly once and half of the "decamillennale" value.

However, this result depends on a lot of coefficient Km value. This will be able to

be the subject of regional study.

9 CONCLUSIONS

This study, focused on analysis and statistical treatments of rainfalls data at various scales, revealed that there is a rupture of sequence in observation series. Indeed, it seems that the general behaviour of rainfall series observed at Redeyef station has changed. The trend is toward the appearance of intense showers. On a yearly scale, we noticed a decrease in annual rainfalls and a number of daily rain. The maximal daily precipitation noticed during the whole observation period is equal to 90 mm. This corresponds to 154 years observations. This same rainfall is lower than the PMP that will be able to be the order of 250 mm / 24 hours. The value of PMP must be verified on other data and prudently considered. A regional study of the coefficient K_m will be helpful to take a decision about PMP values.

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