SPATIAL AND TEMPORAL ASSESSMENT OF DROUGHT IN NORTHERN ALGERIA

A.N GHENIM (1) and A. MEGNOUNIF (2)

(1)(2) Water Resources Research Group, laboratory "Eau et Ouvrage dans Leur Environnement"
Tlemcen University, BP 230 Tlemcen, 13000 Algeria
anghenim@yahoo.fr Megnounif_aslam@yahoo.fr

ABSTRACT

Like other North Africa countries with semi-arid climate, water resources in Algeria are dependent to a large extent on rainfall. This very irregular and unevenly distributed in space, has been in the last century a succession of surplus and deficit rainfall episodes. In this work, based on monthly data from 5 rainfall stations located in the north of Algeria, we will examine using the SPI (Standardized Precipitation Index) the occurrence of dry spells that characterized the region during the last century. The results show that the drought is amplified beyond the middle of the 1970s. Light droughts occupied most of the period study for the majority of rainfall stations.

Keywords: Rainfall, Standardized Precipitation Index (SPI), Drought, North of Algeria.

1 INTRODUCTION

Meteorological drought can be defined as an anormal behavior but recurrent of climate mainly due to the decrease of rainfall in an area during a given period (Xingcai et al., 2009). Many drought indexes have been proposed to assess and monitor the occurrence of dry sequence (Morid et al., 2006). Most of them are either limited to specific regions or require many hydro-climatical parameters witch are not always available (Heim, 2002 ; Akhtari et al., 2009). The Standardized Precipitation Index (SPI) is often used because it has many advantages. It requires only rainfall data and can be expressed at different time scales allowing assessments of drought in short, medium and long term (McKee et al., 1995).

The northern Algeria like the entire North African region has experienced over the last centurie a succession of wet and dry periods, the most important dry sequence lasted nearly four decades (Laborde, 1993 ; Meddi et Meddi, 2009 ; Ghenim and al., 2010 ; Ghenim and al., 2013). The lack of rainfall results in an important decline of surface water resources and groundwater (Ghenim and al., 2010 ; Khaldi, 2005).

To highlight the dry rainfall sequences and assess their temporal and spatial evolution during the last century, we use monthly rainfall data from five rainfall stations situated in the north of Algeria during the period between 1914-15 and 2008-09.

2 STUDY AREA AND DATA

Rainfall stations in Algeria are of 2 types: old and new. The latter have started to operate since the 1970s, and offer as well as short series. The old stations are over a century but most were established during the colonial and/or post-colonial era and have incomplete data. The only stations that offer a complete historical information are located in urban areas. Unfortunately, they are few. For the purpose of this study, five rainfall stations (Figure1, Table 1) located in north of Algeria and divided between the east and west of the country are selected. They offer information for 95 hydrological years between 1914-15 and 2008-09.

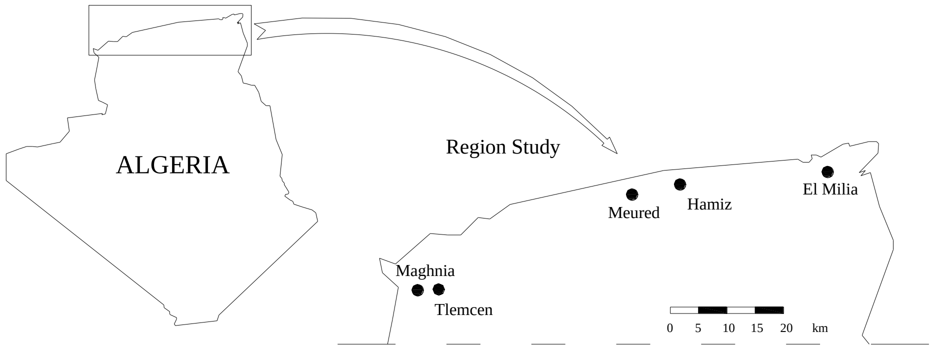

Figure 1. Location of rainfall stations in north of Algeria

Table 1. Characteristics of rainfall stations

N°	Stations	Elevation (m)	Coordinates		Statistics of annual rainfall series (1914-15 to 2008-09)				
			Latitude	Longitud	Mean (mm)	Max (mm)	Min (mm)	C.V	Cs
1	El Milia	100	36°45'21"	6°16'38"	957	1514	501	0.25	0.36
2	Hamiz	130	36°36'21"	3°21'16"	779	1390	341	0.26	0.67
3	Meured	300	36°26'58"	2°24'27"	676	1197	373	0.26	0.55
4	Tlemcen	810	34°52'26"	-1°19'29"	593	1004	311	0.26	0.28
5	Maghnia	395	34°51'12"	-1°43'54"	378	729	125	0.36	0.65

3 METHODOLOGY

Dispersion and shape of the distribution of rainfall contributions to the five stations are analyzed by the coefficients of variation Cv, and skewness Cs (Nel and Sumner, 2006 ; Mohapatra and Mohanty, 2007). These two parameters commonly used in climatology, are used to characterize the interannual variability of rainfall in each of the study sites.

The reduced centered index *Si* of a time series is defined as the ratio of the difference in the interannual to average standard deviation of annual rainfall amounts. Is given by the equation :

$$S_i = \frac{P_i - \overline{P}}{\sigma} \tag{1}$$

i is the rank of the series, $\overline{P}$ and σ are the mean and interannual standard deviation

The index *Si* allows both to observe the temporal variability and detect periods of deficit if *Si* <0 or excess if *Si* > 0, but also to compare the series with each other.

The SPI (Standard Precipitation Index) was applied to investigate the spatial patterns and temporal variations of the dryness/wetness based on the 3, 6, 12 and 24 month-series for the 5 rainfall stations. A brief description of the computation of the SPI is given below.

The standard precipitation index (SPI) was developed for the purpose of defining and monitoring droughts (McKee and al., 1993) and has been widely used to reveal meteorological droughts. The SPI witch the details are listed in Table 2, can track droughts on multiple time-scales and is flexible with respect to the period chosen.

$$\mathrm{SPI} = S\frac{t-(C_2t+C_1)t+C_0}{((d_3t+d_2)t+d_1)t+1.0} \qquad t = \sqrt{\ln\frac{1}{H(x)^2}} \tag{2}$$

$$G(x) = \frac{1}{\beta Ͳ(y)_0 \int_0^x x^{\gamma-1} e^{-x/\beta} dx, x>0} \qquad Ͳ(\gamma) = \int_0^x x^{\gamma-1} dx \tag{3}$$

where x represents the values of precipitation, β and γ, scale and form parameters of Ͳ function, c_0, c_1, c_2 and d_1, d_2, d_3 are calculation parameters, whose values c_0 = 2.515517, c_1 = 0.802853, c_2 = 0.010328, d_1=1.432788, d_2 = 0.189269, d_3 = 0.001308, G (x) denotes the probability distribution of rainfall. Where G (x)> 0.5, H (x) = 1 - G (x), S = 1. For G (x) ≤ 0.5, H (x) = G (x), S = -1.

Table 2. Classes of drought according to SPI index

(wet classes are not displayed).

SPI values	Drought intensity
-0,99 à 0	Mild drought
-1,49 à -1,00	Moderate drought
-1,99 – -1,50	Severe drought
≤-2,0	Extreme drought

4 RESULTS AND DISCUSSION

The rainfall amounts of the five stations undergoes the combined effect of altitude and latitude. Precipitation decreases from east to west. The five rainfall stations although that far from each other have nearly identical temporal variability except Maghnia station where the variability is very high (Cv = 0.36) (Table 1). The strongly positive Cs values confirm inhomogeneous distribution with a pronounced asymmetry left. This certifies that the years of low rainfall dominate with the occurrence of very surplus years. This finding is particularly strong for stations of Hamiz, Meured and Maghnia. For other stations, the variability is relatively less important.

During the last century, rainfall in Algeria have been alternating wet and dry phases, the most important loss phase lasts for more than four decades (Laborde, 1993). The latter is highly visible at the five stations (Figure 2). It started from the beginning and the end of 1970's by region and station positions. For most stations, the driest years of the century were recorded during this period. The succession of dry years varies from 6 to El Milia and Hamiz, 8 at Meured, 9 at Tlemcen and up to 27 at Maghnia. The driest year was recorded at Hamiz in 1996-97.

Table 3. Extremes values of SPI at different time scales

Stations	**SPI-3**		**SPI-6**		**SPI-12**		**SPI-24**	
	Value	Date	Value	Date	Value	Date	Value	Date
El Milia	-4.70	11.1925	-3.83	12.1925	-2.73	05.2001	-2.61	04.1975
Hamiz	-3.55	03.2000	-3.28	03.1997	-3.32	02.2002	-2.90	12.2001
Meured	-3.81	04.1944	-4.10	07.1944	-3.22	11.1982	-2.83	03.2000
Tlemcen	-5.12	03.2000	-4.17	01.1993	-4.23	12.1984	-2.99	12.1985
Maghnia	-3.60	03.1999	-3.15	06.1999	-2.74	10.1920	-2.25	02.2007

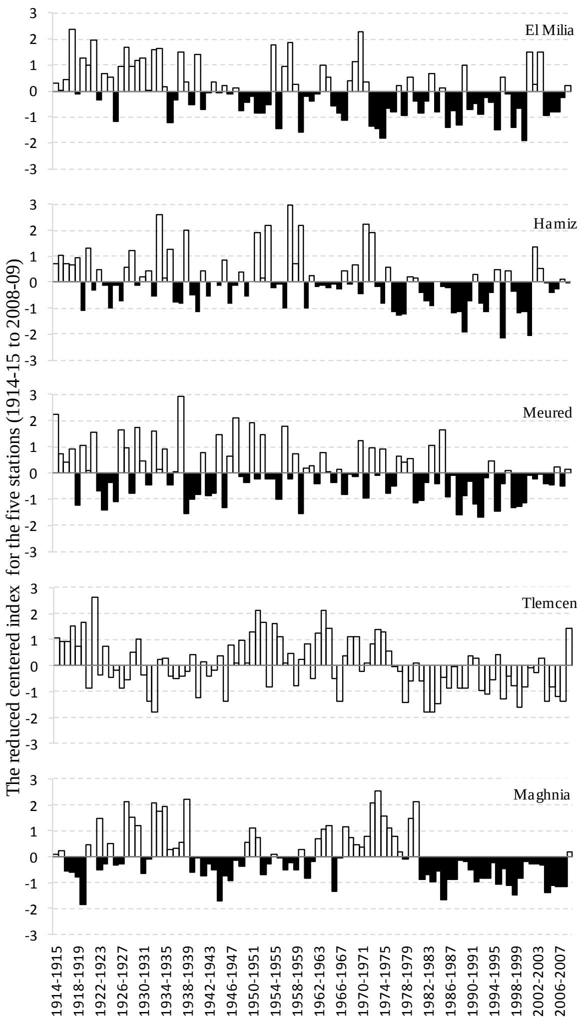

Figure 2. The reduced centered index for the five stations (1914-15 to 2008-09)

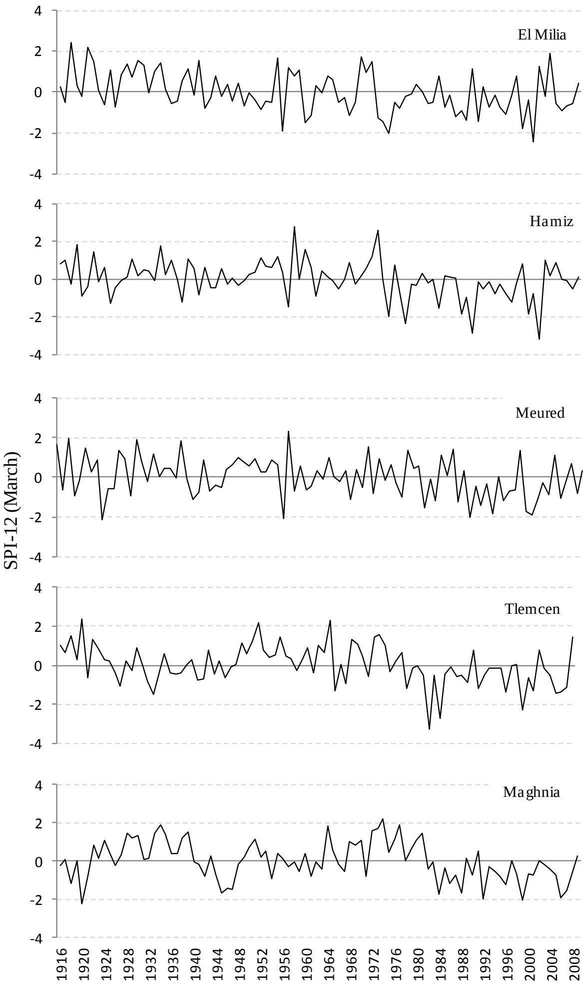

Figure 3. Values of SPI-12 for march

In Algeria, more than 75% of the rainfall occurs during the wet season (winter and spring). Reducing the past four decades has affected mainly the wet season (Ghenim, 2008). Examining the evolution of SPI-12 for March (Figure 3) shows that for more than three decades, this month has been a very significant decline in rainfall contributions over the total duration of the study.

During the 95 years of study, the behavior of the five stations towards the drought is almost identical. The time percentages where droughts have plagued (SPI <0) from the short-term to long-term average about 49.3%, 50.4%, 52.5% and 51.8%. Succession of dry months varies from 1 month minimum to 52 months maximum. However, droughts have been mild in majority (Figure 4). Extreme values are not many except that the values of SPI up to -5.12 were recorded (Table 3).

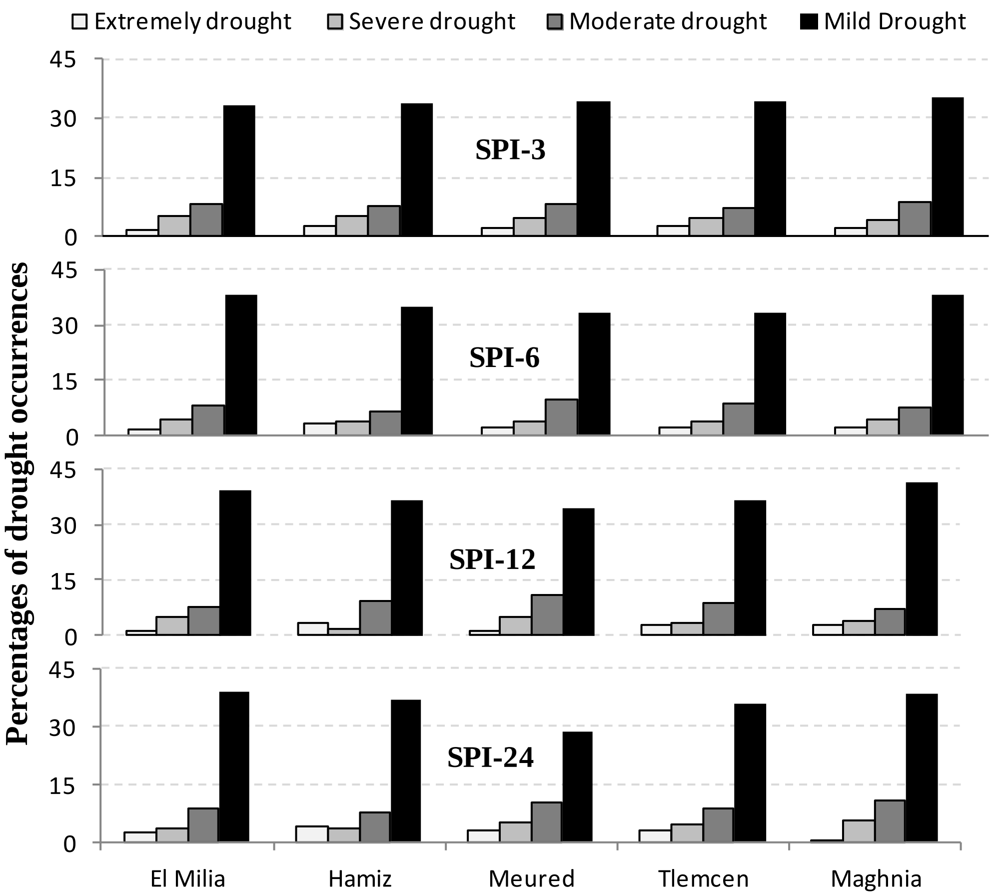

Figure 4. Percentages of drought occurrence at different time scales

5 CONCLUSION

Many studies looking at the interannual variability of rainfall in North Africa have shown that this variability is characterized by a significant decline in precipitation (Meddi and al, 2010 ; Ghenim et al., 2013) Most of these studies, however, have shown that the drought varies widely in time and in space by regions. So Sebbar et al. (2011) estimate the rainfall deficit in Morocco between 8 and 28%. In western Algeria, the decline attributed to Mactaa basin at Ghriss oscillates between 27 and 36% (Meddi et al., 2009) while it is around 20% in the Central Mitija Algeria (Meddi and Meddi, 2009). In central Tunisia, Kingumbi et al. (2001) estimates the deficit between 10 and 35%.

This drought started at the beginning of the 1970s seems to be mild to the values of SPI mostly between 0 and -1. The occurrence of other drought intensities although at low frequencies, can be very detrimental to water resources, agriculture and the environment.

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