

Longest dry spells phenomenon in Northern Tunisia: risk assessments using daily rainfall observations

Majid Mathlouthi & Fethi Lebdi – LRSTE at INAT, University of Carthage, Tunisia



INTRODUCTION

Drought is among the costliest natural disasters due to its long duration and lasting effects on agriculture and other sectors, and its low predictability among all extreme weather and climate events (Wilhite 2000; Mishra and Singh 2010). Although natural variability is often the primary cause for individual drought events. For future drought increases, increases in atmospheric demand for moisture associated with rising temperatures (Scheff and Frierson 2014) are the primary cause, with decreasing precipitation enhancing the drying over subtropical land areas (Zhao and Dai 2015). For historical drought increases since the 1970s (Dai 2013), decreasing precipitation is the primary cause over most areas, although increased atmospheric demand associated with rising temperatures since the 1980s is also a significant contributor (Dai and Tianbao 2017).

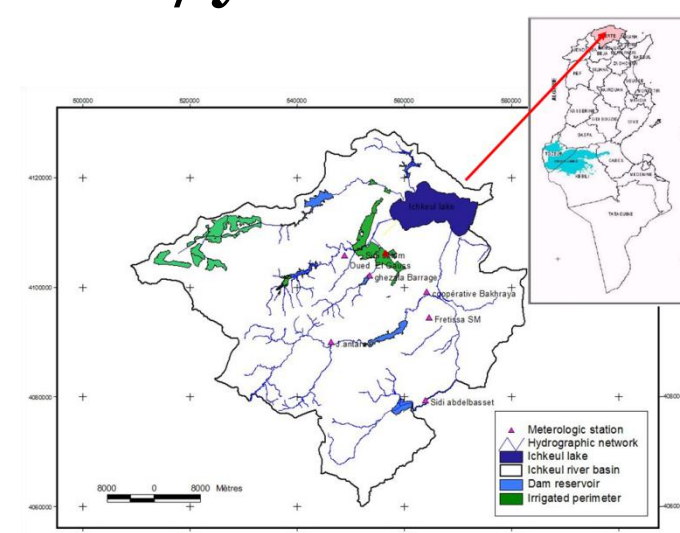
A dry spell is generally defined as a period of multiple consecutive days with no measurable rainfall. The dry spell is preceded and followed by days with measurable rainfall. Drought is perceived as a two-dimensional phenomenon (intensity and duration) which is integrated on a spatial basis (regional drought). The two basic dimensions (intensity and duration) require that bivariate frequency analysis is required for linking return periods to both dimensions levels. This approach should be considered as an intermediate step towards a more comprehensive approach, which is related to anticipate damages of specific sectors. The wet-dry spell model is used as an alternative to the Markov chain process. That is, to simulate wet and dry spells separately by fitting their durations to an appropriate probability distribution such as the negative binomial or geometric distribution (Mathlouthi 2009), or empirical distribution (Rajagopalan and Lall 1999). The characteristics of multi-day wet and dry spells is often important for investigating likely scenarios for agricultural water requirements, reservoir operation, analyses of antecedent moisture conditions (Mathlouthi and Lebdi 2008; 2009), and runoff generation in a watershed.

OBJECTIVES

The purpose of this study is to analyse dry spells depending on the threshold amount of rainfall. The analysis of spatial variations of extreme dry spell and estimate the potential risk of the region, and the historical occurrence of droughts and its probability of recurrence. This information is extremely useful for planning and design applications in agriculture and environment and many other sectors.

DATA

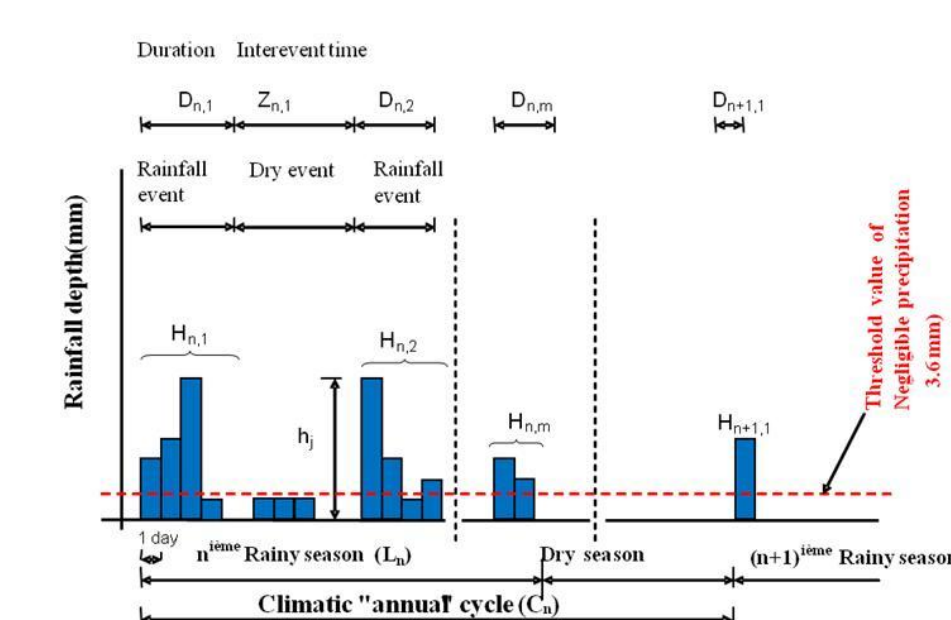
Daily rainfall data collected at rain gauges in Ichkeul Lake basin, Northern Tunisia were used for this study. Regional average of seasonal precipitation is 600 mm, varies from 450 to 700 mm. The average air temperature is 18 °C and evapotranspiration rate is 1330 mm /year.



The Ichkeul Lake Basin (Tunisia); Dam, irrigated perimeter and rain gauges.

METHOD

A rainfall event is associated with a rainfall threshold value which defines wet. As this limit 3.6 mm d⁻¹ (expected daily evapotranspiration rate) has been selected. The process of rainfall occurrences is specified by the probability laws of the length of the wet periods, and the length of the dry periods (time between storms).



Definition for the event based analysis.

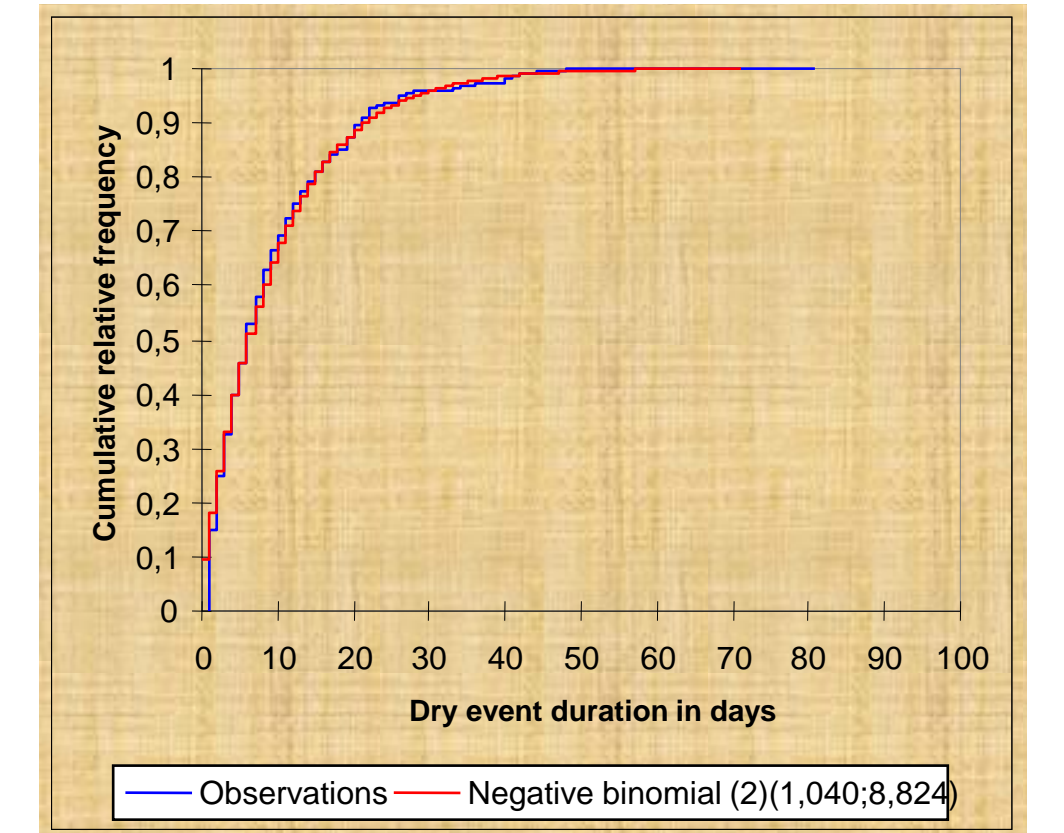
The rainfall event m in a given rainy season n will be characterized by its duration $D_{n,m}$, the temporal position within the rainy season, the dry event $Z_{n,m}$ and by the cumulative rainfall amounts of $H_{n,m}$ of $D_{n,m}$ rainy days in mm:

$$H_{n,m} = \sum_{j=1}^{D_{n,m}} h_j$$

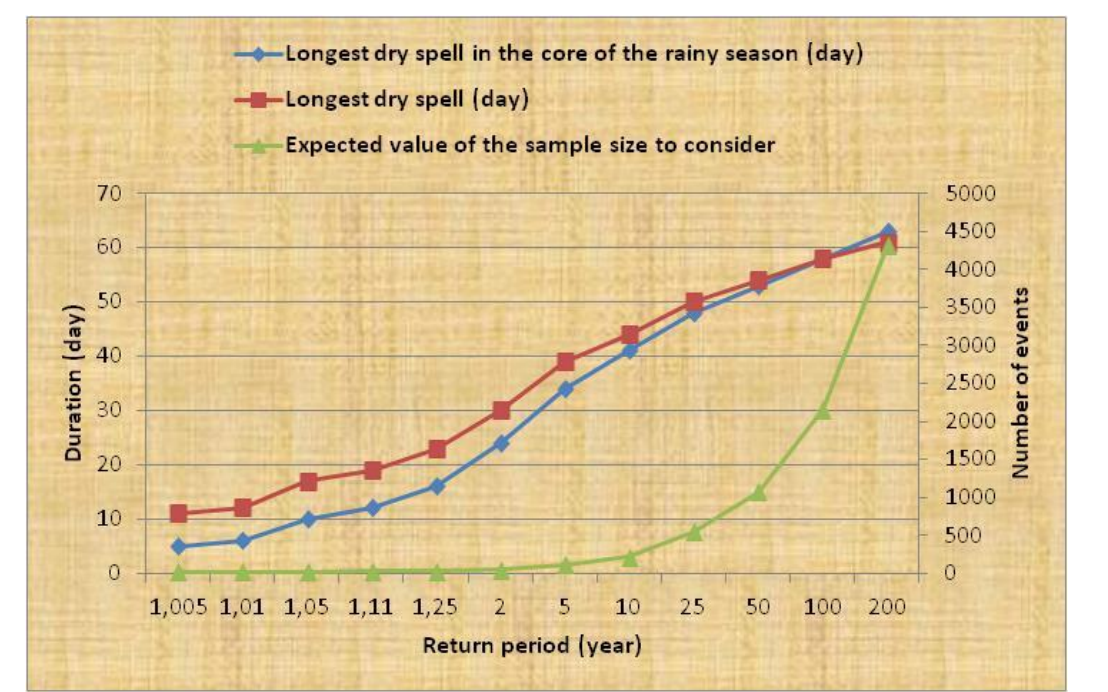
Where h_i is positive and represent the daily precipitation totals in mm. Note that for at least one $h_i > 3.6$ mm.

MAIN RESULTS

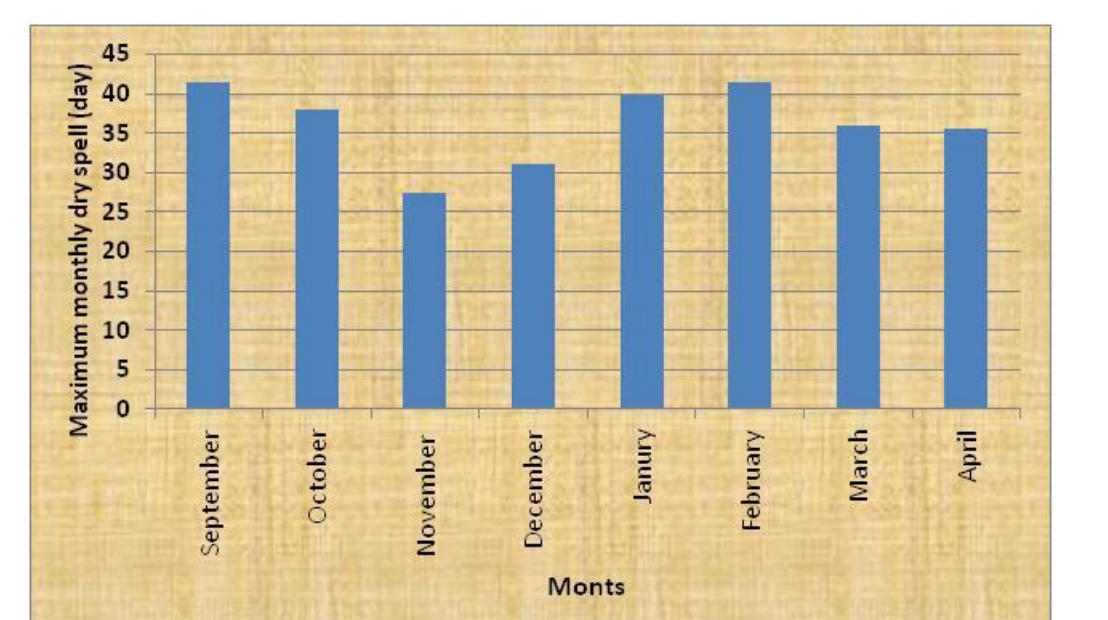
- ❖ Dry periods up to 40 or even days may be recorded, even though the probability of such extreme length occurring in the middle rainy season is small.
- ❖ The mean length fluctuates between 7.4 and 9.5 days, and the high standard deviation (10) are both serious warnings about the unreliability of assuming an evenly distributed precipitation during the rainy season.
- ❖ No significant pairwise correlation between $Z_{n,m}$ and the duration $D_{n,m}$ and $H_{n,m}$ could be detected. Thus, the assumption that rainfall events in a rainy season are elements of an independent random process seems to be justified.
- ❖ A rainy seasons characterized by a favorable rainfall distribution can hide the statistical fact that on 26 dry events it is likely to occur at least one of more than 23 days.
- ❖ 1987-1989 and 1993-1995 were characterized by two successive years of severe drought. It follows a significant shortage in available water resources and regression and decreased production. Livestock disease have been observed, due to the change and imbalance nutrition plan.
- ❖ Water inflows in dams was less than 50% of capacity. 13% of their capacity (93-94) and 0% in 87-88 (Ghezla Dam).
- ❖ The change in rain deficit is 33 to 56% , in the years 1993-1995,



Distribution of dry event duration.



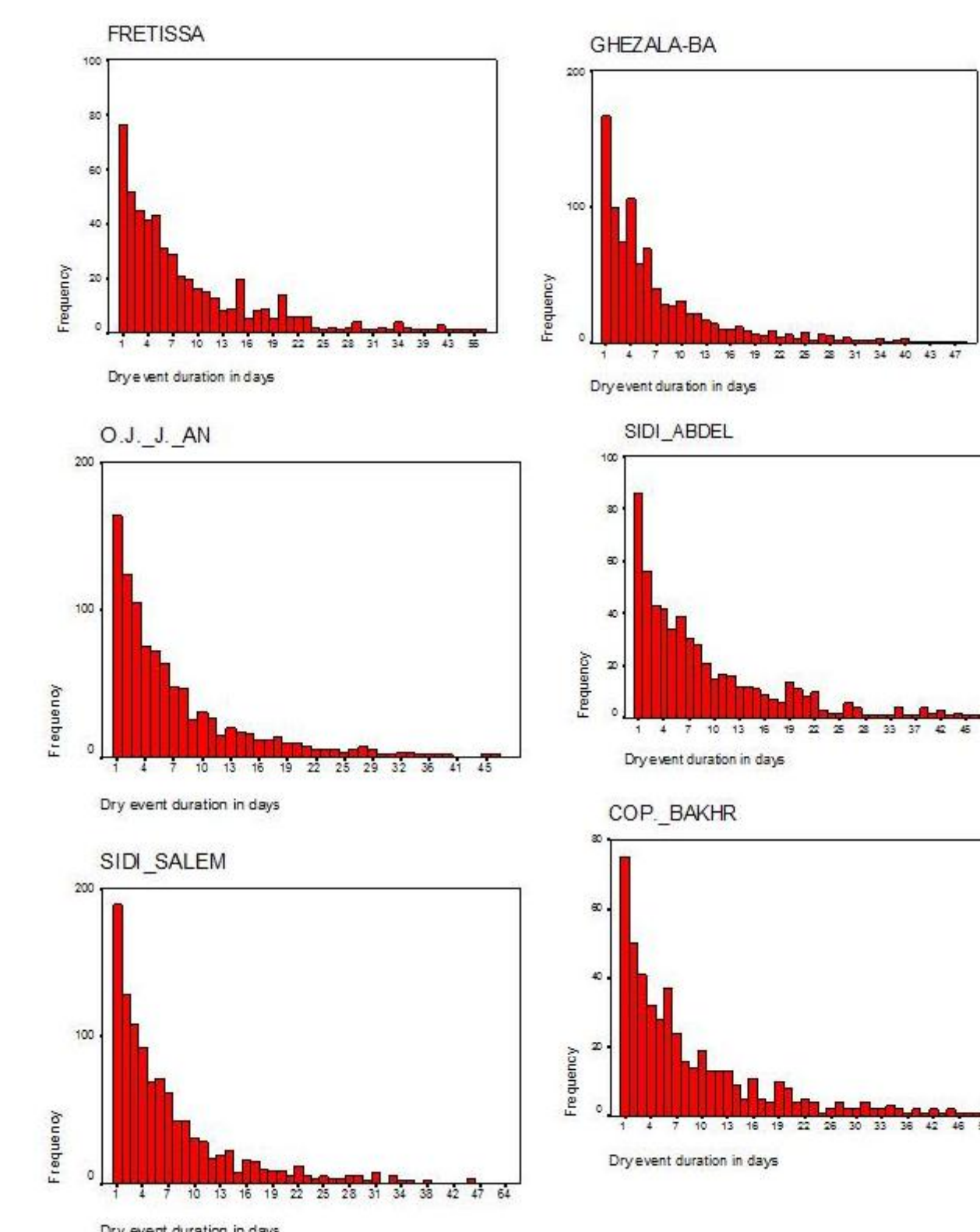
Estimate of extreme dry event durations.



Length of maximum monthly dry spell within the rainy season

CONCLUSIONS

- ❖ This case study, using rainfall records of the Ichkeul lake basin, illustrates the independency between the durations of wet and dry events.
- ❖ In this region dry spells can well be described by the negative binomial pdf.
- ❖ It has to be pointed out that the event-based definition of the rainy season does not exactly fit the theoretical condition. Rainy seasons have variable lengths, as they are a stochastic function of the events themselves.
- ❖ For planning goal, the longest dry spells associated with various return periods are derived on the basis of the fitted GEV distributions.
- ❖ The most important application of the analysis is the generation of synthetic rainfall event time series who can be used to define and calibrate simulation models for realistic reservoir planning or for estimating irrigation water demand.



Frequency of dry event duration in Ichkeul Lake Basin