Meteorological drought characterization for adaption and mitigation of global impacts in Northern Tunisia

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).

Drought is perceived as a two-dimensional phenomenon (intensity and duration) which is integrated on a spatial basis (regional drought). 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 binominal or geometric distribution (Mathlouthi 2009), or empirical distribution (Rajagopalan and Lall 1999). The characteristics of spells is often important for investigating likely scenarios for agricultural water requirements, reservoir operation, analyses of antecedent moisture conditions (Mathlouthi & Lebdi 2009). The objective is to analyse dry spells according the threshold amount of rainfall, spatial variations of extreme dry spell and estimate the potential risk of the region. This is extremely useful for planning and design applications in agriculture , environment and many other sectors.

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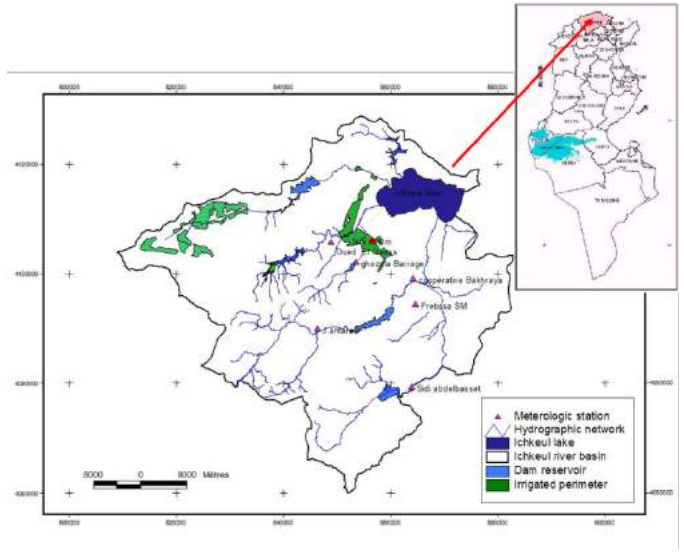
Daily rainfall data collected at rain gauges in Ichkeul Lake basin, Northern Tunisia were used for this study. Regional average of seasonal precipitation is 600 mm, varies from 450 to 700 mm. The average air temperature is 18 °C and evapotranspiration rate is 1330 mm year^{-1}.

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.

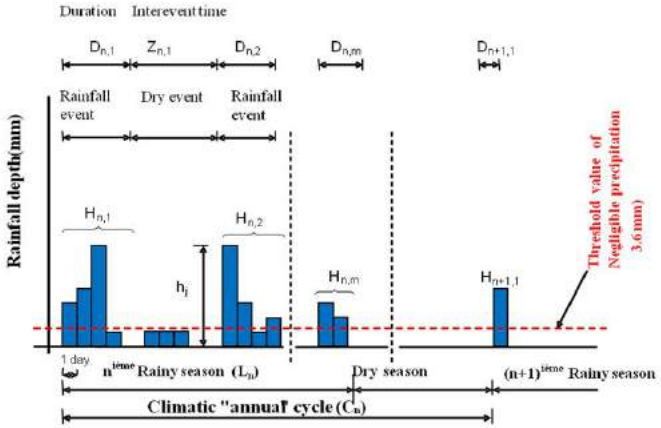
The rainfall event *m* in a given rainy season *n* will be characterized by its duration $D_{n,m}$, the temporal position



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.



Definition for the event based analysis.

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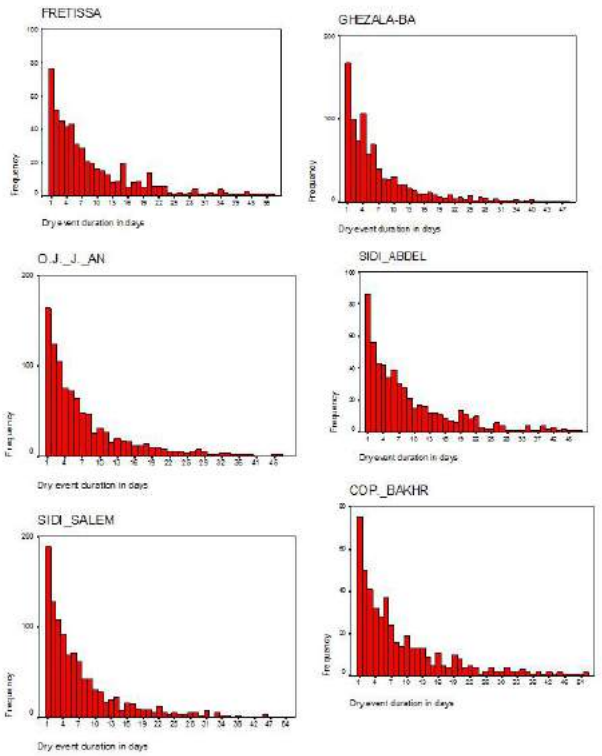
- Dry periods up to 40 or even days may be recorded. The probability of occurring in the middle rainy season is small.
- Serious warnings about the unreliability of assuming an evenly distributed precipitation during the rainy season.
- No significant pairwise correlation between $Z_{n,m}$ and the duration $D_{n,m}$ 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.

- On 26 dry events it is likely to occur at least one of more than 23 days.
- Two successive years of severe drought (1987-1989 and 1993-1995). It follows a significant shortage in available water resources and regression and decreased production.
- Water inflows in dams was less than 50% of capacity. 13% of their capacity (93-94) and 0% in 87-88 (Ghézla Dam).
- The change in rain deficit is 33 to 56% (1993-1995).

Frequency of dry event duration in Ichkeul Lake Basin



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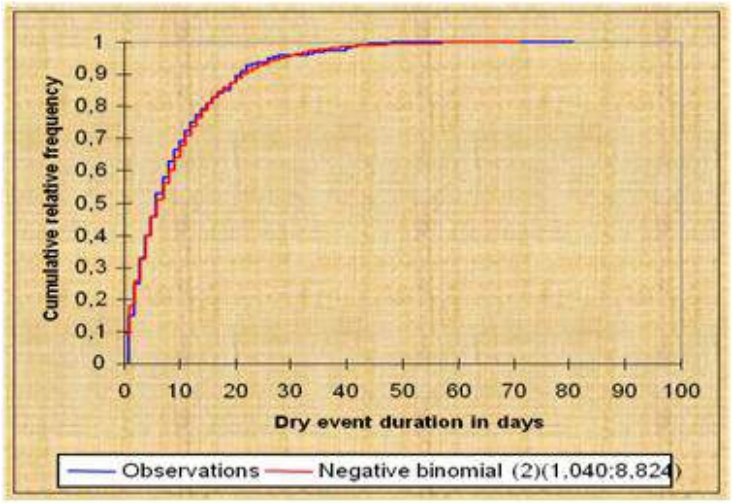
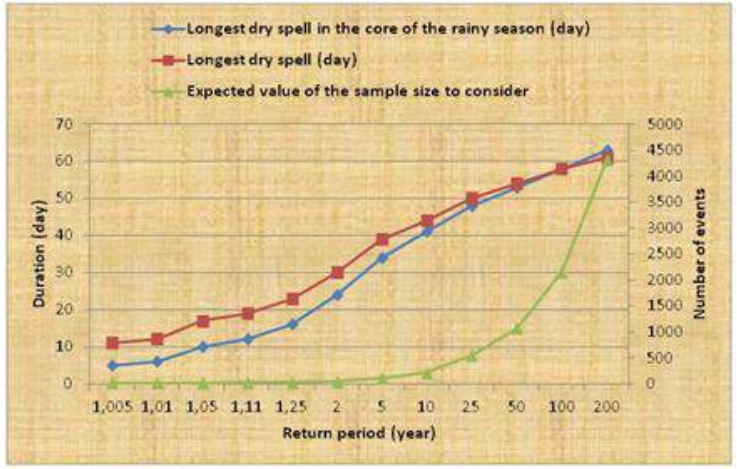
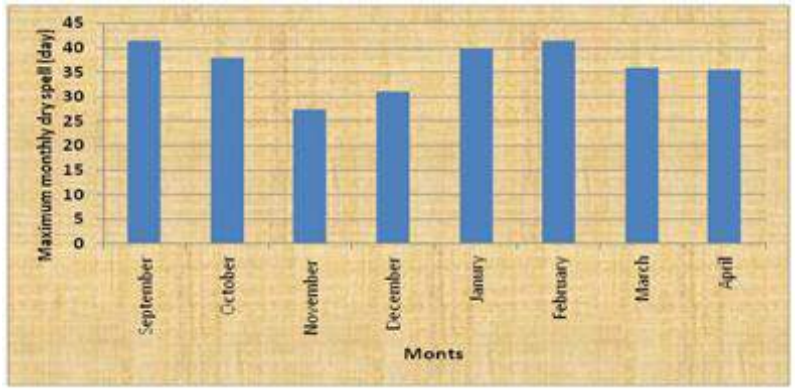
Distribution of dry event duration.



Estimate of extreme dry event durations.



Length of maximum monthly dry spell within the rainy season



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- This case study, using rainfall records of Ichkeul lake basin, Northern Tunisia, 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.
- This procedure for analyzing dry spells allows, among other things, the study of the effects of climate change.