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Drought assessment and projection under climate change in northern Tunisia

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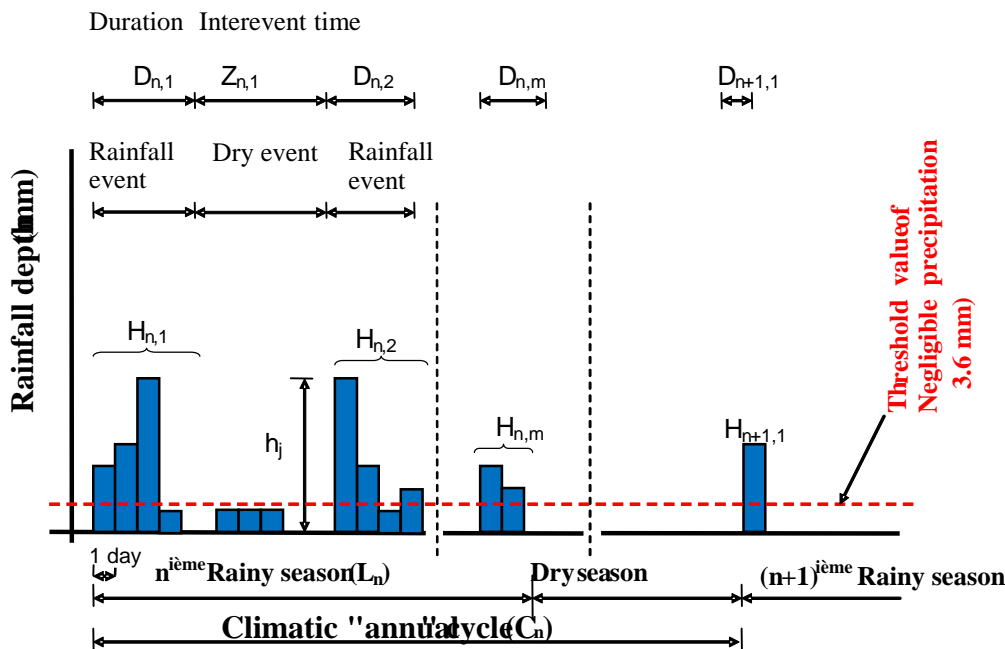
INTRODUCTION

- The study of droughts is one of the focuses of climatology because **droughts** are **recurring phenomenon** with some of the most significant global impacts.
- In most places of the world, **dryness occurs** in **spells**.

- A **dry spell** is generally defined as a period of multiple **consecutive days** with **no measurable rainfall**.
- A **dry spell** is **preceded** and **followed** by **days** with **measurable rainfall**.
- The **goal** of this study is to **assess** the **dry spells** by considering **daily data** from **rain gauges** in Ichkeul lake basin (Tunisia).

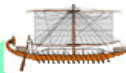
- **Dry spells** have adverse consequences on the **rivers flow**. They govern the inter-annual behavior of decision-makers in **water resource management**.
- The **event based concept** of analysis is favored over **continuous** type data generation methods.
- Synthetic rainfall data have been used, for example, to determine **irrigation water** demand, to estimate extreme floods, study **climate change**, ...

METHODS

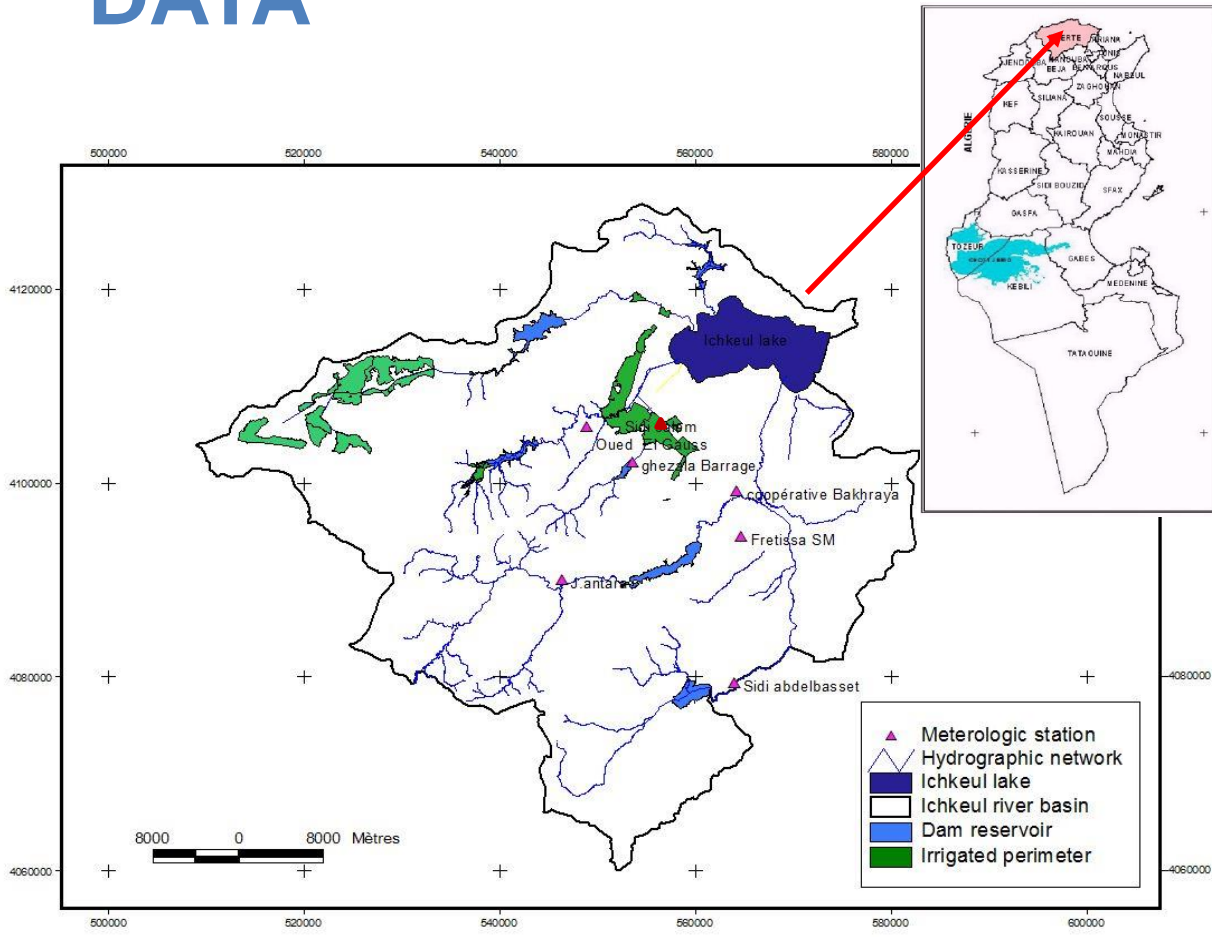


Definitions for the event based analysis

- A rainfall event may be defined as an **uninterrupted sequence** of **rainy days**.
- Rainfall below a **threshold** will only be considered on days which are elements of a **given event**, where in at least **one day** fulfills the condition of having **received rainfall** of more than **3.6 mm**.
- A **dry event** is a **sequence** of **dry days**.
- The length of the **rainy season** is defined as the timespan between the **start of the first** and the **end of the last event** of the given season.



DATA



- ❖ Ichkeul Lake basin, in northern Tunisia.
- ❖ The climate is characterized by one rainy season from September until April.
- ❖ The average seasonal precipitation is about 600 mm. Rainy seasons are separated by almost 4 month dry season.
- ❖ Daily rainfall data collected for stations in the basin were used for this study.

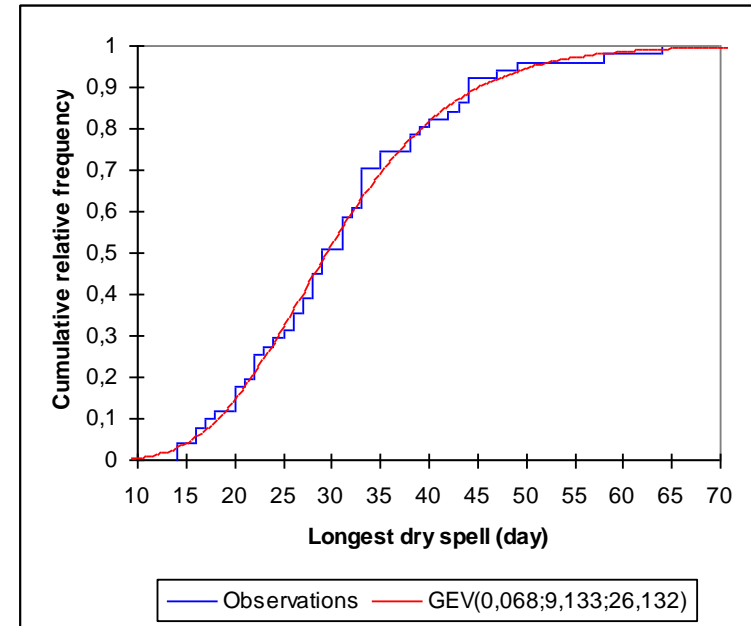
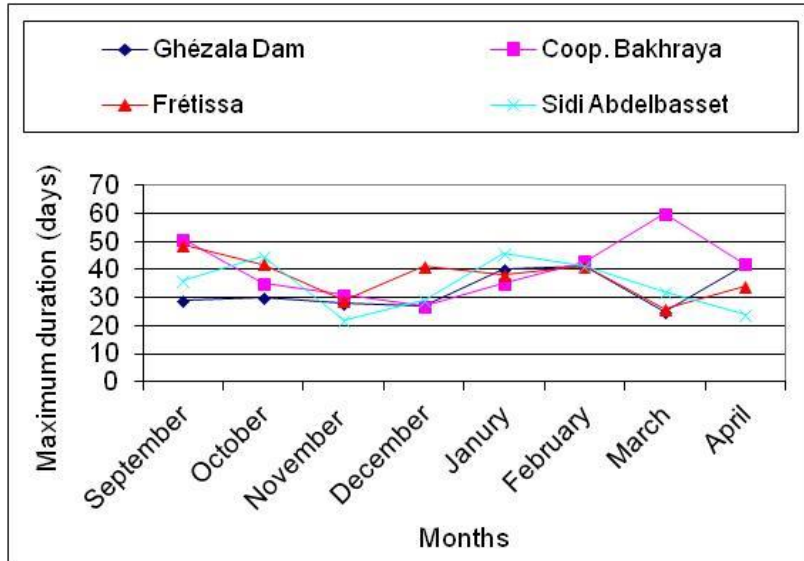
The study area: Ichkeul lake basin (Tunisia)

RESULTS and DISCUSSION

Length of mean maximum monthly dry spell within the rainy season

Station	Observation period	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April
Barrage Ghézala	1968/2010	15.3	14.7	10.0	11.7	11.6	11.7	12.5	14.4
C. Bakhraya	1969/2010	17.8	14.1	12.3	12.2	12.1	13.5	17.5	16.1
Frétissa SM	1982/2010	19.4	17.1	10.4	12.0	11.8	13.6	14.9	12.9
Sidi Abdelbasset	1968/2010	16.9	17.6	10.9	11.9	14.8	15.4	14.4	12.2
Mean (days)		17.4	15.9	10.9	12.0	12.6	13.6	14.8	13.9

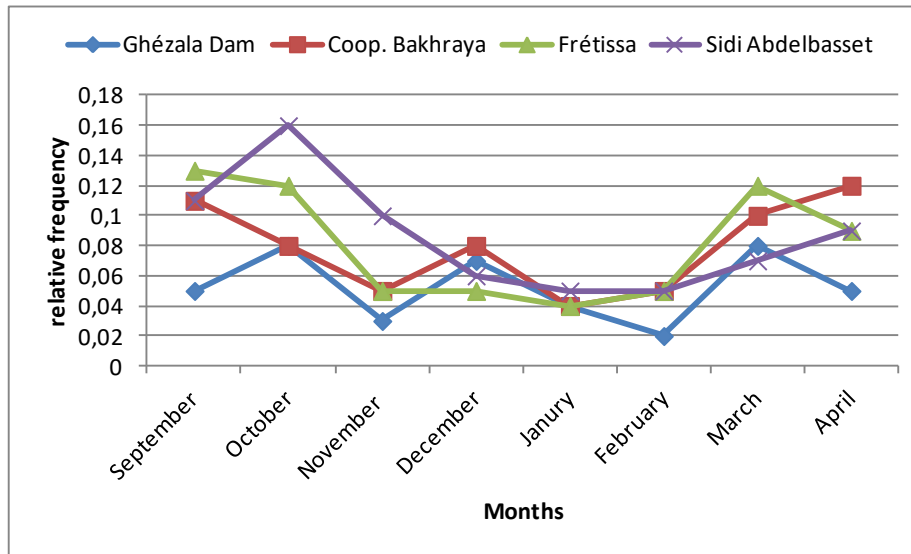
- It is shown that **dry spells** occur **randomly** during the **rainy season**.
- The **average monthly maximum dry spell** during the months of the **middle** of the **rainy season** varies between **12** and **15 days**.
- The **maximum duration of dry spells** is observed at the **beginning** and the **end** of the **rainy season** (**19 – 16 days**).



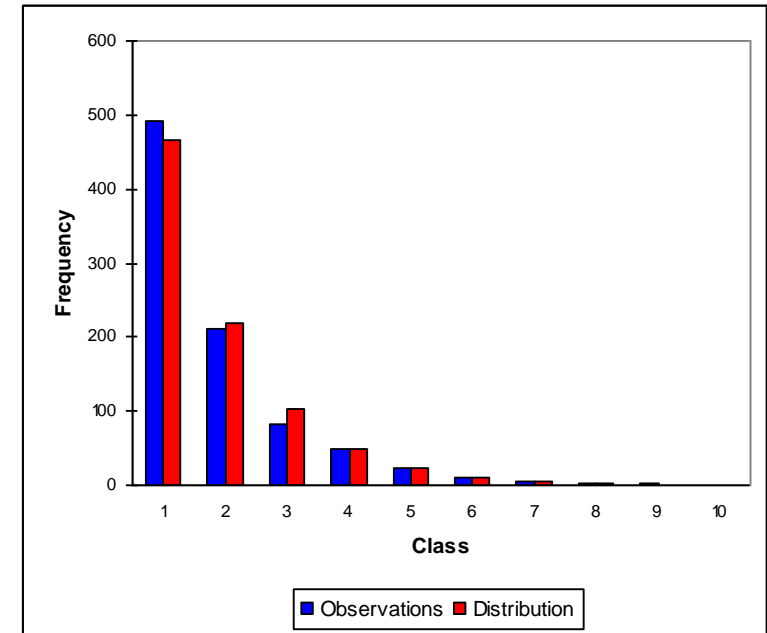
Longest dry spells (days)

Distribution of the longest dry spell

- The mean lengths of the longest dry spells in the middle are less than the corresponding value for the season.
- However, at Ghézala dam station, in more than 45% of the seasons the longest dry spell did occur during the middle. This coincidence was only 40 % for Sidi Abdelbasset rain gauge.



Frequency of monthly dry spells of duration 14 to 21 days



Distribution of dry event duration

- For the **core of the rainy season**, the curves show a **similarity of frequencies** for dry periods of **2 to 3 weeks duration**.
- The **monthly dry periods** of duration **14 to 21 days** are **more frequent** for rainfall stations with **lower precipitation**.

Comparison of the variability of the number of events/season and that of the maximum seasonal event

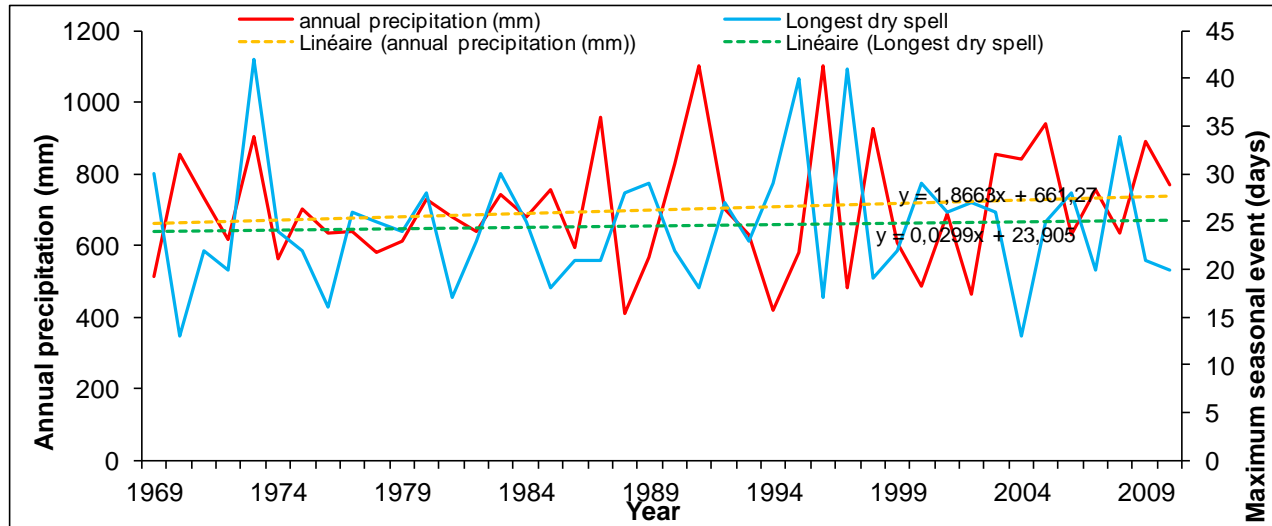
Rain gauge	Observation period	Maximum number of observed dry event/season	Longest dry spells during the rainy season (days)	Average of maximum dry seasonal event
Barrage Ghézala	1968/2010	31	57	30.2
C. Bakhraya	1969/2010	31	60	30.7
Frétissa SM	1982/2010	36	60	36.1
Sidi A.elBasset	1968/2010	32	81	35.7

- The comparison shows that the length of the mean maximum dry spell doubles by replacing the 1 mm/day threshold by 3 mm/day.
- The maximum number observed is for Frétissa and the longest dry event duration for Sidi Abdelbasset rain gauge.

Estimates of extreme dry event durations at Frétissa rain gauge

Surpassement probability (%)	Statistical return period (years)	Longest dry spells during the core season	Longest seasonal dry spells	Expected value of the sample size to consider
95	1.05	14	20	20.7
50	2	27	35	39.4
20	5	37	45	98.5
10	10	43	50	197
4	25	52	57	492.5
2	50	57	61	985
1	100	63	65	1970

- For **planning purpose**, the **longest dry spells** associated with the **various statistical recurrence periods** are derived on the basis of the **fitted GEV function** (table).
- Some rainy seasons characterized by **favorable rainfall distribution** can hide the statistic that about **21 dry events** it is likely to produce at least one of **more than 20 days**.




Annual precipitation and maximum dry sequences. *Dashed lines* represent linear regression trends.

- Annual longest dry spells showed significant positive trends.
- For Ghézala Dam, the presence of high frequencies over a long period of time (43 years) is significant.

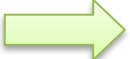
DROUGHT IMPACTS



During 1987-1989 and 1993-1995 drought was characterized by two successive years of 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.



In the years 1987-1989 severe drought was observed.



During this period, water inflows in dams was less than 50% of capacity.



In the years 1993-1995, the change in rain deficit is 33 to 56%.

Water inflows in dams during dry years

Dam	In operation since	Reservoir capacity (Mm ³)	Minimal water inflows (Mm ³)	Year
Joumine	1983-1984	130	17.9	93-1994
Ghézala	1984-1985	11.7	0 0.5	87-1988 93-1994

- For the hydrological year 93-94 the water inflows to dams did not exceed 13% of their capacity.
- There was a very low inflows to Ghezala dam during the hydrological year 1987 - 1988.

ADAPTATION TO DROUGHTS

- The **probability** to have a **dry year** is **7** to **23%** in the region.
- Designing a **water reservoir management plan** according to the **changing climatic conditions** (management system).
- **Reconstruction of water supply aquifers** by artificial recharge.
- Intensification of the extension program related to the choice of crops and farming practices to **maximize the valuation of rainfall**.

