REGIONAL DISTRIBUTION WET AND DRY SPELLS IN NORTHERN LIBYA

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ABSTRACT:

Wet and dry spell statistics are calculated from the available monthly rainfall amounts recorded at 29 meteorology stations scattered over the northern part of Libya. In the assessment of the wet and dry spell durations five different truncation levels are considered based on the average and the standard deviation of rainfall amounts at individual stations. By making use of these truncation levels, regional wet and dry spell maps are prepared for northern part of Libya. These maps are indicators of sub-areas suitable for agricultural activities in addition to identification of water poor areas.

Introduction

In general, the term 'wet spells' corresponds to water surpluses, floods or humid periods whereas 'dry spells' are representatives of water deficits, shortages, droughts or arid conditions. Water is transported along the time axis from wet spell durations for use during dry spells as well as regional water transport from wet to dry localities. In many regions wet and dry spells' are appropriately addressed by Several authors such as (Gabriel and Neumann, 1957, 1962; Green, 1964; Wienser, 1965; Feyerherm and Bark, 1967, 1973), they have pointed out that a many statistical techniques such as first order Markov chain model may provide good results. Many other models have been mentioned and the intricate problem attracted the attention of various authors (Eljadid 1997a, 1997b, Blair-Fish, 1975; Dyer and Tyson, 1977; Sen, 1970, 1980, 1990). All cannot be included herein, but some interesting approaches may be singled out, Theoharatos and Tselepidaki (1990) determined the number of rainy days by using the Polya statistical method probabilities. They obtained results showing that, the Polya distribution is very satisfactorily fitted to the real daily rainfall values.

Rainfall occurrences do not happen on the same amounts at different locations but show fluctuations about constant levels. Hence, periods of more rainfall than a given threshold value (base value) occur alternatively with less than base rainfall amounts. In same context, these are referred to as the wet and dry periods. In any engineering application, more significantly then the rainfall amounts, the wet periods of sufficient and dry periods of insufficient rainfall amounts play dominant roles. In order to achieve the maximum efficiency, it is necessary that during wet periods the rainfall should be conserved for exploitation in the subsequent dry periods. Due to topographic and synoptic features, the rainfall amounts vary rather randomly. In general, most climatic factors have some influence on the problem through their contributions to rainfall. Others exert their influence by modifying the physical characteristics of the catchment. Extreme values of rainfall present a cyclic pattern and a short run is just as likely to contain more peaks than valleys as it is to contain a number of exact cycles.

For many purposes, full information about the number of wet and dry spells becomes more pressing in many fields, such as in water management projects, agricultural planning, and in the industrial activities. Thus, the geographical distribution of these meteorological parameters for the area are helpful in the cases of new water resources development and planning projects especially related to the agricultural activities and environmental engineering (Theoharatos and Tselepidaki, 1990). For instance, in reservoir design, if the total amount of water is in excess of the demand then during wet periods the excess water is stored, whereas during a dry period the extraction of water is necessary, either from the previously stored water in the reservoir and/or if possible, from alternative water resources. Thus the accumulated water excess plays an important role in the reservoir design. In addition, some other important factors which require the prediction of wet and dry spells are water pollution, sedimentation, problems of erosion and size of pipes (Abouammoh, 1991). In general, one can say that this period is wet or dry due to, naturally, a relationship between water supply and demand, i.e., if in a certan location, water supply is greater than the demand, then this location is considered as a wet period location, otherwise, it is a dry period location.

Unfortunately, wet and dry spell periods of rainfall records in Libya have not been studied at all and, therefore, this paper presents some of the saline features of these spells over the country. It presents a simple and straight forward procedure for the identification and treatment of wet and dry spell parameters but meaningful interpretations for the country which exemplifies one of the arid regions of the world. This study examines also wet and dry period statistics of Libyan rainfall and then documents these statistical features on regional basis so as to assess the spatial variability. Hence, the purpose of this paper is two fold. Firstly, to calculate the possible number of wet and dry spells and its durations on different levels at individual stations. Secondly, to construct regional spatial variations (geographical distribution) in the form of maps. These maps are then interpreted for various water activities in the northern part of Libya.

Study area:

The study area lies within the latitude 30° 56 to 32°N and longitude 12° to 22°39E, which represent the northern region of Libya and stretches about 214 km away from the Mediterranean coast towards south, and about 1450 km from west to east along the Mediterranean sea (see Figure 1).

Figure 1. Location map of Libya

Rainfall data calculations:

Monthly rainfall data are considered rather than the daily rainfall since most daily rainfall records in Libya have zeros. Thus daily data do not give reasonable background information for most inferential procedures. Daily rainfall forecasts are only one type of climatic data that are needed for water supply management purposes (Murray, 1968). In some situations, water supply managers may be dependent on weather with rainfall, and how much it will rain on a daily basis. In other situations, water supply managers need to know how much rain will occur over some extended periods of time, such as a week or a month (Sen and Eljadid 1990, 2000. In this paper 29 stations have been considered for the calculations and their characteristics are presented in Table 1. The rainfall records have 43-year duration which is enough to assess the regional characteristics. However, they are distributed over an area covering about 73% from the Libyan coastal line where the climatic conditions are much better than the mid and southern parts of the country.

Prior to processing the rainfall data it is first necessary to assess the reliability and the quality of the observations available and then to correct unreliable data by filling few missing. Missing data are filled from observations at least three stations close to and as evenly spaced around the station by using the normal-ratio method. The rainfall amounts at the index station are weighted by the ratio of normal annual precipitation values (Summer, 1988). Estimates for long intervals such as month or year are more reliable than those for short intervals such as a day. Kohler (1949) and Berndtsson and Niemczynowicz (1986) noted that double mass curve may be used to test short and long periods of rainfall data for homogeneity over time. The mass curve for monthly and annual rainfall will normally approach a straight line, assuming that there is no consistent trend in month to month or year to year precipitation totals. In this study the mass curves are examined in order to know whether the available data are homogenous or not. Mass curve results show that, the rainfall data of about 18 stations became as a straight line which imply that the data are considered reliable. However, other 11 stations consist of a series of straight lines, and the data are corrected accordingly. Even below or above average totals maintained over a few months will ultimately be compensated for by above average sequences. The arithmetic averages of monthly rainfall data and their standard deviations in addition to five truncation levels are presented in Table 2 for the selected meteorological stations over the northern part of Libya. Thus it is clear that both mean and standard deviation values follow almost the same pattern. However, the standard deviation values are bigger than the mean values for most of the stations. It is clear that, some truncation values have negative sign which is due to the big differences between the data mean value and its standard deviation. This means that negative values are related to wet spells at that level because all the actual rainfall amounts will be equal to or more than zero. There is an inverse relationship between the spell properties such as the average duration and the truncation level values that is wet spell percentage increases as the truncation level value decreases.

Table 1. Meteorological station characteristics

No	Station name	Longitude	Latitude	Altitude (Meter)
1	ZWARA	12° 06' E	32° 56' N	02
2	SORMAN	12° 36' E	32° 48' N	42
3	ZAWIYA	12° 44' E	32° 45' N	15
4	AZIZEYA	13° 01' E	32° 32' N	86
5	TRIPOLI	13° 11' E	32° 54' N	25
6	QRABOLLI	13° 43' E	32° 45' N	108
7	KHUMS	14° 16' E	32° 39' N	69
8	ZLITN	14° 34' E	32° 28' N	83
9	MISRATA	15° 06' E	32° 23' N	105
10	KRAREEM	15° 08' E	32° 22' N	108
11	GDAMS	09° 30' E	30° 08' N	345
12	DERJ	10° 26' E	30° 09' N	266
13	SINAWN	10° 36' E	31° 02' N	253
14	MIZDA	12° 59' E	31° 26' N	797
15	NALUT	10° 59' E	31° 52' N	621
16	TIJI	11° 22' E	32° 01' N	259
17	JADO	12° 01' E	31° 57' N	266
18	ZENTAN	12° 02' E	31° 38' N	506
19	YEFRN	12° 31' E	32° 04' N	691
20	GRYAN	13° 01' E	32° 10' N	662
21	TRHONA	13° 38' E	32° 26' N	176
22	ABOGREN	15° 14' E	31° 22' N	49
23	ABONJEM	15° 02' E	31° 17' N	455
24	SIRT	16° 35' E	31° 12' N	13
25	AJDABYA	20° 14' E	30° 48' N	07
26	BENGHAZI	20° 04' E	32° 07' N	130
27	MARJ	20° 54' E	32° 30' N	272
28	DRNA	22° 39' E	32° 46' N	17
29	SLOUQ	20° 15' E	31° 39' N	56

Record Period (43 year), 1960-2003

Table 2. Truncation levels

Station Name	μ mean	σ t.division	$\mu+\sigma$	$\mu+2\sigma$	$\mu-\sigma$	$\mu-2\sigma$
Zwara	17.65	20.68	38.33	59.01	-3.03	-23.71
Sorman	14.71	12.11	26.82	38.93	2.60	-09.51
Alzawya	21.88	23.59	45.47	69.06	-1.71	-25.30
Alazixeyh	17.52	17.33	34.85	52.18	0.19	-17.14
Tripoli	27.60	26.06	53.66	79.72	1.54	-24.52
Qarabolli	22.42	22.26	44.68	66.94	0.16	-22.10
Khums	16.16	16.46	32.62	49.08	-0.30	-16.76
Zlitn	19.46	21.01	40.47	61.48	-1.55	-22.56
Misrata	19.83	20.56	40.39	60.95	-0.73	-21.29
Krareem	12.65	10.16	22.81	32.81	2.49	-07.67
Gdams	02.89	04.37	07.35	11.72	-1.39	-05.76
Derj	02.07	05.20	07.27	12.47	-3.13	-08.33
Sinawn	03.17	04.27	07.44	11.71	-1.10	-05.37
Mizda	05.50	07.87	13.37	21.24	-2.37	-10.24
Nalot	13.10	15.30	28.4	43.70	-2.20	-17.50
Tiji	09.00	11.22	20.22	31.44	-2.22	-13.44
Jado	17.77	26.75	44.52	71.27	-8.98	-35.73
Zentan	16.83	20.25	37.08	57.33	-3.42	-23.67
Yerfn	09.26	08.82	18.8	26.9	-0.44	-08.38
Gryan	22.56	19.77	42.33	62.1	2.79	-16.98
Trhona	16.19	18.18	34.37	52.55	-1.99	-20.17
Abogreen	04.80	10.38	15.18	25.56	-5.58	-15.96
Abonjeem	03.48	05.04	08.53	13.56	-1.56	-06.60
Sirt	16.80	13.73	30.53	44.26	3.07	-10.66
Ajdabya	12.21	11.72	23.93	35.65	0.49	-11.23
Benghazi	23.10	17.25	40.35	57.7	5.58	-11.40
Marj	23.80	20.16	44.41	65.02	3.19	-17.42
Drna	25.92	11.78	37.7	49.48	14.14	-02.39
Slouq	13.93	13.71	27.64	41.35	0.22	-13.49

Wet and dry spell Distributions :

For the study of consecutive rainy i.e., wet (W) and non-rainy i.e., dry (D) periods, a computer software has been developed based on statistical calculations with five truncation levels . The limiting stages, i.e., the beginning and ending of any spell has transition states either in the form of wet-dry or dry-wet successions. Reader should keep in his/her mind that the first spell to be wet or dry depends directly on the first data value whether it is bigger than or equal to threshold level. The consecutive wet and dry spell durations, in nature, have a random character. For instance, wet (dry) day is followed by another wet or dry day and as a result, clusters of adjacent wet (dry) days lead to longer wet (dry) spells. Thus the spell durations depend on the rainfall amount, its time of occurrence and the truncation level.

Figures 2-11 show spatial wet and dry spell distributions over the study area at five truncation levels. In general, the wet and dry spells follow approximately the same pattern over all places of the study area. Both spells are concentrated at the two mainly rainy areas in the country i.e., the Gafara plane in the northwest zone and at the Al-Jabel Al-Akhder at the northeast corner of the country. However, some significant dry spells appear in the middle part of the country. It implies that the air masses distribution over the Gulf of Sirt and the Sahara climate have strong effects on this area that is almost desert.

At the truncation level, Figures 2 and 7 show that, wet spells reach to their maximum values at the coastal areas in both eastern and western zones. It is about 120 months in the western area and 160 at the eastern zone. On the other hand, it decreases to about 40 months in the middle of the country. Furthermore, dry spells follow the same pattern of the wet spells. They reach to about 350 months in both eastern and western zones, and about 150 months around the Gulf of Sirt.

For truncation level, Figures 3 and 8 show that, the number of wet spells start to decrease to about 80 months at the western zone and 100 months in the eastern area. However, the number of the dry spells starts to increase up to about 480 months at western and eastern zones.

On the truncation level, it is possible to observe the minimum distribution of the wet spell over some parts of the study area with about 40 months at the western part and 50 months at the eastern zone.

However, Figure 9 shows the maximum amount of dry spell over the study area. It is 480 months in both eastern and western zones.

For truncation level, Figures 5 and 10 show that wet spell amounts increase to 400 months in the western zone and 320 months at the eastern zone. However, dry spells start to decreases to very low amounts down to about 20 months at the western zone and further smaller at the eastern zone by about 300 months.

Finally, for truncation level, Figures 6 and 11 show that wet spells have their maximum amounts over all parts of the study area in both western and eastern zones that reach to about 500 months in each case. However, the dry spells are distributed in a new shape and it is concentrated at the middle part of the country, recording about 30 months of dry spell in this area, while it reaches to its absolute low in the western and eastern areas. As expected, the wet and dry spells become to have an inverse relationship with the selected truncation levels. The maximum wet spell record is available at the fourth truncation level. However, the maximum dry period exists with the fifth truncation level.

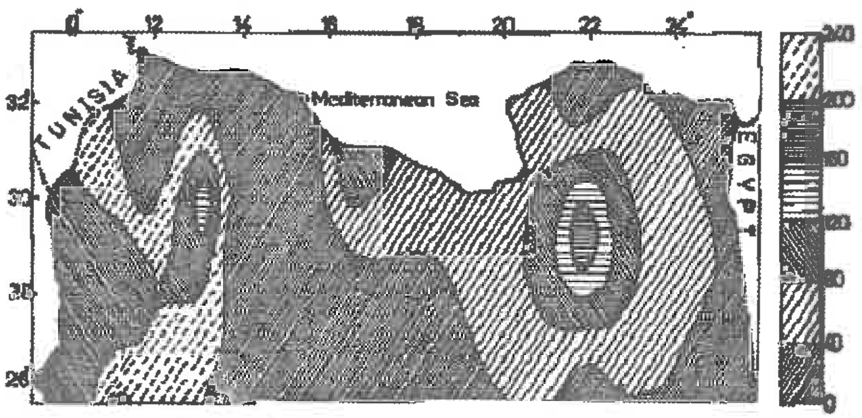

Figure2. Wet spell at first truncation level

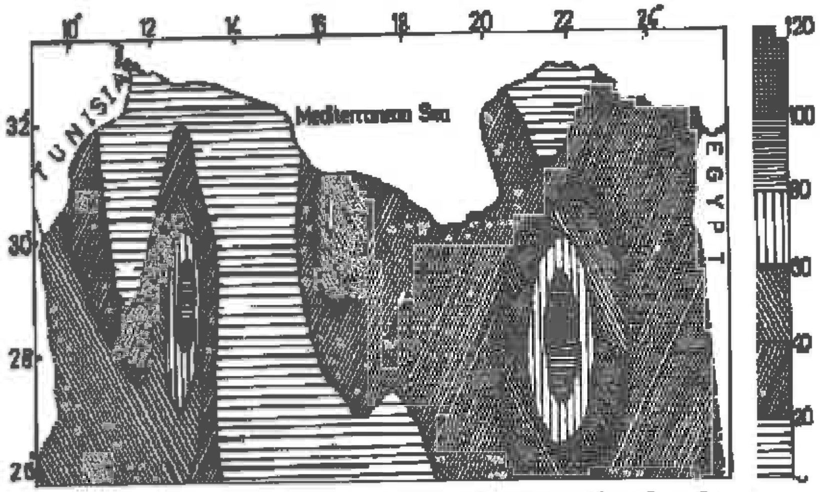

Figure3. Wet spell at second truncation level

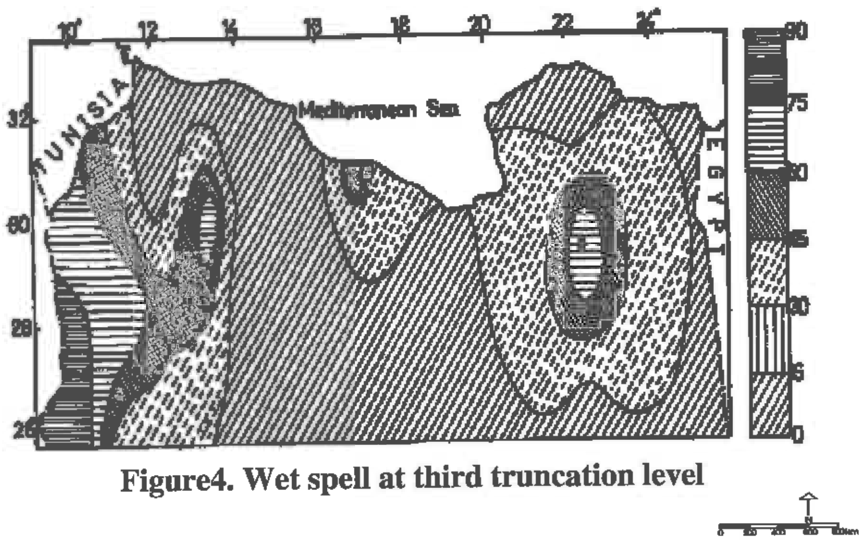

Figure4. Wet spell at third truncation level

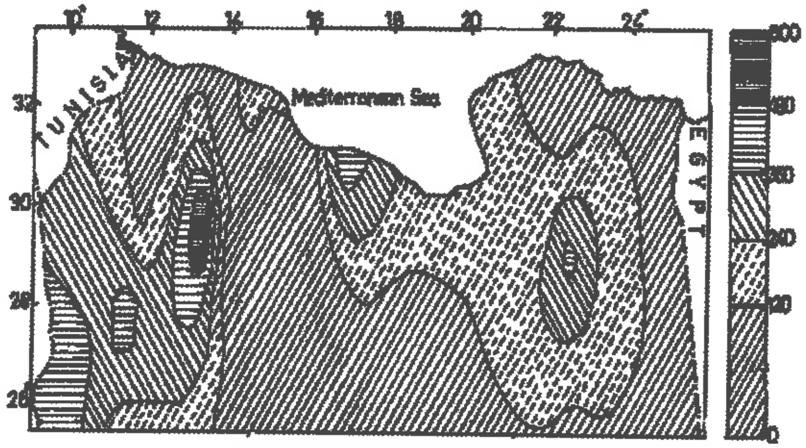

Figure 5. Wet spell at fourth truncation level

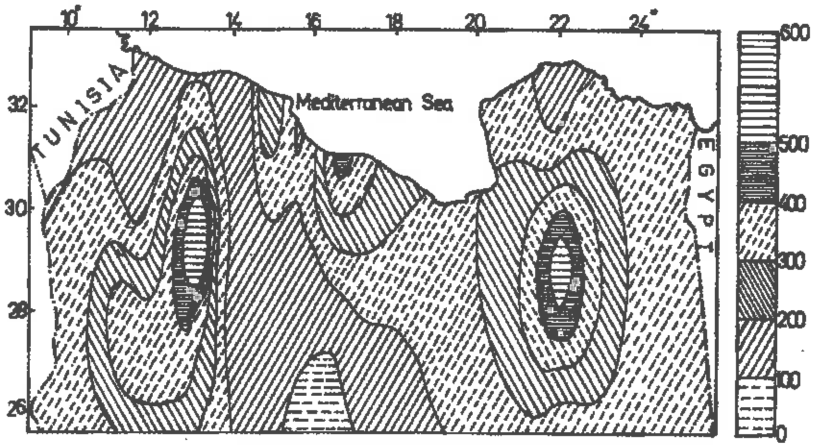

Figure 6. Wet spell at fifth truncation level

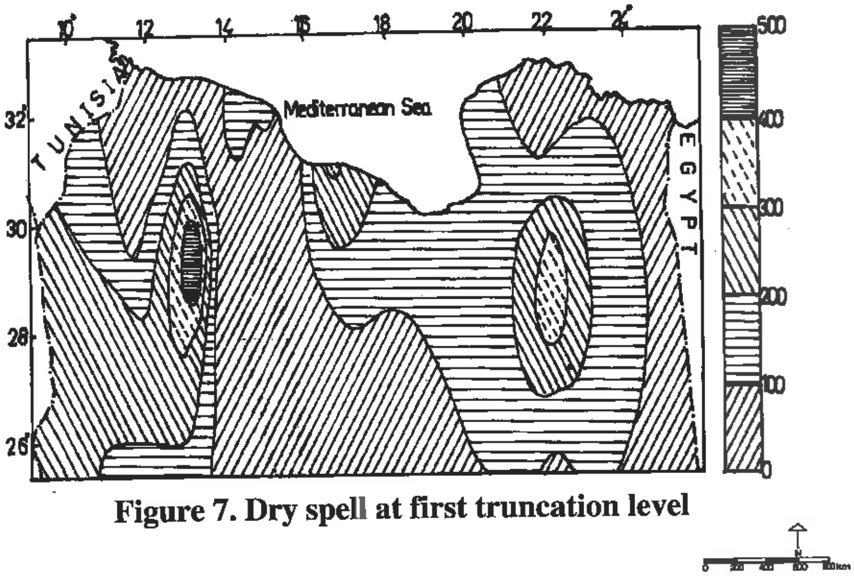

Figure 7. Dry spell at first truncation level

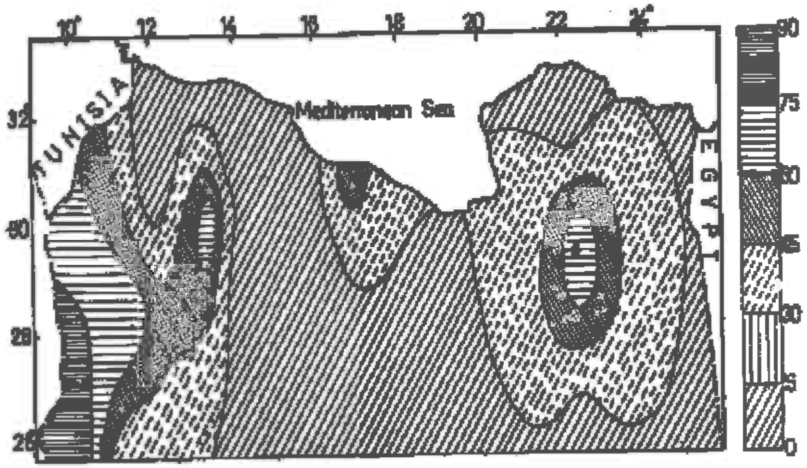

Figure 8. Dry spell at second truncation level

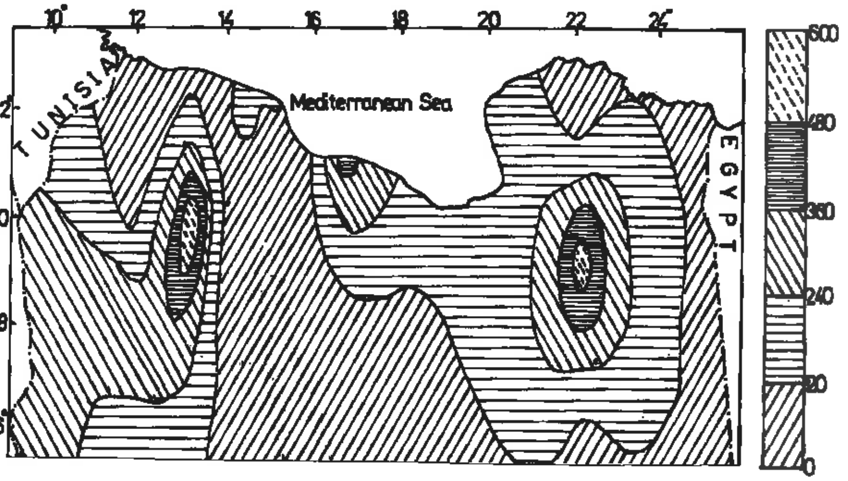

Figure 9. Dry spell at third truncation level

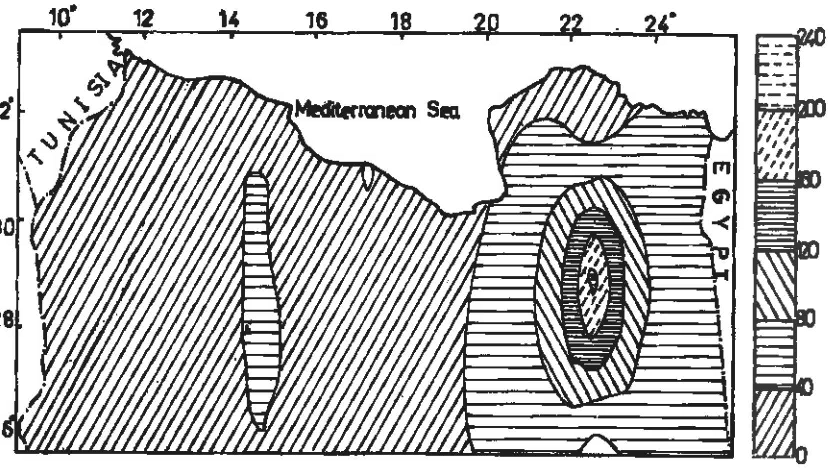

Figure 10. Dry spell at fourth truncation level

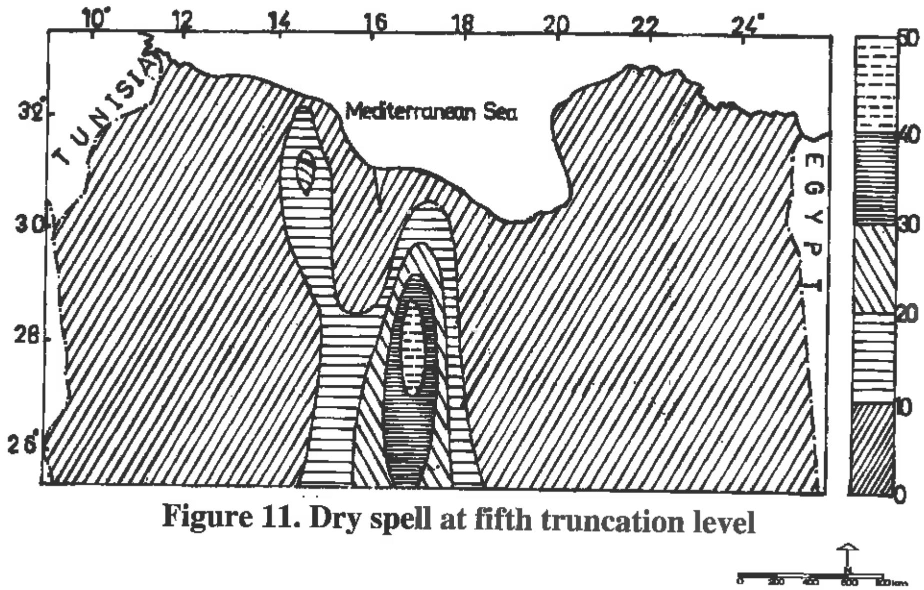

Figure 11. Dry spell at fifth truncation level

CONCLUSION:

The wet and dry spell over the northern part of Libya are studied and identified from the available monthly total rainfall amounts, and the following significant conclusions can be drawn:

(a) dry spells, in general, over all the stations are longer than the wet spells,

(b) long wet spell durations are more abundant in the coastal stations than the inland areas and wet spell shifts toward the north while the dry spell increases southward,

(c) sudden floods in the winter months may have chance to occur along the coastal regions. On the other hand, the maximum peak of groundwater recharge for a short time may occur at these regions,

(d) there are high differences between the quantities of the wet and dry spells, hence, climatologically available water is not considered sufficient to meet the long-term water demand for the study region, and finally,

(e) wet and dry spell information should be combined agriculturally with water and moisture requirements for the corresponding crops in order to justify the precipitation enhancement.

On the other hand, based on the above significant results, drought is inevitable on the middle and southern part of the study area. However, Libya, in general, is located in an arid region with less amount of precipitation over the country. Precipitation deficit occurs in many years within the rainy seasons (winter and spring). A specific research should be conducted concerning the drought, because it is a common occurrence and must be anticipated in water supply planning.

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ملخص:

ترتبط الفترات الممطرة بوفرة المياه فيما تقترن الفترات الجافة بشح المياه ونضوبها وبالجفاف، ونظرا للأهمية البالغة التي تلعبها كميات الأمطار في منظومة الإمداد المائي بشكل عام سواء كانت في شكل مياه سطحية أو مياه جوفية حيث الرشح وتغذية المخزون الجوفي فان تحديد فترات الهطول المطري وتعيين مواقعه ومعرفة توزيعه ومدى انتشاره يعد من الأمور المهمة للمجتمعات وللدول حيث تعتمد عليها عند وضع الخطط التنموية وفي برامج التطوير والبناء وذلك في كافة المجالات المعنية بالشأن الحضري والزراعي والصناعي. تنظر هذه الورقة العلمية في تحديد الفترات الممطرة والجافة لمناطق الشمال الليبي لما يمثله من خصوصية حيث الكثافة السكانية ذات الزيادة المضطردة والامتداد المستقبلي المؤكد وباعتباره سلة البلد الغذائية لصلاحية أراضية للزراعة، كما

وتعنى هذه الورقة أيضا بتحديد التوزيع المكاني الإقليمي لتلك الفترات الممطرة والأخرى الجافة، وتعرض كذلك لخرائط مهمة يتضح من خلالها المواقع الممطرة أكثر من غيرها في مناطق الشمال الليبي وتوضح بشكل دقيق أنماط التتابع المطري الجاف والممطر بشكل عام، وقد اعتمدت الورقة في تحديد كل ذلك على بيانات لكميات الأمطار الفعلية التي هطلت على مناطق الشمال الليبي عبر الفترة الزمنية الممتدة من عام 1960 إلى 2003 م.