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Determination the Quantity of Extreme Rainfall and calculation of the Climatology Mean for Baghdad City

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Abstract

Recently heavy rainfall that occurs in last decade for Baghdad city is part of climate changes effect on Iraq in general and Baghdad in particular. Rain is considered the main part in the water cycle as it enters mainly within the water system and water balance; therefore present study put of a special criterion to determine the amount of rainfall and analyzed in order to quantify the amount and the diagnosis of heavy rain. The availability of data by Iraqi Metrological Organization and Seismology (IMOS) for time period (1985/1986-2014/2015) held achieve the research objective .There are many statistical methods figure out the difference to determine the amount of rain, Climatology mean (C M) is one of them specialized to separate the amount of normal rainfall from heavy rain. The climatology mean of rain for this study has been 15.2mm. Whereas in the rainy season exceeded this limit, in this case considered extreme season, while less than limit called normal rain. The results shown during 30 rainy seasons, have been 12 seasons exceed climatology mean, four of highest extremes rain have been happened in November. The highest extreme rain has been in 2014, with seasonal mean of 34.7mm. The monthly anomaly climatology mean (ACM) has been equal approximate 20mm, November 2014 was equal this value , When calculating the total amount of rainfall for the city of Baghdad during the 30 rainy season found that lightest mount fall 676 mm in January followed by the lowest rate month of November 596 mm, while the lowest amounts of rain fell in October and September, which did not exceed 130 mm.

Key words: Extreme Rainfall, Anomaly Climatology, Mean Special Criterion.

تحديد كمية الامطار الغزيرة وحساب المتوسط المناخي لمدينة بغداد.

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الخلاصة

حدوث امطار غزيرة لمدينة بغداد في العقد الأخيرة تعتبر جزء من التغيرات المناخية التي يتعرض لها العراق عموما و بغداد خصوصا.تعتبر الامطار الجزء الرئيسي في دورة المياه كما انها تدخل بشكل رئيسي ضمن النظام المائي و الموازنة المائية لذلك كانت هذه الدراسة لوضع معيار خاص لتحديد كمية هذه الامطار و تحليلها من اجل بيان كميتها من جهة و تشخيص الامطار الغزيرة منها.ان توفر البيانات من قبل الهيئة العامة للأنواء الجوية و الرصد الزلزالي للفترة (1985/1986-2014/2015) ساعدت على تحقيق هدف البحث.توجد طرق احصائية كثيرة لإيجاد التباين في تحديد كمية الامطار منها حساب المتوسط المناخي (CM) لفصل كمية الامطار الطبيعية عن الغزيرة .ان المتوسط المناخي للإمطار لفترة الدراسة يساوي 15.2

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ملم . فإذا ما تجاوز الموسم المطري هذا الحد اعتبر موسما متطرفا و ان قل اعتبر موسما طبيعيا. عند تحليل 30 موسماً مطرياً، وجد ان 12 موسم منها تجاوز المتوسط المناخي ومن بينها اربع مواسم كانت هي الاعلى في تطرفها اغلبها تقع في شهر تشرين الثاني ،وكانت سنة 2014 هي الاكثر تطرفا من بين سنين الدراسة و بلغ فيها المعدل الموسمي للمطر 34.7 ملم . اظهرت النتائج ان باستخدام (ACM) شذوذ المتوسط المناخي الشهري يساوي تقريبا 20 ملم و كان شهر تشرين الثاني من موسم 2014 مساوي لهذه القيمة. عند حساب مجموع كمية الامطار لمدينة بغداد خلال 30 موسم وجد ان اعلى كمية تساقط كانت 676 ملم في شهر كانون الثاني يليها وبنسبة اقل شهر تشرين الثاني 596 ملم بينما اقل كميات المطر المتساقطة كانت في شهري تشرين الاول وأيلول و التي لم تتجاوز 130 ملم.

Introduction

Rainfall is one of the most important types of precipitation which directly related to human life. The amount of rain and downpour season directly affects the continuity of life of any place on the earth's surface. The type and the source of rainfall determined the type of agriculture i.e. the type of crops that can be cultivation in the area that is role of effects on the country economy.

The Iraqi climate is classified as the dry and semi-dry region in summer, and cold and rainy in winter. The variance of rainfall amount is very high from year to another. The amount of annual rainfall mainly depends on the type of the Pressure system (cyclone), location of the region and its intensity and speed and period of continuity and the amount of moisture loaded [1]. All these factors are major reasons to causes of the different amount of rainfall. The rainfall could divide into two kinds normal and extreme for a year. The scarce rainfall came from Mediterranean Sea the low pressure system, which effect on the northern and central Iraq [2], another source came from Sudan's low pressure system its effect on the south and south-west parts, which is characterized by heavy rainfall and moderate wind speed, is due to high temperature, low pressure and an increase in relative humidity [1]. The low frontal, which are found in most parts of extra tropical, especially between latitudes 35 and 65 degrees, which consist of the convergence of two air mass, equatorial and polar regions. Whenever the big different in them characteristics from accept temperature and humidity. These systems that effect has huge impact on the environment and climate, beside the depressions system have main causes of Iraq's rainfall [3]. In the last decade, Baghdad witnessed some extreme rainstorms, especially in November , 2013.The amount of rainfall for one day was 89 ml, and in October, 2015 for two days rainfall was 81 ml only [4], these causes concern of economic and environmental damage because the infrastructure of city is not able to absorb large amounts of rain caused of changes the nature of the climate of Iraq. At the same time, there are many years have decreased the amount of rainfall than average. Many proportions caused deterioration in agricultural production, especially the areas that depend on the cultivation of the rising rainfall. This study carried out to determines which months possible have extreme rainfall in Baghdad. The **rainy season** is nine months that probabilities have high rainfall begin from September to may of next year, while the rest months of year are almost non rainfall. In order to distinguish between the extreme rainfall and normal and low rainfall, monthly data used form IMOS in this study for time period (1985-1986), and seasonal data for (2014-2015)[4]. The Sigma plot program has an important role to the charts and statistical analyzes that clarify the research idea. .

Methods and dataset

Climate is the stat of weather for long time period and for particular area, i.e the relationship of weather phenomena to the environment. Climatology has been based on set by statistic methods, and dynamic weather for understanding the rainfall yield that direct impact on daily life, and also it's important to collect climatic element.

Quantity of daily rainfall vary, increase in seasons and decrease in other seasons. In order to determine the amount of rainfall that greater than the normal mean used monthly data mean establish by IMOS of Baghdad city and for time period 30 rainy season. The statistical methods include the method of calculating the climatology mean used in climate studies make possible to distinguish the amount of extreme rainfall from the normal rainfall, that's mean separation of heavy for any rainfall seasons. This way, give a prediction vision for any time period of study in future i.e. up to 2050 in the following equation [5]:

$$C.M = \sum \bar{X}/\mathrm{N} \quad \ldots\ldots(1)$$

Where CM: Climatology Mean. ,$\bar{X}$: is a sum of a monthly mean value for each rainy season.
N: Number of rain season (30 season for the current study) .

The seasonal mean rainfall are calculated from the summation of monthly mean data divided by the number of rain months. The monthly rainfall mean is calculated by summing the amount of daily rainfall divided by the number of rainy days as shown in following equation [5].

$$\bar{X} = \sum_{i=1}^{N} \frac{X_i}{N} \quad \text{.....(2)}$$

$\bar{X}$: The seasonal mean rainfall, X_i: summation of monthly Rainfall
N: The number of month rain (9 month for the current study)
Anomaly rainfall is the fluctuation or deviation from the general average of rainfall for each year and is calculated by using the following equation:

$$AP = \bar{x} - X_i \quad \text{.....(3)}$$

[6].
AP: anomaly precipitation, X_i: monthly rain for one month,

Results and discussion:

The oscillation in the quantity of rainfall varies seasonally in various areas of Iraq, Sometimes exceed the measured means dramatically providing an environment suitable for the success of agriculture and sometimes below the normal levels, so that form a threat to the agricultural product, especially the areas that depend on the rain (agricultural demography), In order to determine the abundant seasons and the scarce Seasons, and to know the frequency , determine the most rainy months, and what quantity is considered to be extreme seasonal and monthly rainfall, in an attempt to insurance a constant level of water throughout the one season came this study.

Using the data of the monthly means of rainfall in the city of Baghdad provided by the (IMOS) which begin of September 1985 and ended of May 2015, the sigma plot program have been employed. Figure-1, shows the painted seasonal means for each rainy season for the period (1985/1986) to (2014/2015), according to the definition mentioned in the introduction to the study, the rainy season 1986 includes month September, October, November, December of 1985 and January, February, March, April, May of 1986 and so for that rest of the season, the annual rate of rainy season represents the total amount of monthly rainfall divided by the number of rain months. The amount of rain that exceeded 20mm was in (1985-1986) - (1992-1993) - (1997-1998). while, the amount of rain exceeds 30mm were at the season (2012-2013) and 2013-2014. Thus, heavy rains were repeated every (5-7) years during the period (1986-2000). and the following period of the season (2000-2012) were seasons between normal and low rain.

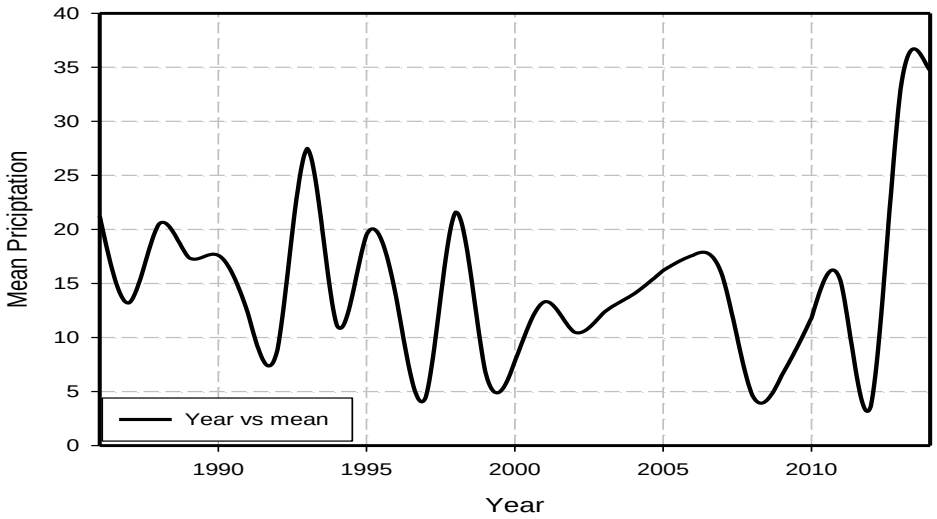


Figure 1- The seasonal rate for each rainy season for the period (1985/1986-2014/2015).

The calculation of the seasonal mean for each rainy season makes it possible to determine which seasons have little rain and what is abundant in rain compared to other rain seasons but in order to put special criterion through which can determine the year that has the extreme rain or within normal limits or scarce without comparable with Other years, The Climatology Mean was calculated for a period of 30 season using equation1, and show that the value of CM is equal 15.2mm (Climatology Mean). This value is considered the boundary between the extreme and natural seasonal values. If the amount of rain in the rainy season is less than this Value was within the normal range and if higher than it is considered extreme rain season, During the period of study, the heavy seasons were 12 out of 30 rain season and higher extremes represented in the 1992/1993 season, 1997/1998, 2012/2013 and 2013/2014. These seasons witnessed rain in higher quantities than other seasons during the period of study and highest rainfall rate was recorded in November, even though the amount rain of this month usually is not abundant. the last half of it is experiencing changes in temperature and humidity and the beginning of the arrival of the Mediterranean depressions to Iraq. These depressions continue to impact from October to May [7], the season of 1992-1993 was the highest amount of rain in month of Jan, which represents the mid of winter as in Figure 2. If the study period is divided into three periods, the **first** period (1985-1995), the **second** period (1995-2005) and the **third** period (2005-2015), the amount of rain in the first period of time is higher than the two periods that followed (second and third period). Where it was approximately 170mm, the second period was 120mm, which is less than the period before and the subsequent was the period followed by the amount of rain in 150mm share of the (2013/ 2014) season of 67mm of the total 150mm, Thus the amount of rain is in a state of decline and it must be taken into consideration that the rain in Baghdad in the case of decline and the amount of water that is obtained from the rain in the case of descent, Therefore Huge storage tanks should be built to collect rainwater in the winter and work on it for the purpose of benefiting from it during the dry season.

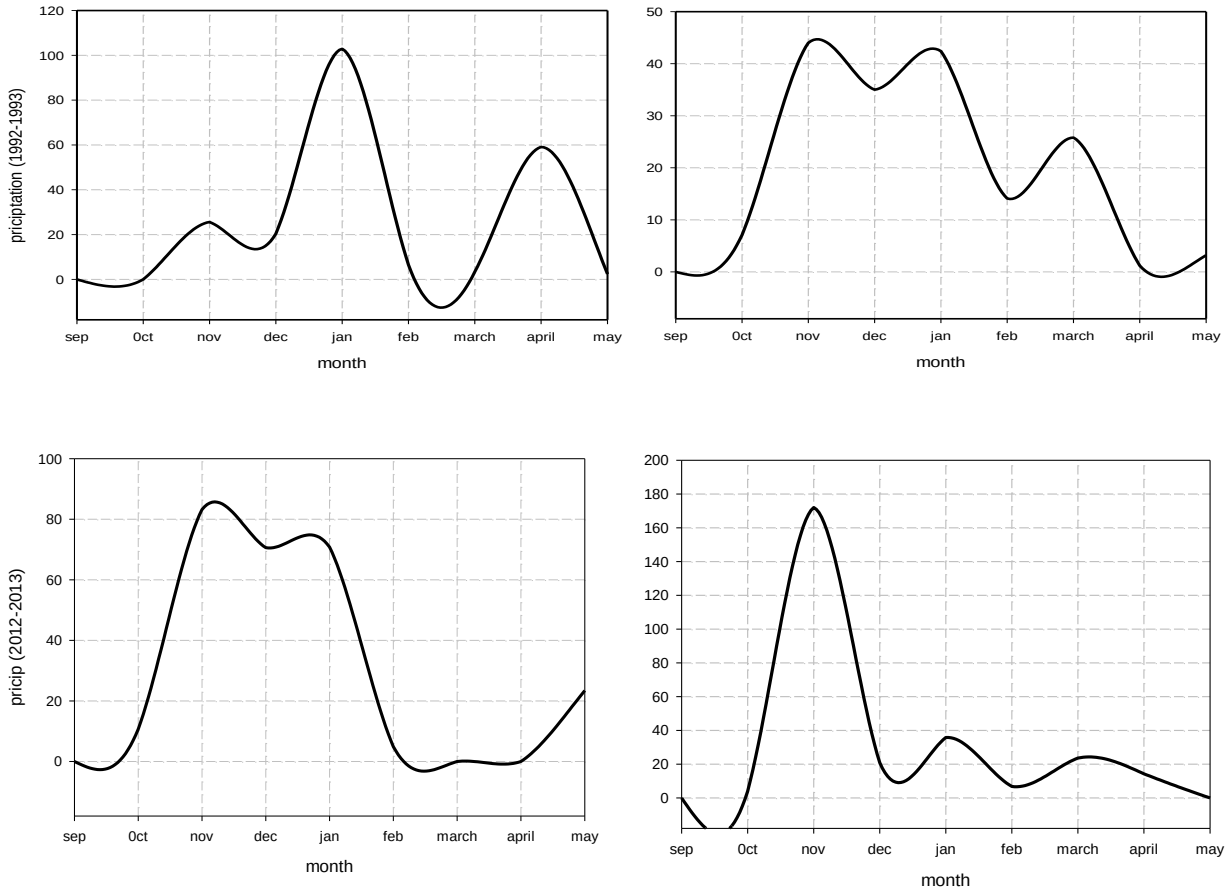


Figure 2- Heavy rainfall seasons during the study period of the 1985/1986-2014/2015.

The rainy season begins in Baghdad from mid-October to the end of May and is often the highest in December or February, but these months are not fixed, Sometimes rain is heavy in January or March and rarely in November or April[1], And through the amount of rain can be determine the most abundant month compared to the amount of rain in the other months. but, In order to determine whether the amount of rain is extreme monthly or natural, The anomaly climate mean (ACM) equation have been used. This method is used to illustrate the variance without affecting the behavior. It is possible to obtain a variation showing the behavior of the rain without return to the original values and give the anomaly a positive and negative variance. In this way can separate the negative values from the positive with maintaining the general behavior of the wave Which is required. This method has given the possibility to determine the highest positive value and the lowest rain value by determining the lowest negative value as shown in Figure-3, using the equation of anomalies (equation 2) show that: If the amount of rainfall per month exceeded 20mm,it is consider as extreme rain, while if it is less than this quantity then it would be normal. For example, in 1998 season, (Which exceeded the seasonal mean of 21.6mm), the months of November, December, January and March were heavy months, with rainfall exceeding 20 mm per month. In 1993 season, January and May were extreme rainfall.

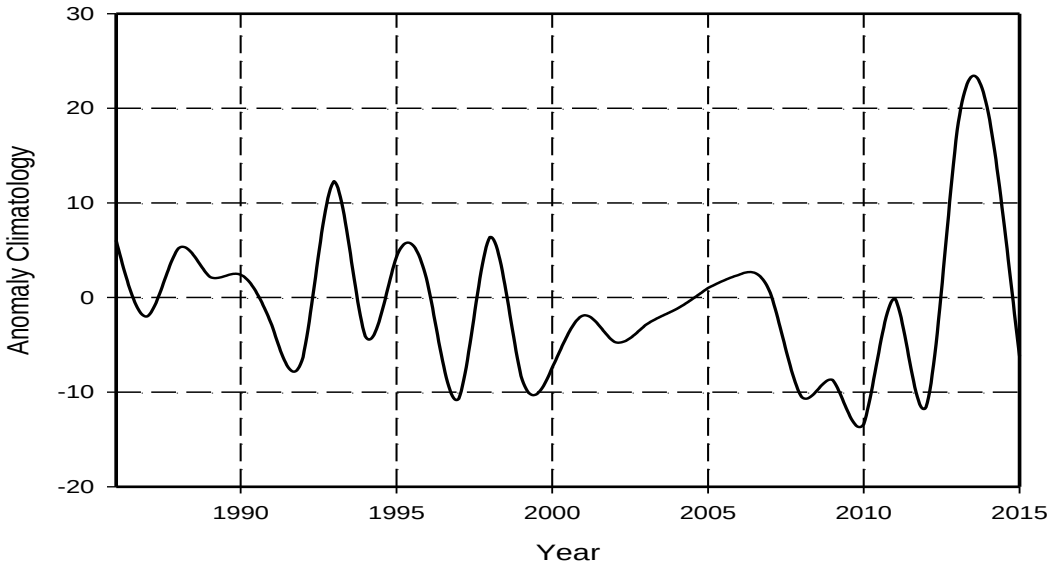


Figure 3-Anomaly climatology mean of the rain for period 1985/1986 – 2014/2015.

The ACM for the season of 2012/2013 was equal 17.7mm. This number of rain amount is unprecedented since 1993, causing sinking of the capital's streets and other damage effect on details of daily life, but this season was not the heaviest season during the study period. Falling rain exceeded 170mm through November of season 2013/2014,So the maximum value of ACM was19.5, which was one of the strongest years of rain and caused the flooding of whole areas and slow movement of traffic due to the rise in water levels from their natural limits As well as other damage caused by the interruption of work and the spread of diseases as shown in Figure-4. where Baghdad was affected by an extension Trough coming from the Red Sea caused heavy rain during this month as shown in Figure-5, which arises from the confluence of northern winds Cold west coming from the north Mediterranean with tropical winds Efficient coming from the south-east to meet in the north of the Red Sea and affects the Arabian Peninsula and sometimes extends its impacts to Iran plateau the asset and Pakistan [8].

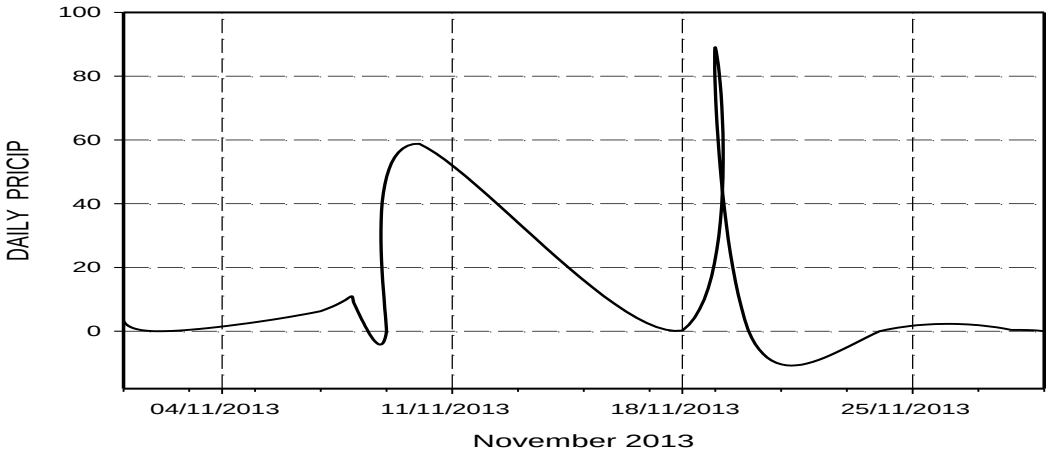
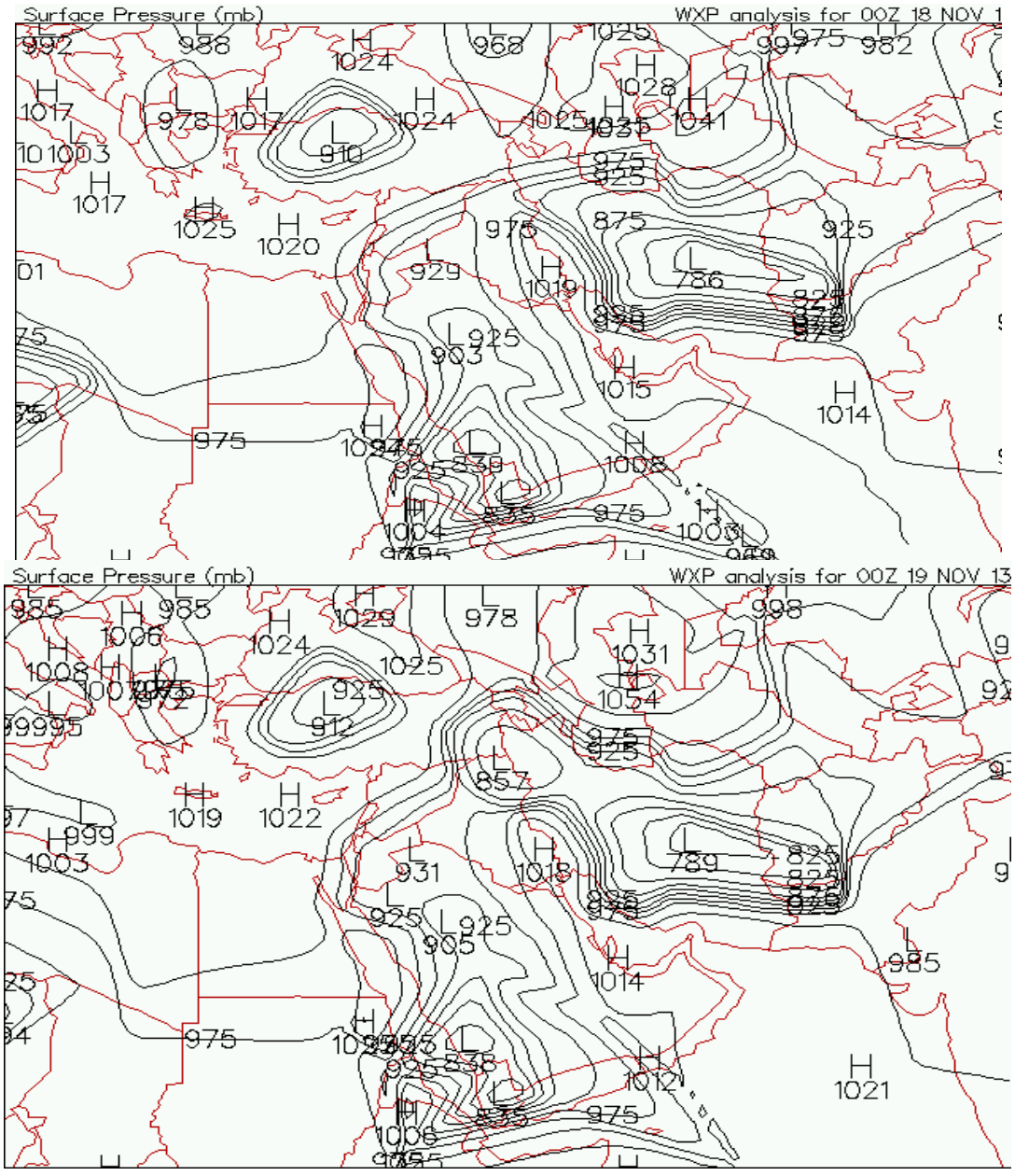


Figure 4- Rainfall during the month of November in the (2013/2014) season.



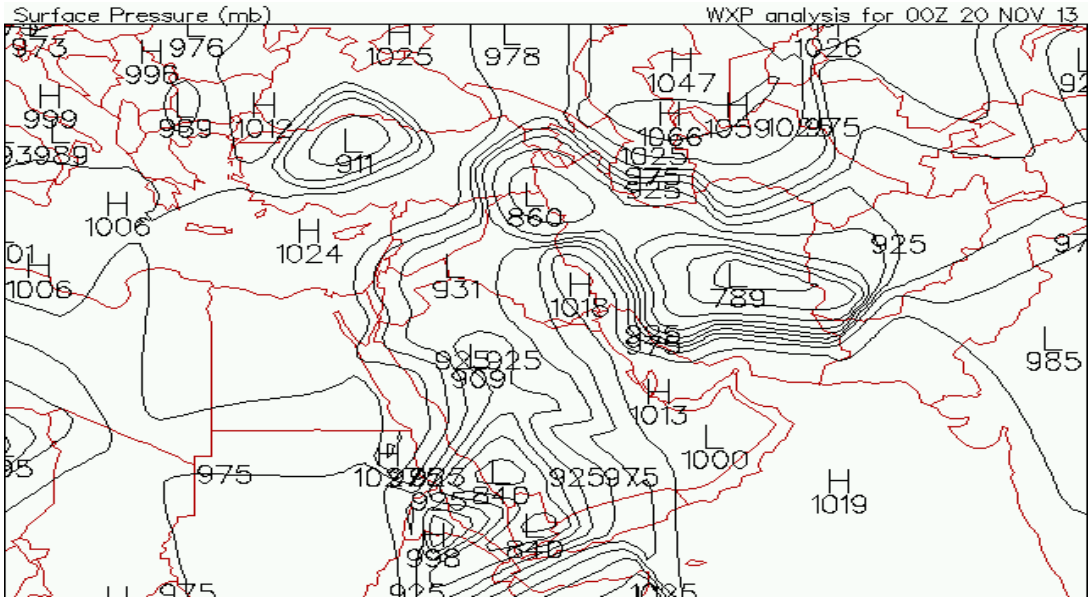


Figure 5- surface weather map for19/11/2013showing the impact 0f the rad sea low pressure system on Iraq.

Climate change and fluctuations result of human intervention and increased land deterioration as a result of the informal use of water affect the amount of precipitation during the season [9], this amount varies from year to another.

The ACM can be use to determine the immoderate season rain (Positive), and season scarce (Negative). From Table-1, The negative sign indicates to a minimum amount of rain, where season 2012,2008,1997 were the least rainy during study period, the amount of rain did not exceed 5mm, its very small amount compared to season 2013 and 2014. This big difference between the seasons (in amount rain) is due to several reasons, most important, neutral of air mass, topographic area, temperature difference between land and water [6].

Table 1-seasonal positive and negative anomaly of rainfall over Iraq.

Positive season		Negative season	
2014	19.5	2012	-11.6
2013	17.7	1997	-10.6
1993	12.3	2008	-10.5
1998	6.4	2009	-8.7
1986	6	1999	-8.3
1988	5.2	2000	-7.4
1995	4.3	2010	-3.4

If the air mass comes from a nearby area (such as the Red Sea and Southern Sudan) the amount of rain is heavy and the period of fall is longer, Also convergence Mediterranean and Sudan low causing falling heavy rain on the area passing over it. If the air mass comes from a far area from Baghdad (such as the Arabian Sea), its rains scarce[7].

Each of these cases a period of time affecting the region, and this is clear through the amount of rain varying from month to month as the highest monthly rainfall amount for Baghdad in the last 30 years was in January exceeded the amount of rain 600 mm followed by the month of October Baghdad's amount of rain is 596 mm, while December, which is the beginning of the winter season in Baghdad, is less rain, as shown in Figure-5, But in this month rain amount should be increased so there are reasons for the lack of rain this month which may be due to the impact of industrial rains in neighboring countries and implemented in the month of December, like Jordan and UAE to increase the stock of groundwater. This, in turn, has a negative impact on Iraq's rainfall [10].

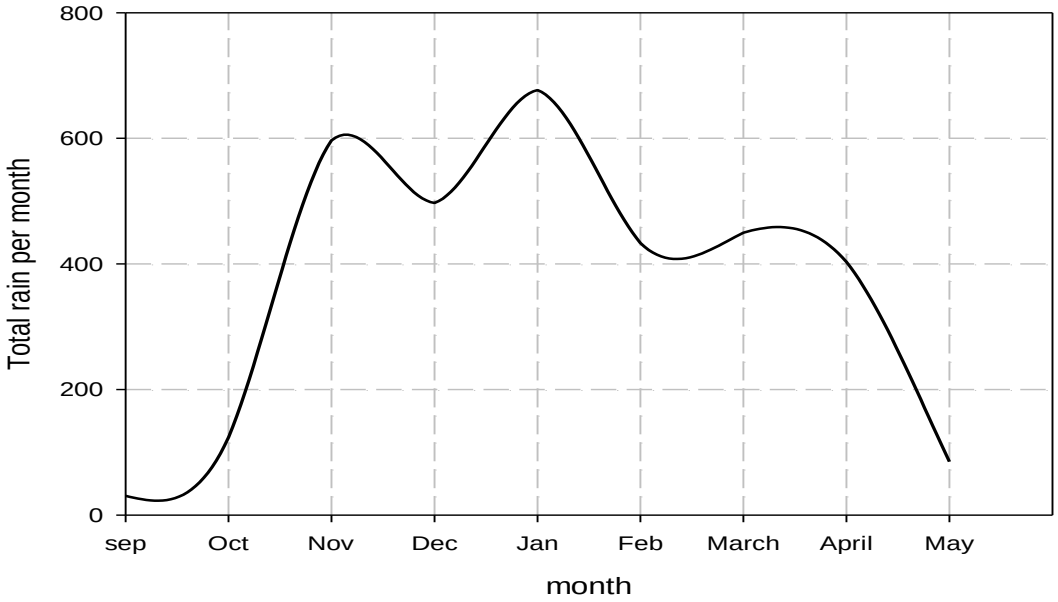


Figure 6-Monthly amount of rain for Baghdad the year (sep1985-may2015).

Conclusions

1- The general mean of rainfall is similar in its behavior to the Anomaly Climatology Mean (**ACM**) despite the differences in values between them. This gives a clear picture of the general behavior of the rain without damaging the real data.

2- The amount of rain is extreme if the (**ACM**) exceeds **15mm** at the season level and **20mm** at monthly level.

3- The largest amount of precipitation was in the month of **November** for the season of **2014**, which exceeded **160mm** during the study period.

4- The cumulative total of quantity rainfall in the city of Baghdad during the month of January was 676mm followed by the month of November With a rain amount of 596mm.

5- The months of **October** and **May** can be considered as a little rainfall months, where the amount of rain during each of them did not exceed **130mm**, as well as the amount of rain in September is very few, the amount of rain is very few, so this month can be excluded in the future studies of Baghdad rain.

6- The quantity of rain in Baghdad in the case of decline, especially in the last decade of the study, where the annual mean in the **last five** years was **944mm** .

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