http://dx.doi.org/10.22161/ijeab/2.5.3 *ISSN: 2456-1878*

Study of the Monthly and Annual Behavior of Temperature and its Impact on Climate Change in Iraq for the Period (1982-2012)

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Abstract— *Temperature in Iraq is an important meteorological factors because of its great impact on the daily life of human in terms of health, work and others. This research aims at identifying and studying the climate change in the study stations and during the specific period of time and its future impact on the climate of Iraq. This study analyzes the behavior of monthly and annual temperature data obtained from the (ECMWF) for selected stations from Iraq (Mosul, Baghdad and Basrah), which represent (Northern, Middle and Southern) Iraq, respectively, for the period of one and thirty years (1982-2012) and found the relationship between the temperature with period of study from 1982 to 2012 using some statistical methods (SLR and Rsqr), The lowest monthly average of temperature was in DEC and the highest monthly average of temperature was in JUL in all stations of the study, and found that the lowest annual average of temperature was in 1992 and the highest annual average of temperature in 2010 and for all stations, and found that there is a change climate in the month of MAY of Spring and the month of SEP of the autumn with the summer months (JUN, JUL and AUG), and found that there is a clear increase in the annual average temperature during the study period, where the Rsqr for Mosul station was (R^2=0.4), Baghdad station was (R^2=0.5) and Basrah station was (R^2=0.4), with the possibility of dividing study stations (Mosul, Baghdad and Basrah) into three regions climate in terms of total annual average of temperature (low, high, and very high) respectively, and Predictability of future drought in Iraq.*

Keywords— Temperature, Climate change, ECMWF, Meteorological factors, Iraq.

I. INTRODUCTION

Temperature can be defined as a form of energy. It is one of the most important components of the climate. It has a direct impact on human activity, clothing, housing and food, as well as other elements of the vital system. Temperature affects most climate elements such as atmospheric pressure, wind, evaporation, and relative humidity. Climate scientists have recently been interested in the subject of changing the climate of the Earth where scientists have tried to determine the nature of climate change and its reasons. The change is the shift from one case to another. It is different from the oscillation (which is about the rate of the situation and for a short period). The case rate continues for decades, and climate change as defined by the Intergovernmental Panel on Climate Change (IPCC) is a climate change that can be determined by the use of statistical tests, for example the change in the average and that this change continues for a long period of decades [1]. There is also another definition of climate change that is directly or indirectly attributable to human activity, which changes the composition of the atmosphere. It should be noted that the atmosphere consists of the two groups of the gas group and the non-gas group [2]. The reason why scientists are interested in changing the Earth's climate is the obvious effect on natural phenomena and its implications for human activity. The cause of climate change is due to natural internal processes or to external cosmic effects (solar radiation processes and solar energy) or continuous human changes in the composition of the atmosphere [3].

- **Causes of Climate Change**

The causes are divided into two groups: natural causes and human causes. Some scientist's divide them into two groups of external causes, namely, astronomical and the group of internal causes, namely natural or human, or both [4] [5]:

a) Natural causes include theories:

1. Displacement of continents theory.
2. Volcanic dust theory.
3. Solar Spots theory.

b) Human causes include theories:

1. Carbon dioxide theory.
2. Human dust theory.
3. Air pollution theory.

- **Geographical Distribution of Temperature**

The main features of temperature distribution in summer and winter are [6]:

1. The world's hottest regions for the summer are the tropics, where the average temperature exceeds 30ºC in some areas. Tropical regions are below 25ºC
2. The temperature of the tropics remains high during the winter as in the summer, while the temperature of the tropics falls below 15ºC.
3. Equivalent heat lines are generally parallel to the circuits for special displays during the summer, in the northern half where the effect of overlapping between land and water is less.
4. The temperature generally decreases as we move towards the Polar Regions, and the rate of decline rapidly during the winter and slow during the summer.
5. The coldest places in winter are located in the middle of the continents away from marine influences.
6. There is no counterpart to this extreme heat in the southern half because of the high proportion of water surfaces.

The most important factors affecting the geographical distribution of temperature on the surface of the earth can be summarized as follows [7] [8]:

1. Latitude angle.
2. Distribution of land and water.
3. Terrain.
4. Marine currents.
5. Prevailing winds.
6. Declinational angle.

- **Daily Temperature Path**

The days that are free of the succession of air mass and fronts of the airways are characterized by a regular course of temperature. The temperature starts to rise since the sun rises and continues to rise to the back two hours or more depending on the location of the place and its proximity to the sea. In the afternoon, the temperature will decrease steadily until it reaches its lowest level before the sunrise the next day, as in “Fig. 1”. The daily path of the temperature is a clear reflection of the daily path of the solar radiation that starts from the sun rising, until it reaches its maximum noon time, and then takes the decrease thereafter, until it stops completely at sunset. The day-to-day path of solar radiation and the daily path of temperature are not exactly the same. The daily path of temperature remains too far away from the daily path of solar radiation. Some of the time in marine areas is two hours. The daily temperature trajectory can be explained by the daily path of solar radiation, as the temperature is the result of the thermal balance of the surface of the earth and the air near it.

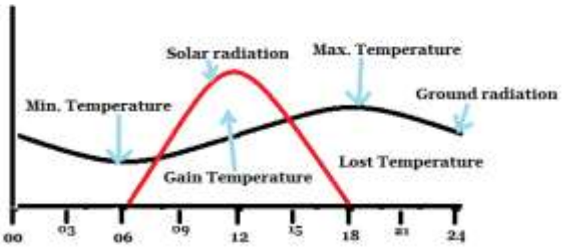


Fig.1: Daily temperature path [9].

- **Daily Fluctuations in Temperature**

The daily path of the temperature does not follow the daily path of solar radiation, especially during the winter. As the control of the weather a number of factors, including the succession of air mass and fronts airways. Therefore, the daily path of the temperature may be completely obscured and instead shows fluctuations in the temperature of one of them or shorten depending on the direction of wind and movement fronts, and so on. In fact, sudden fluctuations in temperature associated with the rotation of air fronts are more pronounced and have a greater impact on human health and activity than the regular daily course of temperature, especially as these fluctuations may be very acute.

- **Annual Temperature Path**

The annual path follows the annual path temperature of solar radiation, as in the daily path, the annual path of temperature remains far behind the annual path of radiation. The length of time in which it is delayed varies depending on whether the area is continental or marine. Ranging from one month or less in continental areas, and nearly two months in marine areas [9].

II. METHODOLOGY

1. **The Statistical Using**

- **Simple Linear Regression (SLR)**

Simple linear regression is the study of the relationship between two variables just to get to the linear relationship (i.e. a straight line equation) between these two variables, a parametric test, which assumes that the data are distributed normally distributed and to find out the gradient value is calculated slope of the regression through the linear equation of the following [10]:

$$\bar{Y} = a + b\bar{X} \quad (1)$$

$$b = \frac{\sum_{i=1}^{n}(X_i - \bar{X}) - (Y_i - \bar{Y})}{\sum_{i=1}^{n}(X_i - \bar{X})^2} \quad (2)$$

http://dx.doi.org/10.22161/ijeab/2.5.3 ISSN: 2456-1878

Where a: Steady decline or part of the cross axis ($\bar{Y}$) to the equation of the straight line (equation 1), b: Slope of the regression and found a slope straight line.

- **Rsqr**

R^2 is the coefficient of determination, the most common measure of how well a regression model describes the data. The closer R2 is to one, the better the independent variables predict the dependent variable.
R^2 equals zero when the values of the independent variable does not allow any prediction of the dependent variables, and equals one when you can perfectly predict the dependent variables from the independent variables [11].

2. The Data Source and Study Stations

Were used the data for monthly averages of temperature from The European Centre for Medium-Range Weather Forecasts (ECMWF) for a period of thirty one years (1982-2012) [12]. Were calculated Temperature values of three different stations Mosul, Baghdad, and Basrah representing the northern, central and southern regions of Iraq respectively, these stations different in terms of climate change, terrain and altitude from sea surface level (see “Fig. 2” and “Table 1”).

Table.1: The latitude, longitude and altitude of the study stations in Iraq [13].

Stations	Latitude (ºN)	Longitude (ºE)	Altitude (meter)
Mosul	36.19	43.09	223
Baghdad	33.14	44.14	34
Basrah	30.34	47.47	2

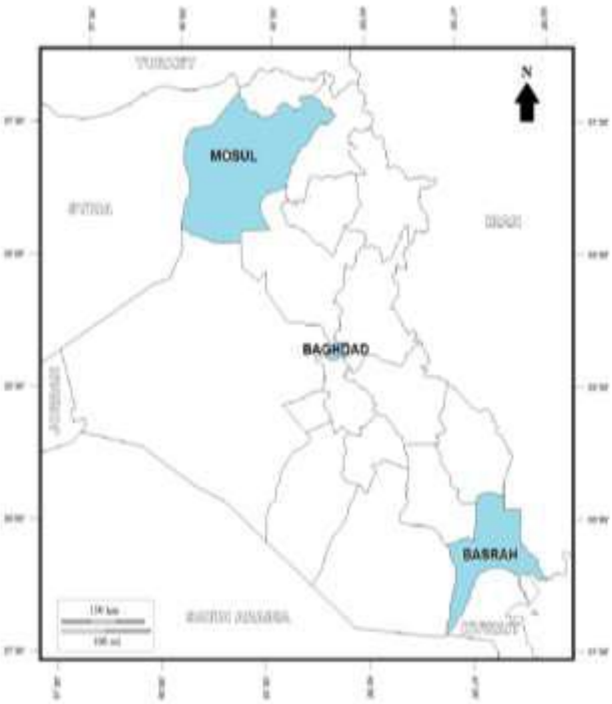


Fig.2: Iraq map, showing stations of the study [14].

III. THE RESULTS AND DISCUSSION

In the “Fig. 3”, which shows the analysis of the monthly average temperature data during the study period (1982-2012) of the Mosul, Baghdad and Basrah study stations, where Mosul station was found to have the lowest temperature followed by Baghdad station and the highest temperature recorded at Basrah station during the study years. The highest temperature was in JUL and AUG and the lowest temperature was in DEC and JAN in all the stations of the study.

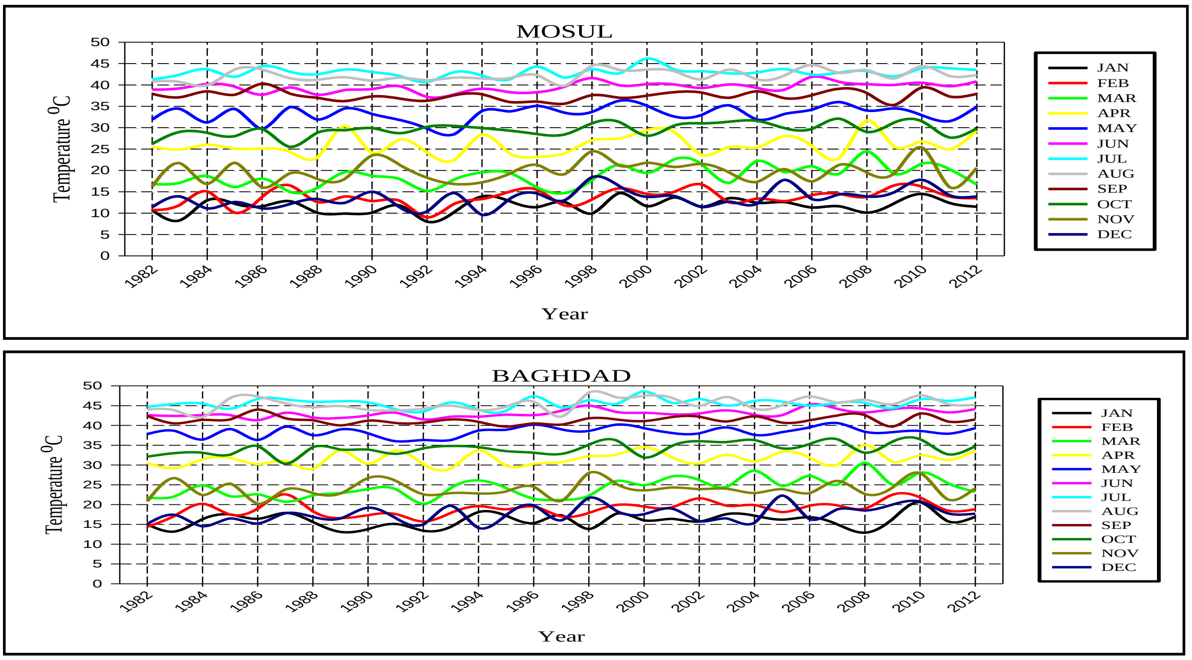
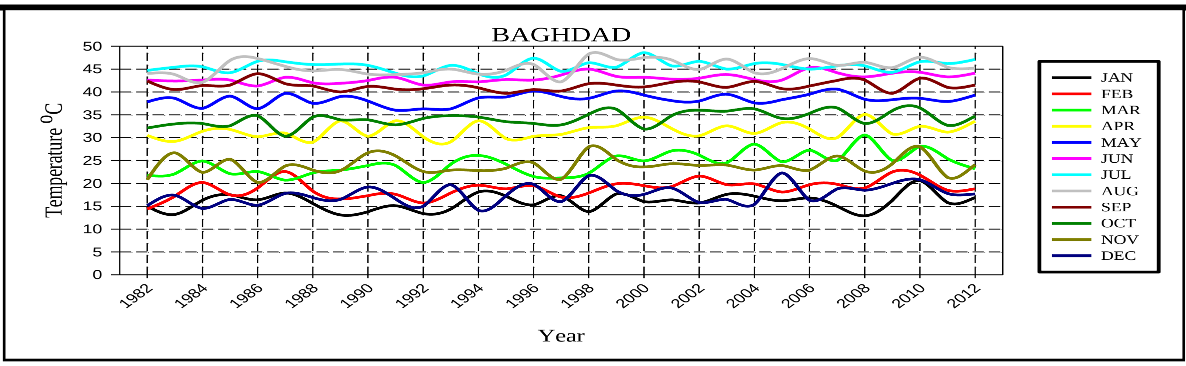


Fig.3: The monthly averages of temperature during the years (1982-2012) for stations (Mosul, Baghdad and Basrah)

http://dx.doi.org/10.22161/ijeab/2.5.3 **ISSN: 2456-1878**



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In the "Fig. 4", which shows the behavior of the monthly average temperature during the period of study one-thirty years (1982-2012) of stations Mosul, Baghdad and Basrah, where found in the Mosul station that the lowest temperature recorded in JAN 11.8°C and highest temperature was recorded in JUL 43°C.

At Baghdad Station, the lowest temperature was recorded in JAN 16°C and the highest temperature recorded in JUL 45.6°C. At Basrah station, the lowest temperature was recorded in JAN 17.9°C and the highest temperature recorded in JUL 46.6°C during the study period.

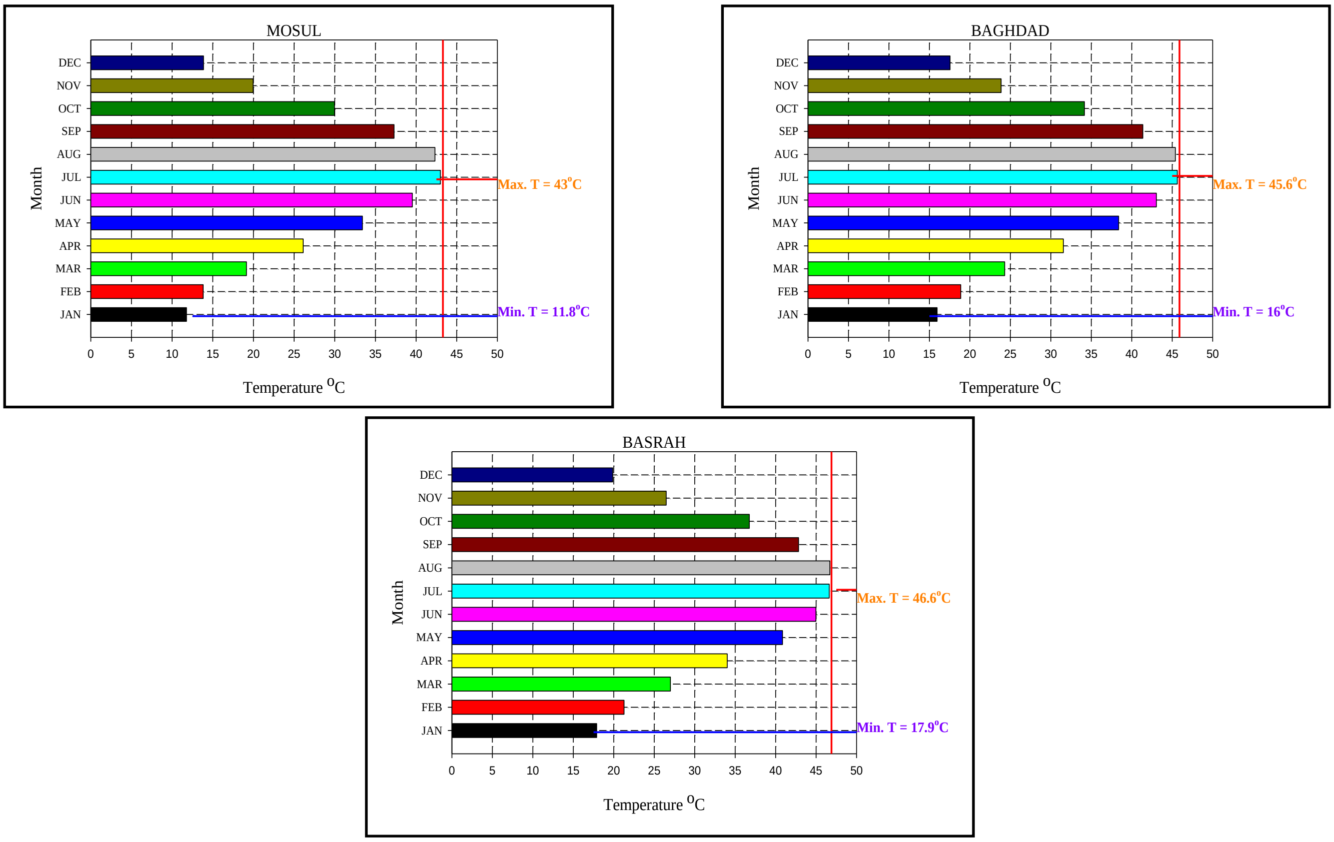

Fig.4: The total monthly average of temperature during one and thirty years from 1982 to 2012 for stations (Mosul, Baghdad and Basrah)

In the "Fig. 5", which shows the behavior of the annual average temperature during the study period one-thirty years (1982-2012) and the study stations Mosul, Baghdad and Basrah where it was found that the lowest temperature recorded in 1992 in all the study stations Mosul, Baghdad and Basrah, 25°C, 29.8°C and 32°C respectively. The highest temperature recorded in 2010 at all study stations Mosul, Baghdad and Basrah, where it was 29.6°C, 34°C and 35.8°C respectively.

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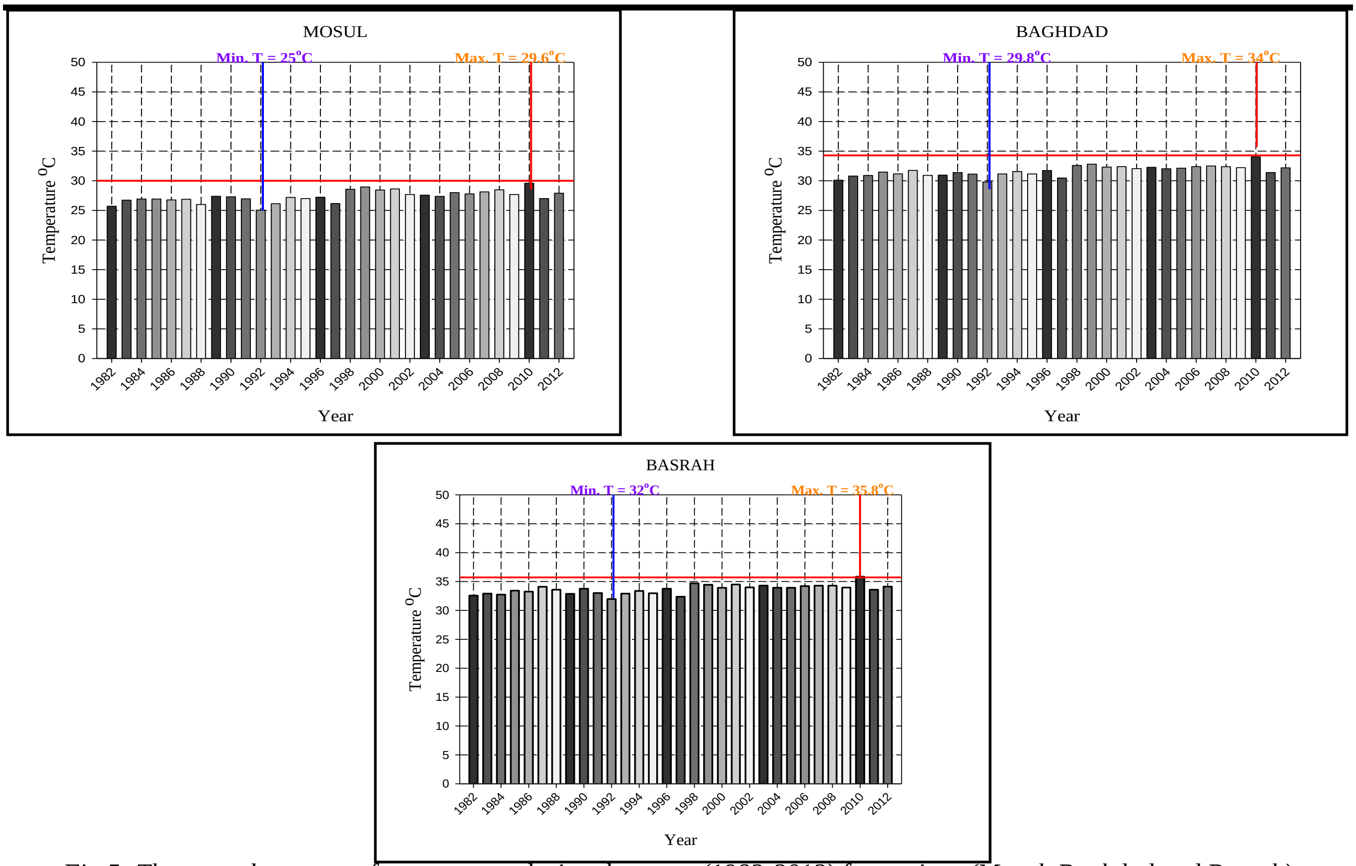


Fig.5: The annual average of temperature during the years (1982-2012) for stations (Mosul, Baghdad and Basrah)

In the "Fig. 6, 7, and 8", showing the temperature during the months of the seasons of the years of study (1982-2012) in stations Mosul, Baghdad and Basrah. The lowest temperature in the seasons was found in winter months (DEC, JAN and FEB) and the highest temperature in the seasons in the summer months (JUN, JUL and AUG), that because winter solstice occurred in 21/DEC and the summer solstice occurred in 21/JUN at all study stations. In spring months (MAR, APR and MAY) and autumn months (SEP, OCT and NOV), temperatures were moderate and varied due to the spring equinox at 21/MAR and the autumnal equinox at 21/SEP at all study stations. The results obtained and the analysis of temperature data showed that there is a high probability of significant climate changes in the study stations in particular and in all regions of Iraq in general in terms of high temperature in MAY of the spring, where temperatures recorded more than 40°C in stations Basrah and Baghdad, as well as recorded a large rise in temperature in SEP of the autumn of more than 42°C in the stations of Basrah and Baghdad, and this indicates the convergence of temperature in these months (MAY and SEP) of temperature in the summer months in the stations of Baghdad and Basrah.

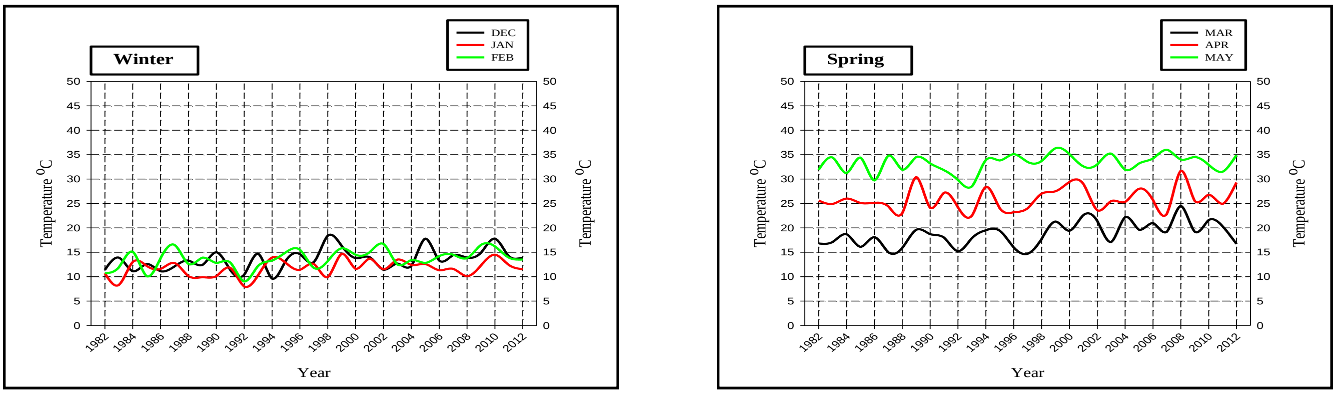
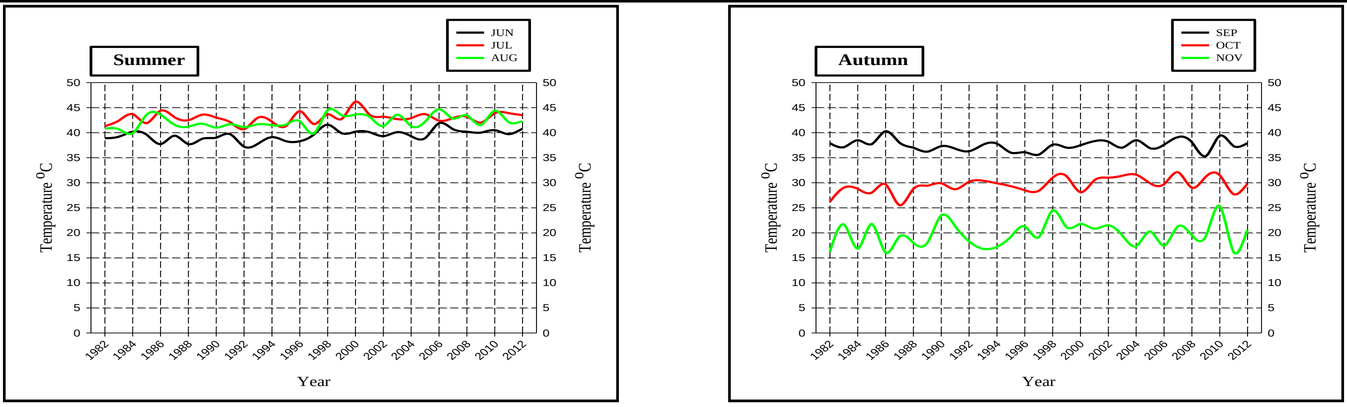


Fig.6: The monthly average of temperature during the seasons for the years (1982-2012) in Mosul station



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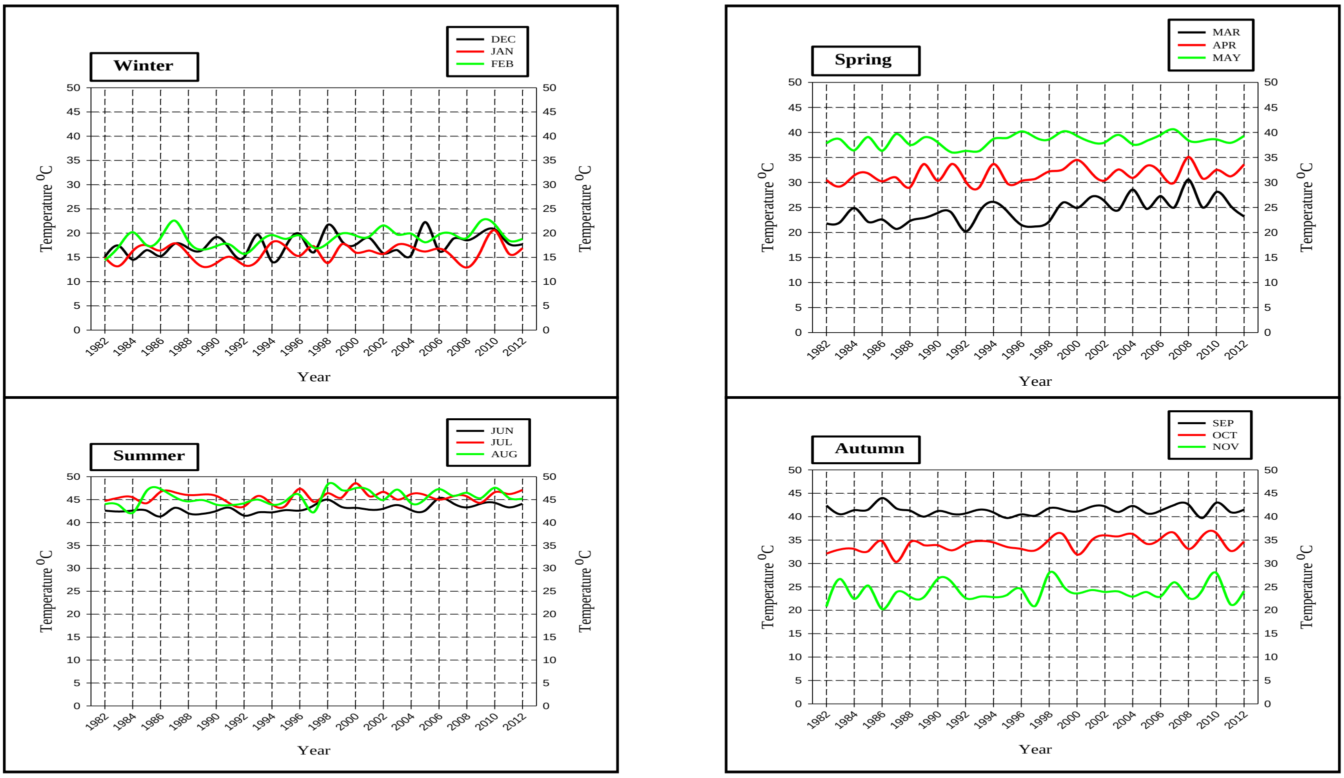

Fig.7: The monthly average of temperature during the seasons for the years (1982-2012) in Baghdad station

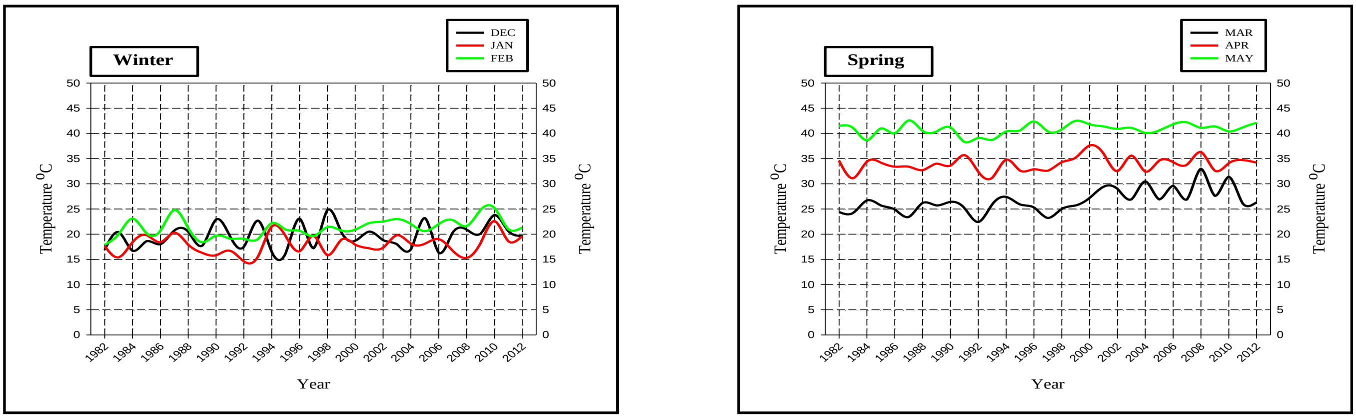

Fig.8: The monthly average of temperature during the seasons for the years (1982-2012) in Basrah station

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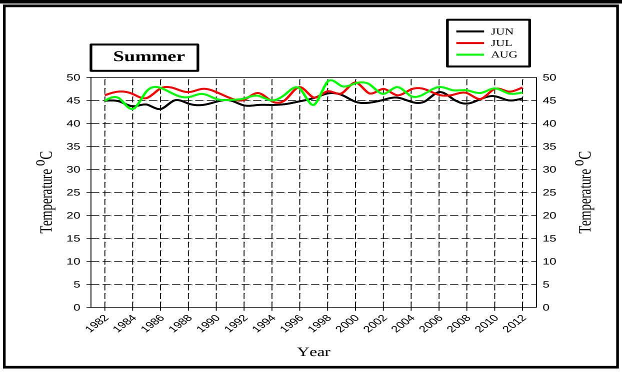
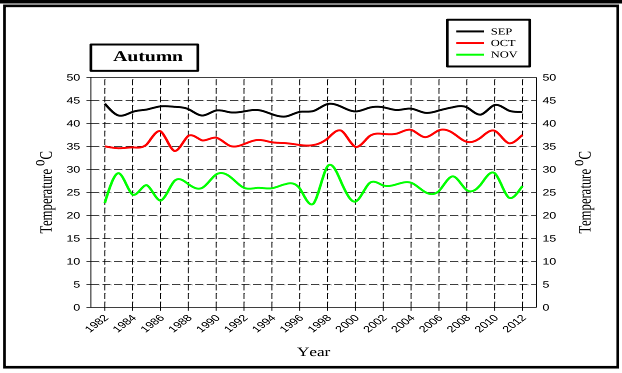
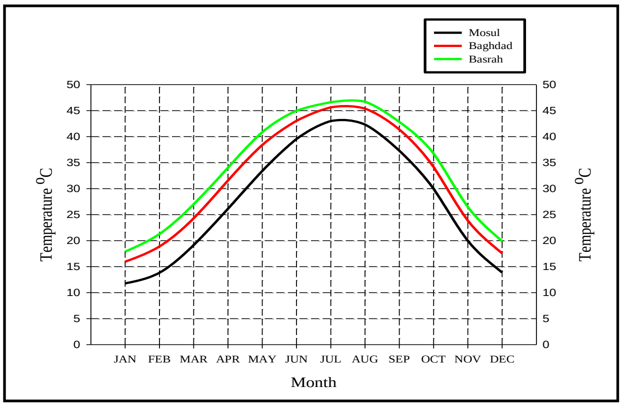




Followed the Fig.8

In the “Fig. 9”, shows a comparison between the monthly and annual average of thirty-one years from 1982 to 2012 for stations Mosul, Baghdad and Basrah. The lowest monthly average of temperature was at Mosul station and the highest monthly average of temperature was at Basrah station, The lowest annual average of temperature was found at the Mosul station (northern Iraq) and the highest annual average of temperature was at the Basrah station (southern Iraq).



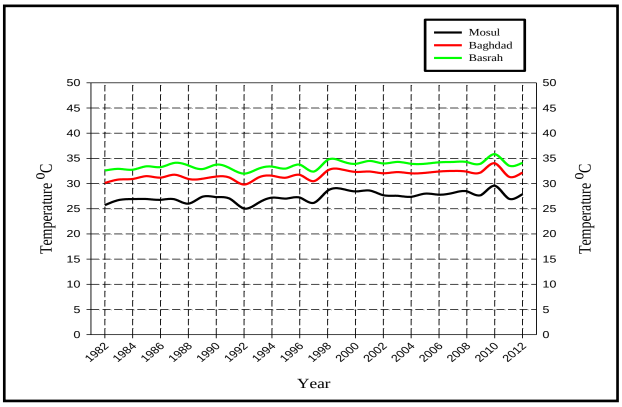
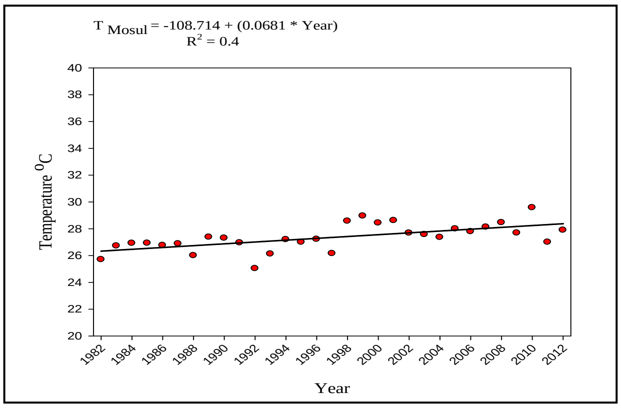


Fig.9: Behavior of the monthly and annual average temperature for the years (1982-2012) for study stations

In the “Fig. 10”, which shows the shape of the positive linear relationship between the temperature average with the years of study from 1982 to 2012 (thirty-one years) where there was a clear increase in temperature over time and for all the study stations Mosul, Baghdad and Basrah and this indicates the existence of climate change in due to the increase in pollutants, the lack of annual rainfall, lack of vegetation and many other factors, which in turn lead to the prediction of future drought, where the Rsqr for Mosul station was (R^2=0.4), Baghdad station was (R^2=0.5) and Basrah station was (R^2=0.4).



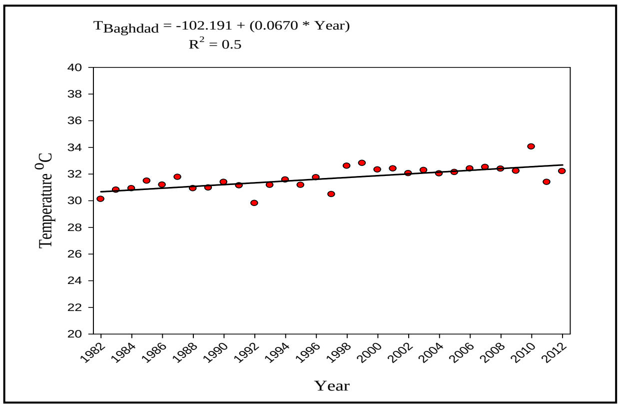


Fig.10: The relationship between the annual averages of temperature with the years (1982-2012) for stations (Mosul, Baghdad and Basrah)

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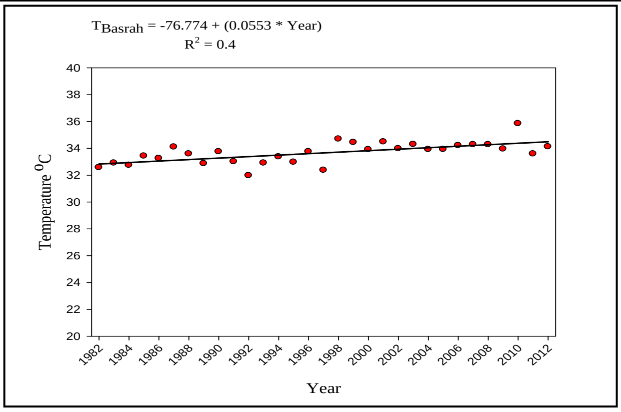

Followed the Fig.10

In the “Fig. 11”, shows the comparison of annual temperature data for three successive decades (1982-1992), (1992-2002), and (2002-2012) for three different stations in Iraq Mosul, Baghdad, and Basrah. Which represent North, Middle and South Iraq, respectively, where it was found that the highest annual average of temperature was in the last decade (2002-2012), where the annual average of temperature to more than 32ºC and the lowest annual average of temperature was higher than 25ºC in the Basrah station. The results have been reached the possibility of dividing study stations into three different climatic regions in terms of change and difference in temperature where it was found that the lowest total annual average of temperature was in the Mosul station was 27.4ºC, the highest total annual average of temperature was in the station of Baghdad was 31.7ºC, and the very highest total annual average of temperature was in the station of Basrah was 33.7ºC, Iraq and the world, where the highest annual average of temperature at Basrah station as shown in “Fig. 12”.

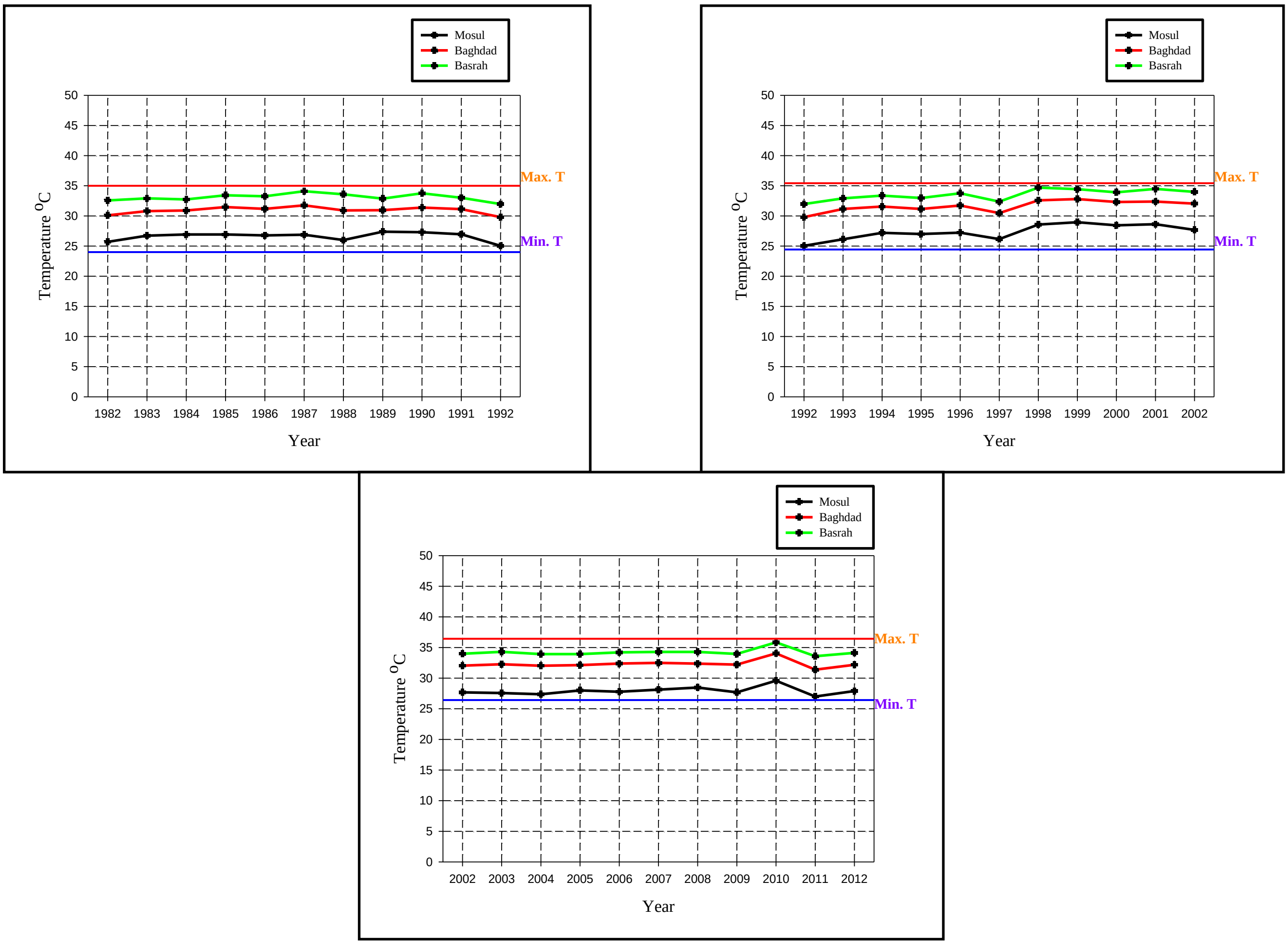

Fig.11: Highest and lowest annual average of temperature for three consecutive decades (1982-1992), (1992-2002) and (2002-2012) for stations (Mosul, Baghdad and Basrah)

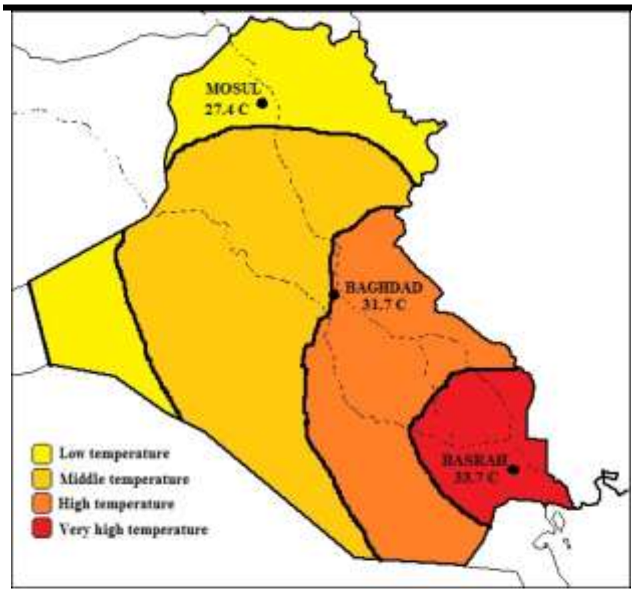

Fig.12: The total annual average of temperature during one and thirty years from 1982 to 2012 for stations (Mosul, Baghdad and Basrah) in Iraq

IV. CONCLUSIONS

- Mosul station is ranked first in the low monthly and annual temperature, followed by Baghdad station and the highest monthly and annual temperature of the station in Basrah.
- The lowest monthly average of temperature in JAN and the highest monthly average of temperature in JUL and all the study stations (Mosul, Baghdad and Basrah).
- The lowest monthly average of temperature at Mosul station was 11.8ºC and the highest monthly average of temperature at Basrah station was 46.6ºC during the study period.
- The lowest annual average of temperature in 1992 and the highest annual average of temperature in 2010 and for all study stations (Mosul, Baghdad, Basrah).
- Recorded the lowest annual average of temperature at Mosul station 25ºC and the highest monthly average of temperature at Basrah station 35.8ºC during the study period.
- The lowest temperature in the seasons was during the winter months and the highest temperature during the summer months and for all stations.
- The lowest annual average of temperature during the decade (1982-1992) and the highest annual average of temperature during the decade (2002-2012) and for all study stations.
- There is a clear increase in the monthly and annual average of temperature during the study years.
- There is a possibility of climate change in the stations of the study because of a clear increase in temperature in MAY of spring and SEP of autumn and the convergence of temperatures from the summer months.
- The possibility of dividing study stations into three climatic regions in terms of differences and variations in total annual average of temperature.
- Predictability of future Drought due to increasing averages temperature in Iraq.

ACKNOWLEDGEMENTS

An acknowledgment to The European Centre for Medium-Range Weather Forecasts (ECMWF) on the data used in this research.

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