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Effect of Increasing Population Density on Air Temperature for Baghdad City

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Abstract

Air temperature is considered one of the important atmosphere elements because of its wide effects on the climate variables and climate system, besides its effects on the human life. This research aims at estimating increasing of air temperature in both of city center and rural side based on increasing of population in city center and more less than rural side. The sources of data come from two stations; the Baghdad International Airport station of the General Authority for Meteorology and Seismic Monitoring, and the station of the Department of Atmospheric Sciences affiliated to the Faculty of Science, University of Mustansiriyah. Supported data are monthly average for mean air temperature. Results showed that there was a strong tendency for a temperature increasing during July and October. The effect of population density on the temperature was clear and significance. Where the difference between the two stations after the addition of the impact for October was 7.4 ^{o}C.

Keywords: Temperatures estimates, population density, Baghdad city, general trend.

الخلاصة

تعتبر درجة حرارة الهواء من العناصر الجوية المهمة بسبب آثارها الواسعة على المتغيرات المناخية وعلى النظام المناخي، إلى جانب آثرها على حياة الإنسان. يهدف هذا البحث الى تقدير زيادة درجة حرارة الهواء في كل من وسط المدينة والجانب الريفي على أساس زيادة عدد السكان في وسط المدينة وزيادة أقل في الجانب الريفي. مصادر البيانات تأتي من محطتين. محطة مطار بغداد الدولي التابعة للهيئة العامة للأرصاد الجوية والرصد الزلزالي، ومحطة قسم علوم الجو الكلية العلوم الجامعة المستنصرية. البيانات المعتمدة هي المتوسط الشهري للمعدل اليومي لدرجة حرارة الهواء. وأظهرت النتائج أن هناك ميلا قويا لزيادة درجة الحرارة خلال شهري تموز وتشرين الاول. كذلك كان تأثير الكثافة السكانية على درجة الحرارة واضحا وكبير. حيث كان الفرق بين المحطتين بعد إضافة التأثير لشهر تشرين الاول 7.4^{o}C.

Introduction

Since the mid-nineteenth century, many studies have examined surface air temperature for both cases variance regional scale. There is an agreement in the literature review that warming has been an obvious phenomenon over recent decades. Specifically, it has been confirmed that over 1880–2012, the globally averaged surface air temperature, as calculated by a linear trend, shown warming of 0.85 °C (0.65–1.06 °C). At the same time, surface warming has been temporally and spatially non-uniform and has accelerated at all latitudes from 1955 onwards [1] .Monthly, seasonal and annual series trends were examined for Tmin, Tmax, and Tmean for Baghdad, Iraq for the period 1941-2000. The most important aspects of the results are a significant increase in Tmax and Tmean during the spring season and a marked drop in temperature every three temperature during the autumn season. It was also eminent that there was a warming period during the 1950's to mid-1960's and a cooling period during the period from mid-1960's to 1980's especially during winter and summer seasons. Further analyses for a longer period of time are needed to see if this cyclic behavior of temperature cooling and warming exists for such period [2].

Methodology and Data

Baghdad Governorate area mean center city and rural side. It has a high population of

approximately 7,665,292 people in 2014, divided into two parts. First urban population: 6,708,853 people and the second are rural population of 956,439 people; the largest percentage of population (87.5%) resides inside the city while the remaining (12.5%) resides in the other areas. Baghdad Governorate area is approximately 4555 Km^2 ,while the area of the city is about 840 Km^2, green space within the city was 19 Km^2 only [3] .This research used two different sources of data: First is site from Baghdad International Airport Station of the Iraqi meteorological organization and seismology, it geographic coordinate latitude is 33° 15` N, longitude is 44° 15` E, supported data are monthly averages for mean air temperature for the period from 1982 to 2015, while the second one is site from Atmospheric sciences department station in Al-Mustansiriyah University, it geographic coordinate latitude is 33° 22` N, longitude is 44° 24` E, supported data are monthly averages for mean air temperature for the period from 2007 to 2015. As a result, the two stations site will be considered the first is Rural station (R) and the second is the Urban station (U) [4], [5][.Iraq is one of the countries which is characterized by relatively high population growth compared to neighboring countries and emphasizes population data during the last decades of the twentieth century that the annual population growth rate of between (2.68% to 3%) [6]. The annual growth rate can account from the following equation [7] :

$$r = \left(\sqrt[n]{\frac{P_1}{P_0}} - 1\right) * 100 \qquad (1)$$

Where:

r is The annual growth rate ,P_1 is Previous the population census, P_o is the next the population census and n is the period between the two censuses.By knowing the growth rate, we can find a census for other years, from the following equation:

$$P_1 = P_0 * (1 + r)^n \qquad (2)$$

The population growth rate, which was adopted by the Ministry of Planning to estimate the population of the city of Baghdad for the coming years was 3%. Population density has an effective impact in increasing the temperature of urban, through the activities carried out by the human. The cities heat is also related to the size of the city. Using population (P) as a surrogate of city size, ΔT_{u-r} is found to be proportional to log P, in the 'ideal' case with calm winds and cloudless skies [8]. Heat Difference between city and rural not occurs only for big cities but also for towns. Oke had a formula for the warming that is tied to population; found that the UHI (in °C) increases according to the formula [9]:

$$UHI = 0.73 \log_{10} P \qquad (3)$$

Where: UHI is urban heat island ,P is population.

Trends of Surface Air Temperature can be calculated from the straight line equation; it is usually written this way [10]:

$$y = mx + b \qquad (4)$$

Where: y ,x are values and m is slope ,b is the y intercept where the line crosses the y axi1fs.

The slope of a linear function (m) is the proportionality constant between Δx and Δy. That is the fraction:

$$m = \frac{\Delta y}{\Delta x} \qquad (5)$$

Where m is slope ,Δy is The difference between the values of y and Δ*x* The difference between the values of *x* .

In the case of the difference in the value of *x* is equal to zero, the slope equation for a linear function as follows:

$$m = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \qquad (6)$$

Where: x_i is the value of x ,y_i is the value of y, $\bar{x}$ is Average values of x and $\bar{y}$ is average values of y .

Results and Discussion

Data were obtained to both the airport and the Al-Mustansiriyah station; the shared data were for the years 2007 to 2015. To obtain continuous series to surface air temperature for Al-Mustansiriyah station during the past 33 years, Sigma plot program used to analyze the shared data by linear regression way and find a relationship between the shared data, and equations that were obtained are illustrated in Table 1.

Table 1:Relationship between airport and Mustansiriyah station data.

Type	Months	Equations
Tmean ^{o}C	January	TU = 0.264 + (1.087 * TR)
	April	TU = -1.001 + (1.098 * TR)
	July	TU = 3.100 + (0.964 * TR)
	October	TU = 0.454 + (1.060 * TR)

Where T_U is the Urban temperature (Al-Mustansiriyah station) ^{o}C and T_R is Rural Temperature (Airport station) ^{o}C.
Then applying equations in Table (1) on the airport station data for the years 1980-2006, to get the estimated data for the station Mustansiriyah for the years 1980-2006. The result was a time series from 1982 to 2015 for each airport station and Mustansiriyah station. Then draw the fit line to find the general direction of the temperature. The variance of mean air temperature was increased since 1982 until 2015. The best fit lines show obvious monthly variance. The fit line inclination for mean air temperatures of the station airport during January increased from (8.23 $^{\circ}$C) in 1980 to (10.34 $^{\circ}$C) in 2015, as shown in Figure 1(a), as for the Mustansiriyah station, there was a rise during January from (10.0 $^{\circ}$C) in 1980 to (11.6 $^{\circ}$C) in 2015, as shown in Figure 1 (b). During April, the fit line inclination for mean air temperatures of the station airport increased from (22.4 $^{\circ}$C) in 1980 to (24.04 $^{\circ}$C) in 2015, as shown in figure (2. a), as for the Mustansiriyah station, there was a rise during April from (23.55 $^{\circ}$C) in 1980 to (25.42 $^{\circ}$C) in 2015, as shown in Figure 2 (b).

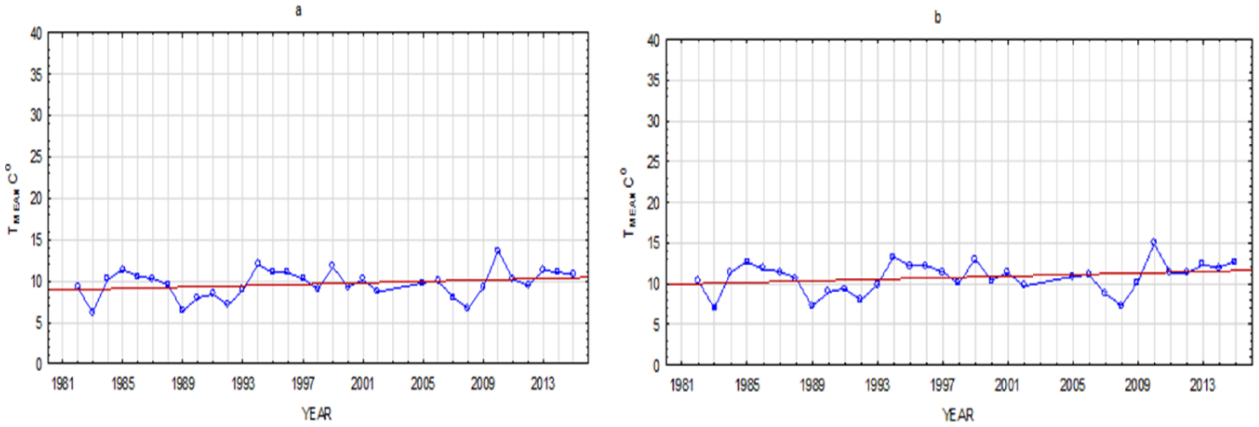

Figure 1: Mean annual variation of mean air temperature for January (a) airport station (b) Mustansiriyah station .

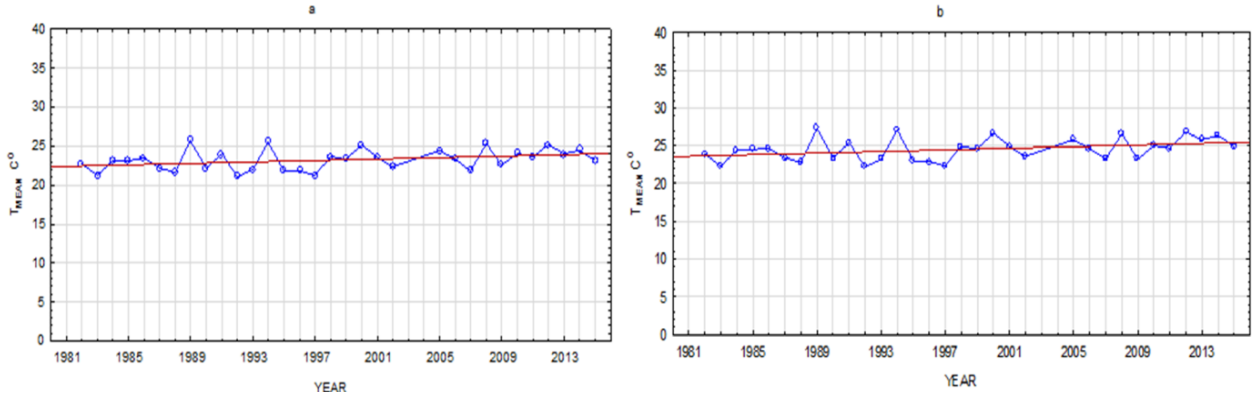

Figure 2: Mean annual variation of mean air temperature for April (a) airport station (b) Mustansiriyah station.

The fit line inclination for mean air temperatures of the station airport during July increased from (34.14 $^{\circ}$C) in 1980 to (36.54 $^{\circ}$C) in 2015, as shown in Figure 3(a), as for the Mustansiriyah station, there was a rise during July from (36.01 $^{\circ}$C) in 1980 to (38.41 $^{\circ}$C) in 2015, as shown in figure (3. b). The fit line inclination for mean air temperatures of the station airport during October increased from (23.75 $^{\circ}$C) in 1980 to (25.78 $^{\circ}$C) in 2015, as shown in Figure 4(a), as for the Mustansiriyah station, there was a rise during October from

(25.30 °C) in 1980 to (27.87 °C) in 2015, as shown in Figure 4(b).

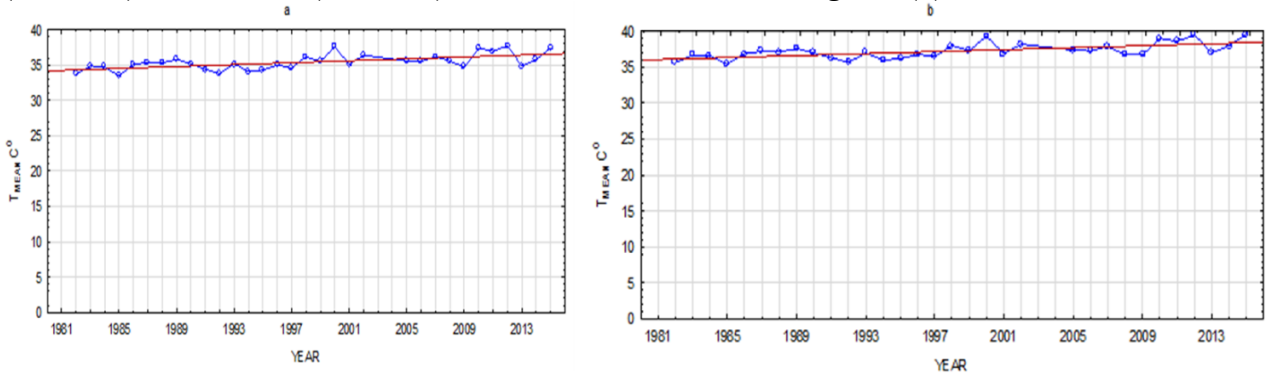

Figure 3: Mean annual variation of mean air temperature for July (a) airport station (b) Mustansiriyah station.

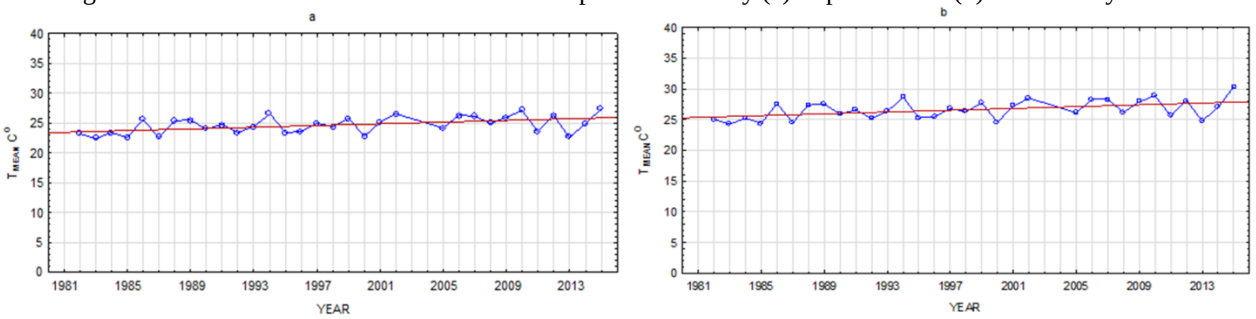

Figure 4: Mean annual variation of mean air temperature for October (a) airport station (b) Mustansiriyah station.

Through previous formats, especially the Fit line, note that the line tends upward this inclination varies from one month to another and from station to station. The straight line equation account for the fit line, using equation 6 and (4 or calculated by the program Statistics, the equations represented the fitting line inclination. Where note that the highest slope was in October for Al-Mustansiriyah station, it reached 0.0734.

Table 2: Equations to estimate the surface air temperature for next years.

Temp. °C	Months	Airport station	Al-Mustansiriyah station
T_{mean}	January	T = 0.0433 x - 76.909	T = 0.0479 x – 84.876
	April	T = 0.0471 x - 70.862	T = 0.0535 x - 82.385
	July	T = 0.0685 x - 101.49	T = 0.0686 x - 99.816
	October	T = 0.0678 x - 110.84	T = 0.0734 x - 120.03

Where: T is Estimate of temperature (°C) and x is the years.

The equations are shown in Table 2 used to estimateA of temperature for future years to both two stations, imposition was not get an increase in population density and not change green space areas. The highest increase of the airport station for 2020 to 2050 for the mean air temperature was 2.1°C in October, while the station Al-Mustansiriyah increased for October 2.2 °C, Tables 3 and 4 illustrates that.

Table 3: Estimate of mean air temperature (°C) for Airport station

Month	2020	2025	2030	2035	2040	2045	2050
Jan	10.6	10.8	11.0	11.2	11.4	11.6	11.9
April	24.3	24.5	24.8	25.0	25.2	25. 5	25.7
July	36.9	37.2	37.6	37.9	38.3	38.6	38.9
October	26.1	26. 5	26.8	27.1	27.5	27.8	28.2

Table 4: Estimate of mean air temperature (^{o}C) for Al-Mustansiriyah station

Month	2020	2025	2030	2035	2040	2045	2050
Jan	11.9	12.1	12.4	12.6	12.8	13.1	13.3
April	25.7	26.0	26.2	26. 5	26.8	27.0	27.3
July	38.8	39.1	39.4	39.8	40.1	40.5	40.8
October	28.2	28.6	29.0	29.3	29.7	30.1	30.4

$$T_{UP} = 0.73 \log_{10} P + T_U \qquad (7)$$

Where T_{UP} is the temperature of urban depending on population density ^{o}C, P is the population density and T_U is the estimated temperature of urban ^{o}C.

Add the impact on mean air temperatures urban. The difference in the mean air temperature between the city center and its rural become greater when adding the effect of population density. Where the difference average for mean air temperatures in January was 6.7^{o}C, in April was 6.7^{o}C, in July was 7.0^{o}C and October was 7.4^{o}C, Figures 5,6,7 and 8 showed that.

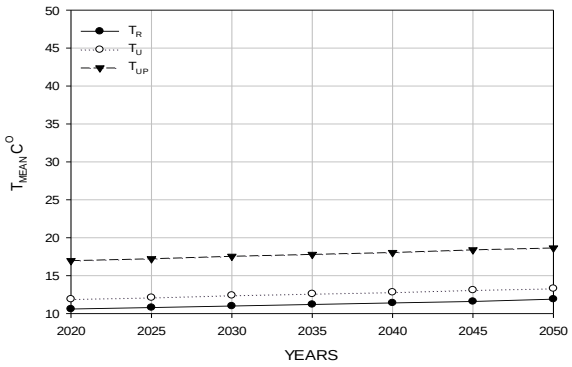

Figure 5: Difference of estimated mean air temperature between airport station and Al-Mustansiriyah station for January.

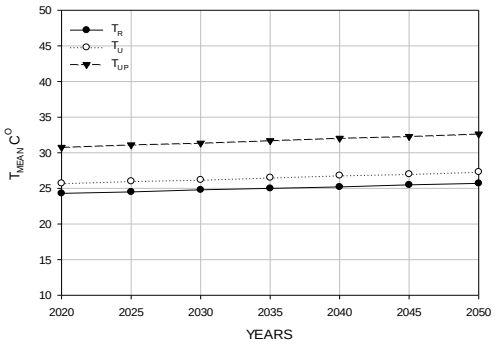

Figure 6: Difference of estimated mean air temperature between airport station and Al-Mustansiriyah station for April.

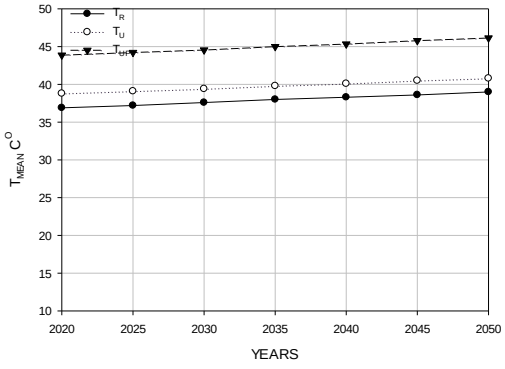

Figure 7: Difference of estimated mean air temperature between airport station and Al-Mustansiriyah station for July.

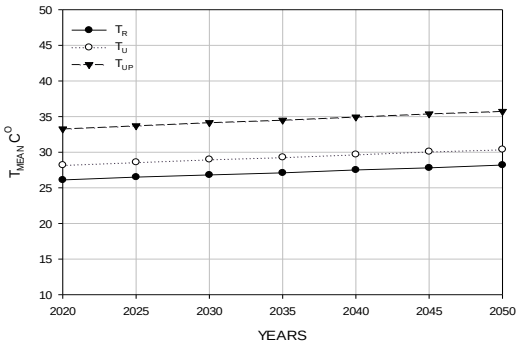

Figure 8: Difference of estimated mean air temperature between airport station and Al-Mustansiriyah station for October.

Conclusions

The study and analysis undertaken have revealed a number of observations and findings: The behavior of air temperature for Baghdad City was tended to increase although annual variance around average. Mean air temperature was tending more for October. The difference in the mean air temperature between the city center and its rural become greater when adding the effect of population density.

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