

Trend Analysis of Annual Surface Air Temperature for Some Stations over Iraq

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ABSTRACT

Surface Air Temperature (SAT) is an important weather element affecting the climate and its nature, as it greatly affects the nature of the atmosphere prevailing in the city of Baghdad, as well as the main influence on the pressure systems affecting Iraq and thus the city of Baghdad. In this study, the annual SAT for three aspects of temperatures (mean, maximum, and minimum) for Baghdad city of approved 11 years had studied, analyzed and discussed. The sources of data came from two sources. First, Iraqi Meteorological Organization and Seismology (IMOS), which represented the arithmetic average annually of the SAT, maximum and minimum temperature for the period (2009 – 2019). Second source of data was from Mustansiriyah University, atmospheric sciences department of Atmospheric Sciences - college of Science, the data are supported as monthly average for SAT for Baghdad. Results shown Basrah was high annual of SAT than four selective cities in Iraq. The variation of annual SAT was in the end study period where reach to 7 oC in mean of SAT for Basrah city. The trend of SAT for Baghdad city was positive for Mean and maximum, while negative for minimum case. Mustansiriyah station was high than IMOS station by 2 °C for mean of SAT, and 5 °C for maximum SAT.

KEYWORDS: Trend, Surface air temperature, Iraq.

الخلاصة

ان درجة حرارة الهواء السطحي (SAT) هي عنصر مناخي مهم يؤثر على المناخ وطبيعته، حيث يؤثر بشكل كبير على طبيعة الغلاف الجوي في مدينة بغداد، وكذلك يؤثر على الانظمة الاساسية والتي تؤثر على انظمة الضغط في العراق وبالتالي مدينة بغداد ايضاً. في هذه الدراسة، تم تحليل ومناقشة درجة حرارة الهواء السطحي السنوي لثلاثة انواع من درجات الحرارة (المتوسطة، ودرجة الحرارة العظمى، ودرجة الحرارة الصغرى) لمدينة بغداد لمدة 11 عاماً. ن مصدر البيانات من مصدرين الاول هو الهيئة العامة للانواء الجوية والرصد الزلزالي العراقية (IMOS) والتي من خلالها تم حساب المتوسط الحسابي السنوي لدرجة حرارة الهواء السطحي ودرجات الحرارة العظمى والصغرى للفترة (2009-2019). المصدر الثاني للبيانات من محطة الجامعة المستنصرية، قسم علوم الجو- لكلية العلوم، البيانات للحصول على المتوسط الشهري لدرجة حرارة الهواء السطحي لبغداد. أظهرت النتائج أن درجة حرارة الهواء السطحي في البصرة كانت اعلى من درجة حرارة الهواء السطحي لاربع مدن مختارة في العراق. وكان التباين لدرجة حرارة الهواء السطحي السنوي في نهاية فترة الدراسة حيث وصلت إلى 7 درجات مئوية بمتوسط درجة حرارة الهواء السطحي لمدينة البصرة. كان اتجاه درجة حرارة الهواء السطحي لمدينة بغداد إيجابياً لمتوسط درجة الحرارة ودرجة الحرارة العظمى، بينما كان سالباً لدرجة الحرارة الصغرى. وأظهرت النتائج ان محطة المستنصرية هي أعلى من بيانات محطة الهيئة العامة للانواء الجوية والرصد الزلزالي العراقية بمقدار درجتين مئويتين بالنسبة لمتوسط درجة حرارة الهواء السطحي، و 5 درجات مئوية بالنسبة لدرجة الحرارة العظمى للهواء السطحي.

INTRODUCTION

Climate change is a global challenge issue for whole world [1]. Air temperature is the most important variables to atmospheric sciences, which can be used to understand the climate of a region and assess the effects of climate change [2].

Climate variability particularly that of the annual air temperature studied for period of 1980–2017 for many stats in India. The spatiotemporal dynamics of meteorological variables in the context of changing climate. The results of SAT showed a

slight warming (increasing STA trend (Sen's slope= 0.29) while the minimum temperature trend showed a cooling trend, increasing trend [3]. The Variation of daily maximum and minimum temperatures in summer for Baghdad city for 43 years analyzed. The results showed that the general trend of temperatures had increased with time in spite of variation in these verges. The maximum and minimum temperatures anomalies showed high increased was 4°C for the minimum temperatures, while was 2°C for the maximum temperatures [4]. The Land surface air temperature

investigated by using the spatial-temporally multidimensional ensemble empirical mode decomposition method. The results found that the noticeable warming (>0.5 K) started sporadically over the global land and accelerated until around 1980. Both the warming rate and spatial structure have changed little since. The fastest warming in recent decades (>0.4 K per decade) occurred in northern mid-latitudes [5]. The inter-annual variability of the SAT is stronger during winters. Analysis reveals was increased in the SAT anomaly (0.10 C/decade) across the Arabian Peninsula, consistently with the global temperature anomalies. Besides the local convective heating, summer SAT variability is associated with the weakening of the Asian jet stream and a Rossby wave train from the Indian Ocean. This variability is also influenced by the anomalous low pressure over the North Atlantic and the Sahara, a high-pressure system over Siberia and the northwest Pacific. Whereas winter SATs are modulated by the subtropical jet stream and the Middle East jet stream [6].

The impact of extreme air temperature for temporal and spatial weather in Iraq. Extreme air temperature that exceed 50 °C based on maximum temperature. The results refer to nine events of extreme cases, one in the beginning of summer, one event in the end of the season, and seven events in middle of seasons. Then found the relation between extreme air temperature with geographical and trajectory of the recipes of pressure pattern [7]. Analyze temperature anomaly events for seven centuries of countries in the Southeast Asia. The correlation analysis was found that temperature variability patterns in Thailand, Myanmar, and Cambodia are moderately correlated to each other, while temperature variation patterns for Malaysia do not correlate. The temperature anomaly of Thailand performance of each model had been assessed and the results reveal that the chi-squared automatic interaction detection, was the best one with 0.624 correlation coefficient and relative error was 0.611 [8]. Monthly Mean surface air temperature at 23 stations in Iraq for 35 years. The analysis method that used was Mann-Kendall test to detect the trend of air temperature. The results refer to the tendency was towards warmer years, especially was warmer in summer. Seasonal and annual temperature was the highest increase is (3.5) °C in Basrah during the summer. The tendency of temperature was in the south and decreasing

towards north, where the trend of spatial temperature was decreasing from south to the north in all the four seasons [9]. Chinese study, used innovative trend analysis (ITA) to investigate the trend in air temperature over the Jinsha River Basin (JRB), from 1961 to 2016. The ITA results shown that annual and seasonal temperatures have significantly increased whereas the variation range of annual temperature tended to narrow. Spatial pattern analysis of the temperature indicates that high elevation areas show more increasing trends than flat areas. The results suitable for future water resources planning and this would help advance the understanding of climate change in many areas in this world [10].

This study investigates the dominant model of SAT variation and associated circulation change over Baghdad. The present work deal with two themes. The first focuses on the annual STA variation for three cases (Mean, Maximum, and Minimum). The second is the comparison between Mustansiriyah station and IMOS for SAT for all studied cases. The objective study to understand the behavior of STA where it has an important impact on life style, agriculture, and climate change.

DATASETS SOURCE

The study region is Iraq, represented by four major cities, (Baghdad, Basrah, Mosul, and Rutbah) were chosen for this research (Central, South, North, and West) of Iraq for the period from (2009-2019). The Baghdad city is the capital and the middle administrative center of Iraq, situated in the central part of Iraq on both sides of the Tigris River with coordinated $33^{\circ} 20''$ N $44^{\circ} 23''$ E 34 m above sea level as illustrated in Figure 1. The population of Baghdad is about 7.8 million, making it the largest city in Iraq according to the last estimations of the ministry of planning. Baghdad climate characterized by semi-arid, subtropical and continental climates. Hot and long dry summers, cold winters and short springs. The maximum summer temperature was 51°C , while the minimum temperature was -4°C . The maximum average temperature for the last 30 years was 30.8 °C; the average minimum temperature for the same period was 15.5 °C [9].

This work was investigated with climatic data, where are annual SAT (mean, Maximum, and Minim), from two different sources. First, Iraqi Meteorological Organization and Seismology

(IMOS) for Four major meteorological stations as shown in Table 1 [9].

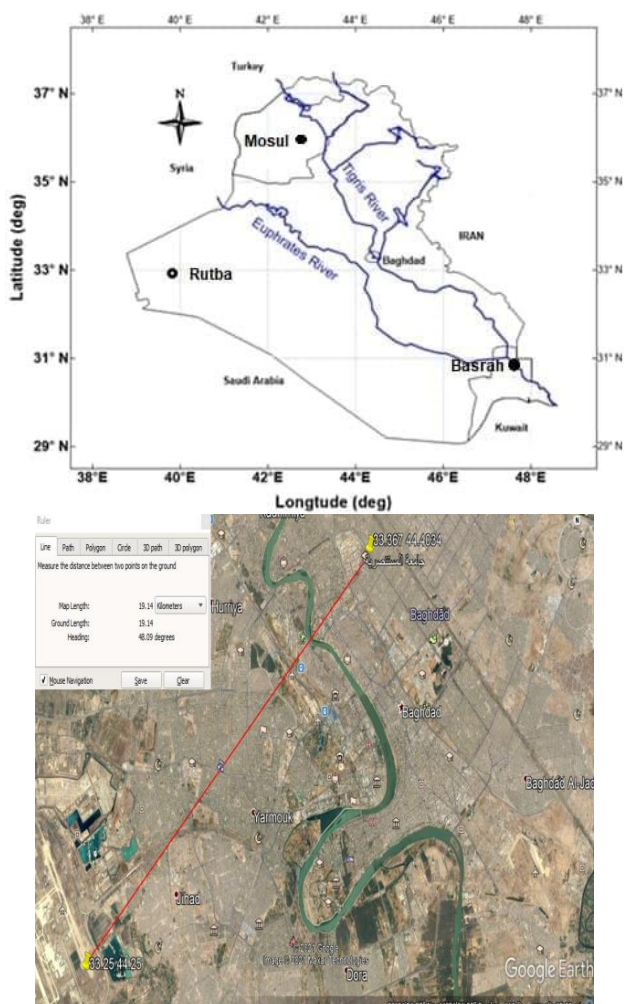


Figure 1. Study area; Iraqi map (upper), Baghdad (lower).

Table 1. Meteorological stations that used in the study

Study Station	Longitude degree	Latitude degree	Elevations (m)
Mosul	43.2	36.3	223.5
Baghdad	44.5	33.3	31.7
Rutba	40.3	33.6	30.8
Basrah	47.5	30.5	2.4

Second source of datasets was from, Mustansiriyah university, atmospheric sciences station for same period for IMOS (2009-2019). The geographic coordinate latitude is 33° 22' N, longitude is 44° 24' E, supported data are monthly averages for SAT for the same period of IMOS. The distance between IMOS station and Atmospheric sciences is 19.14 km, obviously the two stations site will be considered the first is Rural station and the second is the Urban station [11].

RESULTS AND DISCUSSION

The annual SAT for four major cities in Iraq to find out that Basrah had high mean SAT trend than Baghdad and low value were in both Mosul and Rutba. The latitude plays significant role on SAT where high mean SAT reach to 30 °C in 2016. As shown clearly Figure 2, the variation of mean SAT had low value especially for (2009 – 2014), while second period (2015 -2019) shows high variation where amplitude was 7 °C Basrah 2017-2018, this consider a pattern of extreme annual climatic variation. Mosul and Rutbah had same level of mean SAT and variation although each city has different latitude and nature of the earth surface.

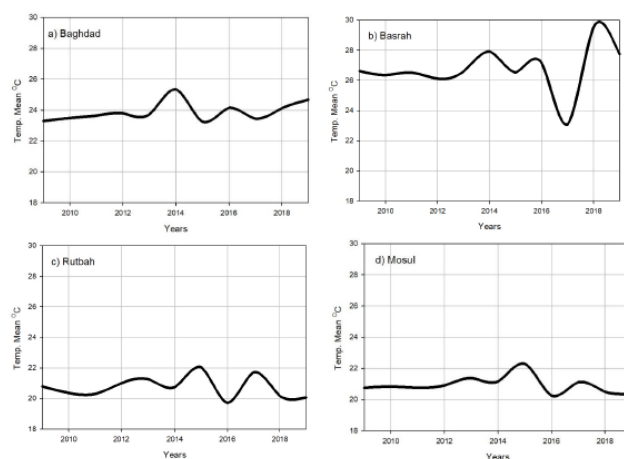


Figure 2. Annual mean surface air temperature for a) Baghdad, b) Basrah, c) Rutbah, d) Mosul.

The annual maximum of SAT as shown in Figure 3, Basrah presented high value, while Baghdad show medium level of SAT, and other cities had low value. The variation was found in second period reach to 5 °C during 2014 -2016, however first period closely to straight line.

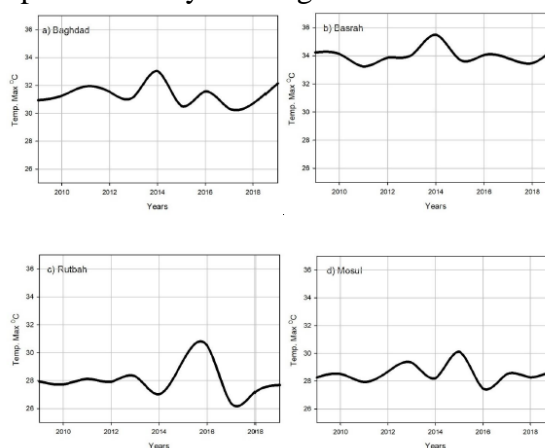


Figure 3. Annual maximum surface air temperature for a) Baghdad, b) Basrah, c) Rutbah, d) Mosul.

The annual minimum of SAT shown low value than mean and maximum, but still Basrah higher value among other cities, where average different from Baghdad was 4 °C, and 6 °C from Mosul and Rutbah. The wave’s behavior was found coherent with another city. The average variation was around 2 °C for all selected cities as shown in Figure 4.

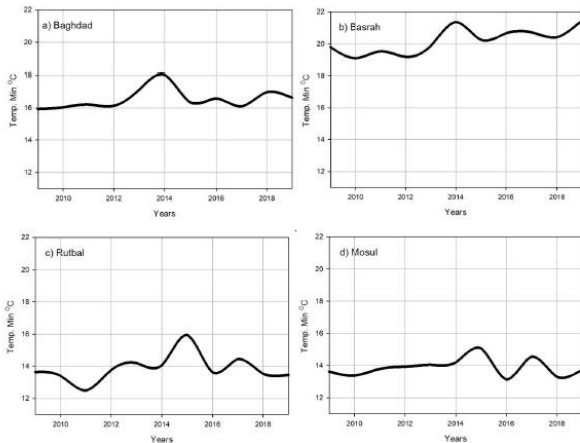


Figure 4. Annual minimum surface air temperature for a) Baghdad, b) Basrah, c) Rutbah, d) Mosul.

The variation among three cases of annual SAT show the annual maximum SAT had high value than mean and minimum, and Basrah city had high annual SAT than other cities among these cases as shown in table 2. The different between Basrah and Baghdad was 4 °C in minimum of SAT, where were 2 °C in mean and maximum case. Mosul and Rutbah had same value of SAT for all cases, but high different from Basrah where was 6 °C in minimum case and 5 °C for mean and maximum case.

Table 2. The average of annual SAT for three cases (Mean, Max., and Min.) among four cities in Iraq.

Cities	Mean °C	Max. °C	Min. °C
Basrah	26	34	20
Baghdad	24	32	16
Mosul	21	28	14
Rutbah	21	28	14

The annual SAT was high variation among study period, beside its shown high different of SAT from city to another. In this section focused on the way of acting annual SAT for two station in Baghdad city. First station called Mustansiriyah according to its location in Mustansiriyah University that placed at the center city. Second station is IMOS station that represented outskirts of Baghdad is a rural area (agricultural area). The distance between these stations is 19.14 Km, for this, want to compare between the annual of SAT of these stations.

The annual mean of SAT for these stations appear same propagation, but Mustansiriyah station was high value than IMOS station by 2 °C as shown in Figure 5.

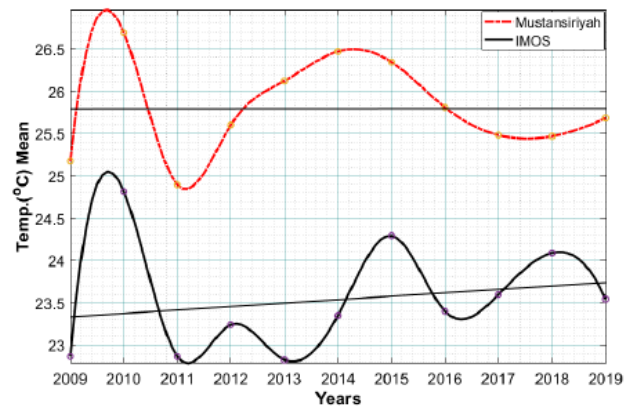


Figure 5. Trend of annual mean of SAT, Mustansiriyah station (red line), and IMOS (black line).

The annual maximum of SAT show approximately same wave, with high value of SAT for Mustansiriyah station (the peak wave reach to 38 °C), where the peak value of IMOS was 32.8 °C as shown in Figure 6. The average different between these station curves (Δ SAT) was 5 °C. The slope of fitting line was 0.25.

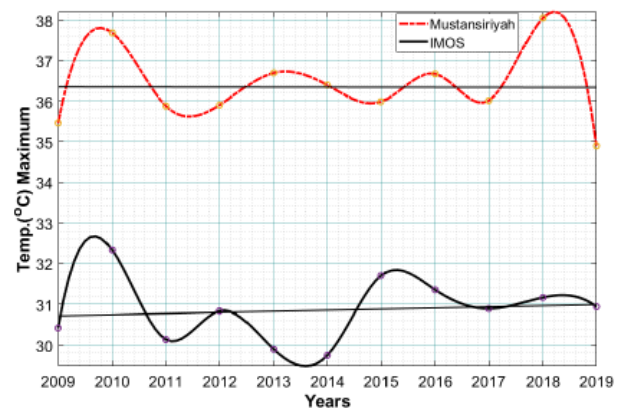


Figure 6. Trend of annual maximum of SAT, Mustansiriyah station (red line), and IMOS (black line).

The Figure 7, represent annual minimum of SAT, that shown different behaviour after 2013 where the value was very near to another, and it was opposite case for period (2009 -2012) that IMOS was high than Mustansiriyah station was reach to 17.5 °C, while 16.3 °C in 2010. The slop fitting line was shown negative value for IMOS, while positive for Mustansiriyah station (1.5).

The annual SAT for Mustansiriyah station and IMOS shows same behavior where the vegetation decreased of SAT, where the different between these stations, 2 °C for mean case, and 5 °C for maximum case. The slope fitting line for both mean and maximum case were positive (0.5, and 0.25) respectively. Unlike the mean, the maximum and minimum cases show the IMOS was higher than the station of Mustansiriyah in period (2009 – 2012) and the opposite case for (2013 -2019) are showing very closely curve.

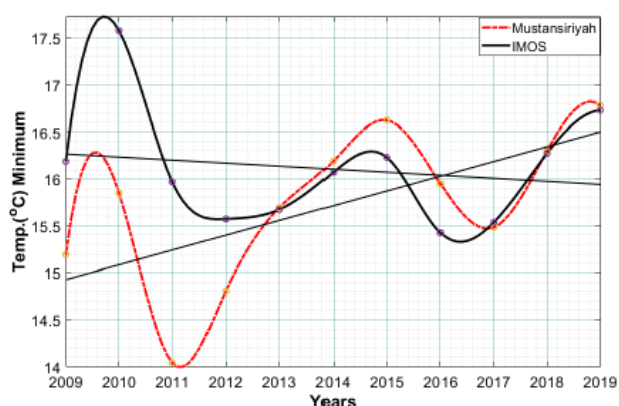


Figure 7. Trend of annual minimum of SAT, Mustansiriyah station (red line), and IMOS (black line).

Table 3. The average of annual SAT for three cases (Mean, Max., and Min.) among Four cities in Iraq.

Case of SAT	Slope	Δ SAT °C
Mean of SAT	0.5	2
Maximum of SAT	0.25	5
Minimum of SAT	1.5	2

CONCLUSIONS

The annual of SAT for four major cities in Iraq shown interesting results main of these mention it in this section. Annual SAT for Basrah was high temperature among four cities and for three cases (mean, maximum, and minimum), then Baghdad come in the second level that explain the sensitivity of SAT toward latitude. Mosul and Rutbah were low temperature even have different analysis; where Mosul is high latitude and Rutbah is located in open and rural area. The variation of SAT during in (2015 – 2019) more than first period, where high amplitude was 7 °C for Basra in annual mean SAT. The behavior of annual of SAT was take same wave during study pored for Baghdad. For this reason, focused on two station in Baghdad to compare between them for SAT aspect. The

different of average curve for Mustansiriyah station and IMOS was 2 °C, while for annual maximum of SAT was 5 °C, while minimum of SAT shown opposite case. The slope of fitting line for annual mean of SAT was 0.5, while for maximum case was 0.25. Annual minimum of SAT divided into period with different wave. First period (2009-2012) exhibit IMOS station high than Mustansiriyah by 2 °C, with negative slope of average curve was 1.5.

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