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Geo-statistical analysis for the natural conditions of temperature in Iraq

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Temperatures degree, Change Climate, ARIMA models, Kruskal-Wallis test, tseries package.

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Abstract: This paper will examine temperatures in Iraq and in five different cites (Baghdad, Mosul, Basra, Rutba and Sulaimaniyah) as they are geographically distributed throughout the Iraq country. Their effects on natural conditions by using statistical methods for climate to study the significant differences in the aforementioned regions in addition to study the stationary of the time series or not for temperatures and rainfall amounts and study the historical movements of climate change and activity, as well as the current debates surrounding global warming. And forecasting temperatures from the year (2018-2020) and on a monthly basis from the by using ARIMA models for each city and compare among them by nonparametric test Kruskal Wallis and by relying on the packages and functions of the R programming language. We will also examine the four data sets that we mentioned earlier, with attention to the severity and frequency of the problem of global warming and Desertification. We will also discuss the issue of modelling disasters statistically as it relates to increased risks and losses and the associated economic impact and how to reduce the problem of global warming. So that financial and governmental institutions can understand to reduce the scale of such disasters and develop proposed solutions.

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التحليل الاحصائي الجغرافي للظروف الطبيعية لدرجات الحرارة في العراق

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المستخلص
تدرس هذه الورقة درجات الحرارة في العراق وفي خمس مدن مختلفة (بغداد والموصل والبصرة والرطبة والسليمانية) حيث أنها موزعة جغرافياً في جميع أنحاء البلاد. تأثيراتها على الظروف الطبيعية باستخدام الأساليب الإحصائية للمناخ لدراسة الفروق المعنوية في المناطق المذكورة بالإضافة إلى دراسة ثبات السلاسل الزمنية من عدمه لدرجات الحرارة وكميات الأمطار ودراسة الحركات التاريخية للتغير والنشاط المناخي، كذلك مثل المناقشات الحالية حول ظاهرة الاحتباس الحراري. والتنبؤ بدرجات الحرارة لعام (2018-2020) وبشكل شهري من خلال استخدام نماذج ARIMA لكل مدينة والمقارنة بينها عن طريق الاختبار اللامعلمي Kruskal Wallis وبالاعتماد على حزم ووظائف لغة البرمجة R. وسنقوم أيضًا بدراسة مجموعات البيانات الأربع التي ذكرناها سابقًا، مع الاهتمام بخطورة وتكرار مشكلة الاحتباس الحراري والتصحر. وسنناقش أيضًا مسألة نمذجة الكوارث إحصائيًا من حيث صلتها بزيادة المخاطر والخسائر وما يرتبط بها من تأثير اقتصادي وكيفية الحد من مشكلة الاحتباس الحراري. حتى تتمكن المؤسسات المالية والحكومية من فهم كيفية تقليل حجم مثل هذه الكوارث ووضع الحلول المقترحة.

الكلمات المفتاحية: درجة الحرارة، تغير المناخ، نماذج ARIMA، اختبار Kruskal-Wallis، الحزمة البرمجية tseries.

Introduction

The term climate change refers to “any significant change in climate measures It lasts for a long period of time. In other words, climate change is of major importance, Changes in temperature, precipitation, or wind patterns, among other influences, occur over several decades or more (1).

The most important effect of global warming is the warming of the atmosphere over time. Many studies have been done on this phenomenon in different parts of the world to determine the rate of temperature change; the general consensus seems to be that global temperatures are rising. (11)
Studies have also been conducted that focus on local or national, rather than global, temperature trends. For example, daily climate data from 305 meteorological stations in China analysed for the period from 1955 to 2000. The authors found that Surface air temperatures in China were increasing with an accelerating trend after 1990. They also found that the daily maximum and minimum air temperature increased by an average of 1.27° and 3.23°C between 1955 and 2000. Both trends were faster in temperature than those recorded for the hemisphere Northern. The range of daily t

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emperature (DTR) decreased rapidly by 2.5 °C from 1960 to 1990; over the same time period, the minimum temperature increased while the maximum temperature decreased slightly. (2)

The temperature became stronger. According to the "Climate Change 2001 Synthesis, the report, "Global average surface temperature increased by 0.6 ± 0.2 °C during the 20th century.

And the land areas warmed more than the oceans. Also, the surface of the northern hemisphere, the temperature increase during the twentieth century was greater than during any other century in the world, During the past thousand years, while the 1990s was the warmest decade of the millennium (3)

Severity and impact of weather phenomena, such as five different cites (Baghdad, Mosul, Basra, Rutba and Sulaimaniyah) as well It seems to have increased. All these changes, as they become more visible will form Challenges to our society and the environment.

The aim of my study is to search for evidence of these climatic factors Changes in these five cites. My main motivation in pursuing this path of research is applying statistical data analysis techniques to climate data for quantification Evaluation of the effects of warming in Iraq. My research focuses on particular Phenomena changing temperatures, for this Purpose I have collected and analysed data on the annual and monthly average, max and minimum temperatures for these five cities and compare among these cities from 2018 to 2020. My aim of the research is to detect any statistically forecasting of temperature degree for the different five cities trend by using ARIMA time series models, and determine the statistical measurements.

Fig (1): shows the geographical distribution of the five cities on the map of Iraq (Google Maps)

And a brief definition of each of the five cities can be given as follows: (4) Baghdad is the capital of Iraq and the second largest city in the Arab world after Cairo. It is located on the banks of the Tigris River, near the ruins of the ancient city of Babylon. In 762 AD Baghdad was chosen as the capital of the Abbasid Caliphate and became the most prominent of the most important developments.

Mosul is a large city in northern Iraq and the capital of Nineveh Governorate. The city is the second largest city in Iraq in terms of population and area after the capital Baghdad, with a population of over 3.7 million. Mosul is located 400 kilometers north of Baghdad on the banks of the Tigris River.

Basra is a city in southern Iraq, located on the Arabian Peninsula on the Shatt al-Arab. It had an estimated population of 1.4 million in 2018. Basra is also a major port in Iraq, although it does not have deep water access, which is handled at the port of Umm Qasr.

Sulaymaniyah is a city in the Kurdistan region of eastern Iraq, not far from the border between Iran and Iraq. There are the Azma, Goyza, and Gawan Mountains in the northeast, the Balanan Mountains in the south, and the Tasluga Mountains in the west.

Al-Rutba District is the largest district in Iraq's Anbar Province, covering an area of 93,445 square kilometers, with the lowest relative and absolute population density, with a population of 24,813 and 0.27 people per square kilometer.

Table (1): shows population statistics and estimates for the five cities (4)

Rank	City or Town	Governorate	1987 Census	1997 Census	2009 Estimate	2018 Estimate[1]
1	Baghdad	Baghdad	3,841,268	5,423,964	6,702,538	8,126,755
2	Mosul	Nineveh	1,479,430	2,042,852	3,106,948	3,729,998
3	Basra	Basra	872,176	1,556,445	2,405,434	2,908,491
6	Suleymaniyah	Suleymaniyah	951,723	1,362,739	1,694,895	2,053,305
39	Ar Rutba	Al Anbar				

Forecasting with ARIMA

ARIMA is a statistical method widely used for time predictions. It is an acronym for AutoRegressive Integrated Moving Average. It is a class of models that processes time-based methods in time series data.

This summary is descriptive and covers the main points of the method. In short these are:

AR: automatic recovery. A model that uses the dependency relationship between an observation and a set of observations. (13)

…(1)

The (unconditional mean) for an AR (1) process, with a constant (μ) is given by:

$$y_t = \mu + \phi_1 y_{t-1} + u_t \rightarrow AR(1)$$

$$E(y_t) = \frac{\mu}{1-\phi_1} \qquad \ldots(2)$$

The (unconditional) variance for an AR process of order 1 (excluding the constant) is:

$$\mathrm{var}(y_t) = \frac{\sigma^2}{(1-\phi_1^2)} \qquad \ldots(3)$$

$$|\phi_1| < 1$$

MA: moving average. A model that uses inter-observation dependence and the residual error of a moving average model fitted to observations.

$Y_t=\mu+ u_t+\alpha 1u_{t-1}+\ldots+\alpha_q u_{t-q}$ …(4)

Each component is clearly defined as a component in the model. Standard ARIMA notation (p, d, q) is used to replace parameters with numbers to quickly identify the specific ARIMA model being used.

$Y_t=\mu+\beta_1 Y_{t-1}+\ldots+\beta_p Y_{t-p}+ u_t+\alpha_1 u_{t-1}+\ldots+\alpha_q u_{t-q}$ …(5)

The components of the ARIMA model are described as follows.

P. The number of lag observations included in the model, also called the lag order.

D. the number of differences between the original notes also called the degree of dissonance.

A. The size of the moving window, also known as the moving average order. Before starting to build the model, we will do a Dickie Fuller progression to make sure the data is really stable. This information is necessary for building the ARIMA model and for defining the hyper-parameter when running the ARIMA model.

Before doing any forecasting, it is necessary to add the ARIMA parameters p, d, q, where p is the number of autoregressive terms, d is the standard deviation, and q is the number of moving averages. (15)

The Box-Jenkins ARMA model is a combination of the AR and MA models:

$X_t=\delta+\phi_1X_{t-1}+\phi_2X_{t-2}+\cdots+\phi_pX_{t-p}+A_t-\theta_1A_{t-1}-\theta_2A_{t-2}-\cdots-\theta_qA_{t-q}$…(6)

Where the terms in the equation have the same meaning as given for the AR and MA model. (12)

Two notes about this model.

The Box-Jenkins model assumes that the time series is stationary. Box and Jenkins recommend splitting unstable rows two or more times to achieve stability. This creates an ARIMA model, where the "I" stands for "integrated".

Some equations transform the series by subtracting the mean of the series from each data point. This gives the series a zero average. It depends on the software you choose for the model.

The Box-Jenkins model can be extended to include seasonal autoregressive terms and seasonal movements. Although this complicates the notation and mathematics of the model, the basic concept of the seasonal autoregressive term and the seasonal moving average term are the same.

The standard Box-Jenkins model includes a stochastic operator, an autoregressive term, a moving average term, a seasonal variation operator, a seasonal autoregressive term, and a seasonal moving average term.

To find the optimal values of p and q, we calculated the AIC using different values of p and q. Using these combinations, we can see where the p and q values are the lowest AIC. I calculated the log-likelihood, AIC and BIC using the model case file R. (14)

If we have a statistical model of some data. Let k be the number of parameters estimated in the model. L is the maximum value of the model's likelihood function. Then the AIC value of the model is as follows.

$AIC = 2K - 2\ln(L)$

Given multiple candidate models for the data, the preferred model is the model with the smallest AIC value. Thus, AIC rewards the quality fit (estimated by the likelihood function), but also includes a penalty that increases the function of the number of estimated parameters. Penalties prevent over fitting, which is desirable because increasing the number of parameters in a model always results in better fit quality. (16)

Kruskal Wallis Test (5):

William Kruskal and Allen Wallis presented a nonparametric test method for comparing three or more groups using classification data,

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Hypotheses are tested by testing a set of k independent samples (where k 2), where at least two samples represent groups with different means. (6)

This test is an extension of the Mann-Whitney U test for projects with more than two independent samples, and a one-tailed Kruskal-Wallis analysis of the ranks of variance will give the same results as those obtained for k = 2 Mann-Whitney test. The one-tailed Kruskal-Wallis variance per rank is significant, indicating that there is a significant difference in the set of k means between at least two sample means. As a result of the latter, the researchers can conclude that there is a high probability that at least two samples represent groups by different means. (7)

ANOVA (sham parametric Kruskal-Wallis test) was clearly violated. It should be noted that information is sacrificed when researchers choose to convert rank/correlation datasets to strings. The last fact explains why it exists.

Some researchers are reluctant to use nonparametric tests, such as the one-way Kruskal-Wallis ANOVA for ranks, even when there is reason to believe that one or more assumptions of the one-way ANOVA are violated. It is common to many nonparametric tests and is often not followed because such tests are often used with dependent variables that are discrete random variables; (d) The principal distributions from which the samples in the graph are drawn are the same. However, the basic pattern of population distribution is not necessarily normal. Maxwell and Delaney (1990) noted that the symmetric distribution assumption means that the data in each distribution is uniformly distributed (8)

For this reason, they note that, like the one-way ANOVA between individuals, the one-way Kruskal-Wallis ANOVA for ranks assumes homogeneity of variance with respect to the underlying population distribution. Since the latter assumption is not universally accepted in a one-way Kruskal-Wallis ANOVA, it is not uncommon for sources to claim that homogeneity violations of the variance hypothesis warrant the use of a one-way Kruskal-Wallis ANOVA. Use order variation instead of a one-way ANOVA. However, it should be noted that there are some experimental studies that show that the sampling distribution of the Kruskal-Wallis test statistic is not similar to the F distribution (i.e., the sampling distribution used in one-way ANOVA). (9)

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(The mean of the first population is equal to the mean of the second population is equal to the median of the third population is equal to the mean of the fourth population. For sample data, when there are an equal number of subjects in each group, the sum of the ranks will be the same for all k groups:

$H_0: \varphi_1 = \varphi_2 = \varphi_3 = \varphi_4$

$H_1: \varphi_1 \neq \varphi_2 \neq \varphi_3 \neq \varphi_4$

The alternative hypothesis states that the three population means must be different from each other for reject the null hypothesis. For sample data, if the number of subjects in each group is equal, then at least two k groups will have unequal rank groups when the alternative hypothesis is true. (10)

A more general form of interpretation (which also implies an unequal sample size) when at least two of k groups have an unequal mean range. It can be assumed (unlike otherwise stated) that implied the alternative hypothesis of the one-way Kruskal-Wallis rank analysis.

$$H = \frac{12}{N(N+1)} \sum_{j=1}^{k} \left[\frac{(\sum R_j)^2}{n_j}\right] - 3(N+1) \qquad \ldots(7)$$

$$\sum_{j=1}^{k} \left[\frac{(\sum R_j)^2}{n_j}\right] \qquad \ldots(8)$$

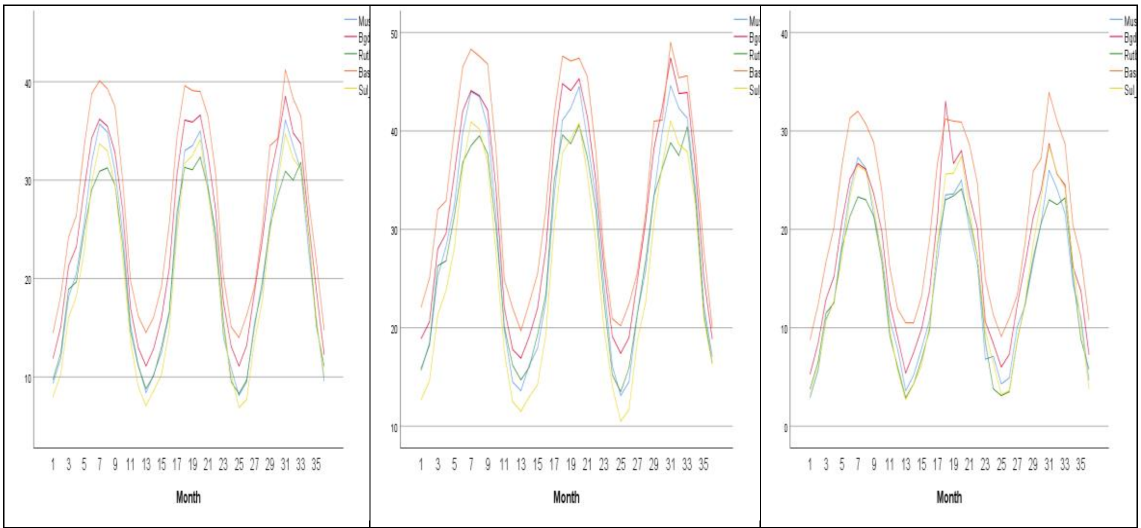
Show that the sum of the ranks of each group is squared and then divided by the number of subjects in the subject. When you do this for all k groups, the resulting values are added together.

Data analysis and the methodology

Five different regions were taken in Iraq distributed geographically: the north westernmost region which is (Mosul), the north easternmost region which is (Sulaimaniyah), the westernmost region (Al-Rutba), the southernmost region (Basra), and middle of Iraq it is capital (Baghdad). The time series was analyzed for the amount of rain and its temperatures degree on an annual and monthly basis respectively using Box Jenkins models, studying stationary, seasonality, and forecasting for the next period, as well as comparisons between the four different cities in temperature and rainfall, based on a non-teaching test, which is (Kruskal Wallis). All tested through the use of functions and packages R programming language in addition to the SPSS program, and the results were as follows:

Table (2): Show Mean, Mode,SD, Variance, Skewness, Kurtosis, and range for the five cities temperatures in duration (2018-2020)

Cities	Mosul			Baghdad			Al-Rutba			Basra			Sulaimaniyah		
Stat.	avg	Max	Min	avg	Max	Min	avg	max	Min	avg	Max	Min	avg	Max	Min
Mean	21.666	29.10	14.53	24.47	31.85	17.13	20.94	27.97	13.91	27.51	34.71	21.08	20.40	25.96	14.8
Mode	33.50	14.50	10.80	11.10	18.90	7.30[a]	11.10	26.80	23.00	14.50	32.00	10.50	10.20	10.50	3.20[a]
Std. Dev	9.5705	10.95	7.722	9.294	10.42	7.998	8.453	9.426	7.509	9.553	10.43	8.294	9.590	10.64	8.58
Variance	91.595	120.0	59.64	86.39	108.6	63.98	71.46	88.86	56.39	91.27	108.8	68.79	91.97	113.3	73.7
Skewness	.076	-.001	.105	-.049	-.056	.091	-.100	-.125	-.067	-.035	-.059	-.030	.063	.036	.078
Kurtosis	-1.517	-1.55	-1.38	-1.56	-1.60	-1.28	-1.59	-1.60	-1.58	-1.60	-1.61	-1.58	-1.53	-1.56	-1.48
Range	28.00	31.50	24.40	27.40	30.50	27.70	24.05	27.10	21.20	27.20	29.30	25.10	27.80	30.50	25.8
Minimum	8.10	13.10	2.90	11.10	16.90	5.30	8.30	13.50	2.90	14.00	19.70	8.80	6.90	10.50	2.70
Maximum	36.10	44.60	27.30	38.50	47.40	33.00	32.35	40.60	24.10	41.20	49.00	33.90	34.70	41.00	28.5
a. Multiple modes exist. The smallest value is shown															



A	B	C

Fig(2): (A) Shows Average temperatures as monthly base from (1-2018 till 12-2020) for Mosul, Basra, Baghdad, Sulaimaniyah and Rutba (B) Shows Maximum temperatures as monthly base from (1-2018 till 12-2020) for Mosul, Basra, Baghdad, Sulaimaniyah and Rutba (C) Shows Minimum temperatures as monthly base from (1-2018 till 12-2020) for Mosul, Basra, Baghdad, Sulaimaniyah and Rutba

Through the figures above, we notice that there is a clear seasonality in temperatures in Iraq, and the city of Basra was the highest in temperature compared to the rest of the cities, followed by the capital, Baghdad, while the cities of Mosul, Rutba and Sulaimaniyah were the lowest sequentially.

H_0: The distribution of Temperature is the same for the five different cities.

H_1: The distribution of Temperature is not same for the five different cities.

Table (3): Shows Rank means for each city and Kruskal-Wallis test about the comparison of five cities Temperature

Ranks	Group	N	Mean Rank
Temp_avg	Mosul	36	83.51
	Baghdad	36	99.63
	Rutba	36	78.18
	Basra	36	115.81
	Sulaimaniyah	36	75.38
	Total	180	

Test Statistics[a,b]	Temp_avg
Kruskal-Wallis H	15.289
df	4
Asymp. Sig.	.004

a. Kruskal Wallis Test
b. Grouping Variable: Group

Through the non-parametric test (Kruskal-Wallis) we notice that there are significant differences in temperature among the five different cities (Baghdad, Mosul, Basra, Rutba and Sulaimaniyah).

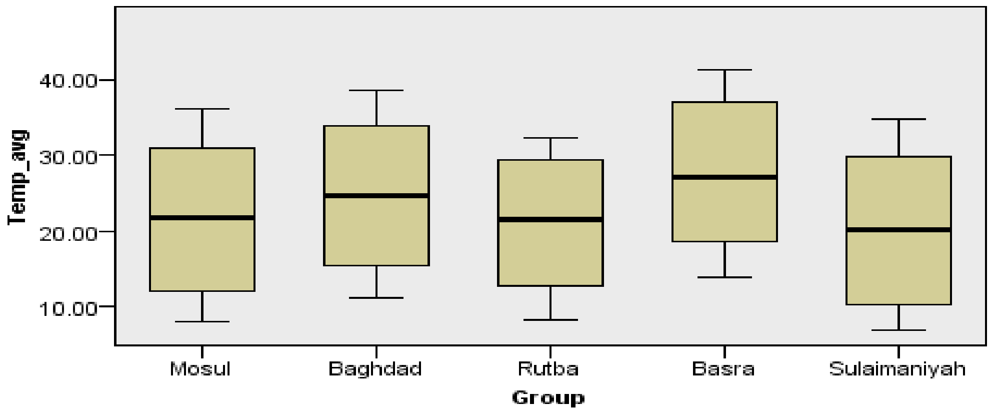


Fig. (3): Show Independent-Samples Kruskal Wallis Test between (Tempertures degrees) and (The five cites)

Through the above figure, we notice that Rutba is the least volatile in temperature on a monthly basis, while Sulaymaniyah is the most in low temperature, and Basra the most in high temperature, relatively among the five cities.

Table (4): Show Pairwise test values comparisons of temperatures among the five cites

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Sulaimaniyah-Rutba	2.806	12.281	.228	.819	1.000
Sulaimaniyah-Mosul	8.139	12.281	.663	.508	1.000
Sulaimaniyah-Baghdad	24.250	12.281	1.975	.048	.483
Sulaimaniyah-Basra	40.431	12.281	3.292	.001	.010
Rutba-Mosul	5.333	12.281	.434	.664	1.000
Rutba-Baghdad	21.444	12.281	1.746	.081	.808
Rutba-Basra	-37.625	12.281	-3.064	.002	.022
Mosul-Baghdad	-16.111	12.281	-1.312	.190	1.000
Mosul-Basra	-32.292	12.281	-2.629	.009	.086
Baghdad-Basra	-16.181	12.281	-1.318	.188	1.000

each row tests the null hypothesis that the distributions of sample 1 and sample 2 are identical, and the asymptotic mean (two-tailed test) is shown. The significance level is 0.05. Significant values were adjusted with Bonferroni corrections for different tests, it’s clear that there is significance difference in temperatures degree between Sulaimaniyah with Baghdad and Sulaimaniyah with Basrah and significance difference between Rutba with Basra and Mosul with Basra.

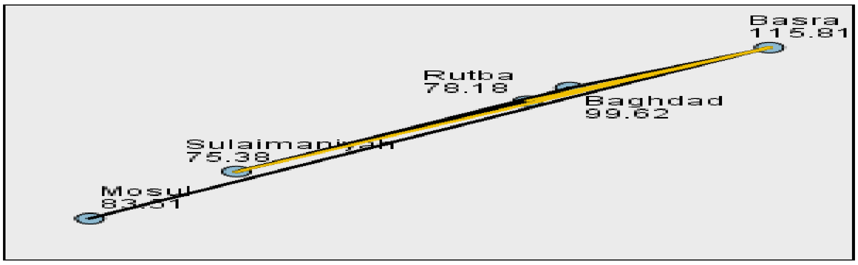


Fig (4): Show the pairwise comparisons of temperatures among the five cites

We note from above figure the basra has the highest rank (115.81) then the capital baghdad by (99.62) after that Mosul its equal to (83.51) then

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Rutba has rank (78.18) and finally Sulaimaniyah city is the lowest among all by (75.38).

And to analyze the temperature time series, we will use forecasting methods, and we will take Baghdad as the capital of Iraq and the most densely populated one, located in central Iraq, then we will analyze the temperature time series for the rest of the cities later:

A time series is just collection of past values of the variable being predicted. Also known as naïve methods, and now for the analysis of the time series of temperatures for the Mosul city, the results were as follows:

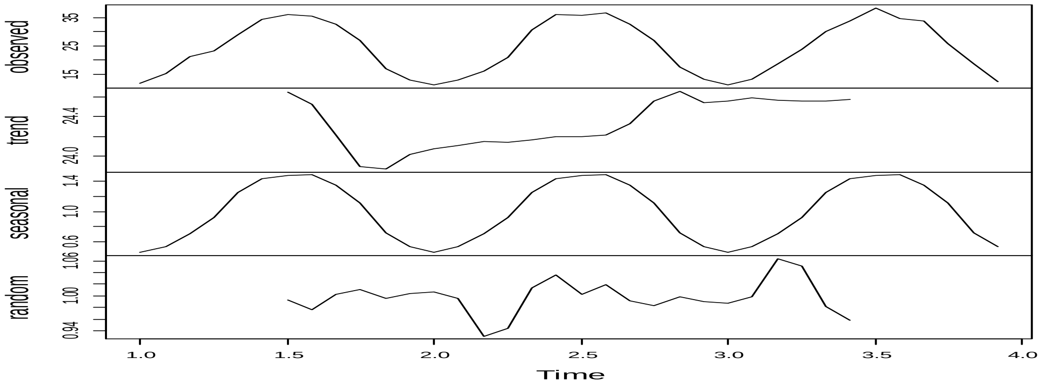

Fig (5): shows the time series analysis of the temperature Baghdad average into the four components for the period (Jan-2018 to Dec-2020) on a monthly basis

There are 4 components: Observed – the actual data plot, Trend – the overall upward or downward movement of the data points, Seasonal – any monthly pattern of the data points, Random – unexplainable part of the data as the above figure.

Fit the model:

Once the data satisfies all the assumptions of modeling, to determine the order of the model to be fitted to the data, we need three variables: p, d, and q which are non-negative integers that refer to the order of the autoregressive, integrated, and moving average parts of the model respectively.

ARIMA model on the data collected from January 2018 to December 2020 temperatures Mosul average and verified it using the appropriate ARIMA (0,0,1) (0,1,0) model was selected based on the Bayesian

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Information Criteria (BIC) and Akakiy's Information Criterion criteria values

Coefficients:

-0.6888

s.e. 0.1518

sigma^2 estimated as 1.838: log likelihood=-44.71

AIC=93.41 AICc=93.98 BIC=95.77

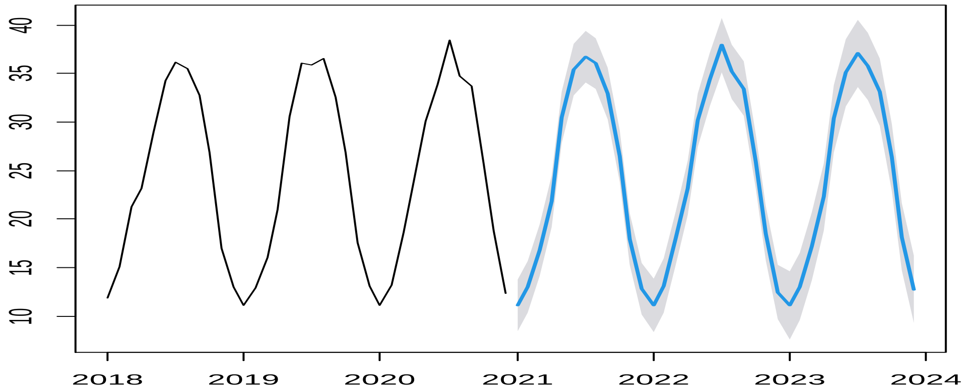
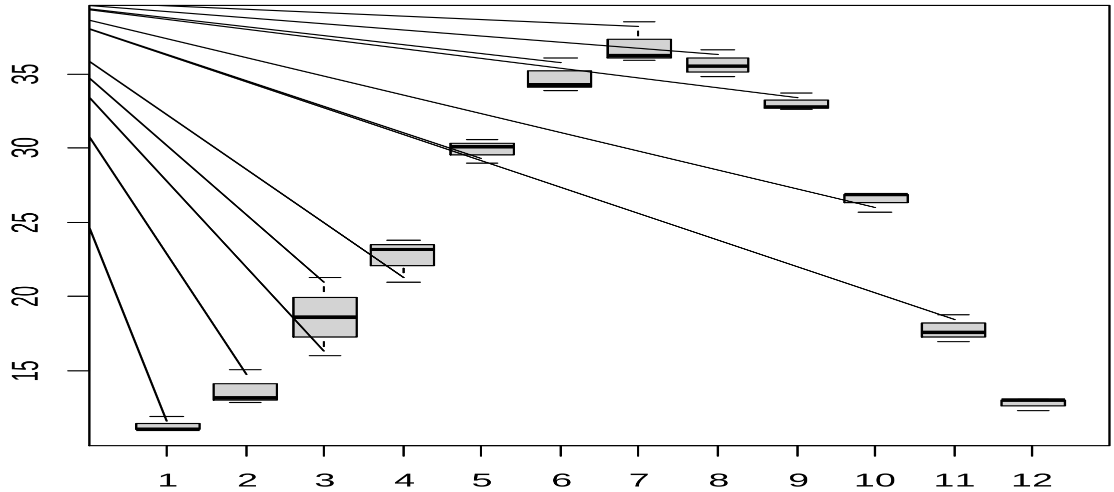


Fig (6): shows the actual and forecasting time series of the temperature Baghdad average on a monthly basis until 2024 by using ARIMA model. The forecasts are shown as a blue line, with the 80% prediction intervals as a dark shaded area, and the 95% prediction intervals as a light shaded area.

it is clear from the graph itself that the data points have follows an overall upward or downward trend with no outliers in terms of sudden lower values but has seasonality. For more assurance we need to do some analysis to find out the exact stationary and seasonality in the data.



Fig(7): Shows the box plot of the temperature Baghdad average on a monthly basis for the period (2018-2020) on a monthly basis.

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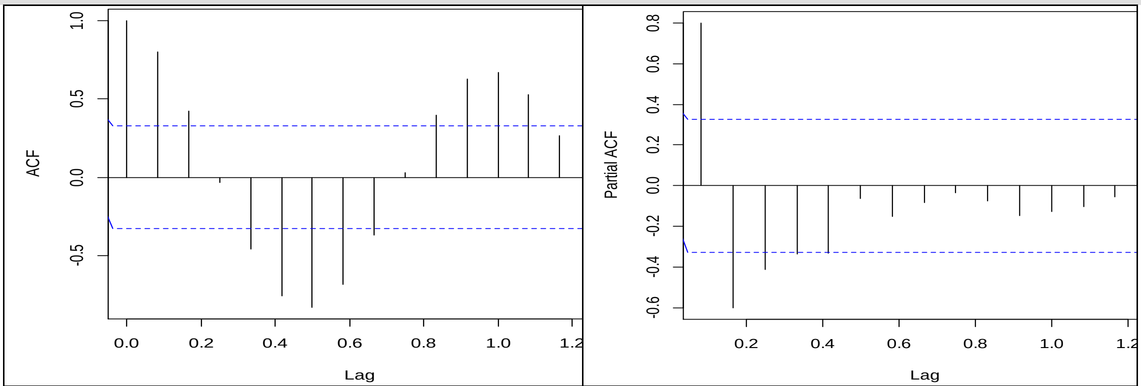
To see the seasonal effects in the above boxplot figure, we notice there are more from that the most volatile month in temperature Baghdad average is the third and fourth month during the study period (2018-2020). Indeed, the sharp decline temperature Baghdad average began with the at the beginning of the August and beyond. As well as the rise in temperature Baghdad average from that started from the beginning of the second month or a little before and thereafter.

We need to make sure that the forecast errors are not correlated, normally distributed with mean zero and constant variance. We can use the diagnostic measure to find out the appropriate model with best possible forecast values.

Augmented Dickey-Fuller Test
Dickey-Fuller = -1.511, Lag order = 0, p-value = 0.7634
Alternative hypothesis: stationary
Dickey-Fuller = -1.511, Lag order = 0, p-value = 0.2366
Alternative hypothesis: explosive
From above (Augmented Dickey-Fuller Test) it's clear the average temperature of Baghdad is non-stationary and Explosive
Box-Ljung test
X-squared = 5.2264, df = 5, p-value = 0.3889
the p-value is quite insignificance that means the model is free from autocorrelation.



A B

Fig. (8): (A) shows the autocorrelation function of the temperature Baghdad average and on a monthly basis for the period (Jan-2018 to Dec-2020) on a monthly basis, (B) shows the partial autocorrelation function of the temperature Baghdad average and on a monthly basis for the period (Jan-2018 to Dec-2020) on a monthly basis

Through the above figure of the autocorrelation function, we note that the time series of temperature Baghdad average is non-stationary because the autocorrelation function has a trend, and the partial correlation function in the above figure, we notice that the first, second and third Lag are out of limits.

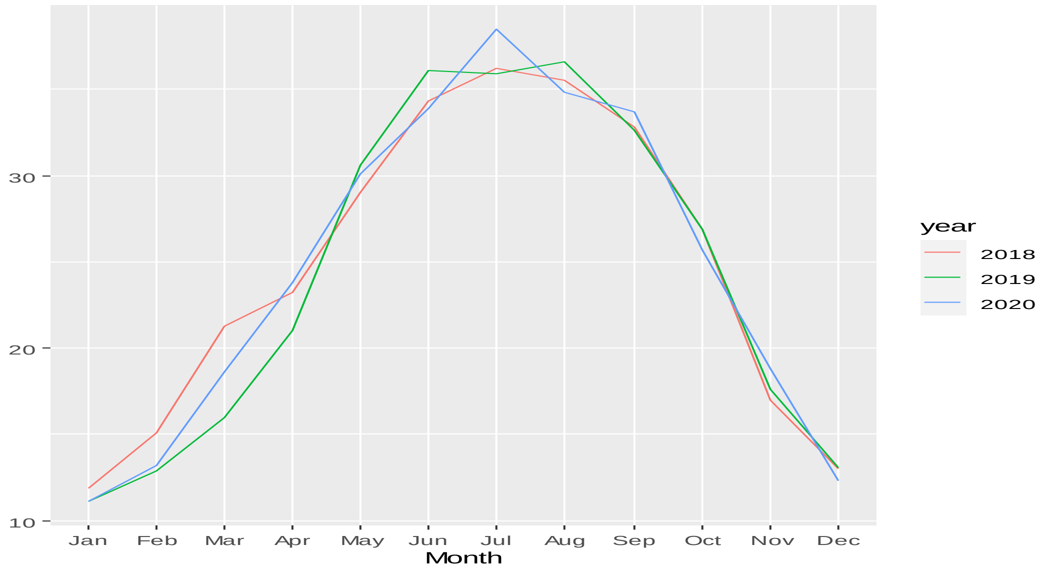


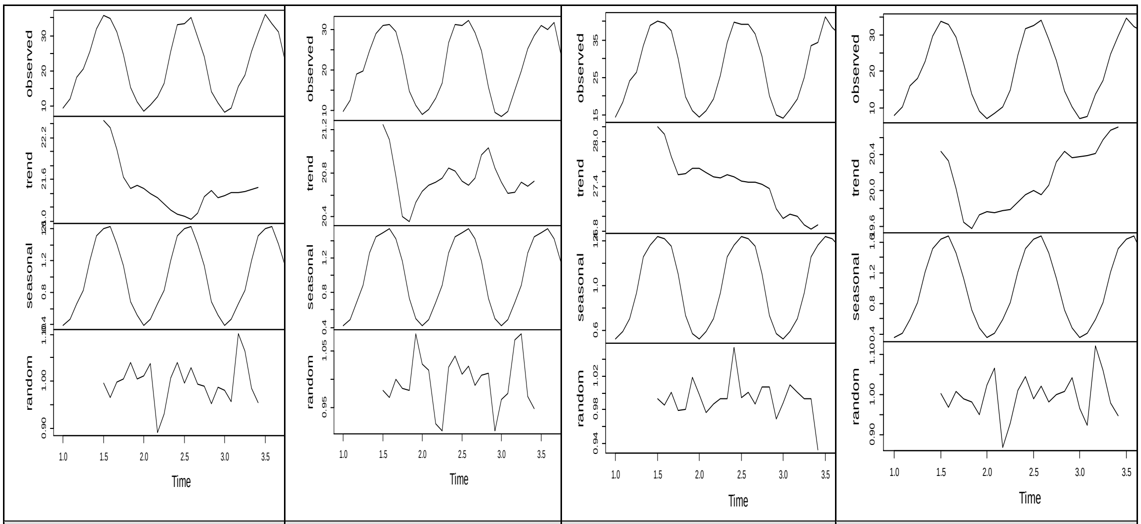
Fig (9): Show the seasonality of Baghdad temperature degree in duration (2018-2020)

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
11.10	15.78	24.75	24.48	33.75	38.50

Table (5): Shows summarization of Mosul temperature average

Through the above table, we notice that the lowest average temperature on a monthly basis for the city of Baghdad is (11.10) while the highest average temperature is (38.50) and the general average is (24.48) for the period (Jan-2018 to Dec-2020)

In same time we applied the previous statistical steps but not by details we give only the analysis of the others three cities and the results are as follows:

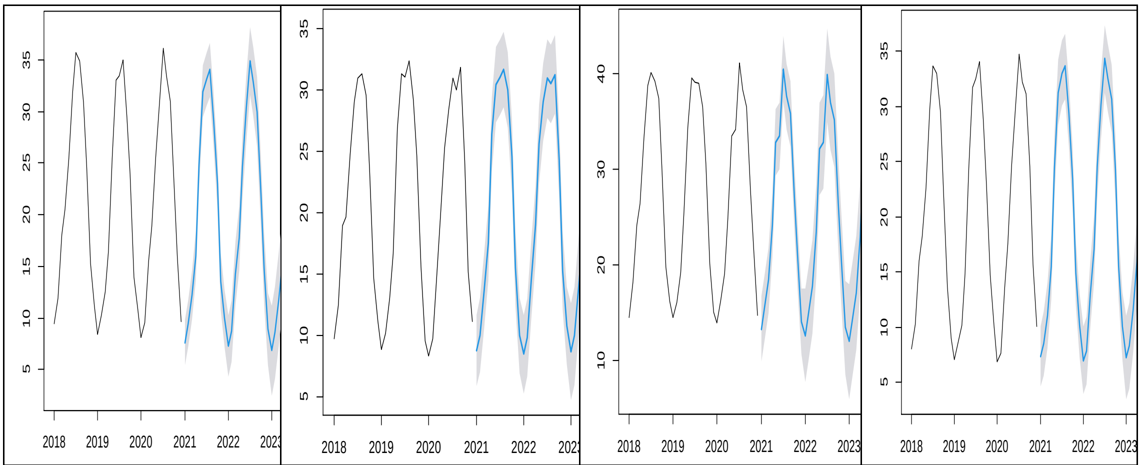


Mosul	Rutba	Basra	Sulaimaniyah

Fig (10): Show the time series decompsitions for the remain four cites (Mosul, Rutba, Basra and Sulaimaniyah)

Table (6): Show the Some Statistics Summary for the remain four cites (Mosul, Rutba, Basra and Sulaimaniyah)

City	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Mosul	8.10	12.35	21.65	21.67	30.93	36.10
Rutba	8.30	12.90	21.55	20.94	29.24	32.35
Basra	14.00	18.90	27.15	27.51	36.75	41.20
Sulaimaniyah	6.90	10.28	20.10	20.40	29.80	34.70



Mosul	Rutba	Basra	Sulaimaniyah

Fig (11): Show the time series Forecasting for the remain four cites (Mosul, Rutba, Basra and Sulaimaniyah)

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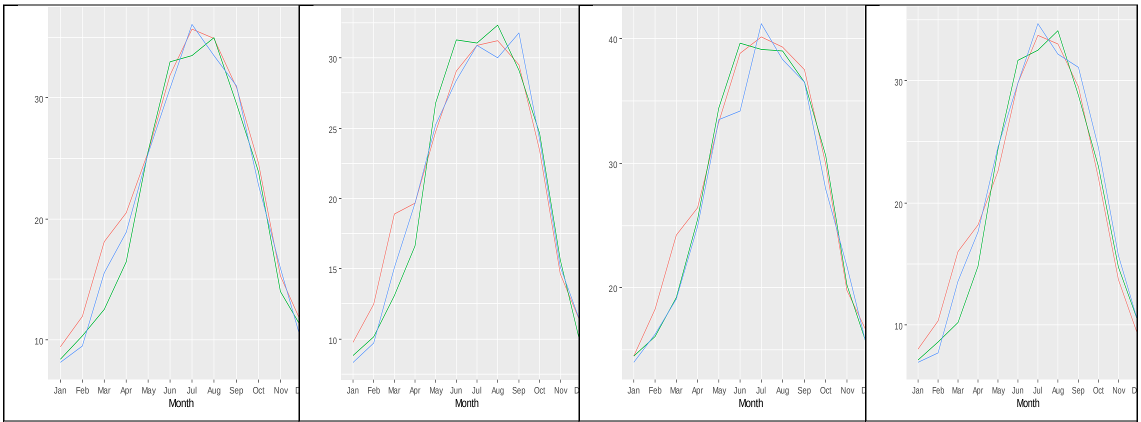
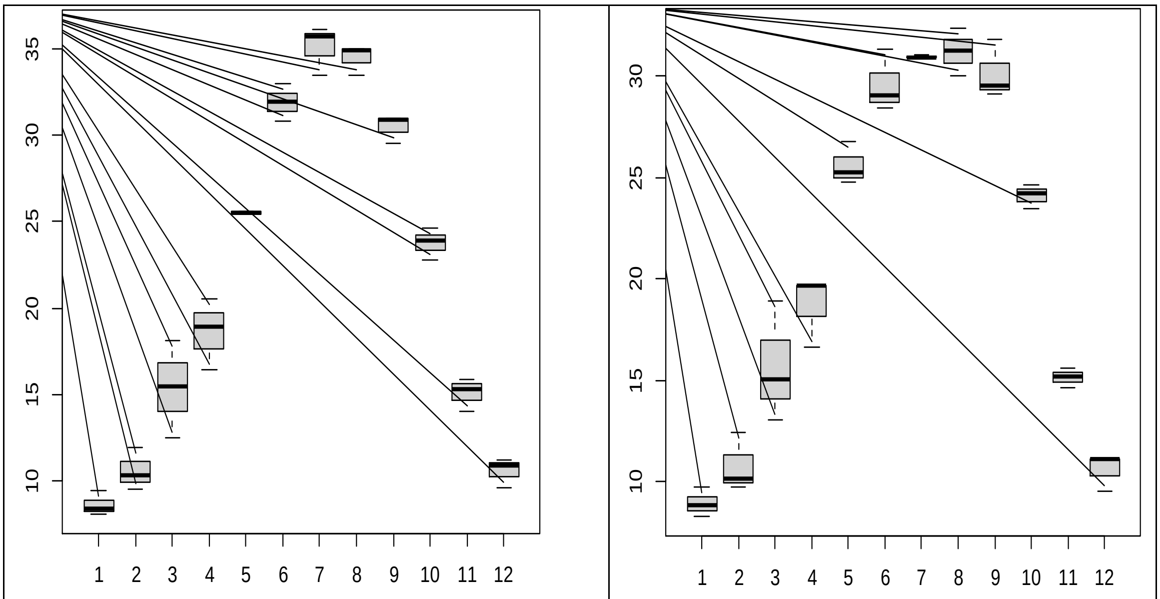
Table (7): Show the ARIMA models Types for the remain four cites (Mosul, Rutba, Basra and Sulaimaniyah)

City	ARIMA	ma1	s.e.	sar1	s.e.	$sigma^2$	log like	AIC	BIC
Mosul	(0,1,1)(1,1,0)	-0.77	0.15	-0.84	0.085	1.293	-42.51	91.0	94.4
Rutba	(0,0,1)(1,1,0)	0.36	0.19	-0.70	0.1474	2.162	-46.37	98.7	102.2
Basra	(0,0,0)(0,1,0)	-0.05	0.02	-	-	3.091	-47.08	98.1	100.52
Sulaimaniyah	(1,0,0)(1,1,0)	0.38	0.19	-0.75	0.1289	1.93	-46.13	98.2	101.8



Mosul	Rutba	Basra	Sulaimaniyah

Fig(12): Show the seasonality of temperature degree in duration (2018-2020) for the remain four cites (Mosul, Rutba, Basra and Sulaimaniyah)



Mosul	Rutba

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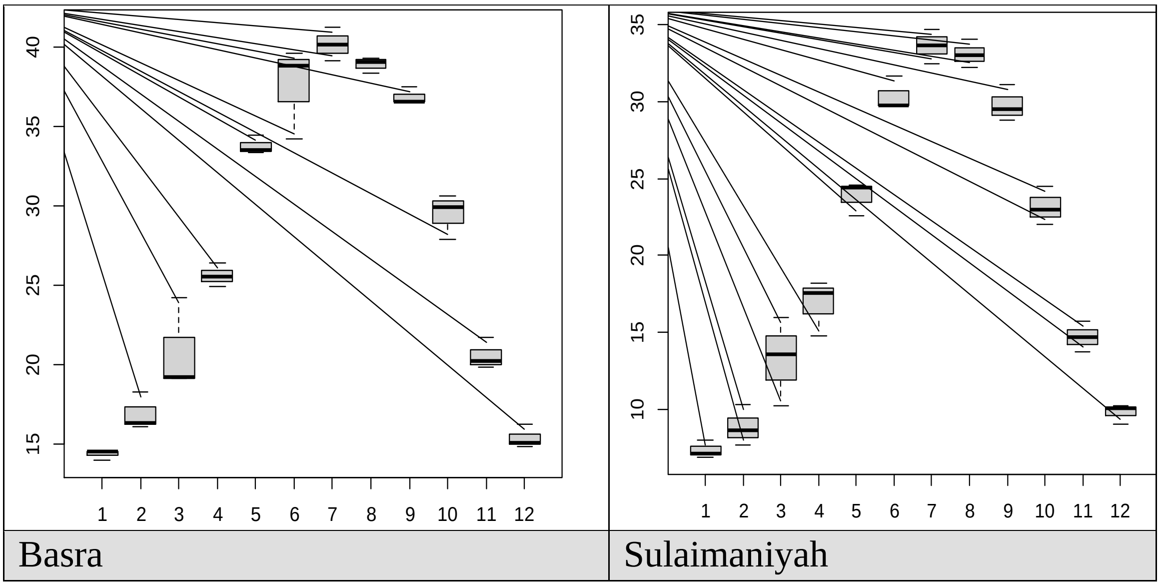

Fig (13): Shows the box plot of the temperature average on a monthly basis for the period (2018-2020) for the remain four cites (Mosul, Rutba, Basra and Sulaimaniyah).

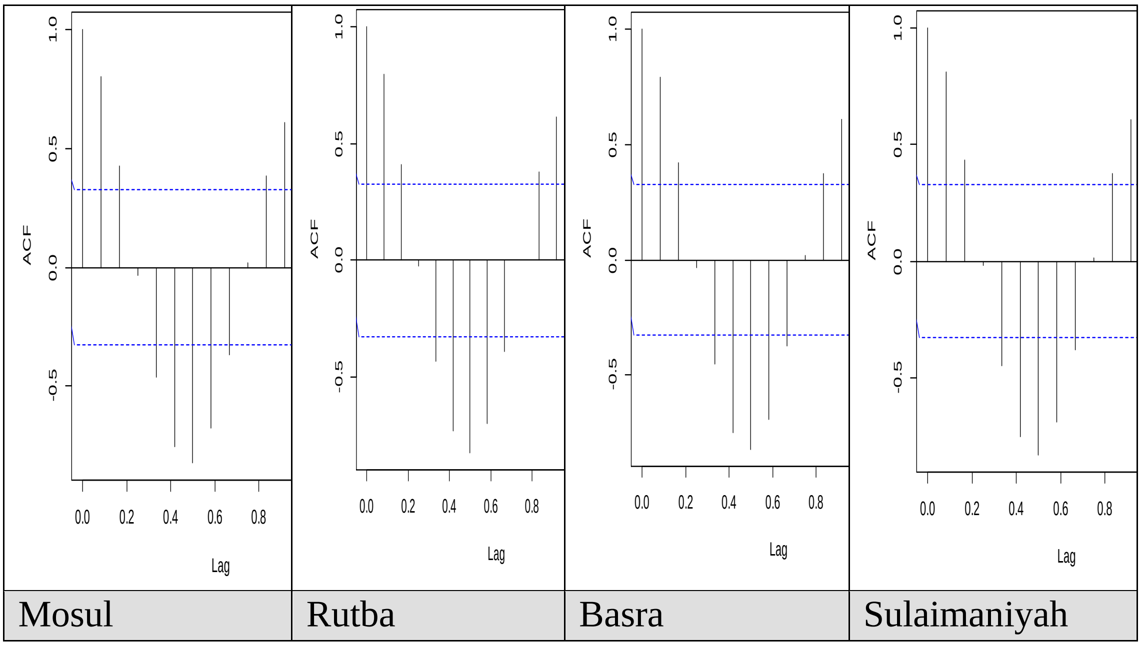

Fig. (14): shows the autocorrelation function of the temperature average and on a monthly basis for the period (Jan-2018 to Dec-2020) on a monthly basis for the remain four cites (Mosul, Rutba, Basra and Sulaimaniyah).

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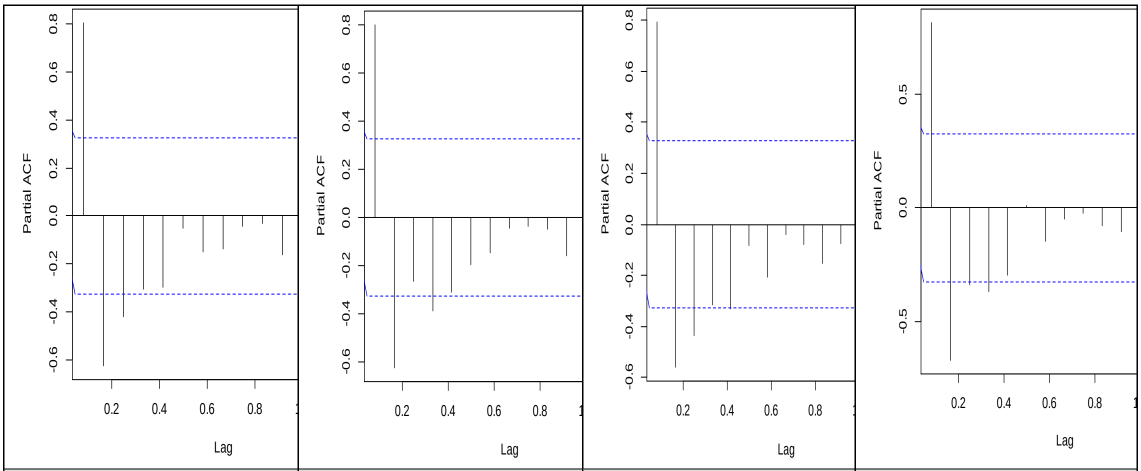

Mosul	Rutba	Basra	Sulaimaniyah

Fig. (15): shows the partial autocorrelation function of the temperature average and on a monthly basis for the period (Jan-2018 to Dec-2020) on a monthly basis for the remain four cites (Mosul, Rutba, Basra and Sulaimaniyah).

Limitations

There are some obstacles that we encountered while conducting the research, including missing data for temperatures, as well as for the amounts of rain for the four different cities, as well as the lack of recent data for the years 2021 and 2022 at the Meteorological Department.

Conclusions:

From the previously mentioned statistical analysis, it can be concluded that the average monthly and average monthly maximum and minimum temperatures in Iraq are increasing slightly over time, and that Basra province is the highest compared to the rest of the city and Sulaymaniyah. The lowest. Through the use of Box Jenkins models by ARIMA and related tests, the chronological Series of temperatures in Iraq is hot and dry in summer and cold and rainy in winter, which is slightly increased and seasonal and non-stationary as well as for the five cities (Baghdad, Mosul, Basra, Rutba and Sulaimaniyah). There are statistically significant differences in temperatures for those cities, which were taken on a geographical basis.

Recommendations

We recommend the following recommendations for future studies:

1. Preserving Iraq's identity as an agricultural country by digging artesian wells in areas that suffer from severe water shortages and benefiting from

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groundwater in an integrated governmental program with the supervision of the Ministry of Agriculture and the Ministry of Irrigation.

2. Paying attention to agriculture and considering it permanent oil, not to mention the other benefits, including achieving self-sufficiency without relying on neighbouring countries, reducing the phenomenon of desertification and environmental pollution, employing manpower. Benefiting from graduates of the Faculty of Agriculture, as well as veterinary medicine, because livestock is closely linked to agriculture, as in Al-Saqi and Al-Kafeel farms in Karbala governorate.
3. Conducting comprehensive statistical studies of the climate of Iraq, especially cities that depend on agriculture, such as the central and southern provinces of the Euphrates periodically, by studying the time series and making a comparison with previous years, such as temperatures and rainfall.
4. The necessity of constructing dams to take advantage of rain water, especially in the southern governorates, and the establishment of artificial lakes, which can be used as tourist resorts or even fish farming.

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