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SPECTRAL CHARACTERISTICS OF CLIMATOGICAL AIR TEMPERATURE FOR SELECTED CITIES IN IRAQ

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ABSTRACT

The results of the analysis of the annual rates of air temperature of the cities studied showed that Basra and Rutba stations are more variation from stations of Baghdad and Mosul, but we noticed through the drawing that the year 2010 had a higher degree of air temperature annual rates throughout the country. The annual standardized anomaly of air temperature was calculated for the stations studied above and has been shown that Basra station does not have a large degree of positive and negative standardized anomaly for this element. From these results the energies of spectral density were calculated for both monthly and annual standardized anomalies of air temperature which show that the maximum values of the energies of spectral density is fair for the mean monthly in Mosul and Baghdad but for the mean annual is abvious in Basra and Baghdad.

Keywords: Climate, Standardized anomaly, Frequency, Percentage of frequencies, Power spectral density.

1. INTRODUCTION

Climate can be defined as 'average weather' and usually is averaged over a period of 30 years. Climate is not like weather, which involves the description of the atmospheric condition at a single instant of time, but may be thought of as an average of weather conditions over a period of time. Temperature is one of the most commonly variables used for describing the state of a given climate over an area. The method of description focuses on statistical parameters, the mean and measures of variability in time such as the range, standard deviation, and autocorrelations.

Over the past 20 years, the research effort has been concentrated on numerical understanding the natural variability of climate using climate models and observing measurements over long time scale. More understanding about climate variability is necessary for an accurate assessment of the human influence on climate. There are several statistical techniques used in interpreting the scientific: such as arithmetic means, variances, correlation coefficients according to time field. These quantities provide little insight into the different types of signals that are blended together to make the recorded data.

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A few papers have been carried out about the power spectral density of atmospheric temperature. For example Pasero et al. [1] using spectral analysis to determine the optimum sampling frequency for a set of nonstationary signals. Power spectra were also calculated by Pelletier [2] from time scales of 10^{-2} to 10^{6} year for continental and marine stations. He found a difference in their spectra as a consequence of the air mass above these stations. Lastly, Talkner and Weber [3] were applied power spectral densities to daily temperature, who found a scaling behavior of the spectral density in an intermediate frequency regime is better reflected by detrended fluctuation analysis, than by fluctuation analysis.

The purpose of this paper is to analysis the monthly and annual time series of the air temperature. Also the monthly and annual standardized anomalies of the air temperature were calculated. Finally the analysis of the spectral density to monthly and annual anomaly rates is applied using Fast Fourier Transform (FFT).

2. STANDARDIZED ANOMALIES

We first consider the standardized anomaly before explaining spectral analysis because it is the first stage to calculate power spectra. Transformations can be useful when one is interested in working simultaneously with batches of data that are related. One instance of this situation occurs when the data are subject to seasonal variations. Direct comparison of raw monthly temperature, for example, will usually show little more than the dominating influence of the seasonal cycle. A record warm January will still be much colder than a record cool July. In situation of this sort, reexpression of the data in terms of standardized anomalies can be very helpful.

The standardized anomaly, Z, is computed simply by subtracting the sample mean of the data raw, X, and dividing by the corresponding sample standard deviation as given:

$$Z = \frac{X-\bar{X}}{S_x} = \frac{\acute{X}}{S_x} \qquad (1)$$

In the jargon of the atmospheric sciences, an anomaly ($\acute{X}$) is understood to be the subtraction from a data value of a relevant average [4].

3. SPECTRAL ANALYSIS OF ATMOSPHERIC TEMPERATURE VARIATIONS

Spectral analysis is a powerful tool for partition the variance of time series as a function of frequency. This means that the area under spectrum is the sum of the contributions of the individual harmonic to the variance. For stochastic time series, contributions from the different frequency components are measured in term of the power spectral density. In addition, spectral density of responsive variables required in modern engineering publication is to be determined to examine the distribution of energy with respect to frequency. In other words, spectral power describes how the variance of a quantity is distributed over different scales or frequency. Spectral analyses then allow one to describe the exchange of kinetic energy associated with different scales [5].

The Fourier transform of the signal Y(f) can be interpreted as a particular kind of scalar product [6]:

$$Y(f) = \int_{-\infty}^{\infty} y(t) e^{-2i\pi ft}\, dt \qquad (2)$$

$$y(t) = \int_{-\infty}^{\infty} Y(f)\, e^{2i\pi ft}\, dt \qquad (3)$$

where $e^{\mp 2i\pi ft} = \cos 2\pi ft \mp i \sin 2\pi ft$, f is the frequency in cycles per unit time. The square of the modulus of the Fourier transform for any frequency is

$$S(f) = [\,Y_{real\ part}(f)]^2 + [Y_{imag.\ part}(f)]^2 = |Y(f)|^2 \qquad (4)$$

where S (f) is the spectral density.

In this work, the real and imaginary parts in above equation are calculated by use of Microsoft Origin 9.1, then discrete spectral intensity (or energy), E (f), is defined as:

$$E(f) = 2\, S(f) \qquad (5)$$

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4. THE DATA AND PROGRAMS USED

In this paper the monthly and annual records for air temperature, measured at the surface observing stations following to the Iraqi Meteorological Organization and Seismology to the stations (Basra / Hay Al-Hussein, Baghdad, Rutba, and Mosul). The geographical features of the stations and data period are shown in Table (1).

Table (1): Feature of the stations and the period of data [7].

Stations names	Stations No.	Longitude	Latitude	Elevation above sea level (m)	Time period
Basra	689	47° 47´	30° 31´	2	1941-2013
Baghdad	650	44° 24´	33° 18´	31.7	1941-2014
Rutba	642	40° 17´	33° 02´	630.8	1931-2013
Mosul	608	43° 09´	36° 19´	232	1941-2013

Programs used in this study are the Excel program and Origin software, one of the important programs in the graphics processing and analysis of diverse data and program features easily dealing with his interactive interface also features fast performance and not its effect on the speed calculator.

5. RESULTS AND DISCUSSION

The monthly and annual averages of air temperature of the studied stations are presented in Figures (1) and (2) respectively. In general as shown from figure 1, the behavior of monthly averages of the Basra station has clear comparison to Baghdad, Rutba and Mosul stations because the Basra station only appears proportional variation of temperature. But the variation in the annual rates of Baghdad and Mosul stations are more heterogeneous than other stations (Basra and Rutba, see Figure 2). This is due to the geographical location of the city of Baghdad and Mosul, as well as the city of Baghdad is the densely populated areas and far away from the sea so there is no moderation in climate they are considered extremist.

The mean monthly standardized anomaly is calculated for studied stations using Equation (1). The results are displayed in figures 3a-3d, respectively. The Basra station figure 3a has negative and positive standardized anomaly values and the highest standardized anomaly observed negative in January of 1964 and value is (-1.96 °C), another negative standardized anomaly in same month of 2008 and value is (-2.03 °C). Figure 3b has negative standardized anomaly higher than positive standardized anomaly and the highest value is (-1.97 °C) in January of 1964 another negative value is (-1.85 °C) in same month of 2008, while Rutba station Figure 3c has negative and positive standardized anomaly with maximum negatively value (-1.88 °C) found in January of 1964, another negative value (-1.89 °C) in the same month but found in 2008. Lastly Mosul station Figure 3d records negative and positive standardized anomaly with negative highest values observed in January of both (-1.75 °C) and (-1.7 °C), in 1964, 2008 respectively.

Figure (4) illustrates standardized anomaly for annual means of air temperature at studied stations. The annual standardized anomaly is calculated using Equation (1). As shown from figure 4a the Basra station does not have a large degree of negative and positive standardized anomaly of air temperature. In contrast to other stations where observed from the drawing that the Baghdad station (see Figure 4b) has positive standardized anomaly higher than negative with the highest value is (1.97 °C) in 2010, while Rutba station has negative standardized anomaly higher than positive and the highest value observed is (-2.08 °C) in 1992 Figure 4c. Lastly, Figure 4d show that the Mosul station for negative standardized anomaly is higher than positive, especially in 1992 with value of (-2.02 °C).

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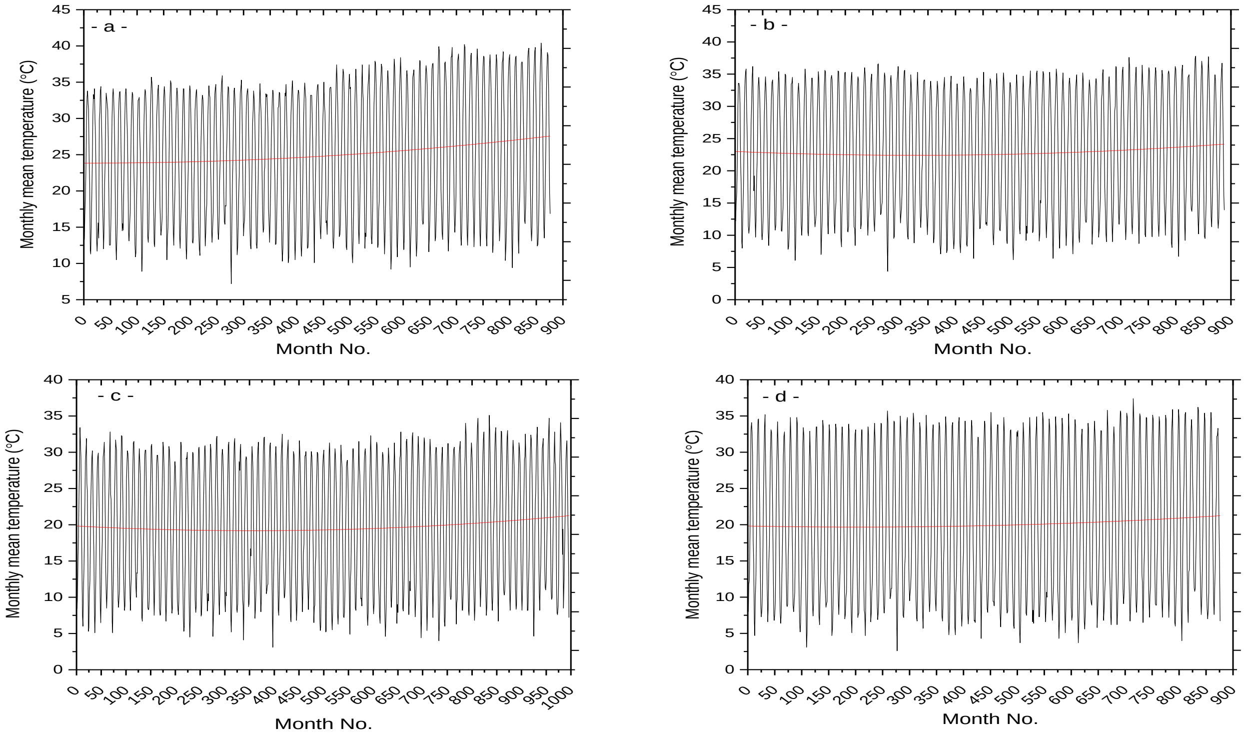

Figure: 1. Mean monthly of air temperature for stations: (a) Basra, (b) Baghdad (c) Rutba and (d) Mosul.

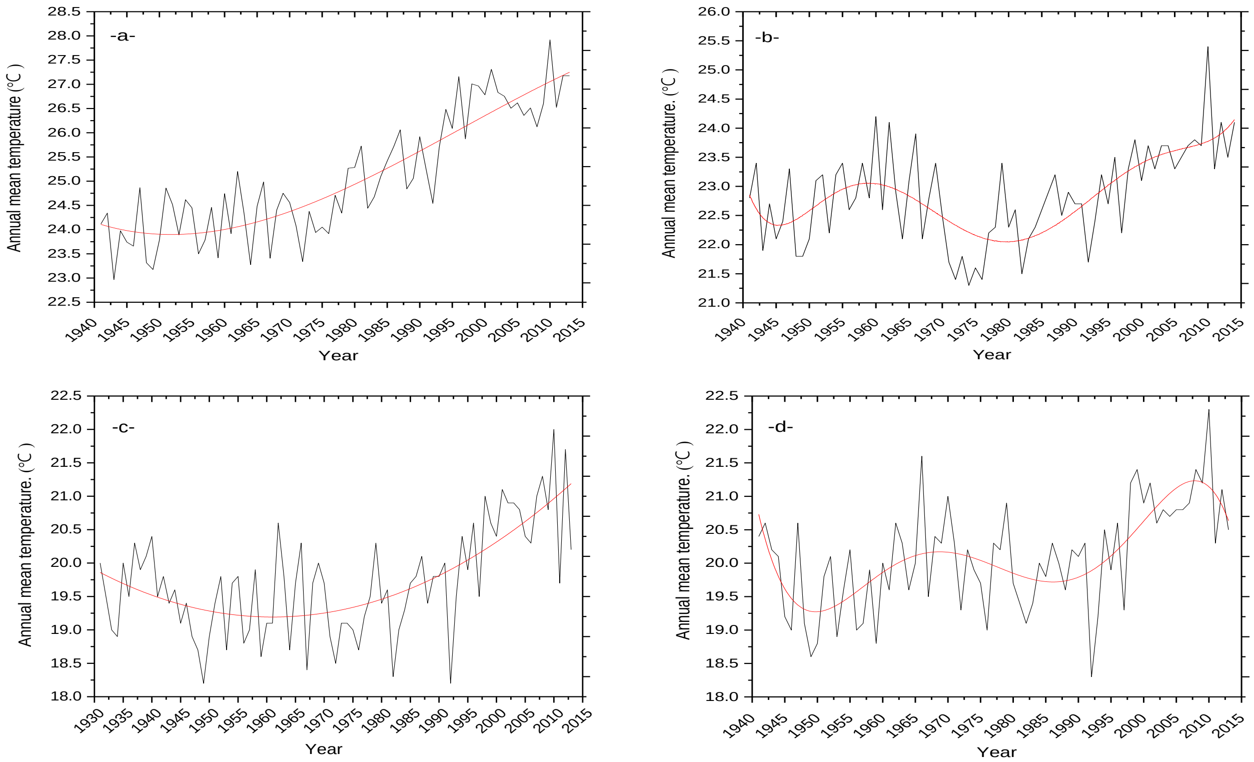

Figure: 2. Annual mean of air temperature for stations: (a) Basra, (b) Baghdad (c) Rutba and (d) Mosul.

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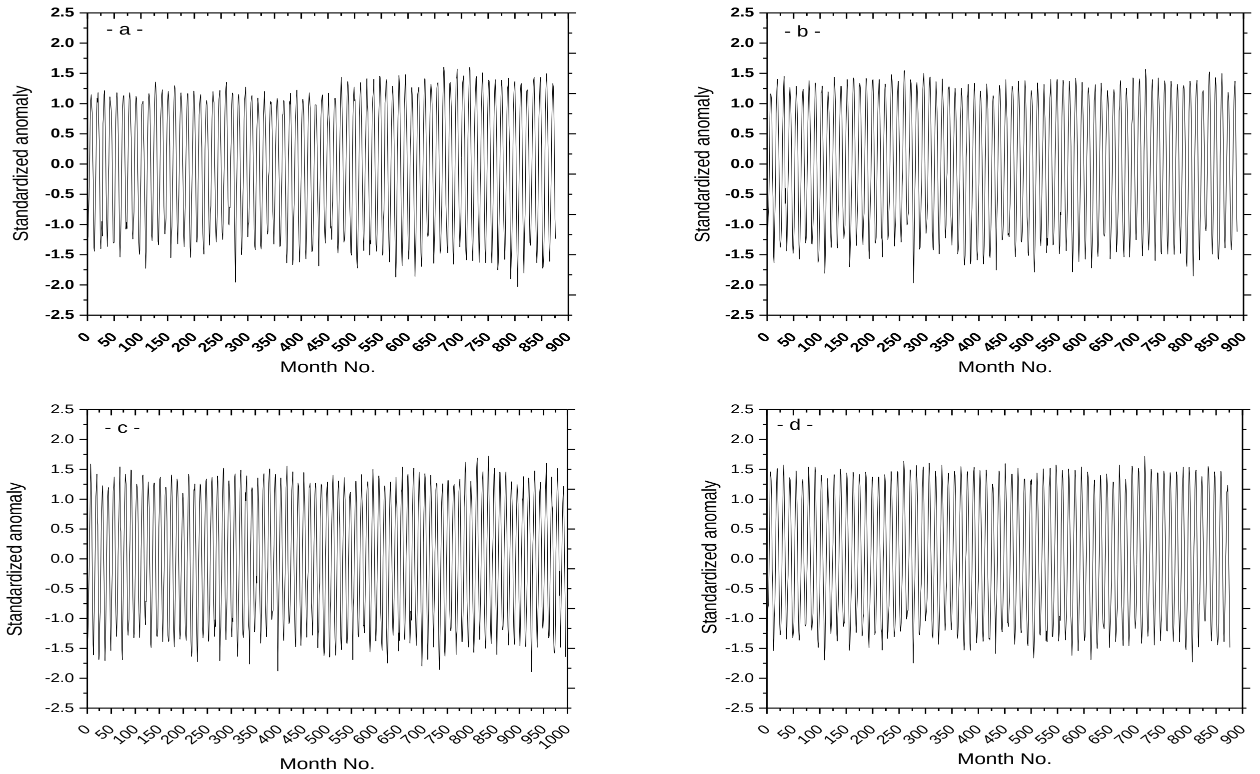

Figure: 3. Standardized anomalies of mean monthly of air temperature for stations: (a) Basra, (b) Baghdad, (c) Rutba and (d) Mosul.

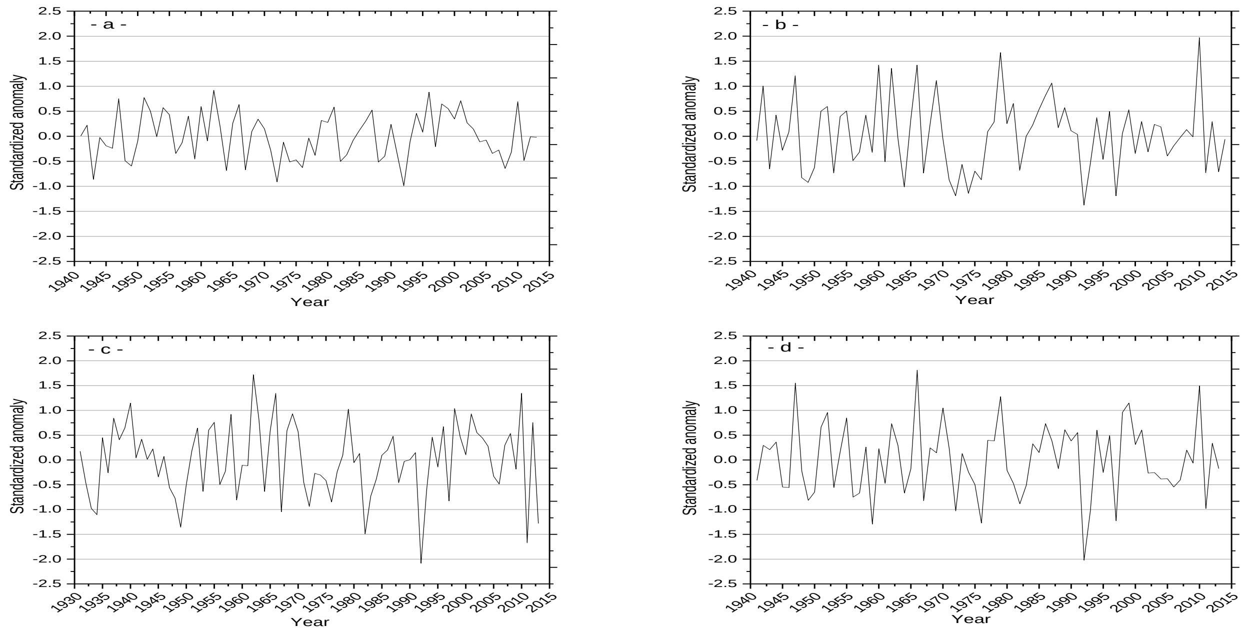

Figure: 4. Standardized anomalies of annual mean of air temperature for stations: (a) Basra, (b) Baghdad, (c) Rutba and (d) Mosul.

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From previous Figures monthly mean frequencies are calculated for both negative and positive standardized anomalies to the four studied stations are presented at Figures 5a, 5b, 5c and 5d. Through these figures it has found that the percentage of monthly mean frequencies appeared the highest value of negative standardized anomaly in the Mosul station (12.0%) and the lowest value in Rutba station (6.8%), while the highest value for positive standardized anomaly in Mosul station (16.2%) and the lowest value in Basra station (3.4%).

In the same way annual mean frequencies have calculated for negative and positive standardized anomaly for the four studied stations. The results are classified to five ranges and plotted in Figures 6a, 6b, 6c and 6d. It has found that the percentage of annual mean frequencies appeares the highest value of negative standardized anomaly in the Rutba station (4.8 %) and the lowest value in Baghdad and Mosul stations (1.4 %), while the highest value for positive standardized anomaly in Baghdad station (6.8 %) and the lowest value in Basra station (2.7 %).

Using the Equations (2, 3, 4, and 5) with helping software origin 9.0. The energies of spectral densities are calculated for standardized anomaly for monthly mean of air temperature for studied stations then calculate mean for this spectrum. The results are shown in the Figure 7, which show the maximum values of the energies of the spectral densities reaches in Mosul station (51059.01) at the frequency (0.002 Hz), and in the Baghdad station (46853.25) at the frequency (0.003 Hz), while the minimum value of the energies of the spectral densities reached in the Basra station (24930.97) at the frequency (0.002 Hz) then the Rutba station (26527.16) at the frequency (0.004 Hz).

In the same way, but for the values of the annual mean of air temperature for studied stations, the results of spectral densities are shown in the Figure (8). The results illustrate that the maximum values of the energies of the spectral densities reach in Basra station (156.97) at the frequency (0.027 Hz) and the Baghdad station (156.45) at the frequency (0.041 Hz), while the minimum value of the energies of the spectral densities reached in the Mosul station (48.97) at the frequency (0.075 Hz).

In order to compare the spectra of both monthly and annual air temperature curves among the stations, the results of their spectra plotted in Figures (9) and (10), respectively. The maximum values of spectral energy at low frequency is at Mosul station then at Baghdad station and lastly at Basra and Rutba stations as shown in figure (9). Mean while this result is different when plotting spectra of annual air temperature, where as the maximum values of them is shifted towards high frequencies (see Figure 10).

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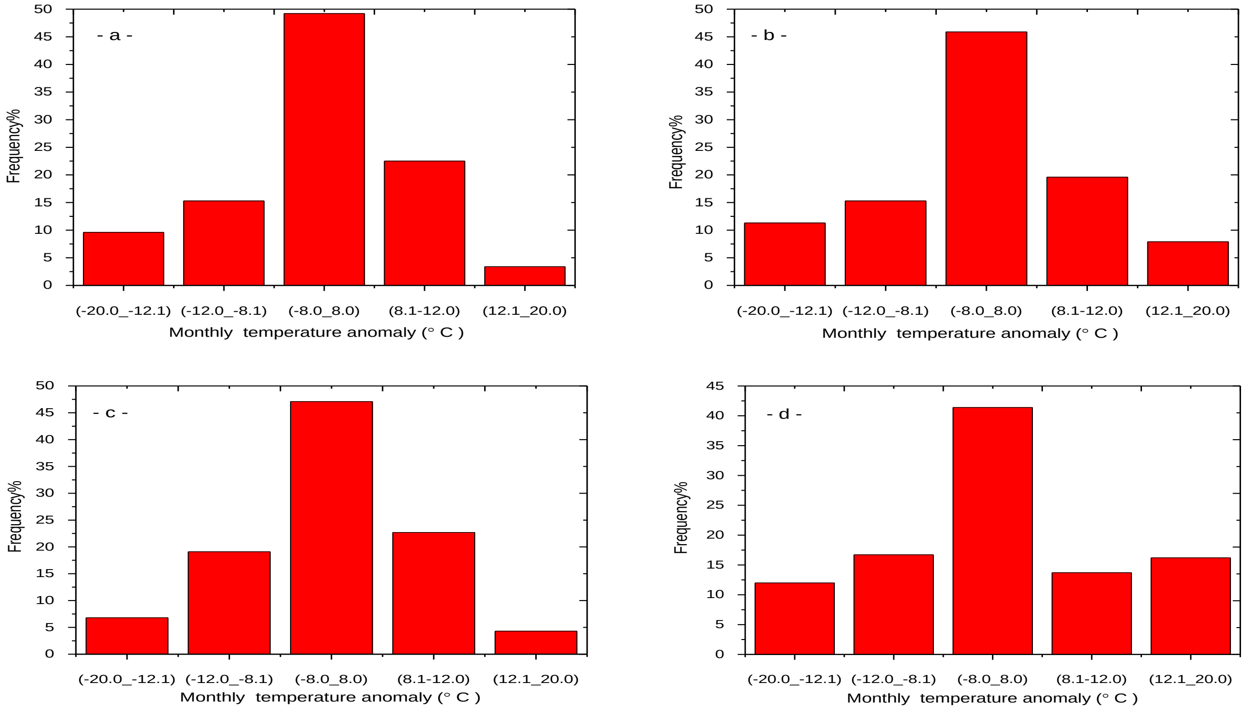

Figure: 5. The percentage of monthly Frequencies for standardized anomalies of air temperature for stations: (a) Basra, (b) Baghdad, (c) Rutba and (d) Mosul.

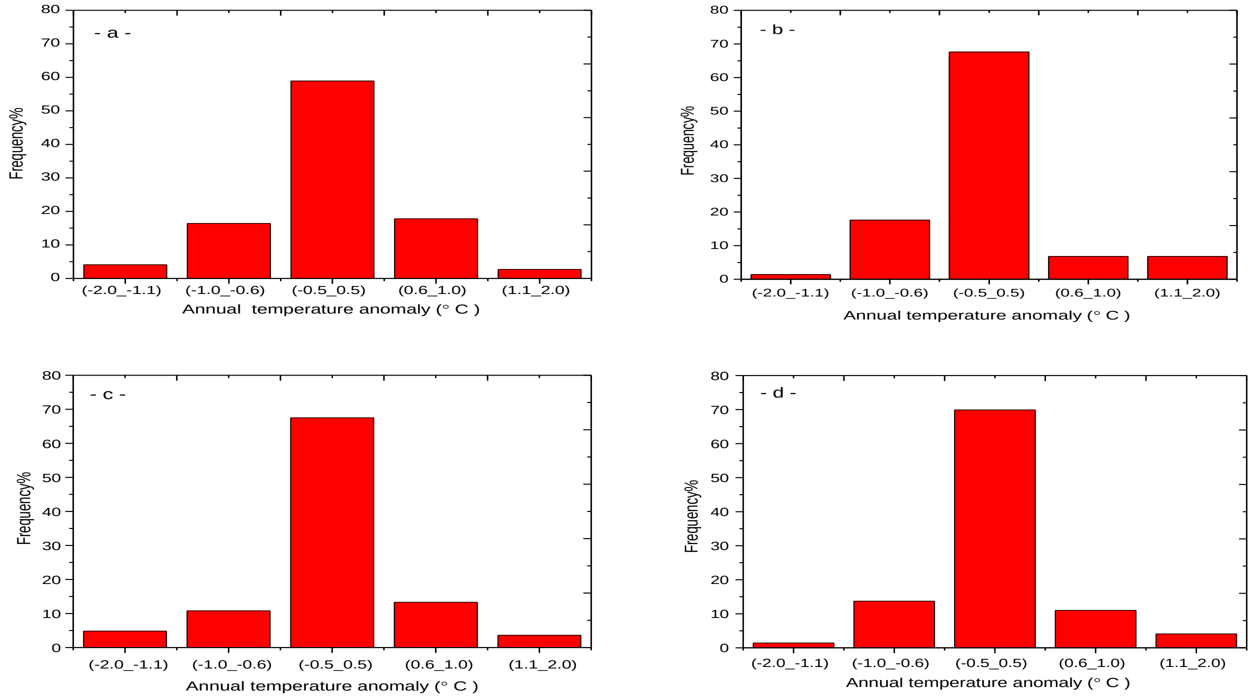

Figure: 6. The percentage of annual Frequencies for standardized anomalies of air temperature for stations: (a) Basra, (b) Baghdad, (c) Rutba and (d) Mosul.

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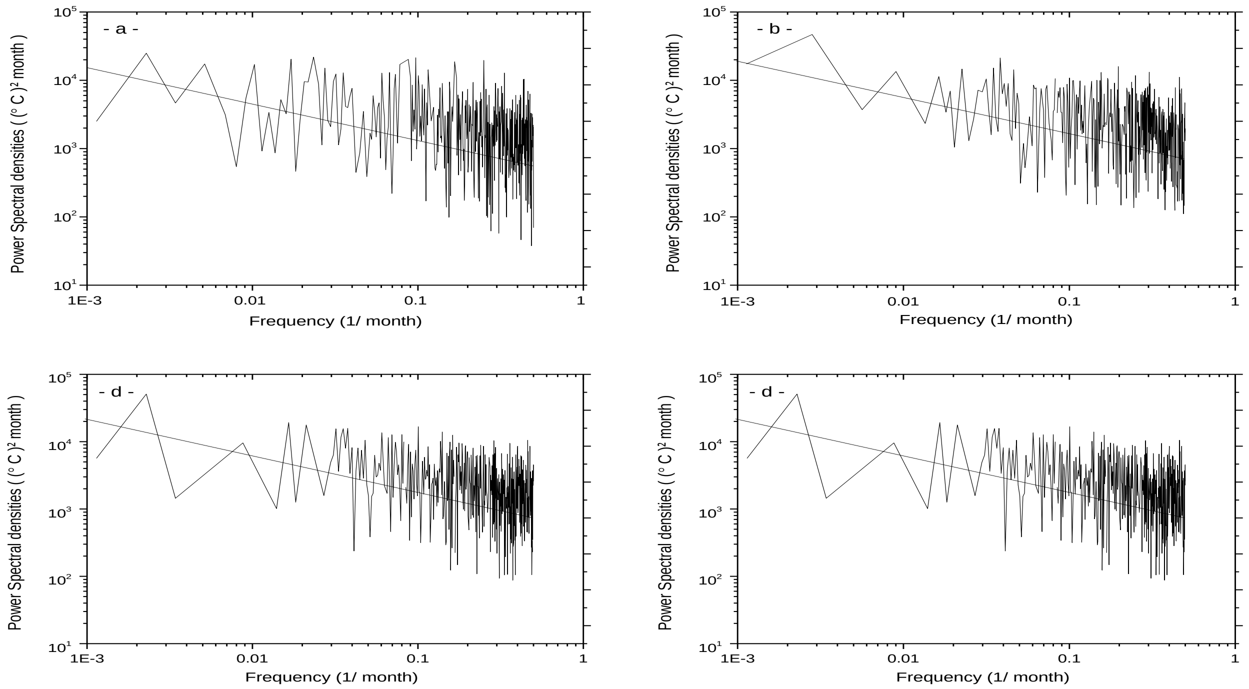

Figure: 7. The energies spectral density of standardized anomalies of monthly mean air temperature for stations: (a) Basra, (b) Baghdad, (c) Rutba and (d) Mosul.

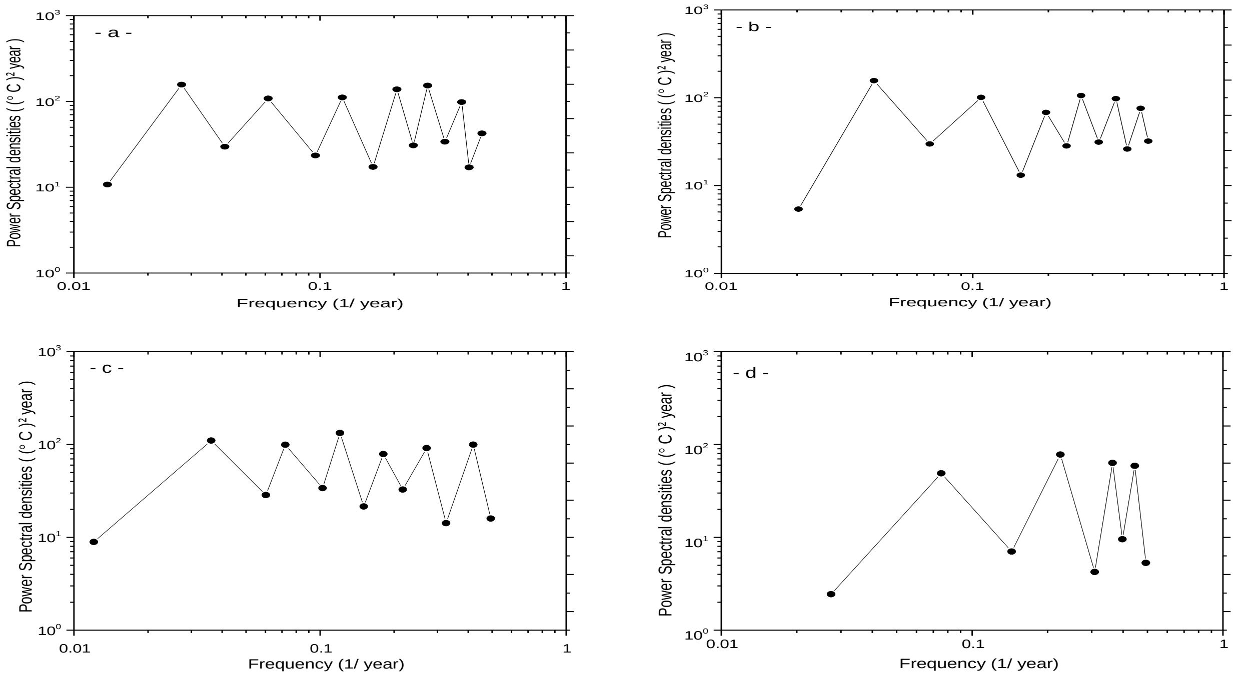

Figure: 8. The energies spectral density of standardized anomalies of annual mean air temperature for stations: (a) Basra, (b) Baghdad, (c) Rutba and (d) Mosul.

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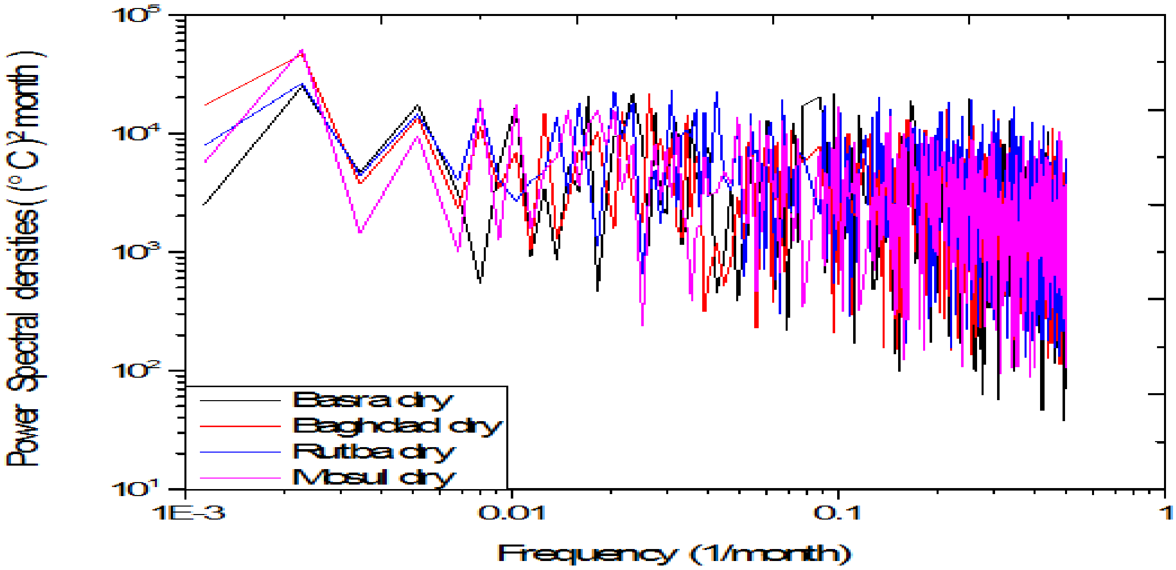

Figure 9: Great values of the energies of the spectral densities calculated for standardized anomaly of monthly mean of air temperature for stations: (Basra, Baghdad, Rutba and Mosul).

Table 2: Great values of the energies of the spectral densities calculated for standardized anomalies of monthly mean of air temperature for stations: (Basra, Baghdad, Rutba and Mosul).

Stations names	Great values ((° C)² Month)	Frequency F_P at great values
Basra	24930.97	0.0023
Baghdad	46853.25	0.0023
Rutba	24930.97	0.0023
Mosul	51059.01	0.0023

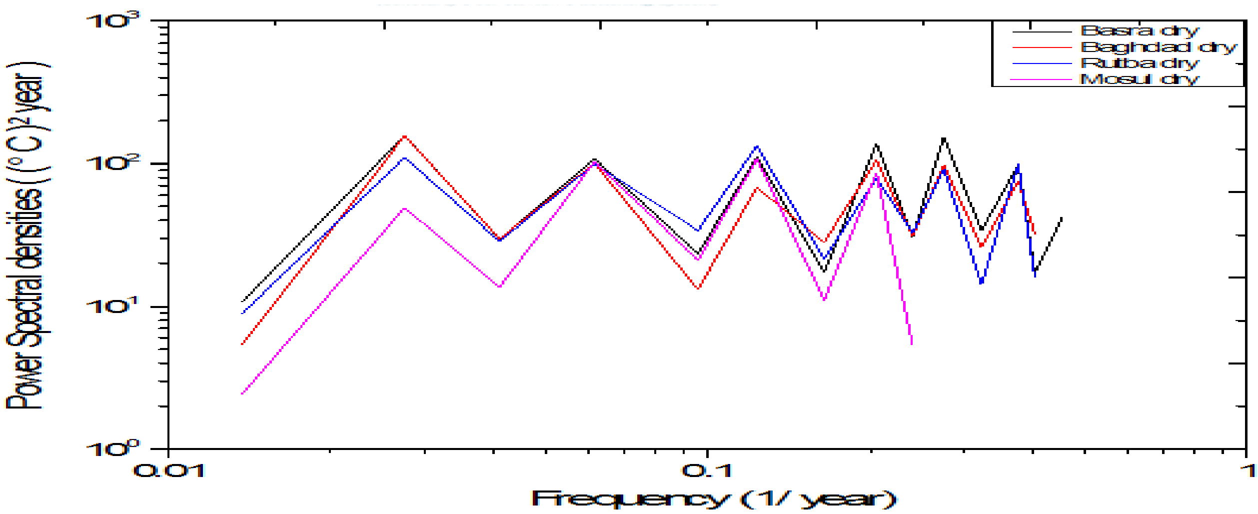

Figure 10: Great values of the energies of the spectral densities calculated for standardized anomaly of annual mean of air temperature for stations: (Basra, Baghdad, Rutba and Mosul).

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Table 3: Great values of the energies of the spectral densities calculated for standardized anomalies of annual mean of air temperature for stations: (Basra, Baghdad, Rutba and Mosul).

Stations names	Great values ((° C)^2 Year)	Frequency F_P at great values
Basra	156.98	0.027
Baghdad	156.98	0.027
Rutba	110.41	0.027
Mosul	49.00	0.027

6. CONCLUSION

It showed annual mean of analyzing the results of air temperature of the cities studied the stations of Basra and Rutba are more variation than Baghdad and Mosul and noticed through the drawing that the year 2010 witnessed the highest degree air temperature rates annually throughout the country and when we go back to the original data of the stations studied, we found that in 2010 there was also a decline in the annual rate of sea pressure facilities for high annual temperature rate. The reason for this is influenced by Iraq during the summer of 2010 to the extension of a warm air mass and dry accompaniment to low seasonal thermal-based Central Asia and that leads deepen to high temperatures across the country and that are higher than the general rates by several degrees and up to (50 °C) in several places in the central and southern regions, which in turn leads to lower atmospheric pressure sometimes for up to (998) hPa.

After this our study of the energies of densities spectral for standardized anomaly of monthly and annual mean of air temperature that different spectrum behavior in all cases and not dependent on a specific climate or specific specifications but noticed that the study of the spectrum need much data where we note that the greater the number of data increased the more spectrum summit which is dependent on the frequency where more data will decrease the frequency and when the minimum frequency spectrum peaks increases where we note that the great values of spectrum will increase when frequencies will decrease.

7. ACKNOWLEDGMENTS

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