International Journal of Religion
2024
Volume: 5| Number 11 | pp. 725 – 729
ISSN: 2633-352X (Print) | ISSN: 2633-3538 (Online)
ijor.co.uk
DOI: https://doi.org/10.61707/m4sgnr17

Analytical Study of Climate Change Indicators for Minimum Temperatures in Selected Regions of Iraq and their Trends

Nisreen Awad Al-Jassani[1] and Shirin Mujbel Abu Jassim[2]

Abstract

Extreme weather conditions have a severe impact on many important aspects of life, so it is necessary to predict the patterns of these conditions in the future in order to control them. To avoid many disasters that may lead to human lives and cause a lot of damage to the natural environment as well as infrastructure, these indicators are calculated based on daily monitoring of minimum temperatures.In this study, we have selected three indicators of extreme climatic phenomena for minimum temperatures, represented by those indicators identified by the Expert Group on Climate Change Monitoring. These indicators reveal the existence of climate change or not. The work of this joint team between the Climate Science Committee, the World Climate Research Program, and the Joint Technical Committee on Oceanography and Marine Meteorology, all of which met under the auspices of the World Organization. Climate indicators calculated from daily temperature data are also one of the ways to describe the frequency and intensity of extreme climatic phenomena. This study was carried out through R clim Dex, an open-source program based on the definitions developed by the World Meteorological Organization's Panel of Experts on Climate Change, which was issued in 2009, as in Table (1), and the analysis of trends in extreme microtemperature chains on various human activities.

Keywords: *Climate Change, Iraq Climate Change Indicators and Their Impact, Microtemperature Indicators, TNn, TNx, DTR*

INTRODUCTION

The importance of studying thermal indicators comes through the importance of climate changes and their results , as well as the temperature among other climatic elements and phenomena, because of their significant effects on the rest of the elements and climatic phenomena and the nature of their behavior and characteristics , as temperature is one of the most important climatic elements that control the distribution of life on the surface of the Earth due to the close relationship between them and all other climatic elements,whether directly or indirectly. It is the main driver of the rest of the other climate elements and at the same time affects and is affected by those elements (3), and the variation in climate between one region and another is only a reflection of the variation in temperature from one place to another or from one season to another. The distribution of atmospheric pressure, which in turn controls the distribution of winds and their flow system, and temperature is the one that controls the amount of evaporation and the amount of water vaporation in the atmosphere is closely linked to temperature, and the decrease in temperature to the level of condensation is a prerequisite condition for the occurrence of condensation and precipitation in its various forms (4). In addition to the impact of temperatures on human activities in various natural and human aspects, therefore (5) all the indicators that will be studied and clarified in the study work to clarify the change, whether positive or negative, in temperatures, as well as the semi-radical change in climate at the local level. This leads to damage to all activities and different sectors of society. What confirms this negative trend is the high level of certainty of temperature forecasts, which all confirm the rise in global temperature around the world and the identification of areas most vulnerable to the impact of climate change. (6) The problem of the study here is summarized by the following question (What is the role of climate changes in the geographical variation of the minimum temperature indicators for selected areas of Iraq) .The hypothesis is that climate changes have a significant role in the

[1] University of Kufa, College of Education for Girls, Department of Geography, Najaf, Iraq

[2] University of Kufa, College of Education for Girls, Department of Geography, Najaf, Iraq E-mail: sherinem.sahn@student.uokufa.edu.iq

geographical variation of the micro-temperature indicators for selected areas of Iraq , as the geographical analysis of the daily, monthly and annual periods was carried out, as well as a comparison between the monthly and annual periods of the micro-temperature indicators for selected stations from the year (1992-2021) and in the form of climatic cycles, according to which the duration of the study was divided to be (three climatic cycles for a period of 30 years).

Maps and graphs were used to give a clear picture of the change in micro-temperature spatially and temporally, as shown by explaining the micro-temperature indicators TNn, TNx, DTR.

Table (1) shows the climate change indicators of the minimum temperature used in the study

	Heat Indicators			
No	**Unit**	**Definition**	**Description**	**Heat Indicator**
1	°C	The coldest daily minimum temperature	Minimum Minimum Temperature	**TNn**
2	°C	The hottest daily minimum temperature	Maximum minimum temperature	**TNx**
3	°C	Average difference between daily maximum temperature and daily minimum temperature	Daily Temperature Change Range	**DTR**

Study And Geographical Analysis of Monthly and Annual Rates of Minimum Temperature Indicators

First, a study and geographical analysis of monthly averages, indicators of minimum temperatures

1- The index of the monthly maximum value of the daily minimum temperature TNx: - We note from the study and analysis of Table (2) that the monthly rates of climate stations varied during the third climate cycles (1992-2021), where they recorded the lowest monthly rate in January, where the general average of the three climate cycles was (11.78). The lowest value in the second period was (11.49), while the highest value in the third climate period was (12.29) .We also note that the highest value during all study periods was (32.46) during the month of July, where it recorded its lowest value in the first period (31.59), while temperatures according to the TNx index rose until it recorded its highest value during the third climate period, which reached (33.44) . The trend of linear regression reached (0.52), which is an average direct correlation, and the value of the coefficient of determination reached (0.06). We conclude from the above that the third climatic period is witnessing a clear rise in the monthly averages of temperatures according to the monthly maximum value index daily minimum temperatures TNx. We also conclude that temperatures have been rising during the last years of the study and very clearly because of the climatic changes in Iraq in particular and the climatic changes in the world in general.

Table (2) shows the monthly averages of the minimum temperatures according to the TNx index for the period from 1992 to 2021

Climatic cycles	January	Feb	March	April	May	June	July	Augst	Septembe r	October	Novemb er	Decem ber
First Climate Cycle (1992-2002)	11.57	12.56	16.62	23.02	27.89	29.33	31.59	30.92	27.88	23.51	17.99	13.20
Second Climate Cycle (2003- 2013)	11.49	13.51	18.38	23.22	28.25	30.63	35	31.77	28.37	24	18.77	13.14
Third Climate Cycle (2014- 2021)	12.29	14.41	18.31	26.37	28.44	30.95	33.44	32.68	29.98	25.27	18.87	65
Rate	11.78	13.49	17.77	24	28.19	30.30	32.46	31.79	28.74	24	18.54	13.66

The research source is based on the Republic of Iraq, the Ministry of Transport, the Public Authority for Weather and Seismic Monitoring, unpublished data,2021.

2- The index of the monthly minimum value of the daily minimum temperature TNn: - We note through the study and analysis of table (3), which shows the rates for the monthly periods of the TNn index that the lowest monthly rate recorded in January during the three cycles (1992-2021) is (0.17), where it recorded its lowest value during the second cycle of (46.0) and its highest value during the third cycle of (0.59). We also note that the highest monthly rates during the third cycles of the TNn index reached (24.31) in July, where the third climate cycle recorded the highest rate of (25.29) and the lowest rate is in the first climate cycle, where it recorded (23.26). The trend of linear regression reached (0.60), which is an average direct correlation, and the value of the coefficient of determination reached (0.06). We conclude from the above that the monthly rates according to the TNn index began to rise during the third cycle compared to the first and second cycles.

Table (3) shows the monthly averages of the minimum temperatures according to the TNn index for the period from 1992 to 2021.

Climatic cycles	December	November	October	September	August	July	June	May	April	March	February	January
First Climate Cycle (1992-2002)	**1.44**	**4.33**	**12.72**	**18.34**	**23.36**	**23.26**	**21.08**	**15.75**	**9.83**	**4.67**	**0.95**	**0.37**
Second Climate Cycle (2003- 2013)	**0.47**	**5.17**	**12.61**	**18.21**	**23.73**	**24.28**	**22.04**	**16.12**	**10.07**	**5.01**	**1.55**	**0.46-**
Third Climate Cycle (2014- 2021)	**2.02**	**6.04**	**13.71**	**19.72**	**24.85**	**25.39**	**22.07**	**17.13**	**9.68**	**6.68**	**1.25**	**0.59**
Rate	**1.31**	**5.18**	**13.01**	**18.76**	**23.98**	**24.31**	**21.73**	**16.33**	**9.86**	**5.45**	**1.25**	**0.17**

The research source is based on the Republic of Iraq, the Ministry of Transport, the Public Authority for Weather and Seismic Monitoring, unpublished data,2021.

3- The average difference index between the daily minimum temperature and the daily maximum temperature DTR: - As we can see from the study and analysis of Table (4), which shows the monthly rates of climatic periods according to the DTR index, that the lowest monthly rate recorded during the three periods of the study was in August, where it recorded (.81). It recorded its lowest rate in the first cycle, reaching (7.56) and its highest rate in the second cycle, reaching (8.04). As for the highest monthly rate, it was recorded in April, it reached (13.38). The third climate cycle recorded the highest value of (13.9) and the lowest value recorded during the second climate cycle (13.15). The trend of the linear regression of the cycle reached (06.- 0), which is an average inverse correlation, and the value of the coefficient of determination was (0.01).

Table (4) shows the monthly averages of the minimum temperatures according to the DTR index for the period from 1992 to 2021

Climatic cycles	December	November	October	September	August	July	June	May	April	March	February	January
First Climate Cycle (1992-2002)	11.75	13.66	10.80	9.54	7.56	8.33	8.25	12.15	13.19	11.95	11.61	11.20
Second Climate Cycle (2003- 2013)	12.67	13.60	12.08	10.15	8.04	8.06	8.59	12.13	13.15	13.36	11.96	11.95
Third Climate Cycle (2014- 2021)	12.63	12.83	11.56	10.27	7.83	8.04	8.88	11.31	13.79	11.63	13.16	11.70
Rate	12.35	13.36	11.48	9.99	7.81	8.14	8.57	11.86	13.38	12.31	12.24	11.62

Source: Republic of Iraq Ministry of Transport, Public Authority for Weather and Seismic Monitoring, unpublished data,2021.

Second: Study and geographical analysis of annual rates, indicators of minimum temperatures

1- The monthly minimum value index for the daily minimum temperature TNn: -

Through the study and analysis of Table (5), which shows the annual rates of study periods (1992-2021) for the lowest temperatures according to the TNn index, we note that the highest annual rates recorded in the first cycle were in the station of Basra and the neighborhood (1.34),(1.69), followed by the station of Nasiriyah and Diwaniyah (0.02),(0.37). We also note the clear decline in the annual rates in the station of Al-Rutba and Mosul, followed by the station of Kirkuk and Baghdad. During the second climate cycle, we note that the highest rates

were recorded in the station of Diwaniyah, where it reached (0.66). The lowest rate recorded during this cycle is in the station of Al-Rutba and Mosul, followed by the station of Kirkuk and Baghdad. During the third cycle, the highest rates were recorded in the station of Basra and Diwaniyah and the lowest rates were recorded in the station of Al-Rutba and Mosul. The slope trend reached (0.70), which is a strong direct correlation and the coefficient of determination reached (0.58). The direction of regression reached (0.58), which is an average direct correlation, and the coefficient of determination reached (0.51). The third period in which the direction of regression reached (0.69), which is an average correlation and the coefficient of determination reached (0.57). From the table, we conclude that Al-Rutba and Mosul stations record the lowest rates during all study periods, while Basra, Diwaniyah and Nasiriyah stations lead the high stations.

Table (5) shows the annual averages of the minimum temperatures according to the TNn index for the period from 1992 to 2021.

Climatic cycles	Basra	Nasiriyah	Diwaniyah	Alhey	Rutba	Baghdad	Kirkuk	Mosul,
First Climate Cycle (1992-2002)	1.34	0.02	0.37	1.64	-4.10	-2.70	-1.69	-3.68
Second Climate Cycle (2003- 2013)	-0.88	-0.73	0.66	-1.30	-4.72	-3.62	-2.68	-3.56
Third Climate Cycle (2014- 2021)	1.82	0.55	1.29	0.85	-4.27	-2.06	-0.99	-3.15

The research source is based on the Republic of Iraq, the Ministry of Transport, the Public Authority for Weather and Seismic Monitoring, unpublished data,2021.

2- The index of the monthly maximum value of the daily minimum temperature TNx: - We note through the study and analysis of Table (6), which shows the geographical analysis of the annual rates of the TNx index that the highest annual rates were recorded during the third cycle compared with the first and second cycles. We also note that the highest annual rates were recorded at the Basra station and the lowest rates were recorded at the Rutba and Mosul stations. The first period that the direction of regression reached (0.32), which is a weak direct correlation and the coefficient of determination reached (0.16). During the second period, the regression trend reached (0.46), which is a weak direct correlation, and the coefficient of determination reached (0.20). During the third period, the regression trend reached (0.55), which is an average correlation, and the coefficient of determination reached (0.43).

Table (6) shows the annual averages of the minimum temperatures according to the TNx index for the period from 1992 to **2021**

Climatic cycles	Mosul	Kirkuk	Baghdad	Al-Rutba	Alhey	Diwaniyah	Nasiriyah	Basra
First Climate Cycle (1992-2002)	31.54	33.96	31.54	28.23	32.99	35	33.87	33.97
Second Climate Cycle (2003-2013)	31.85	35	31.78	28.83	33.46	35	34.55	36.21
Third Climate Cycle (2014-2021)	31.66	35	32.86	30.78	75	35	35	36.43

The research source is based on the Republic of Iraq, the Ministry of Transport, the Public Authority for Weather and Seismic Monitoring, unpublished data,2021.

3- The average difference index between the daily minimum temperature and the daily maximum temperature DTR: - We note from studying and analyzing Table (7), which shows the annual averages of the minimum temperatures according to the DTR index that the highest annual averages were recorded at Basra station and that the second climatic period witnessed a clear increase in annual averages compared to the first and second cycles and that Al-Rutba station witnessed the lowest annual averages over the third cycles. The regression trend during the first cycle reached (38.-0), which is a weak inverse correlation and the coefficient of determination was (0.40). During the second period, the regression trend reached (01.- 0), which is a weak inverse correlation, and the coefficient of determination reached (0.00). During the third period, the regression trend reached (12).0), which is a complete inverse correlation, as the coefficient of determination reached (0.19).

Table (7) shows the annual averages of the minimum temperatures according to the DTR index for the period from 1992 to 2021.

Climatic cycles	Mosul	Kirkuk	Baghdad	Al-Rutba	Alhey	Diwaniyah	Nasiriyah	Basra
First Climate Cycle (1992-2002)	35	65	24	32.33	31.36	32.98	33.85	32.64
Second Climate Cycle (2003-2013)	35	38.56	35	33.55	34.76	34.48	35	37.09
Third Climate Cycle (2014-2021)	34.81	36.23	34.93	35	33.90	34.13	35	34.61

The research source is based on the Republic of Iraq, the Ministry of Transport, the Public Authority for Weather and Seismic Monitoring, unpublished data,2021.

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