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Analysis of the Spatial and Temporal Variability of Thunderstorms and their General Trend in Iraq

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Abstract: The thunderstorm is one of the familiar weather phenomena all over the world. It is one of the sudden electrical discharges accompanied by a flash of light (lightning) and a strong sound (thunder). Since the speed of light is much greater than the speed of sound, the sound of thunder lags behind the sight of lightning after approximately five seconds. The thunderstorm is accompanied by strong wind hea, rain, honing, and thunder. Nevertheless, the thunderclouds only form when controlling a state of instability, a noticeable depth of air in the atmosphere, and if the disturbed air is moist.

The study includes three topics: the first topic (Thunderstorms and their causes), the second topic (the spatial and temporal variability of thunderstorms), and the third topic (the general trend of thunderstorms in Iraq). And the problem of the study was represented (do thunderstorms vary spatially and temporally in Iraq?). The hypothesis states (thunderstorms differ spatially and temporally in Iraq). The research aims to study the frequency of thunderstorms and the ratio of cloud cover in the sky for the period (1980-2012) to report the factors that determine their occurrence and geographical distribution to determine the times when they occur and analyze the spatial and temporal variability of thunderstorms and their general direction in Iraq. The research reached several results, the most important of which are:

1. The month of April records the highest frequency of thunderstorms at all stations except for the wet station, records the month of October at an average of (2.3 days) due to the air turbulence and the rising air currents responsible for the instability as well as the increase in the condensation tendencies flying from the atmosphere which is one of the basic conditions for the formation of clouds Among them are the cumulonimbus clouds which are responsible for the

formation of rainy thunderstorms. Mosul leads the stations of the study area in the frequency of thunderstorms for this month at a rate of up to (4.6 days).

2. During this period, the Mosul station took the lead in total frequency among the stations included in the study (19.8 days) due to its geographical location in northern Iraq and the passage of the Mediterranean lows.

3. The general trend of the thunderstorms is towards the increase in all the stations to reach the trend to (0.05, 0.02, 0.03, 0.05, 0.001, 0.04, 0.003) for the stations (Mosul, Baghdad, Al-Rutba, Karbala, Al-Hay, Najaf, Basra) respectively.

Keywords: Target Costing Technique, Quality Function, Improving Product Value, Production Costs.

Introduction: A thunderstorm is a common atmospheric phenomenon worldwide. It is a sudden electrical discharge accompanied by a flash of light (lightning) and a loud sound (thunder). Since the speed of light is much greater than the speed of sound, the sound of thunder is delayed by approximately five seconds after the lightning is seen.

A thunderstorm is accompanied by strong winds, heavy rain, lightning, and thunder, evidence of the tremendous amount of energy expended during a severe thunderstorm. Most of this energy is derived from the total latent heat released by the condensation of water vapor, with some of this heat converted into kinetic energy, which is explained by the strong winds accompanying the storm. However, thunderclouds only form when there is a noticeable profound atmospheric instability, and the turbulent air is humid.

Research Problem:

(Do thunderstorms vary spatially and temporally in Iraq?)

1- How are thunderstorms distributed spatially and temporally in Iraq?

2- What is the general trend of thunderstorms?

Research Objective:

(Thunderstorms vary spatially and temporally in Iraq)

1- Thunderstorms are distributed spatially and temporally in Iraq, increasing in the northern and western parts and decreasing in the central and southern parts. Temporally, they increase in the spring.

2- The general trend of thunderstorms in Iraq is toward an increase.

Research Objectives:

The research aims to study the frequency of thunderstorms and the percentage of cloud cover in the sky (1980-2012) in different parts of the country. It also aims to determine the factors that determine their occurrence, their geographical distribution, and the times of their occurrence.

Boundaries of the Study Area:

The following climatic stations represent the spatial boundaries:

(Mosul - Baghdad - Rutba - Karbala - Al-Hayy - Najaf - Basra).

The temporal boundaries are limited to the period (1980-2012). Table (1) Climate stations included in the study.

Longitude	Latitude	Height in meters	Stations
˚43 09	˚36 19	223	Mobile
˚44 24	˚33 18	31.7	Baghdad
˚40 17	˚33 02	630	Anbar
˚45 43	˚33 32	33	Karbala
˚46 02	˚32 08	17	Al-Hay
˚44 19	˚31 57	32	Najaf
˚47 47	˚30 31	2.4	Basra

Source: Republic of Iraq, Ministry of Transport and Communications, General Authority for Meteorology and Seismic Monitoring, Climate Atlas of Iraq, Baghdad.

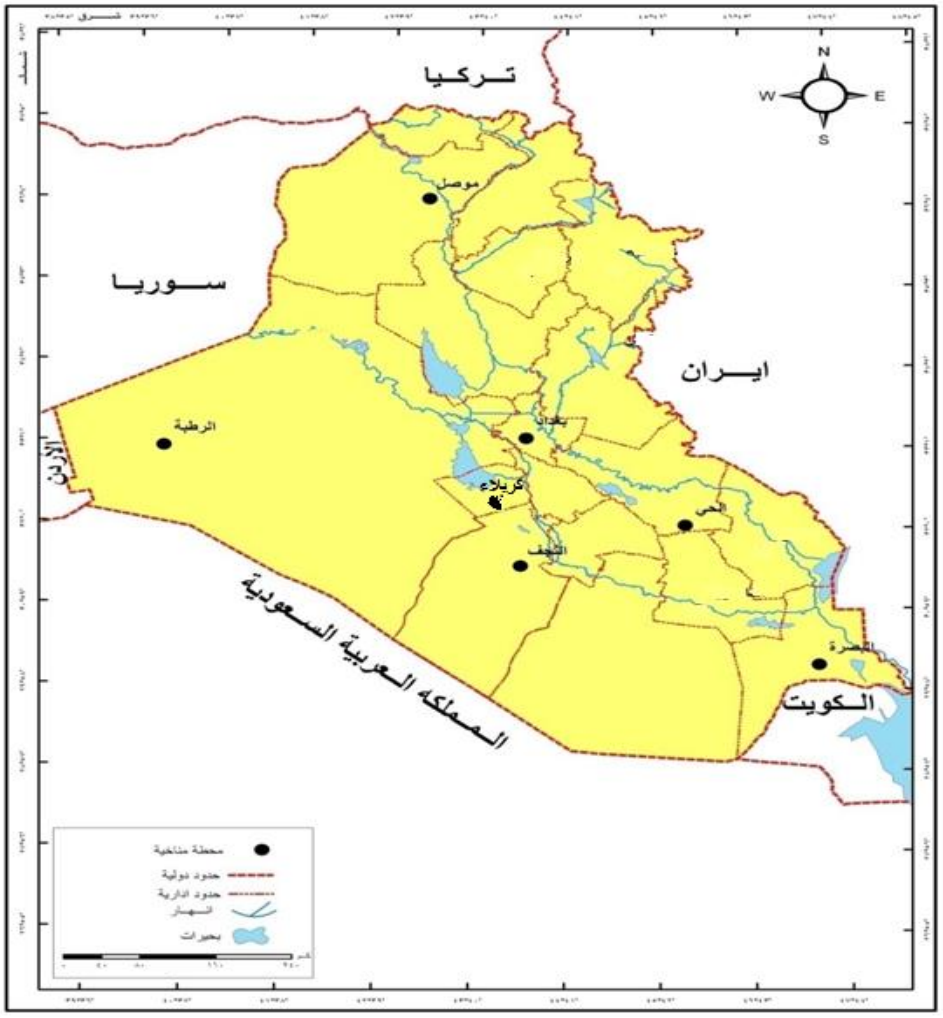


Figure (1)

Location of stations in the study area

Source: Republic of Iraq, Ministry of Transport and Communications, General Authority for Meteorology and Seismic Monitoring, Iraq Climate Atlas, Baghdad, 1979.

Section One

Thunderstorms and their causes

First: Definition of thunderstorms and their results

Thunderstorms are sudden electrical discharges that can occur in all regions of the world, including the study area, due to their association with the visible and audible phenomena of lightning and thunder, which are among the primary conditions required in every storm. Despite the small area occupied by thunderstorms, which are formed by strong ascending air currents, they are often accompanied by intense lightning and thunder, high-speed winds, and very heavy rain, with hail in most cases. Due to the varying intensity of ascending air currents and the amount of moisture they carry, they have been divided into rainy and non-rainy thunderstorms. Thunderstorms are localized storms accompanied by thunder, lightning, and heavy rain, forming over a short period of time and preceded by violent gusts of surface wind, although air speed is primarily vertical.

Cumulonimbus clouds, formed by strong upward air currents, are not responsible for all thunderstorms. They rapidly rise upward in the form of a massive anvil, like large towers. They also appear dark when viewed from their base due to their great thickness. The importance of this phenomenon lies in its role as a major source of water vapor and energy distribution in the atmosphere, as they absorb heat and moisture from the layers of the atmosphere and transfer it to the upper atmosphere, contributing to wind generation and the consolidation of thermal energy. They are also the basis for generating atmospheric electricity on clear days.

Thunderstorms are also known as powerful storms containing lightning and thunder. They are constantly

present in the atmosphere, so aircraft encountering thunderstorms is inevitable. Thunderstorms are a frightening weather phenomenon for pilots and cause significant delays to flight schedules. The pilot works hard to avoid thunderstorms by circling them and staying away from their locations.

Thunderstorm Formation:

For a thunderstorm to form, there must be currents carrying water vapor from the surface, and there must be an uplift of moist air in the atmosphere. This uplifting mechanism includes mountain ranges, cold fronts, depressions, and atmospheric troughs.

• Conditions for Thunderstorms:

The conditions for thunderstorm formation include:

1. The presence of moist air near the Earth's surface. The source of the moisture may be local or external.

2. The presence of atmospheric instability, as this helps activate updrafts.

3. The presence of a driver for updrafts, along with a surface heating factor, such as terrain or air fronts.

4. The presence of an upper thermal inversion, which contributes to the formation of large thunderstorms, as heating continues in the atmospheric layer below the thermal inversion, and the intensity of the instability increases until cumulus clouds can penetrate the thermal inversion layer. Therefore, small cumulus clouds grow below the thermal inversion layer and do not form a strong storm unless the instability intensifies and the clouds penetrate the thermal inversion layer, growing and rising to the tropopause.

5- Dew point temperatures rise to more than 10°C, which activates condensation and rain formation. It has been found that a storm is weak if the dew point temperature is below 10°C. Second: The Life Stages of a Thunderstorm

A thunderstorm goes through three stages, depending on the prevailing direction and the magnitude of vertical air movement. These stages are:

• The first stage: called the cumulus stage, typically lasting between 10 and 15 minutes. This stage is characterized by the presence of only ascending air currents and the absence of descending air currents. These ascending air currents are pushed to heights of up to 5 kilometers, in turn leading to the formation of the clouds responsible for the thunderstorm, particularly the cumulonimbus type. This occurs when a state of severe atmospheric instability prevails at a significant depth in the atmosphere. Furthermore, the turbulent air is associated with high humidity, as well as the lifting force of the ascending air currents, which are similar to the intense heating of the Earth's surface or along the air fronts accompanying the low-pressure system, particularly the cold ones. The temperature in most parts of the cloud is above zero degrees Celsius, except for some areas at the top of the cloud.

• The second stage: called the mature stage, typically lasting between 15 and 30 minutes. It is considered one of the most dangerous stages of a thunderstorm due to the presence of ascending and descending air currents, along with the electrical charges that pervade the cloud. This stage also includes the lightning and thunder phenomena that accompany this stage. These air currents rise to high altitudes, possibly exceeding the troposphere. The speed of the electrical currents reaches 300 km/h. The temperature in most areas of the cloud falls below zero degrees Celsius. This indicates the presence of solid water, which may be in the form of ice crystals, hail, or hail.

• The third stage: called the dissipating stage, typically lasting approximately 30 minutes. It is characterized by the dispersal of the large cloud, with its upper part remaining at the tip of the anvil. Downward air currents dominate over upward air currents due to the cooling of the ground surface caused by the cold air current, which interrupts the upward air currents, stopping them in the direction of the thunderstorm. Factors responsible for the formation of thunderstorms:

1- Surface winds:

When a thunderstorm arrives, cold, descending air currents collide with the ground and spread in all directions, spreading at a greater speed toward the front of the thunderstorm. Wind speeds can reach 25 m/s. These winds play a significant role in determining whether the thunderstorm dissipates or continues as it was.

1- Atmospheric Pressure:

When a thunderstorm forms, the atmospheric pressure tends to decrease due to the dominance of ascending air currents. However, its value changes as the thunderstorm matures, i.e., when the ascending and descending air currents become active. With each descending current, there is a rise in pressure, and with each ascending current, there is a decrease in pressure, with the overall pressure remaining low as the storm passes.

2- Temperature:

Temperature is associated with a drop during the passage of a thunderstorm due to the cold descending air that spreads upon impact with the ground. The temperature drops suddenly, by approximately 10°C, mitigating the intensity of the heat, which is then accompanied by a rapid drop in pressure.

3- Rainfall:

Despite the many types of clouds responsible for forming a thunderstorm, cumulonimbus clouds are directly responsible for the phenomenon. They are characterized by the heavy rainfall that accompanies them during the storm, but their short duration of rainfall, which does not exceed 30 minutes.

4- Hail

Hail is a product of thunderstorms associated with cumulonimbus clouds, also known as hail clouds, because their repeated descent and ascent allow the initial hailstones to grow and become larger. • Types of Thunderstorms

1- Rainy Thunderstorms:

These are storms accompanied by heavy rain due to the thickness of the clouds responsible for thunderstorms, which are linked to the type of air fronts accompanying the frontal depression. Cold fronts play a major role in creating instability and contribute to the formation of the clouds responsible for thunderstorms. This is due to the movement of cold air, which lifts warm, moist air into the upper layers of the atmosphere. Upon reaching the level of elevation condensation, it condenses, forming dense Cumulonimbus clouds, which lead to heavy rain accompanied by thunderstorms along a narrow band of the front. The intense heating of the Earth's surface also leads to the formation of cumulonimbus clouds, which develop into cumulonimbus clouds as a result of the rise of moisture-laden air to high levels due to convection currents, which are responsible for the formation of this type of rain cloud. Therefore, it is clear from the above that the main factors responsible for the rainfall accompanying thunderstorms are the type of depression, which comes in the order of The second, particularly during the fall and spring seasons, is the unstable weather associated with the Red Sea depressions and other thermal depressions.

2- Non-rainy thunderstorms:

These are storms characterized by thunder and lightning, but are not accompanied by rain due to the thinness of the clouds responsible for them, resulting from low relative humidity values. This occurs when the air is relatively dry and stable, which in turn leads to the formation of medium and high clouds, which are responsible for the occurrence of non-rainy thunderstorms.

• Thunderstorm Contents:

1- Lightning: Thunderstorms are named so because they are accompanied by thunder. Thunder always occurs with lightning, as humans can see and hear. Lightning occurs in large cumulus clouds and does not occur in small, thin clouds. Most lightning occurs in tropical regions where strong weather storms are frequent. Lightning results from the separation of negative and positive charges within the cloud during thunderstorms. This creates a gradient in electrical potential. When this gradient reaches a critical value, electrical contact occurs between the areas of negative and positive charges, resulting in lightning. Lightning can occur within the cloud itself, between a cloud and another cloud, or between a cloud and the ground. The most common type is lightning that occurs within a cloud or between clouds and lightning. Lightning occurs between the bottom of the cloud and the ground, causing bodily harm. Lightning occurs in pulses that occur in stages. The lightning bolt begins between the bottom of the cloud and the lightning bolt, with a spark moving rapidly from the area of negative charge accumulation at the bottom of the cloud. Towards the ground, it attracts the positive charges that form on areas or objects high on the surface of the earth, so a positively charged flash rises from the ground upwards when the negative atmospheric charges approach the surface of the earth, and lightning occurs.

When an electrical discharge occurs between negative and positive charges (lightning), the air along the lightning bolt, with a diameter of about 2 cm, heats up, reaching temperatures exceeding 15,000 degrees Celsius. This sudden and rapid heating results in the sudden expansion and contraction of the air, creating shock waves that radiate from the lightning strike area, causing a loud sound known as thunder. Lightning can be seen from great distances, but thunder can only be heard at a distance of about 25 kilometers from the lightning strike. Therefore, a person may see lightning but not hear the thunder when the storm is far away.

• Types of Lightning:

Lightning appears during thunderstorms in various forms, including:

1- Sheet lightning: It occurs in the form of wide, luminous sheets. It is seen when lightning illuminates part of the sky and clouds.

2- Heat lightning: It occurs when the cloud is far away. Lightning is seen on the horizon, but the sound of thunder is not heard.

3- Forked lightning: This is the most common type and usually extends from the base of a cloud to the ground.

4- Ribbon lightning: This is in the form of lines or bands and occurs when strong winds pull lightning along with the wind and carry it downward at high speed.

5- Broken lightning: This occurs at short, intermittent intervals and is often seen as a seven-pointed star.

6- Bell lightning: This is a rare and unexpected occurrence. It falls from the sky in the form of a small, luminous, and hot ball, about 15 cm in diameter. Ball lightning does not last long on the ground and disappears within a few seconds. Ball lightning is not well understood.

• Harmful effects of lightning:

Lightning has been documented to cause significant damage on Earth. It can down power and communication cables, cause forest fires, and kill or injure large numbers of people annually. It is responsible for the deaths of 5,000 people worldwide annually. It is noted that lightning damages high areas or objects, such as electricity poles, radio or television transmission poles, and people. It kills people who are higher than the surrounding areas, such as those riding a horse or swimming in open water. In these cases, the person is high up and is struck by lightning. Lightning kills a number of people who are near or in contact with high areas, such as people near metal fences, under tall or isolated trees, or when using electrical appliances such as telephones and televisions.

To protect yourself from lightning during thunderstorms:

1. It is preferable to stay indoors or in your car during a strong thunderstorm, as the car is a safe place from lightning.

2. Do not use your phone unless necessary, and do not touch your television to change channels.

3. Stay away from open water, such as seas and lakes, and stay away from telephone and electricity poles, fences, metal pipes, tall or isolated trees, and avoid using agricultural machinery and bicycles.

4- If you are outside, seek suitable shelter, avoiding high objects and moving your body toward objects in the area. Take shelter in a low-lying area.

• Phenomena associated with thunderstorms:

1- Lightning

2- Blizzard

3- Tornado

4- Downdrafts

5- Heavy rain

6- Lightning pellets that may be of enormous size

• The role and importance of thunderstorms:

Thunderclouds are important mechanisms in distributing energy in the atmosphere, taking heat and moisture from the lower layers of the atmosphere and transferring them to the upper layers. The energy of a thunderstorm is equivalent to 10 times the energy generated by the nuclear bomb dropped on Hiroshima. There are approximately 2,000 active thunderclouds on Earth at one time, but only 1% of these clouds produce hail the size of 3/4 inch or generate strong downdrafts.

Section Two

Spatial and Temporal Variation of Thunderstorms

First: Spatial and Temporal Variation of Thunderstorms

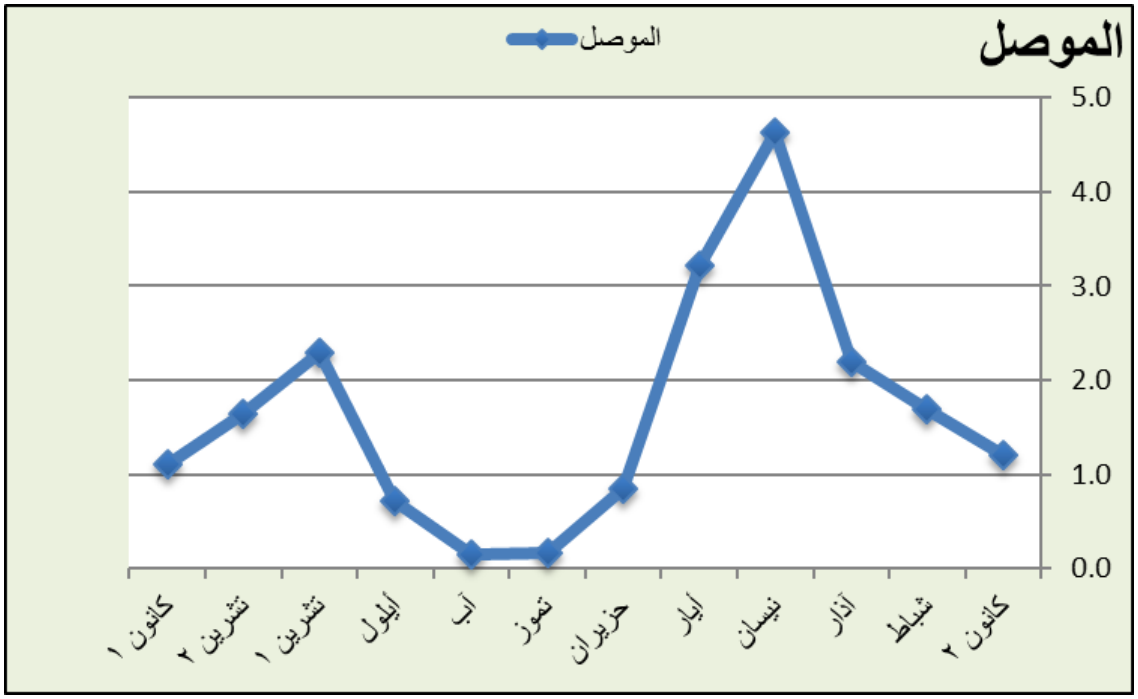
By observing Table (2) and Figure (2), which show the monthly average frequency of thunderstorms with rain, it is clear that there are variations in frequency between stations depending on their location and the multiple factors responsible for their formation, and for all stations during the study period. During this period, Mosul Station occupied the top spot in total frequency among the stations included in the study, with a total of (19.8 days), due to its geographical location in northern Iraq and its position as a corridor for Mediterranean low-pressure systems. April records the highest frequency of thunderstorms at all stations, with the exception of Rutba Station, which records an average of 2.3 days in October. This is due to air disturbance and rising air currents responsible for the instability, as well as an increase in condensation nuclei emanating from the atmosphere, which are a prerequisite for cloud formation, including cumulonimbus clouds, responsible for the formation of rain-laden thunderstorms. Mosul tops the study area stations in the frequency of thunderstorms for this month, with an average of 4.6 days.

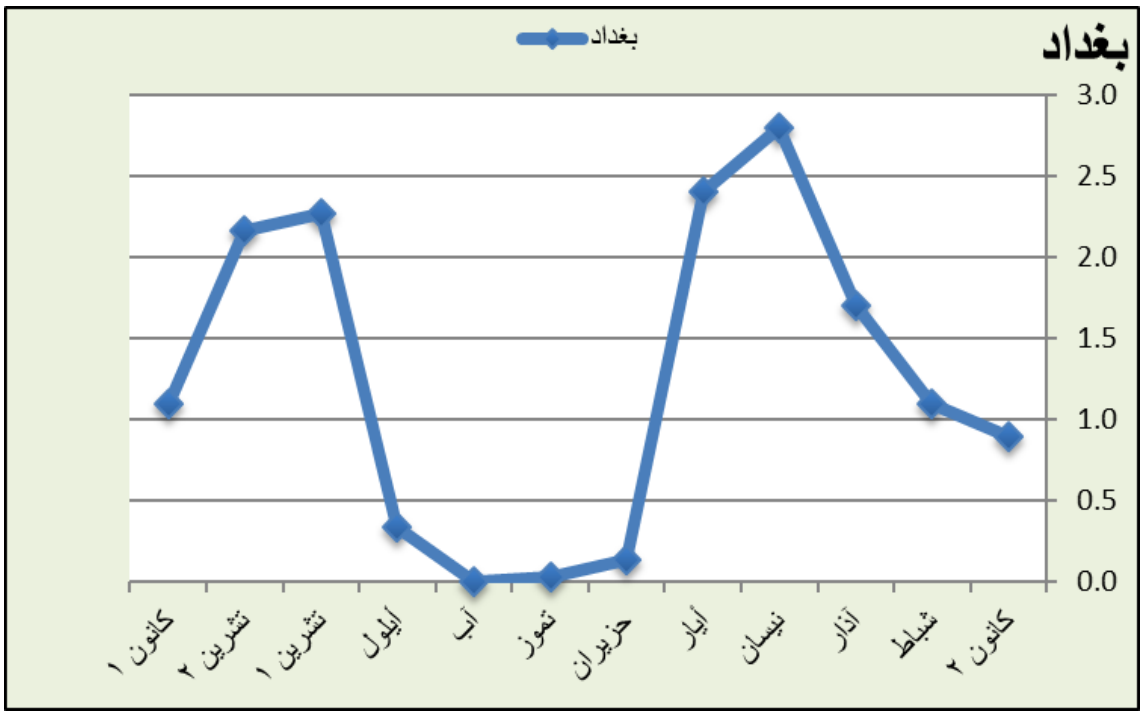
Table (2) :Monthly average number of thunderstorm days and annual total in the study area for the period (1980-2012)

Annual total	December 1	November	October 1	September	August	July	June	May	April	March	February	December 2	Stations

19.8	**1.1**	**1.7**	**2.3**	**0.7**	**0.2**	**0.2**	**0.8**	**3.2**	**4.6**	**2.2**	**1.7**	**1.2**	Mosul
14.9	**1.1**	**2.2**	**2.3**	**0.3**	**0.0**	**0.0**	**0.1**	**2.4**	**2.8**	**1.7**	**1.1**	**0.9**	Baghdad
10.6	**0.5**	**0.8**	**2.3**	**0.1**	**0.1**	**0.1**	**0.2**	**2.2**	**2.1**	**1.2**	**0.6**	**0.4**	Anbar
11.1	**1.1**	**1.3**	**1.7**	**0.1**	**0.0**	**0.0**	**0.2**	**1.3**	**2.5**	**1.6**	**0.7**	**0.7**	Karbala
11.3	**1.0**	**1.6**	**1.3**	**0.1**	**0.1**	**0.0**	**0.2**	**1.2**	**2.5**	**1.4**	**1.2**	**0.8**	Al-Hayy
11.3	**1.0**	**1.3**	**0.9**	**0.0**	**0.0**	**0.0**	**0.2**	**2.0**	**2.3**	**1.7**	**0.8**	**1.0**	Najaf
14.9	**1.3**	**2.1**	**1.6**	**0.2**	**0.0**	**0.0**	**0.1**	**1.7**	**2.6**	**2.4**	**1.7**	**1.1**	Basra

Source: Republic of Iraq, Ministry of Transport and Communications, General Authority for Meteorology and Seismic Monitoring, Climate Department, unpublished data, 2013.

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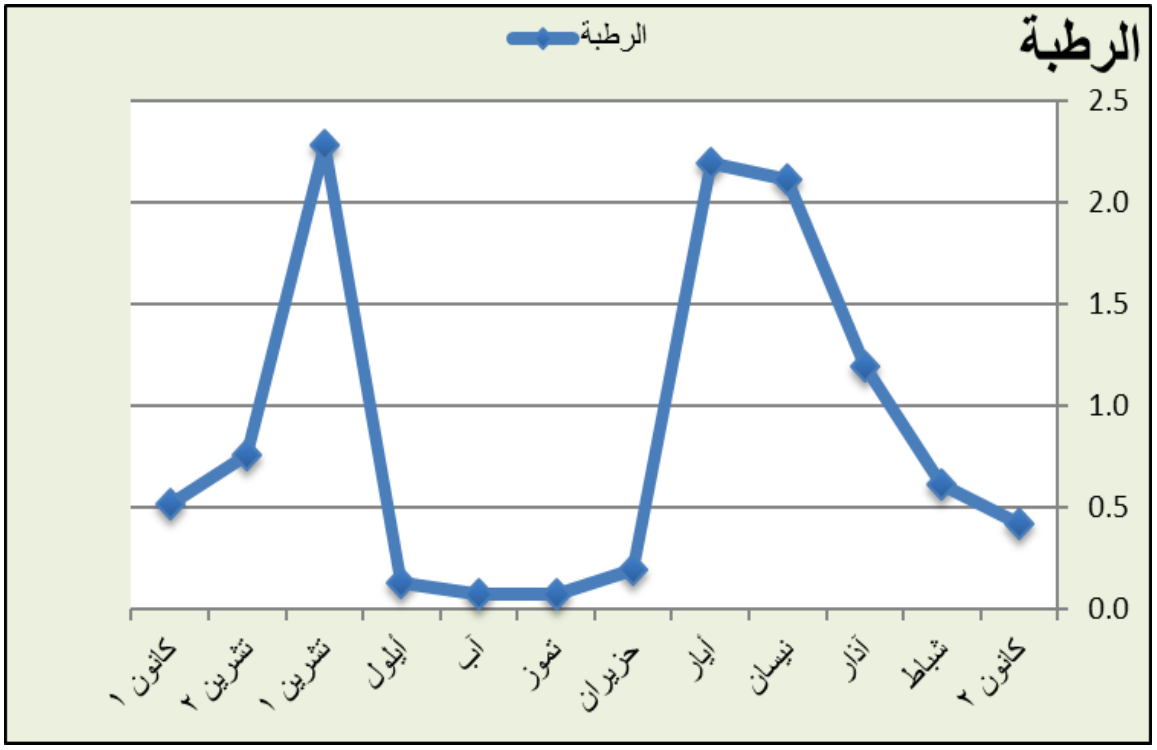
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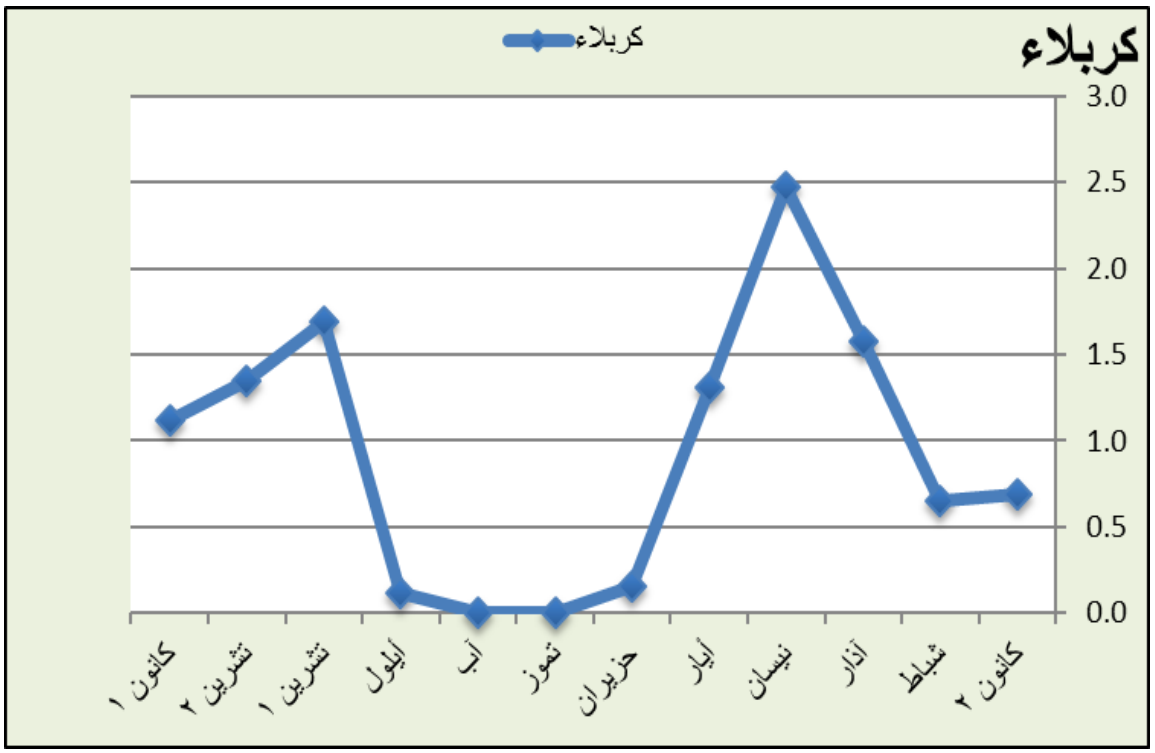
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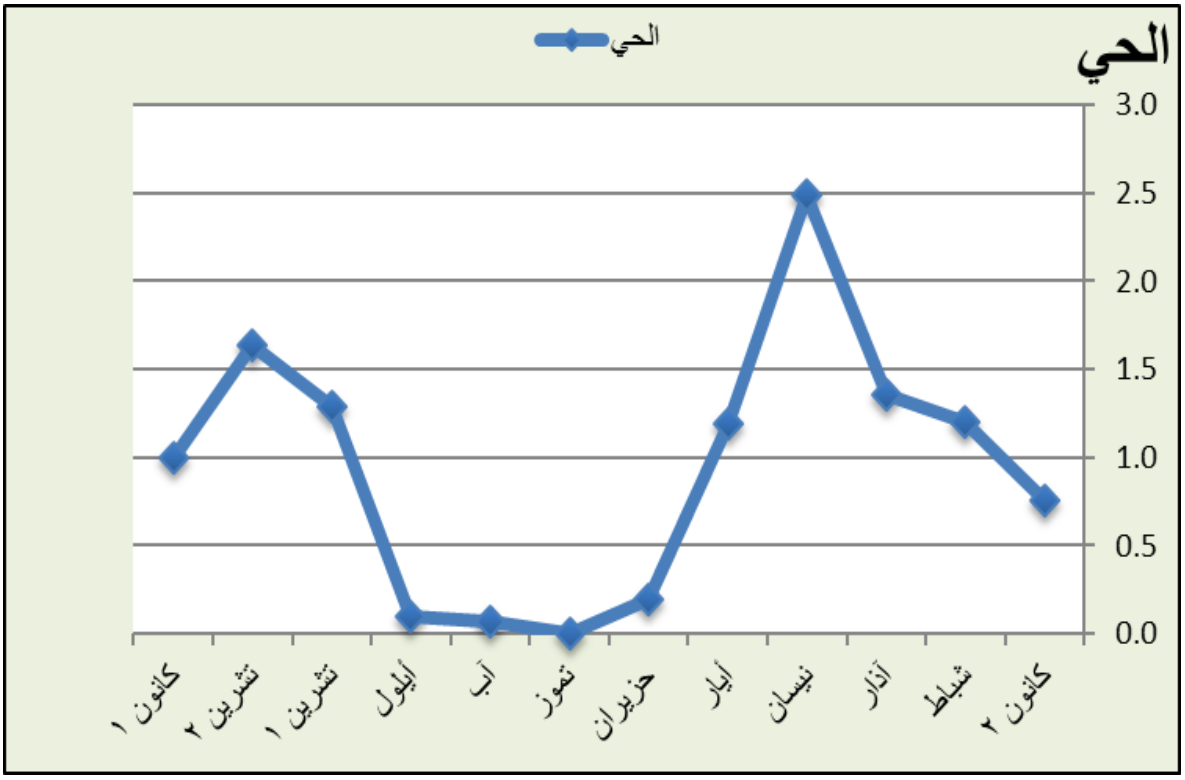
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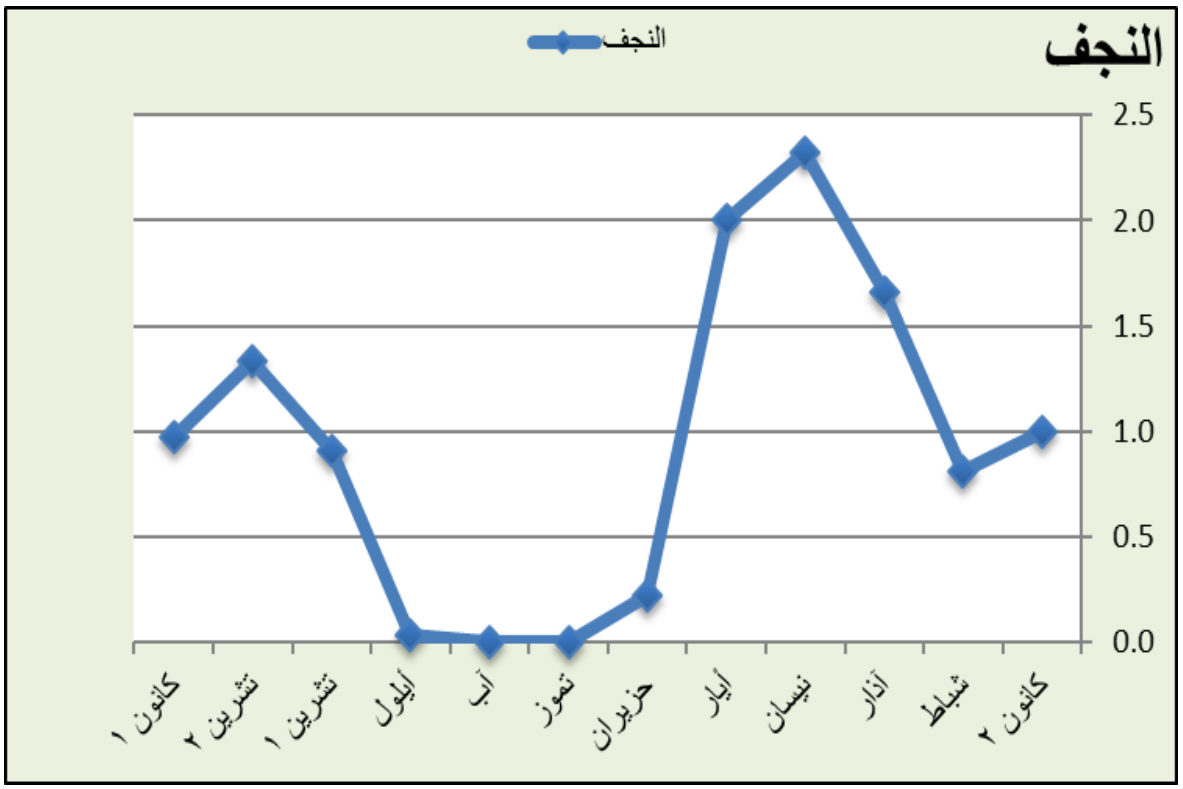
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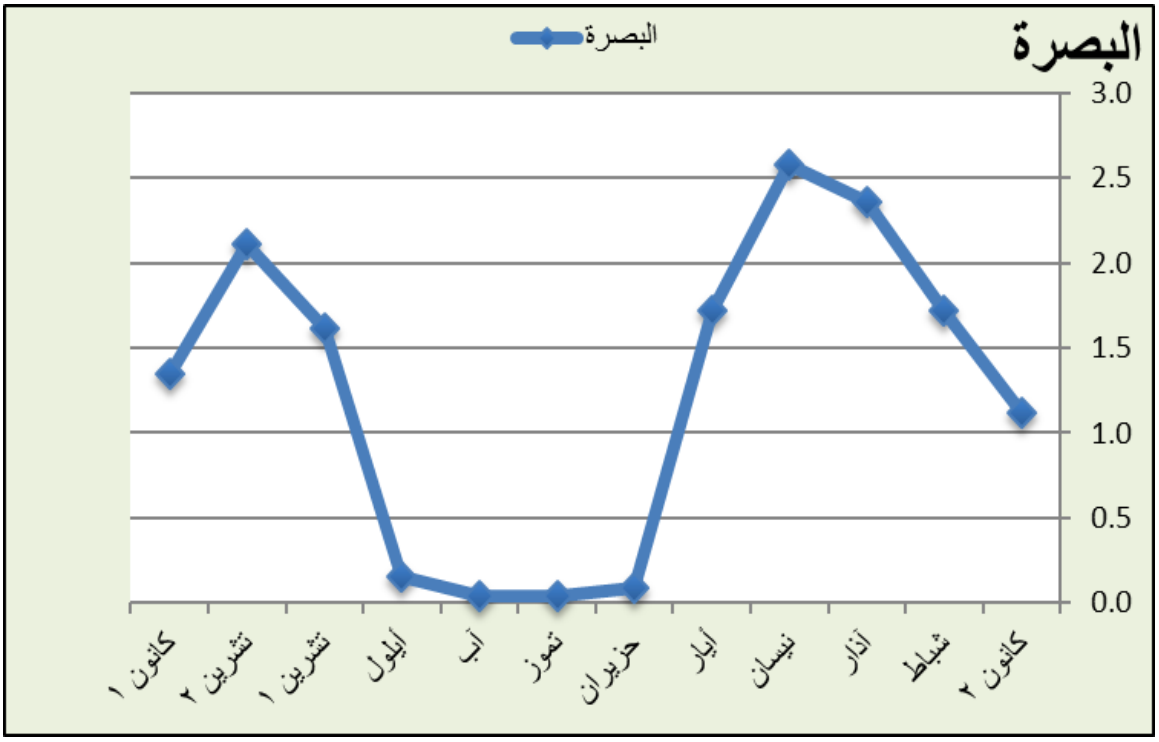
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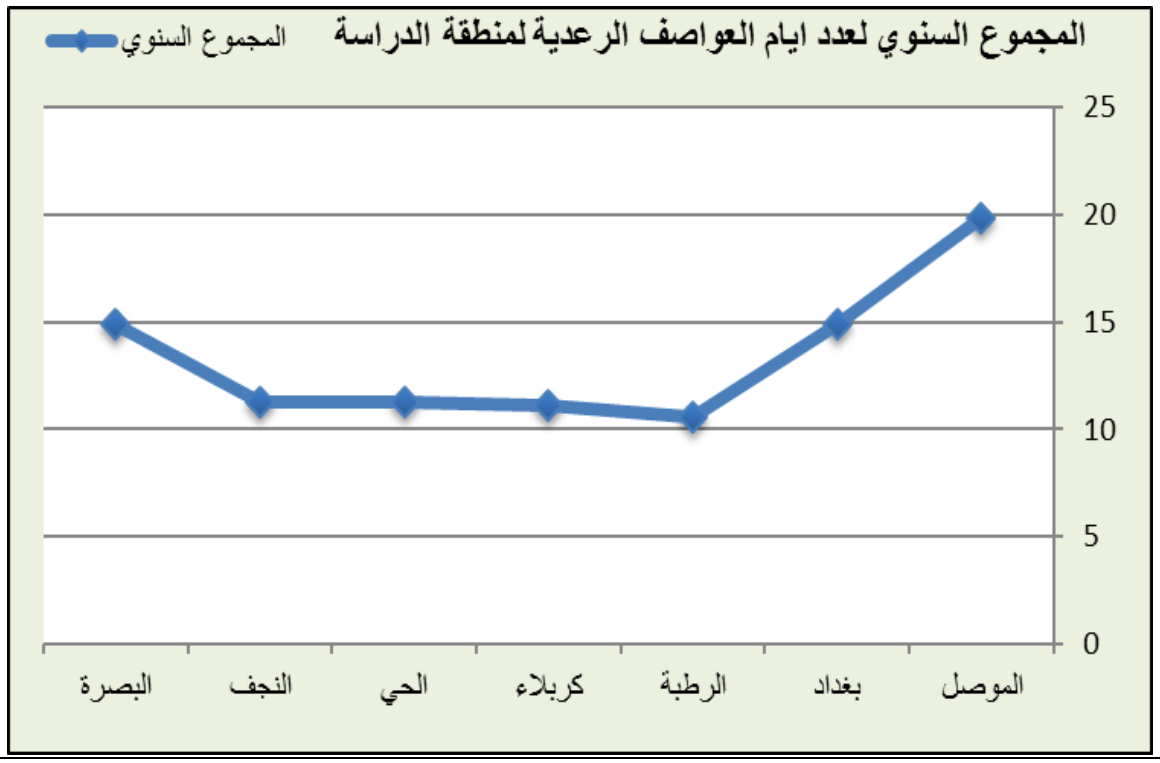


Figure (2) :Monthly average number of thunderstorm days and annual total in the study area for the period (1980-2012)

Source: Table (2) :Second: Geographical distribution of thunderstorms

Thunderstorms can occur anywhere on Earth, but with varying frequencies. Thunderstorms are most common in areas between the equatorial latitude and the latitude, with a frequency of approximately 225 thunderstorms per year. This rate decreases to 100-180 thunderstorms per year in the highlands of North and South America and Central Africa. The number of thunderstorms in desert areas decreases to less than 10 storms per year, as in the Kalahari Desert in southwest Africa.

• Spatial and temporal distribution of rainy thunderstorms:

Thunderstorms occur either at the front or rear of a low-pressure system, as cold fronts pass through the low-pressure system during the winter. The geographical distribution of the number of days with thunderstorms in the study area reveals a clear variation between the study stations, due to the different topographical features and the increased frequency of frontal depressions and their direct and indirect effects on the frequency of thunderstorms. By observing Table (3), which shows the monthly and seasonal frequency of thunderstorms, it is clear that there are variations in frequency between stations, depending on their location and the multiple factors responsible for their formation.

Table (3)

Monthly frequency of thunderstorms in the study area for the period (1980-2012)

Total	May	April	March	February	January	December	November	October	September	Stations
16,1	3,2	3,5	2,6	1,4	0,9	1,5	1,5	1,5	/	Mosul
16,7	2,3	3,1	1,9	1,2	0,8	1,9	3,1	2,3	0,1	Baghdad
11,	2,4	1,5	1,3	0,6	0,5	0,7	1,5	2,8	0.3	Rutba

6										
9,0	0,3	3,1	1,2	0,9	0,5	1,0	1,3	0,7	/	Al-Hayy
14,5	1,9	3,1	1,5	1,1	1,1	2,3	1,2	2,2	0.1	Basra

Source: Nader Mohammed Siam, Air Masses and Fronts, Journal of Science and Technology, Riyadh 1999, p. 7

Overall, during the study period, Baghdad station ranked first in total seasonal occurrences among the stations included in the study, with an average of (16.7) storms. This is because Baghdad is considered one of the cities with a broader local climate than other cities, where air turbulence and rising air currents are responsible for the instability, in addition to the condensation nuclei emanating from its atmosphere, which are one of the basic conditions for cloud formation, including cumulonimbus clouds, which are responsible for the formation of rainy thunderstorms.

Next, Mosul station came in second with an average of (16.1) storms. The increased frequency of thunderstorms in the northern and central regions is due to the increased frequency of air fronts accompanying frontal depressions within their general eastward movement, as well as the intense heating of the mountain slopes facing solar radiation during the months of March, April, and May. This causes the formation of cumulus clouds, often followed by active thunderstorms as a consequence of the passage of a frontal depression. Regarding the temporal distribution of thunderstorms, it is noted that there is a clear concentration in the number of days during which thunderstorms occur during certain months of the year. Most cases of atmospheric instability occur during the rainy season, from late autumn to late spring. Most of these cases occur when the study area is under the influence of cold fronts, especially if the fronts are associated with cold upper basins. As shown in Table (3), the spring months occupied the top spot in the total frequency of rainy thunderstorms for all stations included in the study. The reason for this is that the lower layer of air adjacent to the Earth's surface is exposed to intense heating, so convection currents become active in the afternoon during the spring days, accompanied by cold air masses in the upper layers of the atmosphere, in addition to the effect of the study area with some cold spring air fronts that are sometimes active, so the weather becomes ready for the occurrence of a state of instability, causing rainy thunderstorms during this period. Autumn ranks second in the average number of days with thunderstorms and rain across all study stations. The reason for the high frequency during autumn can be attributed to the increased instability in the humid air that prevails in the region when low-pressure systems pass. There is a significant difference between the temperature of the warm surface and the air adjacent to it, on the one hand, and the cooler air above it, on the other. This causes unusual instability that leads to thunderstorms accompanied by rain. Despite the activity of low-pressure systems passing through the study area during the winter, the average number of days with thunderstorms is lower compared to the fall and spring seasons. This is due to the small temperature differences between opposing air masses, which prevents the occurrence of atmospheric instability during which thunderstorms form. • Spatial and temporal distribution of non-rainy thunderstorms:

The geographical distribution of the number of days of non-rainy thunderstorms in the study area does not differ from the geographical distribution of the number of days of rainy thunderstorms, despite variations in their total frequency among stations in the study area. Table (4) shows that the stations where this phenomenon occurs most frequently are the central stations in the region.

Table (4)

Monthly average frequency of non-rainy thunderstorms in the study area for the period (1980-2012)

Total	May	April	March	February	January	December	November	October	September	Stations
3,0	0,5	0,9	0,3	/	0,1	0,3	0,3	0,5	0,1	Mosul
5,3	1,3	1,1	0,6	0,3	/	0,5	0,7	0,5	0,3	Baghdad
3,4	0,6	0,9	0,4	0,1	/	0,2	0,1	0,9	0,2	Anbar
4,0	0,4	1,1	0,4	0,0	0,5	0,3	0,5	0.6	0,2	Al-Hayy
2,6	0,5	0,2	0,5	0,1	0.3	0,1	0,4	0.5	/	Basra

Source: Nader Muhammad Siam, Air Fronts, Journal of Science and Technology, Riyadh 1999, p. 7.

Baghdad Station ranked first in terms of total seasonal frequency among the stations in the study area, with an average of (5.3) storms, followed by Al-Hayy Station with an average of (4.0) storms. Al-Rutba Station ranked third with an average of (3.4) storms. This is due to the arrival of dry air masses causing instability, resulting in the formation of non-rainy thunderstorms. Meanwhile, Mosul Station recorded an average of (3.0) storms, followed by Basra Station with an average of (2.6) storms.

To achieve the purpose of the temporal distribution of the number of days with non-rainy thunderstorms, it is necessary to analyze the reasons for the variation in their frequency from one season to the next and from one month to the next. Table (3) shows that the unstable months, during which frontal depressions recur, recorded the highest frequency of this phenomenon due to the activity of upward convection currents. It is noted that the spring months occupy the forefront in this regard for all the stations included in the study. While May ranked second after April in frequency, March ranked third.

Referring to Table (4), it is noted that autumn maintains a distinguished position in the total number of days with recurring non-rainy thunderstorms. October recorded the highest frequency of this phenomenon. The Rutba station had the highest frequency, with an average of 0.9 storms, due to its desert location and the arrival of dry air masses to the region, which leads to instability that allows for the formation of non-rainy thunderstorms.

Meanwhile, the average number of days with recurring non-rainy thunderstorms decreased during the winter months for all stations included in the study due to the recurrence of cold atmospheric highs, which lower temperatures and create smaller temperature differences between the ground surface temperature and the air layer above it, reducing the occurrence of instability. Section Three

(General Trend of Thunderstorms in Iraq)

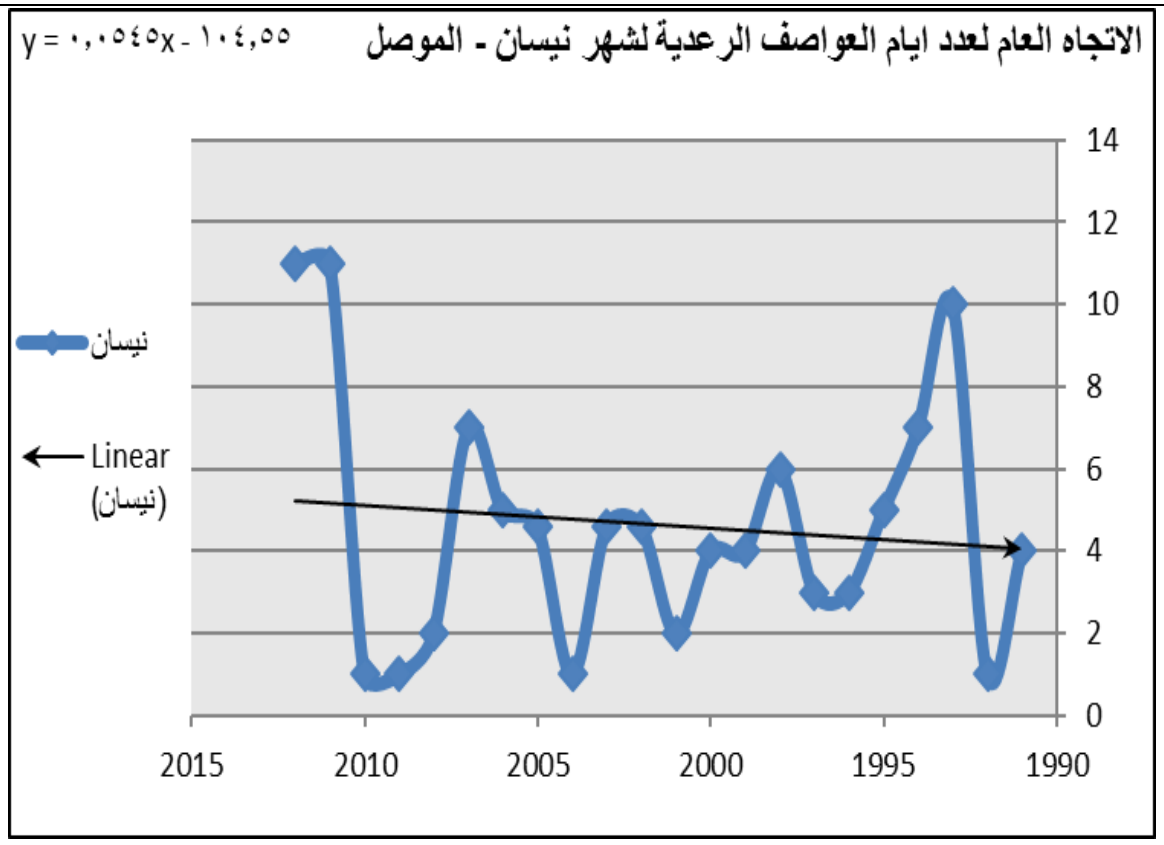
By observing Table (5) and Figure (3), which show the general trend of thunderstorms for the most frequent months in the study area, it is noted that the general trend of thunderstorms is increasing at all stations, reaching (0.05, 0.02, 0.03, 0.05, 0.001, 0.04, 0.003) for the stations (Mosul, Baghdad, Rutba, Karbala, Al-Hay, Najaf, and Basra), respectively.

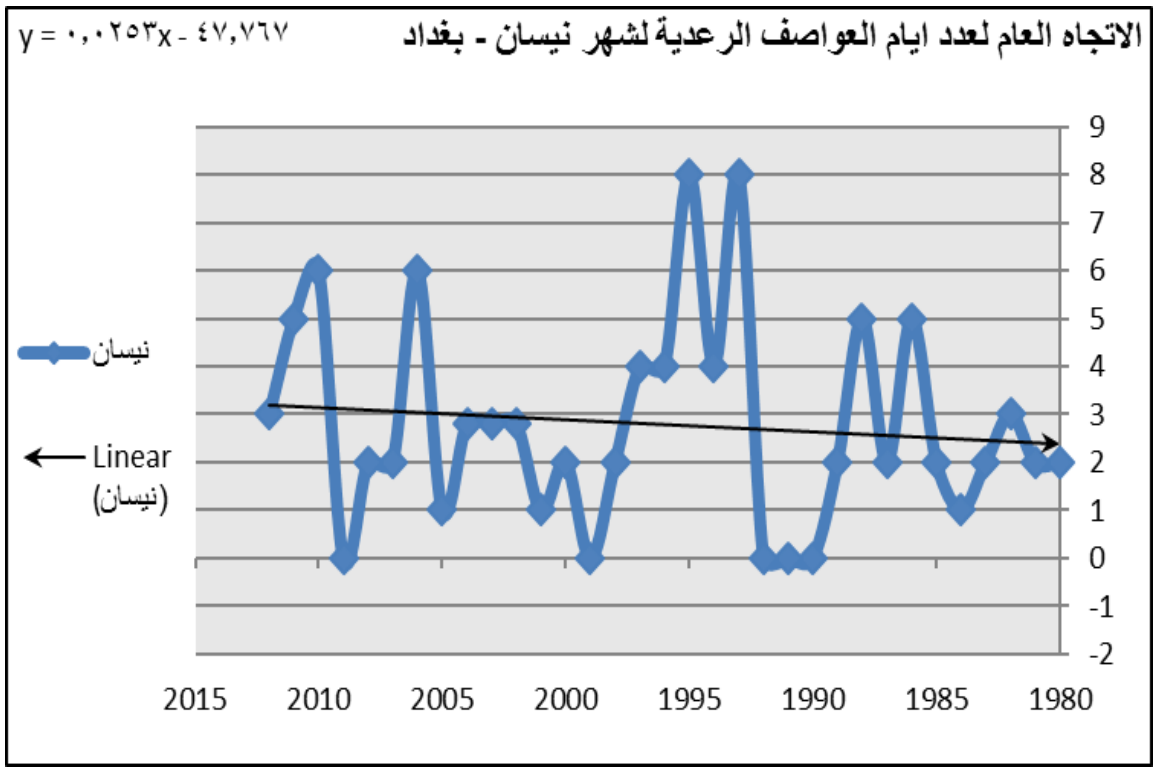
Table (5) :General Trend of Thunderstorms for the Most Frequent Months in the Study Area for the Period (1980-2012)

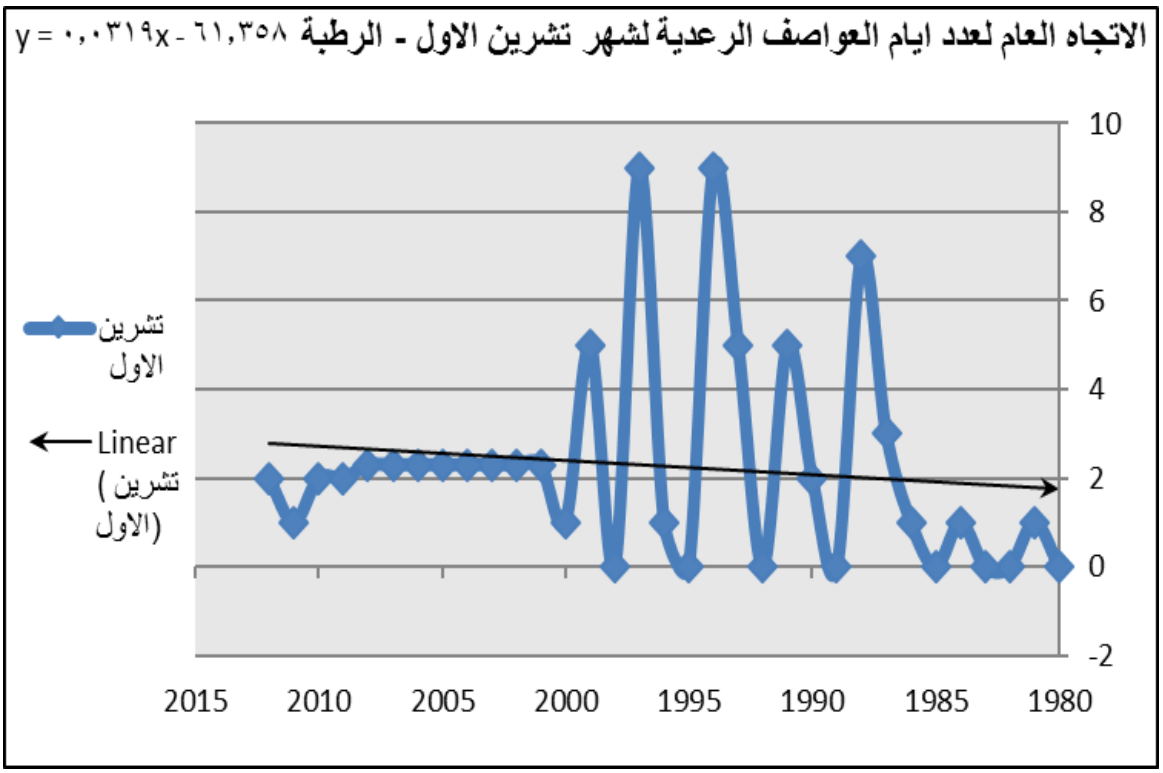
General trend	Month	
0.05	April	Mosul
0.02	April	Baghdad
0.03	October	Rutba
0.05	April	Karbala

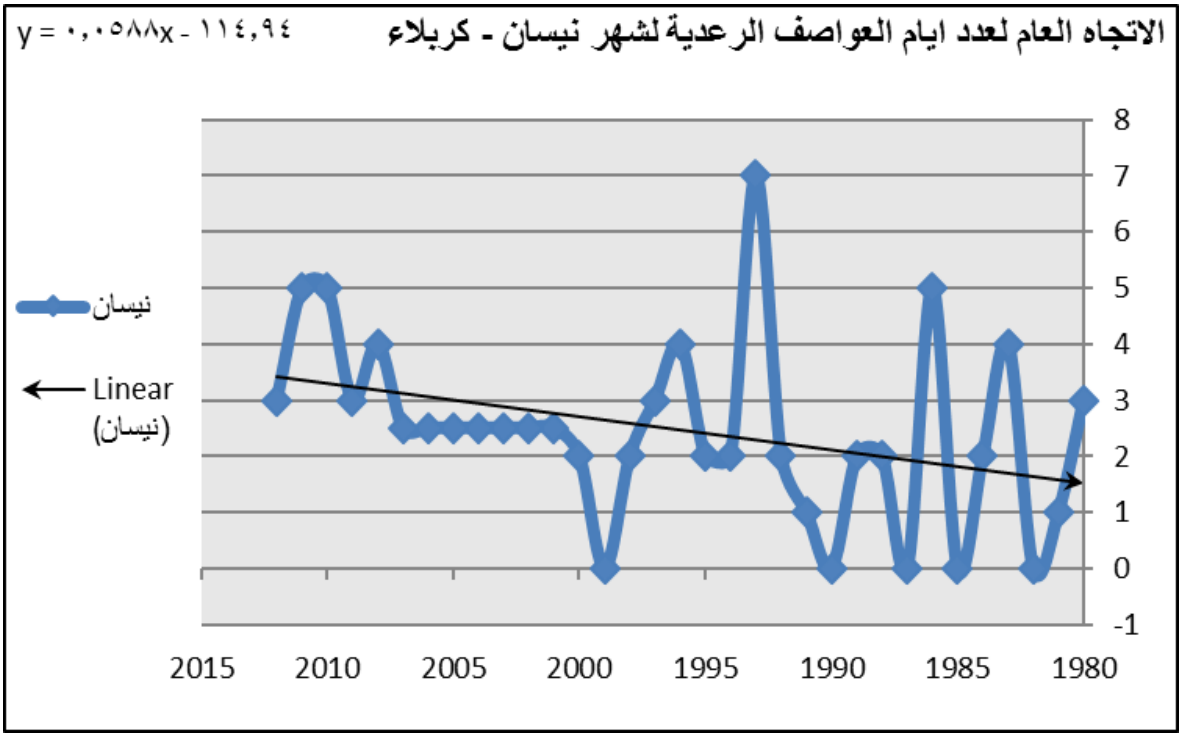
0.001	April	Al-Hayy
0.04	April	Najaf
0.003	Month	Basra

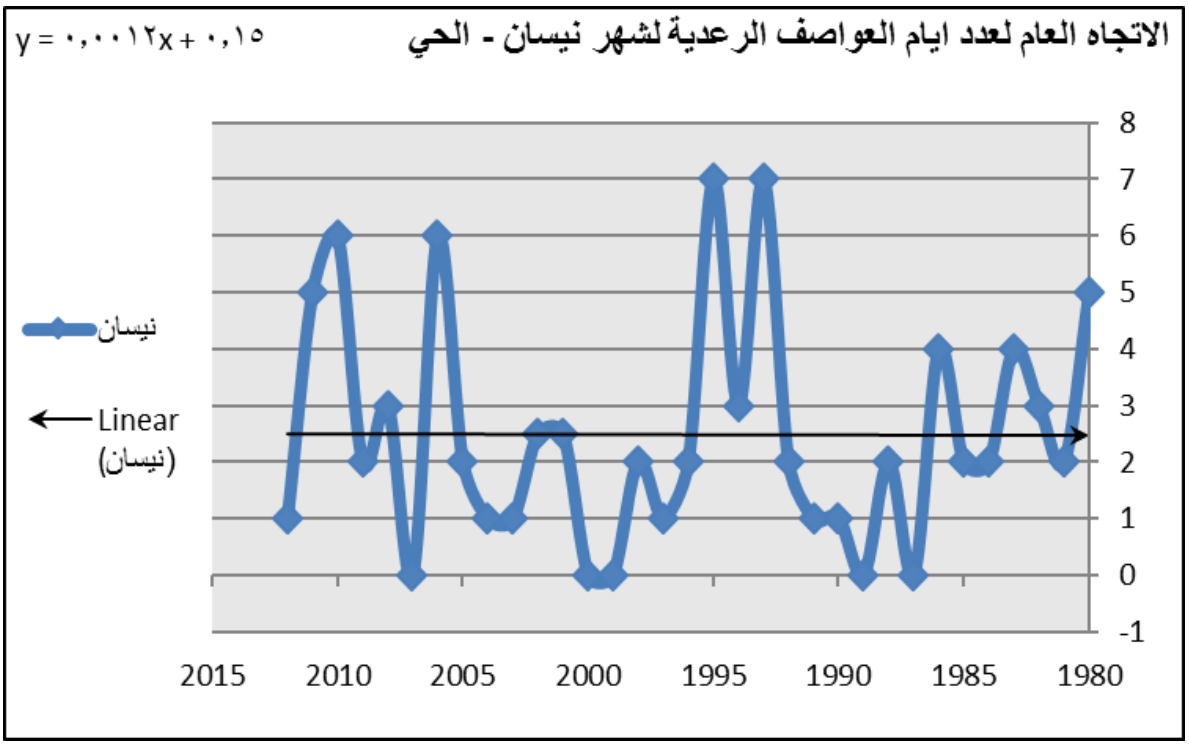
Source: Researcher's work

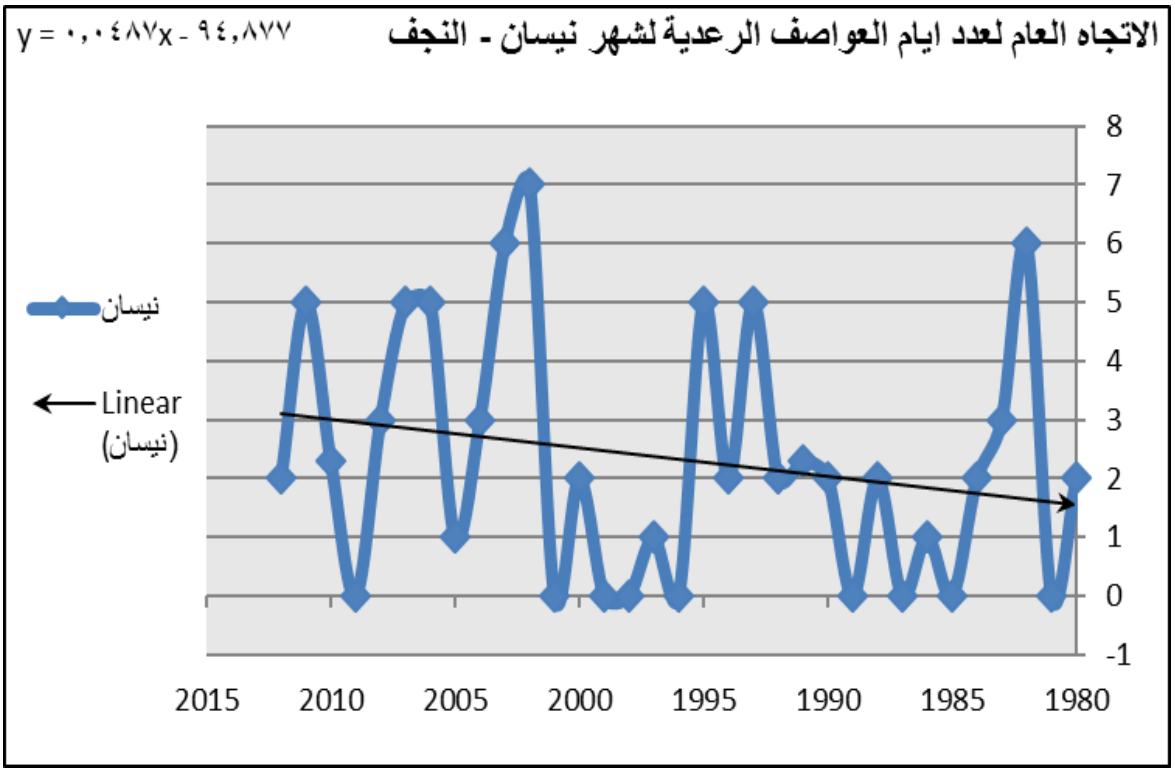





الاتجاه العام لعدد ايام العواصف الرعدية لشهر تشرين الاول - الرطبة y = ٠,٠٣١٩x - ٦١,٣٥٨
تشرين الاول
Linear (تشرين الاول)
10
8
6
4
2
0
-2
2015
2010
2005
2000
1995
1990
1985
1980


الاتجاه العام لعدد ايام العواصف الرعدية لشهر نيسان - كربلاء y = ٠,٠٥٨٨x - ١١٤,٩٤
نيسان
Linear (نيسان)
8
7
6
5
4
3
2
1
0
-1
2015
2010
2005
2000
1995
1990
1985
1980


الاتجاه العام لعدد ايام العواصف الرعدية لشهر نيسان - الحي
y = ٠,٠٠١٢x + ٠,١٥
نيسان
Linear (نيسان)
8
7
6
5
4
3
2
1
0
-1
2015
2010
2005
2000
1995
1990
1985
1980


الاتجاه العام لعدد ايام العواصف الرعدية لشهر نيسان - النجف
y = ٠,٠٤٨٧x - ٩٤,٨٧٧
نيسان
Linear (نيسان)
8
7
6
5
4
3
2
1
0
-1
2015
2010
2005
2000
1995
1990
1985
1980

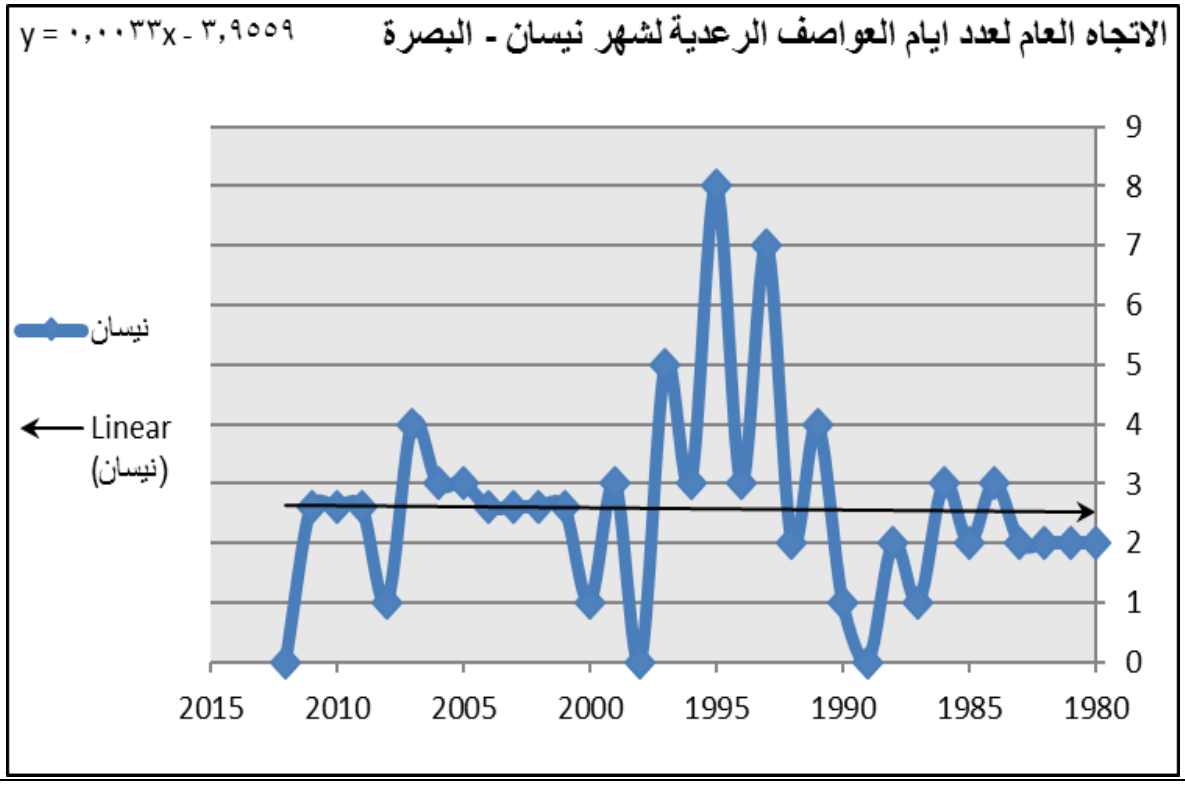


Figure (3)

The general trend in the number of thunderstorm days for the most frequent months in the study area for the period (1980-2012)

Source: The researcher's work is based on the Republic of Iraq, Ministry of Transport and Communications, General Authority for Meteorology and Seismic Monitoring, Climate Department, unpublished data, 2013

CONCLUSIONS

1- April records the highest frequency of thunderstorms at all stations, except Rutba Station, which records an average of 2.3 days in October. This is due to air disturbance and rising air currents responsible for the instability, as well as an increase in condensation nuclei emitted from the atmosphere, which are one of the basic conditions for cloud formation, including cumulonimbus clouds, responsible for the formation of rainy thunderstorms. Mosul leads the stations in the study area in the frequency of thunderstorms for this month, with an average of 4.6 days.

2- Mosul station ranked first in total frequency among the stations included in the study, with a total of (19.8 days), due to its geographical location in northern Iraq and its position as a corridor for Mediterranean low-pressure systems.

3- The general trend of thunderstorms is increasing at all stations, reaching (0.05, 0.02, 0.03, 0.05, 0.001, 0.04, 0.003) for the stations (Mosul, Baghdad, Rutba, Karbala, Al-Hayy, Najaf, and Basra), respectively.

SOURCES

Yahya Muhammad Nabhan, Dictionary of Air Guidance Terms, Dar Al-Bidaya, Amman, Jordan, 2007, p. 179.

Ali Sahib Talib Al-Mousawi, An Analytical Study of Climatic Characteristics and Severe Weather Phenomena in Najaf Governorate, Journal of Geographical Research, College of Education for Girls, University of Kufa, Issue 2, 2010, p. 162.

Ali Ahmed Ghanem, Climatic Geography, Amman, Dar Al-Masirah for Publishing, Distribution, and Printing, 2003, pp. 229, 230.

Ne'mah Al-Fatlawi, Cloud Physics, Dar Al-Asdekaa Press, Baghdad, 2007, p. 108.

Ali Hassan Musa, Storms and Hurricanes, 1st ed., Dar Al-Fikr, Damascus, 1988, p. 100.

Nader Muhammad Siam, Air Masses and Fronts, Journal of Science and Technology, Riyadh, 1999, p. 7.

Nu'man Shahada, Climate of Jordan, Dar Al-Basheer, 1st ed., Amman, 1991. p. 115

Saud Abdul Aziz Shaaban, previous source, 1996, p. 129.

Basil Ihsan Al-Qashtini, "Air Masses Exposed to the Baghdad Region During the Rainy Season," Iraqi Geographical Society, Issue 25-24, 1990, p. 116.

Abdul-Ilah Razouki Karbal, Majid Al-Sayed Wali, Meteorology and Climatology, College of Arts, University of Basra, 1986, p. 59.

Joan Mikhail Tilla, "Thunderstorms in the Western Iraqi Plateau," Journal of the College of Arts, University of Baghdad, Issue 64, p. 492.

Bushra Ahmed Jawad Saleh, "A Comprehensive Study of Cases of Temperatures Dropping Below Zero Celsius in Iraq," Al-Ustadh Magazine, University of Baghdad, Issue 69, 2008, p. 68.

Rahim Eidan Fadhil Al-Atfi, "A Climatic Study of the Recurrence of Weather Phenomena: Clouds, Thunderstorms, and Hail in Iraq," Unpublished Master's Thesis, College of Arts, University of Basra, 2010, p. 44.

Republic of Iraq, Ministry of Transport and Communications, General Authority for Meteorology and Seismic Monitoring, Climate Department, Unpublished Data, 2013.