Research Article

Studying Recorded lightning over Iraq for Period 1998-2011

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Abstract
This research studies distribution of thunderstorm in Iraq for the period (1998-2011). The result showed that the largest regions which had been hit by lightning stroke were between latitude (35-36∘)E and longitude (45-46∘)N, and April was the most frequent of lightning occurrence, also the results showed that the number of flashes of most lightning cases were between (50-100) with higher number of flashes for some special cases. The studying of meteorological parameters which accompanied thunderstorm formation such as (Mean sea level pressure, Lifting index, relative humidity and Vertical velocity) illustrates the values of mean sea level pressure were increased during the hours after lightning occurrence comparing with their values before and at the time of lightning occurrence and their monthly mean value much greater than that recorded at the time of lightning occurrence, in addition the values of lifting index were negative at the time of lightning occurrence that refer to instability whereas their monthly average showed positive values. The values of relative humidity were greater at lightning recorded time at the three levels (500, 700, 1000) mb and also through the hours before and after this time comparing with their monthly mean. Vertical velocity values were negative for the three levels at the time of lightning occurrence that is referring to upward motion which is necessary for thundercloud initiation, and their monthly mean values were mostly negative at (500, 700) mb whereas were positive at the surface level.

Keywords: lightning, Iraq, thunderstorm, Vertical velocity, lifting index.

الخلاصة
في هذا البحث تم دراسة توزيع العواصف الرعدية في العراق للفترة(1998-2011) وان اكثر منطقة تعرضت لضربات البرق هي المنطقة المحصورة بين خطي عرض(35-36∘) شمالا وخطي طول (45-46∘) شرقا وان شهر نيسان هو اكثر شهر تعرض لحدوث البرق وان عدد الضربات لمعظم حالات البرق كانت بين (50-100) ضربة مع عدد ضربات عالي لبعض الحالات الخاصة. وقد بينت دراسة المتغيرات الجوية المرافقة لحدوث العواصف الرعدية مثل (ضغط مستوى سطح البحر, معامل الرفع, الرطوبة النسبية بالاضافة الى سرعة الرياح الرأسية) ان قيم الضغط تزداد في الساعات بعد حدوث البرق مقارنة بقيمه قبل واثناء حدوث البرق وقيم المعدل الشهري تكون اكبر من القيم اثناء حدوث البرق,اضافة الى قيم معامل الرفع التي تكون سالبة في وقت حدوث العاصفة وهو مؤشر على عدم الاستقراريةوقيم المعدل الشهري تكون موجبة. قيم الرطوبة النسبية تزداد قبل واثناء حدوث البرق للمستويات(1000,700,500) وكذلك في الساعات قبل وبعد حدوث البرق مقارنة بقيم المعدل الشهري. اما قيم سرع الرياح الرأسية تكون سالبة للمستويات الضغطية الثلاثة في وقت حدوث العاصفة مما يدل على الحركة الرأسية والتي تكون ضرورية لتكوين الغيمة الرعدية ومعدلاتها الشهرية تكون سالبة للمستويات mb(700,500) وتكون قيمها موجبة عند السطح.

Introduction
Lightning is a natural phenomenon that affects human life; it is one of the oldest phenomenon on the earth. The importance of lightning studying increased since the fundamental hypothesis of atmospheric electricity, which considered each thunderstorm acts as a generator, so that the sum of all thunderstorms occurring simultaneously over earth contributes the charging mechanism that maintains earth-Ionosphere charged [1].

Lightning is a high electric discharge between cloud and ground, inside cloud and from cloud to ionosphere [2]. Lightning discharges can be divided into several kinds, the cloud-to-ground flashes are the greatest threat to life and property and they had most frequent appearance in convective clouds. Due to the sudden heating and expansion of air along the

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electric discharge, sound wave are produced, which are perceived as a thunder, thus electric clouds or storms are also refer to as thunderclouds or thunderstorms [3]. About 90 % or more of global cloud-to-ground lightning is accounted for by negative (negative charge is effectively transported to the ground) downward lightning. Other types of cloud-to-ground lightning include positive downward. There are also bipolar lightning discharges sequentially transferring to ground both positive and negative charges during the same flash. The cloud-to-ground flash is greatest threat to life and property of all known types [4], and passes the flowing stages:

a. Stepped leader

The cloud-to-ground flash starts by a weakly luminous discharge that propagates from cloud to ground in steps of the order of 50 meter, which passes between steps of about 50µs. Luminosity is only observable during the advancing period (~1µs) [4]. At the start of a new step, the leader sometimes branches and then branches themselves continue downward in a series of steps which may also branch. Thus the Zigzag features of the lightning channel are due to the hesitant progress of the stepped leader searching for the most favorable bath. After some 20 ms, the propagation (average velocity of about 105 m/s) brings the tip of the leader close to the ground. This discharge called the stepped leader [5].

b. Return stroke

When the tip of the stepped leader has reached a short distance from the ground (say 10-20 m), the electric field at the ground underneath it has become high enough for a new discharge to be initiated from some pointed object (tall building, tree, lightning rod). This goes to meet the tip of the stepped leader and continue further upward through the ionized channel already produced. This is now a much stronger discharge, carrying peak current of the order 10000A propagating at speeds of order 107-108 m/s and strongly luminous [6]. It reaches the cloud in about 100µs, it is the return stroke or main stroke.

c. Dart leader and second return stroke

The lightning may have finished with the return stroke ('single-stroke' flash). More frequently, a 'multiple-stroke' flash will occur. In that case, some hundredth of a second later new discharge is produced from cloud to ground, draining changes from a region close to the origin of the stepped leader. But now it will propagate swiftly and continuously through the still ionized channel. This dart leader, it is followed by a second return stroke in the same fashion as after the stepped leader. The whole sequence repeat itself for variable number of times after which the ionized channel decays and lightning flash is finished [7].

Materials and Methodology

Data Source

Lightning data obtained from University of Utah [8] for the period (1998-2011), for Iraq between latitude (29-38^o) N and longitude (39-48^o) E for 51 cases of lightning with their number of flashes and rainfall rate for each thunderstorm. Meteorological variables data such as relative humidity, vertical velocity, mean sea level pressure and lifting index were obtained from (NCEP) National Center of Environment Prediction [9], for daily times (00, 06, 12 and 18) UTC.

Results and Discussion

Distribution of lightning occurrence in Iraq by using GIS system

The spatial distribution of lightning number of occurrence during the studied period (1998-2011) by using GIS system shown in Figure 1, this Figure illustrates the regions which showed greatest lightning number of occurrence which located between latitude (35-36^o) E and longitude (45-46^o) N.

Statistical study of flashes number of occurrence

The statistical study of lightning flashes number during the studied period shown in Figure 2. It is clear that the maximum numbers of flashes were between (300-350) and the minimum between (50-100) which had the more frequent of occurrence.

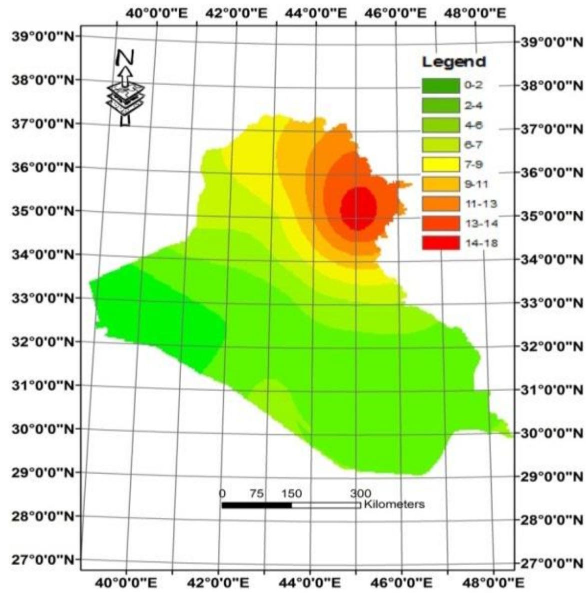

Figure 1: Distribution of lightning number of occurrence distribution for period (1998-2011).

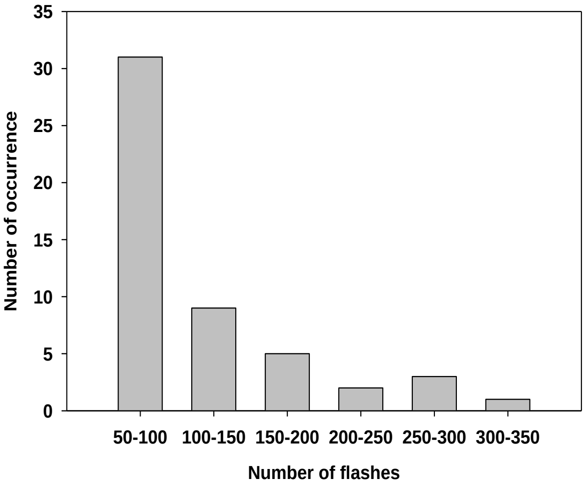

Figure 2: Number of flashes occurrence in Iraq for the period (1998-2011).

Annual and monthly distribution of lightning occurrence

The annual average of thunderstorm days for the same period for the rainy months in Iraq (October, November, December, January, February, March, April and May) were illustrated in Figure 3 which showed that the maximum number of flashes lightning days were in 2002 and 2006 and the minimum were in 1998 and 1999. The monthly average for lightning occurrence was in April with 25 days decreased during January and February as illustrated in Figure 4.

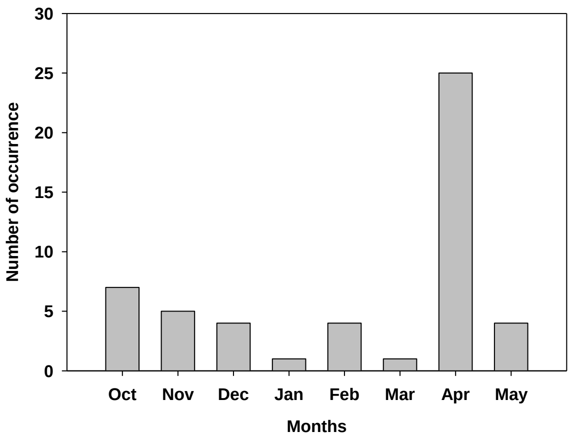

Figure 3: Monthly distribution of lightning.

Pressure, lifting index, relative humidity and vertical velocity. Some cases have been chosen for this purpose to study these parameters and their variation at the time of observing lightning as well as before and after this time depending on four daily times (00, 06, 12 and 18).

Storm on 1st of April 1999

On 1st of April 1999 a lightning stroke was recorded at 12.3 UTC with 59 lightning flashes at (35.04o N,45.72o) E near Chamchamal northeast of Iraq. The measured rainfall was 8.3 mm/hr covering an area of 8691 km^2.

Storm on 14th of May 2007

On 14th of May 2007, a lightning strokes with 59 flashes were recorded at 11.4 UTC was 59 flash stork at (35.55o N, 45.15o E) northeast of Iraq, the measured rainfall was 5.3 mm/hr covering an area of 7794 km^2.

Storm on 9th of December 2002

On 9th of December 2002, a lightning stroke recorded at 14.5 UTC with 59 flashes at (35.48^o N, 45.11^o E). The measured rainfall was 10 mm/hr covering an area of 2849 km^2.

Storm on 17th of October 2002

On 17th of October 2002, a lightning stroke was recorded at 19.3 UTC with 83 flashes at (32.27^o N, 40.06^o E) on the west of Iraq. The measured rainfall was 5 mm/hr covering an area of 14326 km^2.

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Storm on 23rd April 2011

On 23 of April 2011, a lightning flashes number recorded at 2.2 UTC were 256, at (35.49^{o} N, 42.99o E) in the north of Iraq. The measured rainfall was 8.1 mm/hr covering an area of 20879 km^2.

Tables (1) to (5) gave summaries for the values of mean sea level pressure, lifting index at the surface , relative humidity at three levels (500,700 and 1000) mb, and the vertical velocity also at three levels heights in addition to the monthly mean value for these variables for the selected cases at four daily time (00,06,12 and 18) UTC respectively.

Table 1: Meteorological parameters of 1st of April 1999 recorded at 12.3 UTC and their monthly mean.

Meteorological Parameter	**Level (mb)**	**Time (UTC)**				**Monthly mean**
		00	**06**	**12**	**18**	
MSLP(Pa)	Surface	101060	101040	101040	101230	101289
LFTX (k)	Surface	2.7	0.2	-3	-0.89	1.3
RH %	1000	52	69	82	87	35
	700	88	98	84	57	43
	500	56	45	91	0	27
PVV (pa/s)	1000	0.001	-0.063	-0.213	-0.048	0.001-
	700	-0.446	-0.221	-0.351	-0.016	0.01
	500	-0.684	-0.207	-0.521	-0.197	-0.01

Table 2: Meteorological parameters of 14th of May 2007 recorded at 11.4 UTC and their monthly mean.

Meteorological Parameter	**Level (mb)**	**Time (UTC)**				**Monthly mean**
		00	**06**	**12**	**18**	
MSLP(Pa)	Surface	100760	100780	100650	100740	101071
LFTX (k)	Surface	0.1	-1.7	-2.7	-0.8	1
RH %	1000	46	47	33	47	38
	700	63	58	72	72	41
	500	26	42	40	44	37
PVV (pa/s)	1000	-0.013	0.003	-0.072	-0.007	0.02
	700	0.002	-0.184	-0.09	-0.116	0.013
	500	0.007	-0.245	-0.134	-0.163	0.01

Table 3: Meteorological parameters of 9th of December 2002 recorded at 14.5 UTC and their monthly mean.

Meteorological Parameter	**Level (mb)**	**Time (UTC)**				**Monthly mean**
		00	**06**	**12**	**18**	
MSLP(Pa)	Surface	101940	101860	101760	101870	1012037
LFTX (k)	Surface	-2.2	-1.5	-3	-3.7	7.9
RH %	1000	92	98	64	83	68
	700	25	25	69	82	53
	500	40	80	47	80	40
PVV (pa/s)	1000	-0.035	0.072	-0.035	0.012	0.006-
	700	0.098	-0.002	-0.097	-0.2	-0.03
	500	-0.04	-0.055	-0.059	-0.228	-0.03

Table 4: Meteorological parameters of 17th of October 2002 recorded at 19.3 UTC and their monthly mean.

Meteorological Parameter	**Level (mb)**	**Time (UTC)**				**Monthly mean**
		00	**06**	**12**	**18**	
MSLP(Pa)	Surface	100860	100920	101050	101170	1015247
LFTX (k)	Surface	1.7	0.5	-4.7	-3.1	3
RH %	1000	45	56	45	62	32
	700	66	57	69	71	49
	500	47	45	48	34	30
PVV (pa/s)	1000	0.089	0.057	-0.008	0.018	0.001
	700	-0.139	-0.1	-0.127	-0.125	-0.05
	500	-0.39	-0.19	-0.133	-0.17	-0.05

Table 5: Meteorological parameters of 23rd of April 2011 recorded at 2.2 UTC and their monthly mean.

Meteorological Parameter	**Level (mb)**	**Time (UTC)**				**Monthly mean**
		00	**06**	**12**	**18**	
MSLP(Pa)	Surface	101290	101410	101240	101450	101809
LFTX (k)	Surface	-0.2	-3.6	-1	3.2	1.4
RH %	1000	75	86	62	56	38
	700	74	83	27	34	49
	500	98	72	37	13	27
PVV (pa/s)	1000	-0.025	0.032	0.046	0.022	0.1
	700	-0.031	-0.1	0.08	0.039	-0.03
	500	-0.094	-0.11	-0.014	-0.047	-0.06

These Tables elaborated that:

1. The mean sea level pressure values increased through the hours after lightning occurring comparing with their values before and at the time of recording lightning, the monthly average value much greater than that recorded at the storm time.
2. As thundercloud formation needs unstable conditions so that the lifting index had negative values referring to instability, at the time of recoding lightning and lasting more or less than 12 hours after and before lightning occurrence. Their monthly mean showed positive values an indication of stable condition.
3. The relative humidity values for the studied cases were observed to be greater at lightning recording time at the three levels (500, 700, and 1000) mb and also through the hours before and after this time comparing with their monthly mean values.
4. Finally, as far as the values of vertical velocities are concerned, all the tables showed, negative values at the three levels at lightning occurring time referring to updraft motion which is, necessary for thundercloud initiation. The negative values of the vertical velocities kept appearing within 12 hours before and after recording the strokes especially at levels (500 and 700) mb, the monthly mean values mostly were negative at (500 and 700) mb, whereas positive at the surface level.

Conclusions

The followings are the main concluding remarks for this study:

1. Statistical study showed that the greatest regions that suffered from lightning in Iraq for the period (1998-2001) were between latitude (35-36◦) E and longitude (45-46◦) N and the number of flashes for the most lightning cases were between (50-100), reaches to number of 321 for some special cases. In addition among the rainy months (October, November, December, January, February, March and April) April showed the more frequent of lightning occurrence.
2. Studying meteorological parameters which accompanied thunderstorm formation and lightning occurrence such as (Mean sea level pressure, Lifting index, Relative humidity and Vertical velocity) tend to be:

a. The mean sea level pressure values were less before and at time of recording lightning comparing with their values after lightning occurrence.

b. The lifting index had negative values at the time of recording lightning referring to instability.

c. The relative humidity values were greater at lightning recording time at the three levels (500,700 and1000) mb and also through the hours before this time.

d. The vertical velocity values were negative for the three levels at the time of lightning occurrence

3. By comparing the monthly mean of meteorological parameters with their values at the time of lightning occurrence found that:

a. The mean sea level pressure values much greater than that recorded at the storm time.

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b. The values of lifting index had positive values as indication of stable conditions.
c. The values of relative humidity were less than their values at the time of lightning occurrence.
d. The vertical velocity values were negative at (500 and 700) mb whereas mostly positive at the surface level.

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