Rafidain Journal of Science
https://rsci.mosuljournals.com
Vol. 32, No.4, pp. 78-91, 2023

Rainfall over Iraq was Affected by Solar Wind Parameters

Anfal A. Mohammed **Imad A. Hussain**
Department of Physics/ College of Science/ University of Mosul
Igor V. Kopytin
Department of Physics/ Voronezh State University/ Russia

p-ISSN: 1608-9391
e -ISSN: 2664-2786

Article information

Received: 2/10/2022
Revised: 25/ 11/ 2022
Accepted: 2/12/2022

DOI: 10.33899/rjs.2023.181268

corresponding author:
Anfal A. Mohammed
anfal.20scp6@student.uomosul.edu.iq

Imad A. Hussain
dr.imad1972@uomosul.edu.iq

ABSTRACT

The solar wind affects the Earth's atmosphere, whether directly or indirectly, through its parameters that can cause climatic disturbances. The importance of this topic and the lack of studies on Iraq are the reasons behind conducting this study to investigate the relationship between the parameters of the solar wind (the radio frequency of solar activity (F10.7cm), the disturbance of the magnetic storm (Disturbance Storm Time DST), Electric Field- Ey, SW Plasma Speed and Geomagnetic Indicator (Ap)) and its effect on rainfall amounts in Iraq for the period (1/10/1988-31/5/2019). The data of the solar wind parameters were adopted from the official website of NASA (NOAA); rain data were adopted from the Iraqi General Meteorological Authority and seismic monitoring for four different stations (Mosul and Kirkuk as the northern region/ Baghdad as the central region and Basra as the southern region). The data was statistically analyzed by the statistical program (Minitab 19.0). The results show that the effect of each of F10.7 and (Ap) on the amounts of rainfall was negative for all phases, but there is no significant effect for each of (DST), (Ey) and (SW). As for the effect of the parameters as a whole on the amounts of Rainfall for the total duration, it was found out that there was a direct effect, except for (F10.7), where no effect was seen.

Keywords: solar wind parameters، rainfall, effect solar relationship- climate.

This is an open access article under the CC BY 4.0 license (http://creativecommons.org/licenses/by/4.0/).

INTRODUCTION

The solar wind is a storm of charged particles emitted from the upper layers of the solar atmosphere known as the corona. This plasma consists of accelerated electrons, protons and alpha particles. When the solar wind approaches the earth, it interacts with its atmosphere and magnetic field to generate disturbances in them. The parameters of the solar wind represent the gauges of these disturbances (McComas, 2003). The disturbance of the magnetic storm (Disturbance Storm Time) (DST-index) is one of the geomagnetic indicators widely used to denote the intensity of the global magnetic disturbances. It is a measure of the magnetic field (nT) that provides information about the strength of the Earth's ring currents generated by electrons, protons and charged particles emitted from the sun. It serves as a barometer for space weather. These cyclic currents form a magnetic field that faces the Earth's magnetic field and in the opposite direction. When the difference between each of the solar electrons and protons is higher; in this case, the Earth's magnetic field becomes weaker. So, the value of the DST is negative and indicates the weakness of the Earth's magnetic field. This occurs during solar storms (Banerjee *et al.*, 2012). As for the geomagnetic index, Ap, it is an indicator of the general level of the geomagnetic activity on the globe, and it is derived from the measurements that were made at a number of stations in the world on a large scale of the variation of the geomagnetic field due to currents flowing in the ionosphere of the earth (Rostoker *et al*., 1972). As for the velocity resulting from the interaction of the solar wind and the earth's atmosphere, which produces a magnetic envelope that protects the earth, it is known as the velocity of the plasma which is measured in km/sec The velocity of the quasi-constant solar wind plasma ranges from 300 to 400 km/s in the slow solar wind and to 800 km/s in the fast solar wind (Matteini *et al.*, 2014). The solar radio flux (F10.7) is one of the most widely used indicators of the solar activity. It determines the strength of the emission of the solar radio waves in the range of 100 MHz with a wavelength of (10.7) cm, measured in (sfu=10-22Wm-2Hz-1), and has a thermal emission formed in the chromosphere and the corona, as well as the plasma concentrations that are found in both the chromosphere and the corona by the magnetic field of the active region (Tapping, 2013).

Electric field-Ey is measured in (mv/m). There are two types of electric fields in the magnetosphere: the electric field associated with the solar wind from dawn to dusk, known as convection, and the electric field associated with the rotation of the Earth (Dommermuth, 2021).

Rain is one of the most important climatic phenomena and is a source of life on land. Rain results from the condensation of water vapor and falls down by the gathering of water vapor molecules around tiny particles in the air known as condensation nuclei. They coalesce with each other and as a result of their collision turn into water droplets that then grow into complete water droplets or ice crystals or both. These processes occur within the troposphere, which is the first layer of the atmosphere. (Musa, 2004).

The solar activity has an impact on the climate and long-term climate change and has a major role in the formation of clouds that produce rain (Singh *et al*., 2011). Studies indicate that rainfall is affected by solar phenomena. Researchers noted a close relationship between rainfall and sunspot change in the Beijing region (Zaho *et al*., 2004). In India, researchers studied the difference in solar activity that occurs from one solar cycle to another for the period (1871-2000). With rainfall, they found that the higher the solar activity, the lower the rainfall (Hiremath, 2006). The researcher showed that the shape and size of the raindrop is affected by the strength of the electric field, meaning that the shape of the raindrop is affected by the electric field (Rasmussen, 1985). The two researchers (Karagioras and Kourtidis, 2021) also noted, when studying the relationship between rain and the electric field near the ground in northern Greece for a period of 10 years, that there is an inverse relationship between PG and Rainfall. However, the two researchers (Riehl and Hardy, 1986) analyzed 262 polar rain data. They selected data that show an extended region of polar Rainfall, for which solar winds and interplanetary magnetic field data were available. No clear relationship was found between the temperatures of the solar wind and the polar

rains or their numerical intensity. The researchers (Prikryl *et al.*, 2021) used a Rainfall data set based on rain gauges and satellite sensor measurements to examine the relationship between high-speed solar wind currents and daily Rainfall rates over several mid-latitude regions. The results show an increased incidence of high Rainfall rates after the arrival of high-velocity streams, including recurrences with a solar rotation period of 27 days. These findings are further demonstrated by heavy Rainfall, floods and flash floods in Europe, Japan and the USA, which sheds light on the role of the pairing of the solar wind to the magnetosphere - the ionosphere - within the atmospheric system of severe weather, by auroral gravitational waves. The researchers (Ramadan and Hussain, 2022) also proved that solar phenomena play an important role in influencing the near-Earth space and the Earth's atmosphere, interacting with the Earth's magnetic field and causing climatic disturbances that affect the globe, including rain and thunderstorms.
This study aims to identify the effect of solar wind parameters on rainfall amounts in Iraq and to find the relationship between them.

The Solar and Climatic Data

The NASA satellites located in the central orbits of the Earth and located at the Lagrange point were used to obtain data for the parameters of the solar wind for each of the geomagnetic index, electric field, solar activity flow, and plasma velocity. These data are collected from their own website on the Internet.
(http://omniweb.gsfc.nasa.gov/vitmo/iri HYPERLINK"http://omniweb.gsfc.nasa.gov/vitmo/iri2012_vitmo.html"2012 HYPERLINK "http://omniweb.gsfc.nasa.gov/vitmo/iri2012_vitmo.html"_vitmo.html

The monthly average for the period (1988-2019) was found. The climatic data on rain for the rainy season during (1988-2019) was approved by the Iraqi General Authority for Meteorology and Seismic Monitoring - Ministry of Transport, as these stations differ in geographical location in the region of Iraq as shown in Fig. (1), (Table 1).

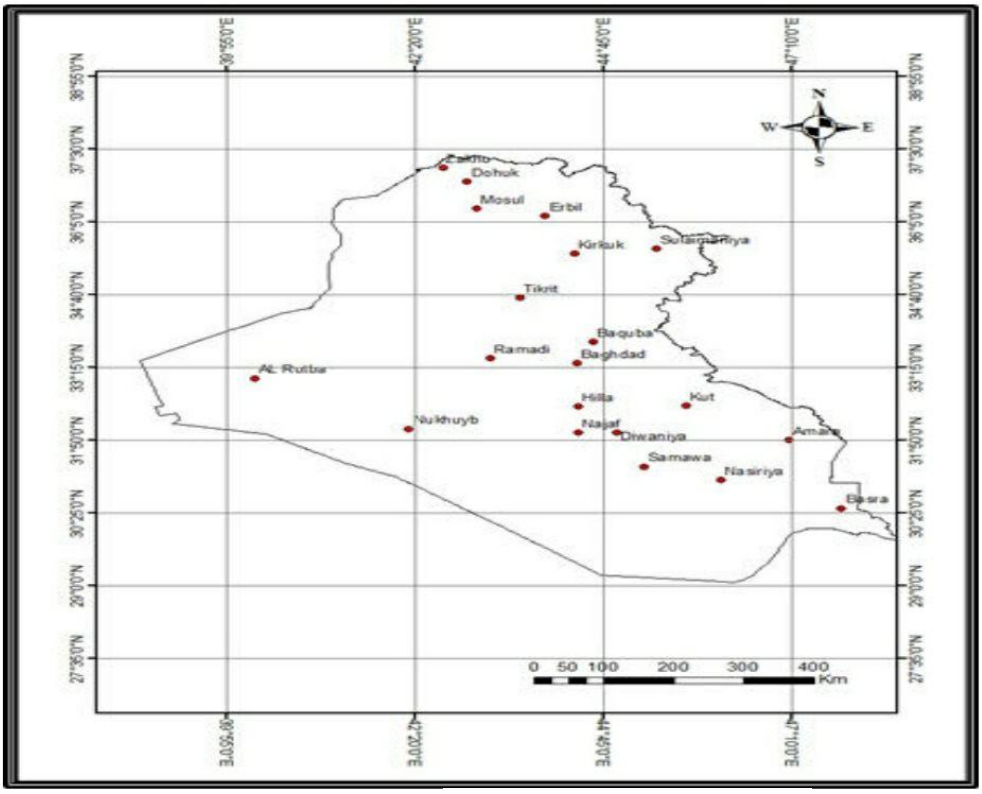


Fig. 1: Map of Iraq [Rijabo and Abdullah, 2019]

Table 1: Coordinates of climate monitoring stations

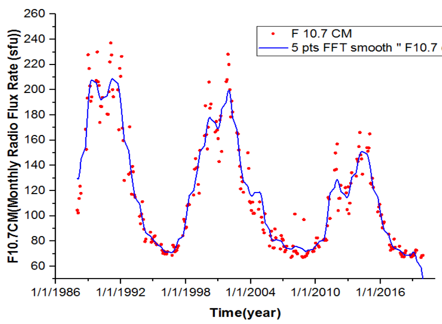
Weather station	Latitude (North)	Longitude (East)	Elevation (m)
Mosul	36° 19′	43° 09′	222
Baghdad	33° 20′	44° 26′	31.1
Kirkuk	35° 28′	44° 40′	331
Basra	30° 30′	47° 50′	2.4

Research Methodology

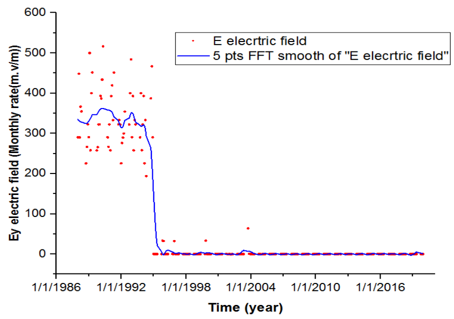
In order to study the impact of rainfall amounts in Iraq on solar wind parameters for the period (1988-2019) and after finding the monthly average of the data, this period will be divided as follows:

- The descending phase of the 22nd solar cycles (1988 - 1995)
- The ascending phase of the 23 solar cycles (1996 - 2001)
- The descending phase of the 23 solar cycles (2002 - 2007)
- The ascending phase of the 24th solar cycles (2008-2013)
- The descending phase of the 24th solar cycles (2014-2019)

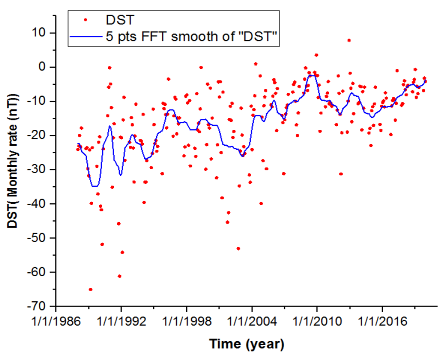
Statistics program (Minitab 19.0) was used. It is considered the most accurate and best statistical program (Ramadan and Hussain, 2022). In the first stage, all data is filtered using (FFT) and a 5-grade filter is used to remove and filter extreme data Fig. (2). Then, the Pearson's correlation coefficient is found, as well as the binary correlation between the dependent and independent variables (Bivariate Correlations).



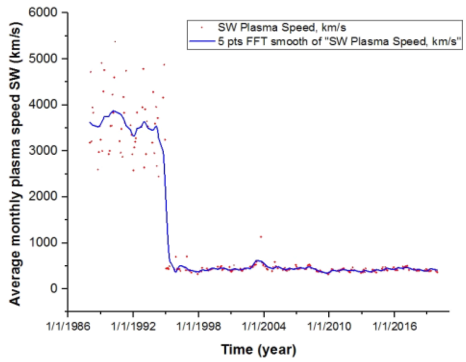
A



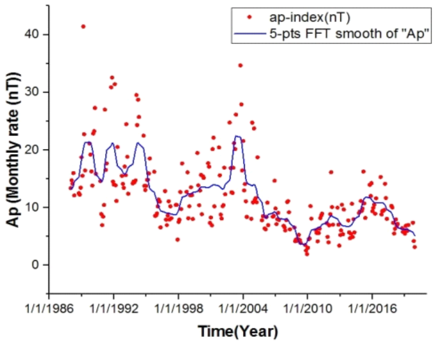
B



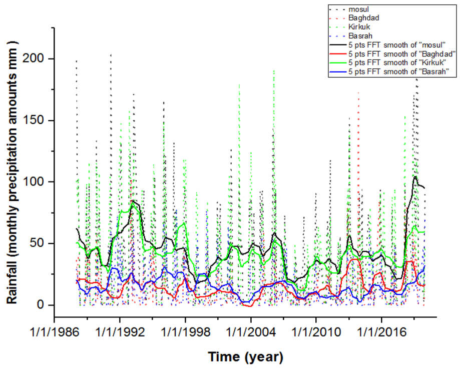
C



D



E



F

Fig. 2: The monthly average for (A) F10.7 (B) Ey (C) DST, (D)SW, (E) Ap, (F) Rain

RESULTS AND DISCUSSION

The data have been statistically analyzed between each of the parameters of the solar wind (F10.7, DST, Ey, SW, Ap) and the amounts of rainfall in order to find the influence relationship between them:

The effect of F10.7 on the amounts of Rainfall

Fig. (3) shows the relationship between F10.7 and the amounts of Rainfall over Iraq for the four stations in the period 1988-2019. The results were as follows:

In the statistical analysis of the total period, it is noted that there is no clear relationship for the effect of the monthly average of (F10.7) on the amounts of rainfall for the four stations, with a statistical significance higher than (5%). It is an indication of the occurrence of random chance in the data.

It is noted from the descending phase of the solar cycle 22 that the effect of the monthly average of (F10.7) on the amounts of rainfall had a weak counter effect for the stations of Mosul and Baghdad. Pearson's correlation coefficient reached (R_M=-0.39, R_{Bag}=-0.33) with a statistical significance level of less than (5%), while there is no correlation for Kirkuk and Basra stations.

The statistical analysis shows the effect of the monthly rate of the flow of solar activity on the amounts of Rainfall in the ascending phase of the solar cycle 23. The effect was reversed for all stations (R_M=-0.61, R_{Bag}=-0.29, R_{Bas}=-0.65, R_{Kr}=-0.58) at a Statistical significance level less than (5%).

It is noted in the solar cycle 23 the descending phase that the relationship is inversely weak in the stations of Baghdad and Basra. The Pearson correlation coefficient was (R_{Bag}=-0.43, R_{Bas}=-0.46). In addition, the direct relationship is weak in the Kirkuk station (R_{Kr} = 0.37). As for the Mosul station, it does not show a clear relationship.

In the ascending phase of the solar cycle 24, the statistical analysis shows a positive relationship for all stations except for Basra station. The Pearson coefficient was (R_M = 0.54, R_{Bag} = 0.66, R_{Bas} = 0.50) with a significance level of less than (5%) because the Rainfall increases when the speed of the solar wind currents is high (Prikryl *et al.*, 2021).

In the descending phase of the solar cycle 24, the statistical analysis shows that there is an inverse relationship for all stations except for the Baghdad station. Pearson's coefficient was (R_M=-0.41, R_{Bas}=-0.42 R_{Kr}=-0.55), with a level of significance less than (5%).

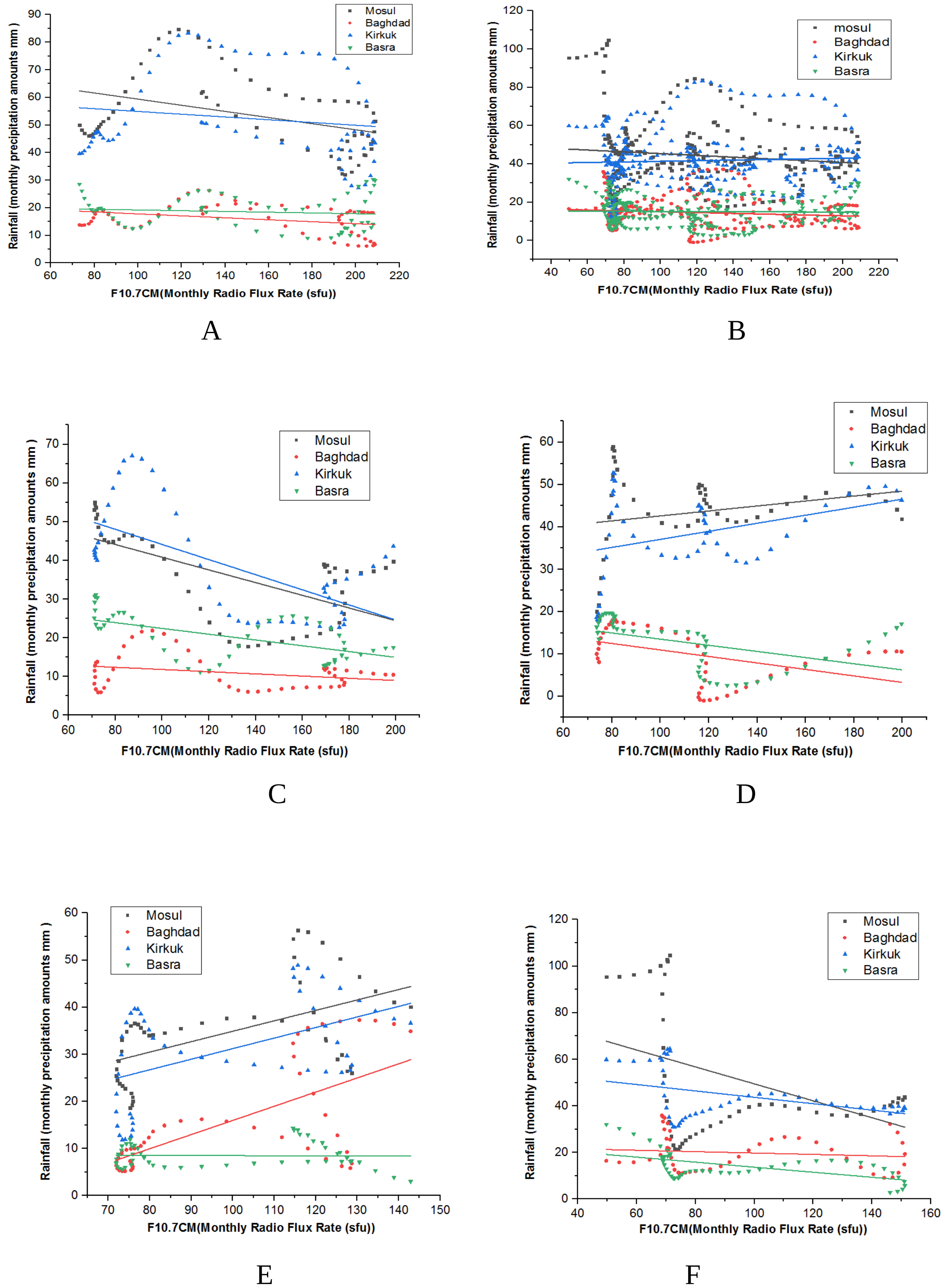


Fig. 3: Effect of F10.7 on Rainfall amounts. (A) The total duration (1988 - 2019), (B) the descending phase of the solar cycle 22, (C) the rising phase of the solar cycle 23, (D) the descending phase of the solar cycle 23, (E) the rising phase of the solar cycle 24, (F) The descending phase of the solar cycle 24.

Effect of DST and Ap on Rainfall

Fig. (4) shows the relationship of DST and Ap with the amounts of rainfall over Iraq and for the four stations in the period 1988-2019. The results were as follows:

In the statistical analysis of the total period, it is noted that there is a weak inverse relationship of the effect of the monthly average (DST) on the amounts of rain for the stations of Mosul, Basra, and Kirkuk. The Pearson correlation coefficient was (R_{Bas}=-0.14, R_{Kr}=-0.3, R_{M}=-0.07), and the direct relationship is weak in the Baghdad station. Pearson's coefficient is (R_{Bag} = 0.43). As for the effect of the monthly average (Ap) on the amount of rain, it was inversely weak in Baghdad station and weak directs in Kirkuk station. The Pearson correlation coefficient was (R_{Bag}=-0.42, R_{Kr}=0.28) with a lower statistical significance (5%).

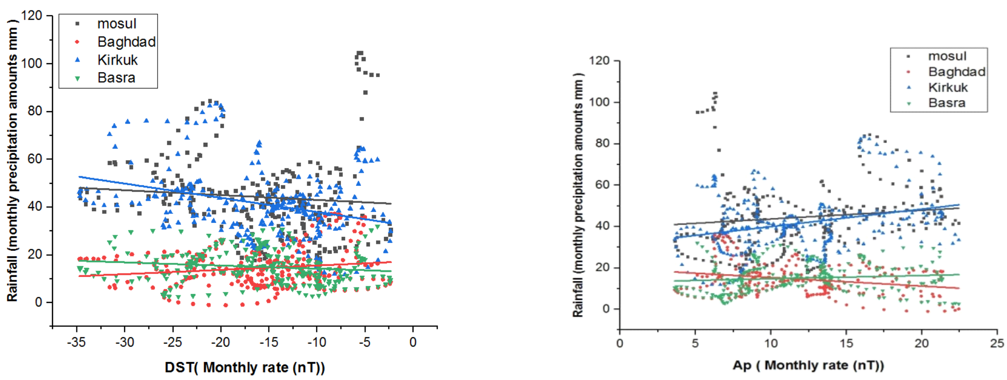
In the descending phase of the solar cycle 22, the monthly average (DST) and (Ap) do not affect the amounts of Rainfall for all stations except for Basra station for DST because it is located near the Arabian Gulf. The Pearson correlation coefficient (R_{Bas} = 0.43) was relatively weak, with a level of statistical significance of (sig = 0.00).

During the rising phase of the solar cycle 23, the statistical analysis shows that there is no effect of the monthly average (DST) on the amounts of Rainfall for all stations except for Basra station. The Pearson correlation coefficient (R_{Bas} = 0.67) was a mean direct correlation with a level of statistical significance of (sig = 0.00). While there is an inverse effect of the monthly average (Ap) on rainfall amounts for all stations (R_{M}=-0.64, R_{Bag}=-0.35, R_{Bas}=-0.58, R_{Kr}=-0.79) with a significance level less than (5%).

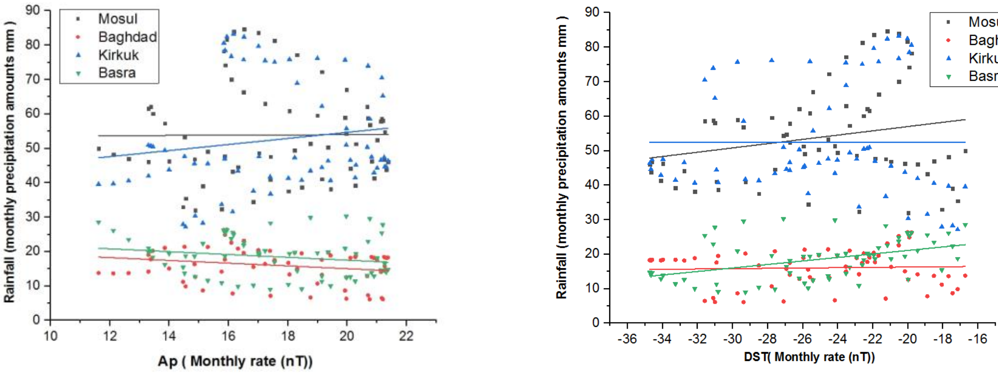
The statistical analysis in the descending phase of the solar cycle 23 shows that there is no effect of the monthly average (DST) on the amounts of Rainfall for all stations except for Basra station. The Pearson correlation coefficient (R_{Bas} = 0.68) was a mean direct correlation with a level of statistical significance of (sig = 0.00). The statistical analysis of the effect of the monthly average (Ap) on rainfall amounts shows a strong inverse relationship in the Baghdad and Basra stations. The Pearson correlation coefficient was (R_{Bag}=-0.84, R_{Bas}=-0.93) with a level of significance less than (5%). In Mosul and Kirkuk stations, there is no clear relationship.

In the ascending phase of the solar cycle 24, the effect of the monthly average (DST) and (Ap) on rainfall amounts does not show a clear relationship.

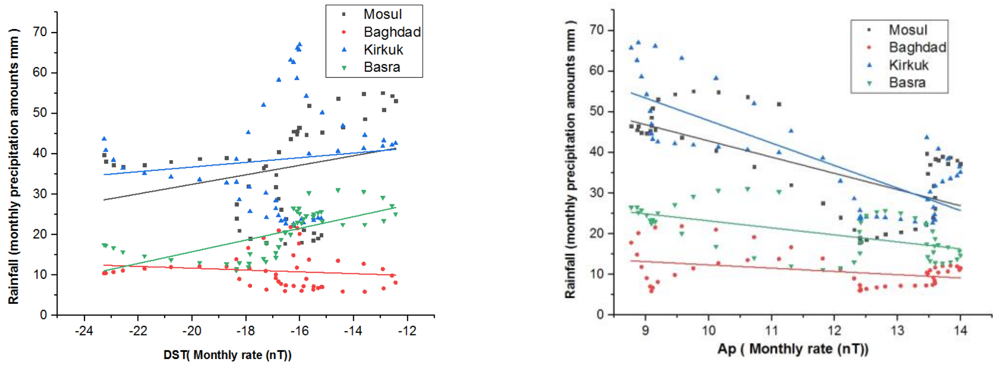
The statistical analysis of the effect of the monthly average (DST) shows that there is a direct relationship for all stations selected in the descending phase of the 24 solar. Pearson's correlation coefficient was (R_{M} = 0.7, R_{Bag} = 0.43, R_{Bas} = 0.55, R_{Kr} = 0.63), with a statistical significance of less (5%), while (Ap) had an opposite effect for all stations in the phase. The Pearson correlation coefficient was (R_{M}=-0.74, R_{Bag}=-0.42, R_{Bas}=-0.41, R_{Kr}=-0.65), with a level of significance less than (5%).



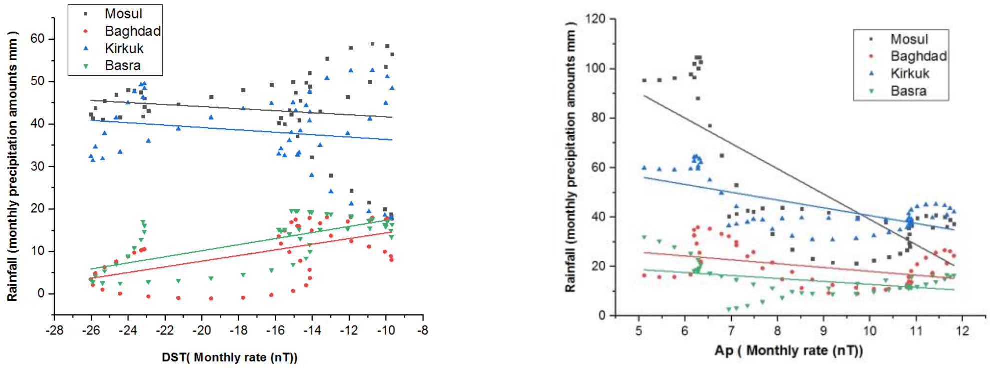
A


Mosul
Baghdad
Kirkuk
Basra
Rainfall (monthly precipitation amounts mm)
Ap (Monthly rate (nT))
DST(Monthly rate (nT))

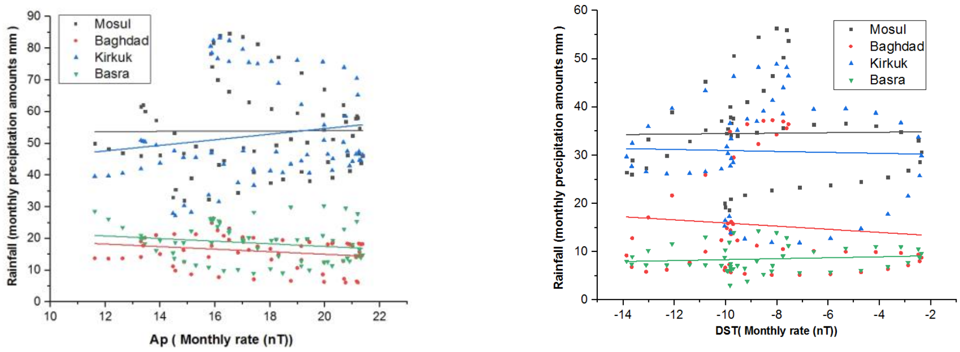
B


Mosul
Baghdad
Kirkuk
Basra
Rainfall (monthly precipitation amounts mm)
DST(Monthly rate (nT))
Ap (Monthly rate (nT))

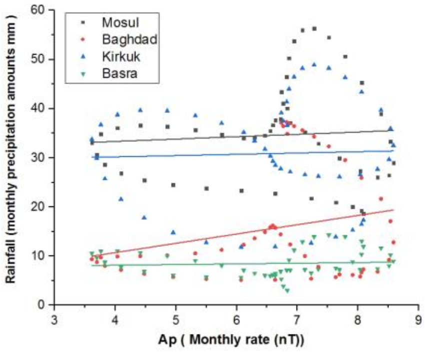
C

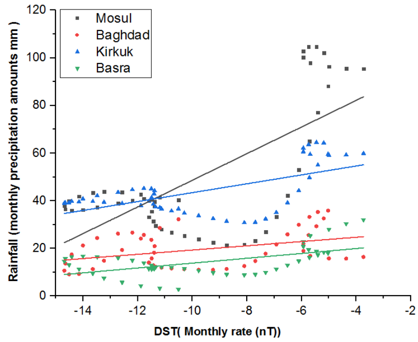

Mosul
Baghdad
Kirkuk
Basra
Rainfall (monthly precipitation amounts mm)
DST(Monthly rate (nT))
Ap (Monthly rate (nT))

D


Mosul
Baghdad
Kirkuk
Basra
Rainfall (monthly precipitation amounts mm)
Ap (Monthly rate (nT))
DST(Monthly rate (nT))

E





F

Fig. 4: The effect of (DST) and (Ap) on the amounts of Rainfall: (A) the total duration (1988-2019), (B) the descending phase of the solar cycle 22, (C) the rising phase of the solar cycle 23, (D) the descending phase of the solar cycle 23, (E) the ascending phase of the solar cycle 24, (F) the descending phase of the solar cycle 24.

The effect of the electric field Ey on the amount of rain

Fig. (5) shows the relationship of Ey with the amounts of rainfall over Iraq and for the four stations during 1988-2019. The results were as follows:

The statistical analysis of the total period shows that there is a direct relationship for the effect of the monthly average (Ey) on the amounts of rainfall for the Mosul, Basra and Kirkuk stations. The Pearson correlation coefficient was (R_M = 0.3, R_{Bas} = 0.24, R_{Kr} = 0.44), with a statistical significance of less than 5%.

It was noticed in the descending phase of the solar cycle 22 that the monthly average (Ey) does not affect the amounts of Rainfall for all stations except for Basra station. The Pearson correlation coefficient (R_{Bas} = -0.25) was a weak adverse effect with a level of statistical significance (sig = 0.050).

The statistical analysis shows the effect of the monthly average (Ey) on the amounts of Rainfall in the ascending phase of the solar cycle 23, which had an adverse effect on the Baghdad station. The Pearson correlation coefficient (R_{Bag} = -0.30) reached a level of statistical significance (sig = 0.033) and there was a strong direct effect of the Basra station. The Pearson correlation coefficient reached (R_{Bas} = 0.70) with a significance level (sig = 0.00). The stations of Mosul and Kirkuk have no effect because they are located at approximately the same latitude. This result is consistent with the study of the researcher (Al-Kinani, 2015), which proved that the daily amounts of rain vary according to time and place.

It was noticed that he descending phase of the solar cycle 23 had a strong adverse effect in the Baghdad and Basra stations. The Pearson correlation coefficient was (R_{Bag}=-0.70, R_{Bas}=-0. 75) with a statistical significance level of less than (5%). As for the stations of Mosul and Kirkuk, there is no clear relationship.

In the ascending phase of solar cycle 24, the statistical analysis shows that there is no clear relationship. The level of the specialist significance was greater than (5%).

In the descending phase of the solar cycle 24, the statistical analysis shows that there is no clear relationship. The level of the statistical significance is greater than (5%) because the solar cycle 24 is the weakest cycle during the last century (Ramadan and Hussain, 2021).

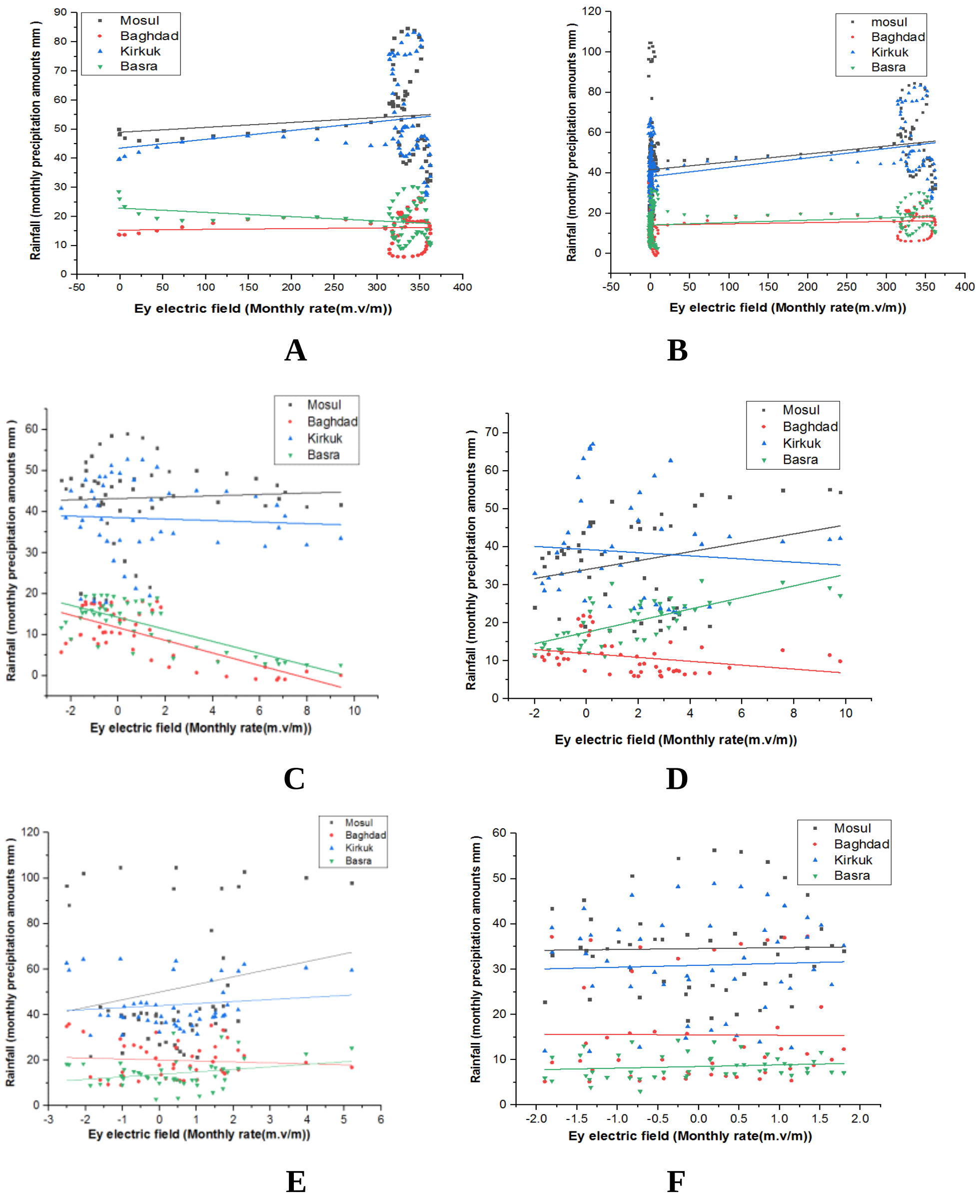


Fig. 5: Effect of (Ey) on Rainfall amounts. (A) The total duration (1988 - 2019), (B) the descending phase of the solar cycle 22, (C) the rising phase of the solar cycle 23, (D) the descending phase of the solar cycle 23, (E) the rising phase of the solar cycle 24, (F) The descending phase of the solar cycle 24.

Effect of SW plasma velocity on rainfall amounts

Fig. (6) shows the speed of the plasma with the amounts of Rainfall over Iraq and for the four stations for the period from 1988-2019. The results were as follows:

In the statistical analysis of the total period, it was noted that there is a weak direct relationship for the effect of the monthly rate of plasma velocity on the amounts of Rainfall or the Mosul, Basra and Kirkuk stations. The Pearson correlation coefficient was (R_M=0.3, R_{Bas}=0.23, R_{Kr}=0.43). As for the Baghdad station, the relationship was moderately inverse. The Pearson correlation coefficient was (R_{Bag}=-0.55), with less statistical significance (5%).

It was noticed in the solar cycle 22 the descending phase that there is no relationship for the effect of the monthly rate of plasma velocity on the amounts of rainfall for all stations except for the

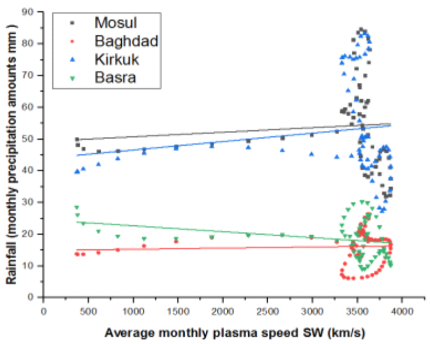
Basra station. The relationship was inversely weak. The Pearson correlation coefficient was (R_{Bas}=-0.30), with a level of significance less than (5%).

The statistical analysis shows the effect of the monthly average velocity of the plasma on the amounts of Rainfall in the ascending phase of the 23 solar cycles, which had an average adverse effect for the Baghdad and Kirkuk stations. The Pearson correlation coefficient was (R_{Bag}=-0.65, R_{Kr}=-0.54). In addition, it was weak direct at the Basra station. The Pearson correlation coefficient was (R_{Bas} = 0.29). As for the Mosul station, there is no clear relationship. There is a study that proved that the amounts of rain in Iraq vary from one region to another. This is due to the nature of the depressions affecting them and their paths, as well as the prevailing weather conditions with them and the accompanying pressure systems in the upper layers of the atmosphere (Al-Kinani, 2015). These results are in agreement with it.

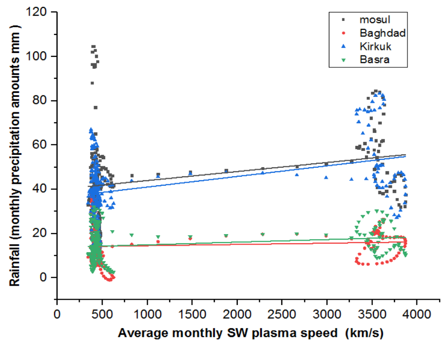
It was noticed in the descending phase of the solar cycle 23 that the relationship is strong inverse in the stations of Baghdad and Basra. The Pearson correlation coefficient was (R_{Bag}=-0.81, R_{Bas}=-0.86) with a level of significance less than (5%). While there is no clear relationship to the two stations of Mosul and Kirkuk.

In the ascending phase of the 24 solar cycles, the statistical analysis shows an inverse relationship for all stations except for Basra. The Pearson correlation coefficient was (R_M=-0.53, R_{Bag}=-0.32, R_{Kr}=-0.62) with a significance level less than (5%).

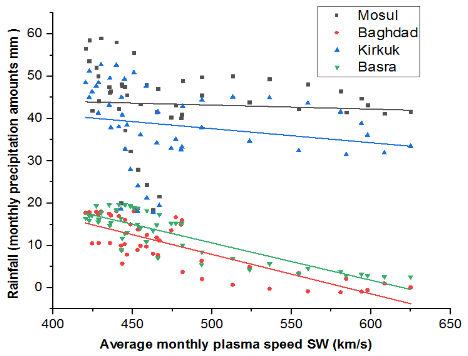
The statistical analysis of the descending phase of the solar cycle 24 shows that there is an inverse relationship for all stations except Basra station. The Pearson correlation coefficient was (R_M=-0.54, R_{Bag}=-0.55, R_{Kr}=-0.47) with a level of significance less than (5%).



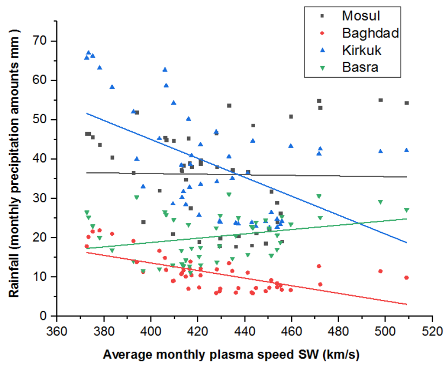
A



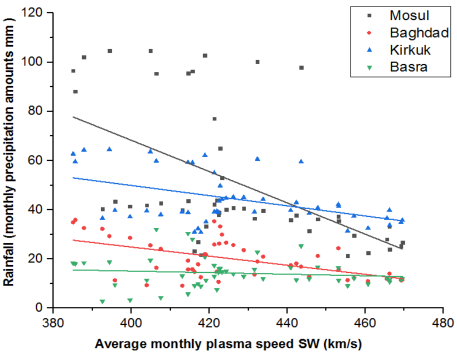
B



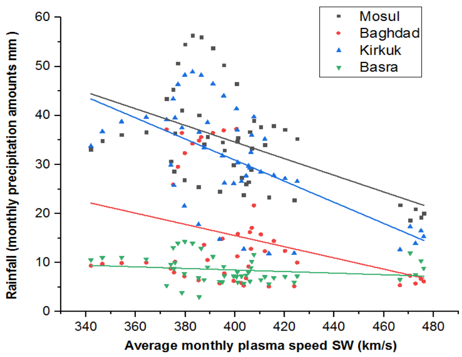
C



D



E



F

Fig. 6: The effect of plasma velocity on Rainfall amounts: (A) The total duration (1988 - 2019), (B) the descending phase of the solar cycle 22, (C) the rising phase of the solar cycle 23, (D) the descending phase of the solar cycle 23, (E) the rising phase of the solar cycle 24, (F) The descending phase of the solar cycle 24.

CONCLUSIONS

When studying the effect of the monthly rate of radio flux (F10.7) on the monthly repetition of the amount of rain for the total period, it was noticed that there was no effect. As for the descending phase of the solar cycle (22), the effect is reversed in the Baghdad and Mosul stations. But when analyzing the solar cycle (23) it was found out that the effect of the monthly average (F10.7) is inverse to all stations in the ascending phase. As for the descending phase, it will have an opposite effect in the Baghdad and Basra stations. It was found out that the effect of (F10.7) on rain in ascending phase of the solar cycle (24) was a direct one. As for the descending phase, the effect is reversed.

When analyzing the statistical effect of the monthly rate of the magnetic field (DST) on the monthly recurrence of the amounts of rain for the total period, there was an inverse relationship, and for all stations except for Baghdad station, a direct relationship was found. As for the descending phase of the solar cycle (22), it was noticed that there is no correlation between them, except for Basra, which is a direct relationship, as well as the case in the solar cycle (23). There is no correlation in both phases except for Basra, which was a direct relationship. It was noticed in the ascending phase of the solar cycle (24) that there is no relationship. As for the descending phase, the effect is direct for all stations.

The statistical analysis of the effect of the monthly average of the electric field (EY) on the monthly frequency of the amounts of rain for the total period, shows a direct effect for all stations. There was no effect of the solar cycle 24 and the descending phase of the solar cycle 22 except the opposite effect in Basra. As for the solar cycle 23, it is reversed in Baghdad and for both phases and for Basra it is direct in the ascending phase and reverse in the descending phase.

The statistical analysis of the effect of the monthly rate of plasma speed on the monthly recurrence of the amounts of rain for the total period shows that the relationship was positive for all stations. As for the descending phase of the solar cycle (22), there is no effect except for the Basra station, a reverse effect. And in the ascending phase of the solar cycle (23) the effect is reversed in Baghdad and Kirkuk, but negative in Basra. There is no effect in the Mosul station. The statistical analysis of the descending phase of the solar cycle (23) shows an adverse effect in Baghdad and Basra. And there is no effect in the stations of Kirkuk and Mosul. There was an opposite effect in the descending phase of the solar cycle (24), but there was no effect in the ascending phase.

When analyzing the statistical effect of the monthly average of the geomagnetic index (Ap) on the monthly recurrence of the amounts of rain for the total period, it was noticed that there is a direct relationship for the Kirkuk station and inverse for the Baghdad station. There is no correlation in the descending phase of the solar cycle (22). The effect is reversed for the solar cycle (23) with the exception of Mosul and Kirkuk in the descending phase. It was noticed from the statistical analysis that the ascending phase of the solar cycle (24) has no relationship, but in the descending phase it is a reverse effect.

REFERENCES

(http://omniweb.gsfc.nasa.gov/vitmo/iri HYPERLINK"http://omniweb.gsfc.nasa.gov/vitmo/iri2012_vitmo.html"2012 HYPERLINK "http://omniweb.gsfc.nasa.gov/vitmo/iri2012_vitmo.html"_vitmo.html.

Al-Kanani, M.N. (2015). Daily record rain in Iraq (a comprehensive study). *J. of Education College*, Wasit University, **1**(18), 145-170. Doi: https://doi.org/10.31185/eduj.Vol1.Iss18.291.

Banerjee, A.; Bej, A.; Chatterjee, T.N. (2012). On the existence of a long-range correlation in the geomagnetic disturbance storm time (DST) index. *Astrophys. and Space Sci.*, **337**(1), 23-32. Doi:10.1007/s10509-011-0836-1.

Dommermuth, D.G. (2021).” A Parametric Study of the Electric Field in the Atmosphere due to the Transport of Space Charge Density by the Meandering Wind over the Ocean Surface”. Research Gate preprint, 2. Doi:10.13140/RG.2.2.28136.19204.

Hiremath, K.M. (2006). The influence of solar activity on the rainfall over India: Cycle-to-Cycle Variations. *J. Astrophys. Astr*. **27**, 367–372. DOI: 10.1007/BF02702543.

Karagioras, A.; Kourtidis, K. (2021). A study of the effects of rain, snow and hail on the atmospheric electric field near ground. *Atmosphere*, **12**(8), 996. Doi:10.3390/atmos12080996.

Matteini, L.; Horbury, T.S.; Neugebauer, M.; Goldstein, B.E. (2014). Dependence of solar wind speed on the local magnetic field orientation: Role of Alfvénic fluctuations. *Geophys. Res. Lett.*, **41**(2), 259-265. Doi: 10.1002/2013GL058482.

McComas, D.J.; Elliott, H.A.; Schwadron, N.A.; Gosling, J.T.; Skoug, R.M.; Goldstein, B.E. (2003). The three-dimensional solar wind around solar maximum. *Geophys. Res. Lett.*, **30**(10). Doi: 10.1029/2003GL017136.

Musa, A. H. (2004). “Fundamentals of Climatology”. Dar Al-Fikr, Damascus.

Prikryl, P.; Rušin, V.; Prikryl, E.A.; Šťastný, P.; Turňa, M.; Zeleňáková, M. (2021, August). Heavy rainfall, floods, and flash floods influenced by high-speed solar wind coupling to the magnetosphere–ionosphere–atmosphere system. *In Annales Geophys*., **39**(4), 769-793. Copernicus GmbH. Doi:10.5194/angeo-39-769-2021.

Ramadan, M.; Hussain, I. (2022). Studying the effect of solar activities on thunderstorms in Iraq for solar-cycles 23 and 24. *Malaysian J. Sci*., 76-90. Doi: https://doi.org/10.22452/mjs.vol41no1.5.

Ramadan, M.A.; Hussein, I.A. (2021). Studying the Effect of Coronal Mass Ejections and Solar Flares on Thunderstorms in the City of Mosul for Solar Cycles 23 and 24. *Raf. J. Sci.*, **30**(4), 33-45. DOI: 10.33899/rjs.2021.169982.

Ramadan, M.A.; Hussein, I.A. (2022). Solar activities and their relationship to the maximum temperatures of the city of Baghdad for the solar cycles 23 and 24. *Raf. J. Sci.*, **31**(1), 34-42. Doi: 10.33899/RJS.2022.172938.

Rasmussen, R.; Walcek, C.; Pruppacher, H.R.; Mitra, S.K.; Lew, J.; Levizzani, V.; Barth, U. (1985). A wind tunnel investigation of the effect of an external, vertical electric field on the shape of electrically uncharged rain drops. *J. Atmosph. Sci*., **42**(15), 1647-1652. Doi: https://doi.org/10.1175/1520-0469(1985)042<1647:AWTIOT>2.0.CO; 2.

Riehl, K.B.; Hardy, D.A. (1986). Average characteristics of the polar rain and their relationship to the solar wind and the interplanetary magnetic field. *J. Geophys. Res.: Space Phys*., **91**(A2), 1557-1571. Doi: https://doi.org/10.1029/JA091iA02p01557.

Rostoker, G. (1972). Geomagnetic indices. *Rev. of Geophys.*, **10**(4), 935-950. Doi: https://doi.org/10.1029/RG010i004p00935.

Siingh, D.; Singh, R.P.; Singh, A.K.; Kulkarni, M.N.; Gautam, A.S.; Singh, A.K. (2011). Solar activity, lightning and climate. *Surveys in Geophys.*, **32**(6), 659-703. Doi**:**10.1007/s10712-011-9127-1.

Tapping, K.F. (2013). The 10.7 cm solar radio flux (F10. 7). *Space Weather*, **11**(7), 394-406. Doi**:** 10.1002/swe.20064.

Zhao, J.; Han, Y.B.; Li, Z.A. (2004). The effect of solar activity on the annual precipitation in the Beijing area. *Chinese J. Astr. and Astrophys.*, **4**(2), 189. Doi**:** 10.1088/1009-9271/4/2/189.

تأثر تساقط الامطار فوق العراق بمعلمات الرياح الشمسية

انفال احمد محمد **عماد احمد حسين**

قسم الفيزياء / كلية العلوم/ جامعة الموصل

ايكر فاسيلفج كابتين

قسم الفيزياء/ جامعة فارونيش الحكومية/ روسيا

الملخص

تؤثر الرياح الشمسية على الغلاف الجوي للأرض بشكل مباشر أو غير مباشر من خلال مَعلماتها التي يمكن أن تسبب اضطرابات مناخية. ولأهمية هذا الموضوع وعدم وجود دراسات حول العراق هي سبب اجراء هذه الدراسة لبحث العلاقة بين مَعلمات الرياح الشمسية وهي كل من ((التدفق الراديوي للنشاط الشمسي (F10.7cm)، اضطراب العاصفة المغناطيسية (وقت اضطراب العاصفة DST)، المجال الكهربائي– Ey، سرعة البلازما SW والمؤشر المغناطيسي الارضي (Ap)) وتأثيرها على كميات هطول الأمطار في العراق (1/10/1988-31/5/2019). تم اعتماد بيانات معلمات الرياح الشمسية من الموقع الرسمي لناسا (NOAA) ؛ تم اعتماد بيانات كميات الامطار من الهيئة العامة للأرصاد الجوية العراقية والرصد الزلزالي لأربع محطات مختلفة (الموصل وكركوك المنطقة الشمالية / بغداد باعتبارها المنطقة الوسطى و البصرة كمنطقة جنوبية) تم تحليل البيانات إحصائياً بواسطة البرنامج الإحصائي (Minitab 19.0) وأظهرت النتائج أن تأثير كل من F10.7 و (Ap) على كميات الأمطار كان سلبياً لجميع الاطوار، ولكن لا يوجد تأثير كبير لكل من(Ey)، (DST) و (SW) أما بالنسبة لتأثير المَعلمات ككل على كميات هطول الأمطار للمدة الإجمالية، وقد تبين وجود تأثير مباشر باستثناء (F10.7) حيث لم يلاحظ أي تأثير.

الكلمات الدالة: مَعلمات الرياح الشمسية، هطول الأمطار، تأثير، العلاقة الشمسية–المناخ.