Al-Mustansiriyah Journal of Science
ISSN: 1814-635X (print), ISSN: 2521-3520 (online)
Volume 28, Issue 1, 2017
DOI: http: //doi.org/10.23851/mjs.v28i1.239

Research Article

The Effect of Sunspot Cycles on the Precipitation over Iraq

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ArticleInfo

Received
19/6/2016

Accepted
5/10/2016

Abstract
Continuous wavelet transformation (C.W.T) by MATLAB technique has been used to study the relations between the sunspot cycles (solar activity) with annual precipitation over Iraq (for about 10 cycles). Results indicated that the sunspot numbers have three main periods, around 11, 21 and 33 years, while the precipitation has the same periods in addition to a small period (3-7 years). By applying moving average according to the periodicities that found by continuous wavelet transformation, relations between solar cycles were closely related to the annual precipitation over Iraq.

Keywords: solar activity, Sunspot, Iraq, wavelet, precipitation.

الخلاصة
تم استخدام تقنية Continuous Wavelet Transformation ذو الابعاد الثلاث من خلال برنامج MATLAB لدراسة العلاقة بين الدورات الشمسية (النشاط الشمسي) والمعدل السنوي للتساقط (الامطار) في العراق لعشر دورات شمسية. وقد بينت النتائج ان هنالك ثلاث فترات زمنية ((periods لعدد البقع الشمسية عند 11، 21، 33 سنة تقريبا وكذلك الحال بالنسبة للامطارمع وجود دورة زمنية اضافية قصيرة عند 3-7 سنة تقريبا.وقد تبين بعد استخدام المتوسط المتحرك (moving average) لتلك الفترات ان هنالك علاقة واضحة بين دورات البقع الشمسية والامطار في العراق.

Introduction

It is known that the sun is responsible for climate system in a dominant way. Since the sun, by far, is the largest supplier of energy to the earth, it could influence the climate on earth.

It has increasingly to determine the relative importance of solar activity on climate. On the other hand good understanding of climate variability (especially precipitation) is essential for the management of agriculture, water resources and land use.

The term solar activity comprises photospheric and chromospheric phenomena such as sunspots, prominences and coronal disturbances. Solar activity also refers to the level of solar magnetism, often giving rise to sunspots. Prominences and coronal disturbance are often associated with sunspot, but there are also types of solar activity which do not involve sunspot directory, such as the appearance of magnetic flux tubes and variations in the global solar magnetic field [1] [2]. Solar activity has been measured via satellites during recent decades and through 'proxy' variables in prior times [3].

Sunspots are dark regions on the photosphere associated with strong magnetic fields and lower temperature than the surrounding area (photosphere). Where intense magnetic activity inhibits convection and cools the photosphere. Or (other define): Sunspots are storms on the sun's surface that are marked by intense magnetic activity and play host to solar flares and hot gassy ejections from the sun's corona [4] [5].

Sunspots often appear in pairs or groups with specific magnetic polarities that indicate electromagnetic origins.

Telescopic observations of sunspots show that they range in size from pores, which are less than 2500 km across and last for less than an hour, to spots as Large as 50, 000 km across, or four times the diameter of the Earth [6].

The sunspot cycle is a regular increasing and decreasing of the number of sunspot on the sun. Solar cycles are cyclic changes in behavior of the Sun. The number of sunspots varies in a periodic manner, usually described as the 11 year cycle. The 11 year sunspot is related to a 22 year cycle for the reversal of the Sun's magnetic field [7].

Solar cycle 24 is the 24th solar cycle since 1755, when recording of solar sunspot activity began. It is the current solar cycle, and began on 8 January 2008, but there was minimal activity through early 2009 [8].

Study Area and Data Acquisition

Iraqi country lies in the western south of Asia continent, in the eastern north of Arab homeland. It extends between the latitudes (37° 22′-29.5 north) and longitude (48.45°-38°.45′east) [9].

The annual and monthly sunspot numbers for the same period (1878-2010) are taken from solar geophysical data center (SGDC) of national oceanic and atmospheric administration (NOAA) and national geophysical data center (NGDC) of USA (Hiremath and Mandi, 2004), (Hiremath, 2006).

The total monthly amount of precipitation for Iraq is obtained for the period (1910-2000).

These annual data of precipitation are taken in unit of (mm), observations from meteorological stations were assimilated into grid covering the land surface of the Earth. The gridded data were transformed into (country) averages by allocating each 0.5° grid-box to a single (country) and calculating the weighted mean of the constituent grid-boxes of each country.

Wavelet Analysis

The computing program that used was MATLAB (matrix laboratory) program; it has a high level language to do an interactive environment with users, because of its ability to solve the entire mathematics problem like numerical computations, linear algebraic Equations, complex numbers and matrices. Matrices are the essential element in MATLAB program in both two and three dimensions [9] [10]. Continuous wavelet transform techniques have been applied to determine the periodicity of solar activity cycles as well as the above climate elements to understand the role of natural driving forces in controlling the climate variability over Iraq, as well as some other areas.

A wavelet is a wave-like oscillation with amplitude that starts out at zero, increase, and then decrease back to zero. It can typically be visualized as a "brief oscillation" like one might see recorded by a seismograph or heart monitor. Generally, wavelets are purposefully crafted to have specific properties that make them useful for signal processing. Wavelets can be combined, using a "shift multiply and sum" technique called convolution, with portions of an unknown signal to extract information from the unknown signal. Wavelet transform method has been choosing to analyze the correlation between the annual sunspot number and the climate elements, because of its ability of detailing the local characteristics of the signals in both the time and frequency domains. i.e.: wavelet analysis is use to analyze non-stationary time series. A way to analyze non-stationary time series, wavelet analysis, permits an automatic localization of objects such as periodic cycle sequence in time and frequency domain. It permits to identify the main periodicities in a time series. By varying the wavelet time scale and translating the scaled versions of the wavelet, it's possible to build a graph showing the amplitude versus frequency (or scale) and how they vary with time.

Results and Discussion

Wavelet analysis (continuous wavelet transformation) of the total annual sunspot numbers have been done by using international sunspot numbers, the upper part of Figure 1 shows the time series of the original sunspot numbers and the lower part shows the result of the wavelet analysis. Sunspot numbers have obvious periods of 11, 22, and 33. The periods obviously vary in time. Among all period, the 11-years period has the strongest amplitude.

Energy is indicated by the shading (maximum energy, darkest) the energy of the signal is concentrated at certain frequencies; the strongest concentration is at the center of the circle enclosed by the solid contour line.

Both of the length and intensity of the periods vary with time. For example, the length of the well-known 11-year solar cycle period was sometimes less than 11 years, such as around 1950, whereas it was greater than 11 years, such as around 1900. The length actually ranges from 10 years to 12 years.

Variation in the intensity was also obvious. Weaker intensity was around 1910, and then got stronger around 1957.

The 33 year's period (actually ranging from 28 to 33 years), this period became obvious for about 1910.

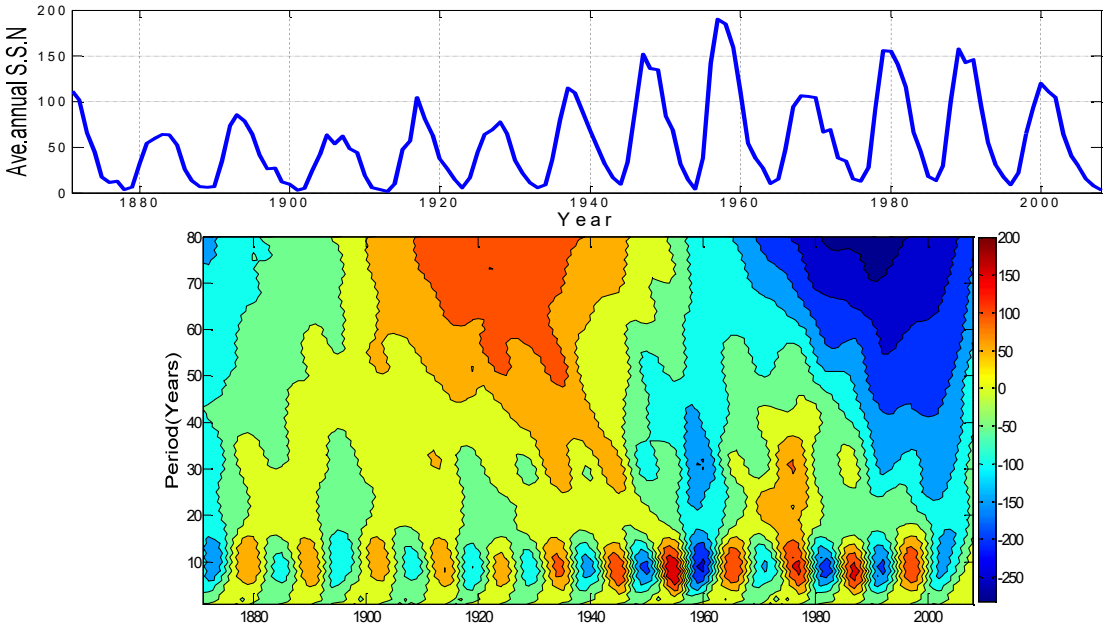


Figure 1: Wavelet analysis of annual Sunspot numbers.

Wavelet analysis of the annual precipitation has been done, like in sunspot numbers. The corresponding period and energy are calculated by wavelet transform. Here the lengths of the periods were somewhat uncertain; the periods of the annual precipitation also have an obvious time-varying character, as for the corresponding sunspot number. There are about four main periods, it is difficult to determine the small periodicity which is under 10 year, but it is generally around (4-7), these shorter periods were clear in annual precipitation, the second ones were about 9-13, around 19-23, around 30-35, and around 65-75 years. The upper part of Figure 2 is the original data of the annual precipitation, while the lower part is the result of continuous wavelet transform of the upper panel. The maximum intensities in the upper panel were observed during 1955-1957 as well as around 1969, corresponding the darkest regions in the lower panel, on the other hand the lightest regions were around 1935-1937 and around 1964-1965, the same lower intensities were showed at the upper panel.

For further investigations of the correlated character between the two datasets, moving averages of degrees 11, 21, 33 have been applied (after detraining the 11, 21, year components). Considering the lengths of the datasets, the results were shown in Figure 3 for the original datasets after taking moving average of degrees 11 and 21 respectively.

In fact, moving average is a special kind of low-pass filter, and taking moving average weakens the independence of the dataset. The degree of freedom will be decreased by this moving average, the larger the latter, the smaller the signal remaining in the dataset, and vice versa.

Therefore, the correlation coefficient between two dataset will increase after taking moving average (only if there is an actual relationship between them).

Figures 3a, 3b show a relative irregularity between the two original datasets and some regularity emerges after taking moving averages of degree (11).

The two dataset after taking moving average of degree 21 vary in similar manner (see Figure 3c). The values of correlation coefficients are 0.4 and 0.71 respectively.

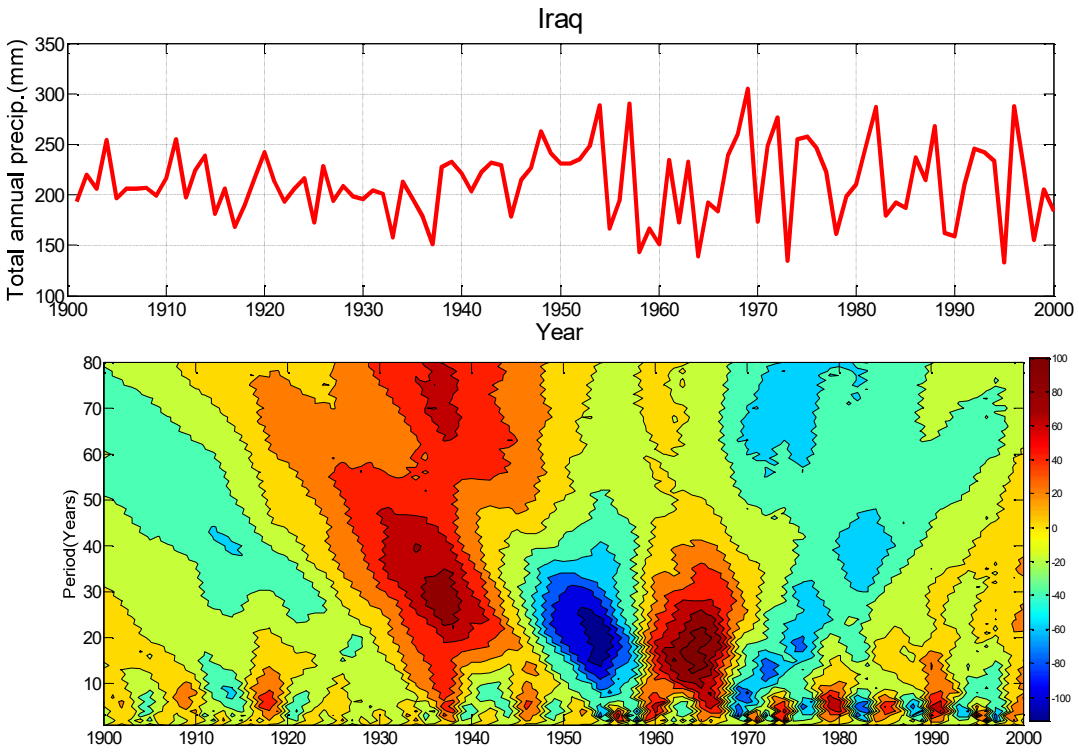
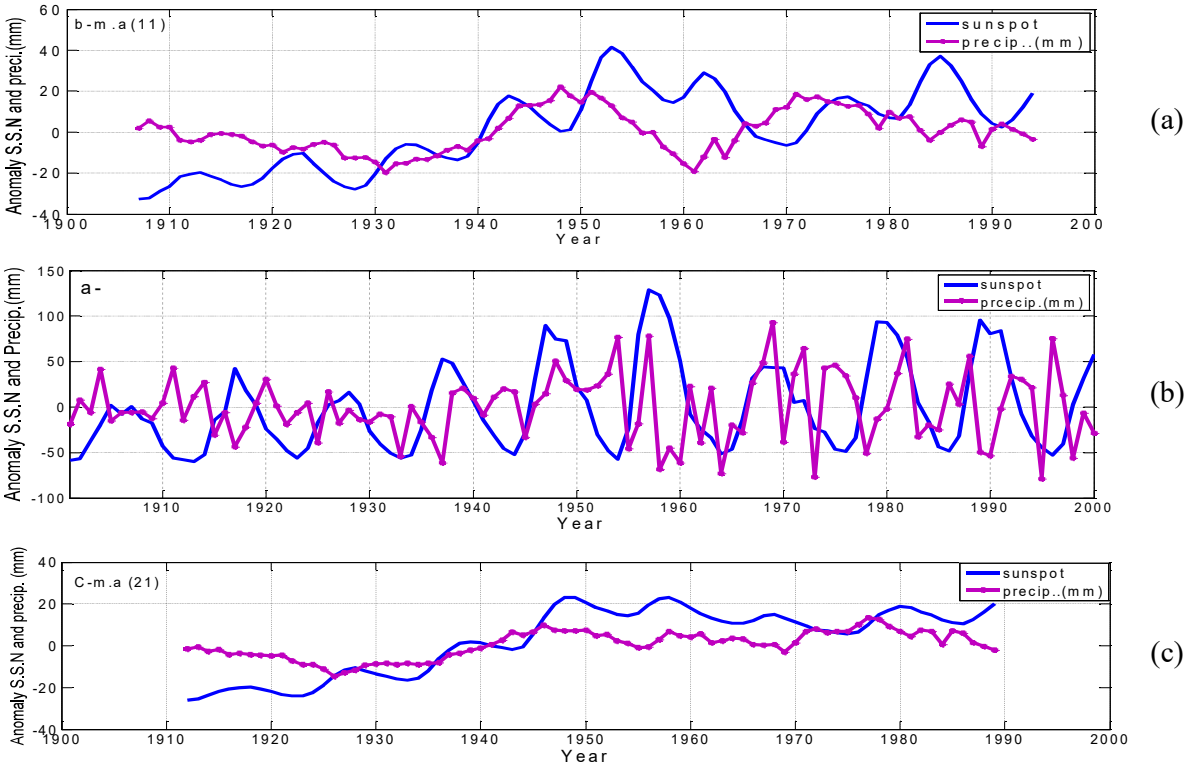


Figure 2: wavelet analysis of annual precipitation in Iraq.



(a)

(b)

(c)

Figure 3: (a, b, c): Relationship between anomaly S.S.N and Precipitation Original data, (b) moving average of degree (11) years, (c) moving average of degree (21) years.

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Conclusion

Sunspot numbers have obvious period around 11, 22, and 33 years, the periods obviously vary in time, among all the period the 11 years period has the strongest amplitude. Both the length and intensity of the periods vary with time. Weaker intensity of sunspot is around 1910, strongest intensity is around 1957. There are main periodicities for annual precipitations, they are: around 4-7, 9-13, and 19-23 years. Maximum correlation coefficient between solar activity and annual precipitation 0.71 after taking moving average of degree 21 year.

References

[1] A Hanslmeier, *The Sun and space weather*. United States of America: Kluwer Academic Publishers, 2004.

[2] Vardavas, I. M., Taylor F.W, *Radiation and climate*. New York, USA: Oxford University Press Inc, 2007.

[3] R. E Benestad, *Solar Activity and Earth's Climate*. Chichester, UK: Praxis publishing Ltd, 2006.

[4] D.F John, *Astronomy*.: Mc Grow – Hill Companies, 2006.

[5] Baker, D. N., Klecker, B., Schwartz, S. J., Schwenn, Von Steiger, R, *Solar Dynamics and its Effects on the Heliosphere and Earth*.: Space Sciences Series of ISS, 2007.

[6] The Role of Sunspots and Solar Wind in Climate change, (https: //www. scientificamerican.com/article/sun spots - and-climate-change/), 2014.

[7] Hathaway, David H., Robert, M, "What the Sunspot Record Tells Us about Space Climate, " *journal of solar physics,* vol. 224, pp. 5-19, 2004.

[8] D. H Hathaway, *The sunspot cycle*.: NASA/Marshall solar physics, 2012.

[9] J. H Mohammed, Dust Storms and their Relation with some Meteorological Parameters and Synoptic Patterns to Selected Stations in Iraq, 2010, Ph. D. Thesis, Atmospheric Science department college of Science, Mustansiriyah University, Iraq. 2010.

[10] Hahn, Brian D., Valentine, Danie, *Essential MATLAB for Engineers and Scientists*.: Elsevier, 2007.