Mausam, (1990), **41**, 3, 393-402

551.521.31 : 556.166 (282.263)

Variations of the solar activity and irradiance, and their influence on the flooding of the river *Nile*

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(*Received 6 March 1989*)

सार — निम्नलिखित आंकड़ों के काल श्रेणियों की विभिन्न लम्बाइयों के लिए स्वतः सहसंबंध और विद्युत स्पेक्ट्रा विश्लेषण को पूरा किया गया :

(1) सौर गतिविधि (2800 माइक्रोहर्टज पर सूर्यधब्बा, प्रद्युतिक और रेडियो फ्लैक्स),

(2) किरणित ऊर्जा मान (पृथ्वी की सतह पर मापित सौर स्थिरांक) और कृत्रिम उपग्रह (निम्ब्रस-7) द्वारा,

(3) काहिरा में मापित नील नदी की बाढ़ (पुराना जलस्तर, अधिकतम बाढ़ स्तर और दोनों स्तरों के मध्य विविधता)।

इनसे प्राप्त परिणामों में सौर गतिविधि, किरणित ऊर्जा मान (सौर स्थिरांक) और नील नदी की बाढ़ के विद्युत स्पेक्ट्रा के मध्य असाधारण रूप से एक समानता दिखाई दी।

हमने निष्कर्ष निकाला कि सौर गतिविधि में किसी भी प्रकार की अल्प या दीर्घावधि विविधताओं अनियत सौर में इसी प्रकार की विविधताओं की ओर ले जाती है। सौर गतिविधि की वार्षिक और दीर्घकालिक विविधताओं से भी नील नदी की बाढ़ की संभावित वार्षिक और दीर्घकालिक विविधताओं की सूचनायें मिलती है।

ABSTRACT. Autocorrelation and power spectra analysis are carried out for different lengths of time series of the following data : (1) Solar activity (sunspot, faculae and radioflux on 2800 MHz); (2) Irradiance (solar constant measured at earth's surface and by the artificial satellite (Nimbus-7); (3) River *Nile* flood (old water level, maximum flood level, and the difference between the both levels) measured at Cairo.

The results showing remarkable similarity between the power spectra of solar activity, irradiance (solar constant) and river *Nile* flood.

We conclude that any short or long-term variations in the solar activity lead to similar variations in the solar constant. Also, annual and secular variations of solar activity yield informations on the suspected annual and secular variations of the river *Nile* flood.

1. Introduction

Earlier investigations have shown that the large decreases in the solar constant, measured by the Nimbus-7 and SMM satellites, are mainly caused by sunspot groups (Hickey *et al.* 1982, Wilson *et al.* 1981, Hudson *et al.* 1982). The earlier studies have also indicated that these sunspot-related irradiance dips are in connection with the activity of the sunspot groups (Pap 1985, 1986). Moreover, there are some suggestions that beside the effect of sunspots, variation of the solar constant is also correlated with coronal activity (Smith *et al.* 1982). Also, in a review paper, Chapman (1987) concentrated on solar luminosity variability due to magnetic activity of the sun.

Many authors have suggested that a large portion of climatic change arises from variations in solar constant (luminosity) and activity (Gilliland 1982, Sofia 1984, Schmidt 1986). It is postulated that a change in the ratio of umbral/penumbral areas is proportional to change in solar luminosity and that long-term variations in the luminosity lead to corresponding changes in the climate of the earth (Hoyt 1979).

The correlation between sunspot numbers and annual rainfall may be positive, negative, or non-existent, depending on where the meteorological measurements are made (Herman and Goldberg 1978). Other indirect indicators of rainfall include water level in lakes and river flooding. The correlation coefficient of the mean annual water level of lake Victoria and sunspot number from 1880's to 1920's is +0. 88 (Shaw 1928). This implies an excess of rainfall at sunspot maximum for the region of lake Victoria (2. 0° S, 32. 2° E) in Africa, in agreement with Clayton's distribution (Clayton 1923), showing excess rainfall in equatorial regions. But according to Bargman *et al.* (1965), the correlation broke down around 1930. Beginning Circa 1950 the water level has been

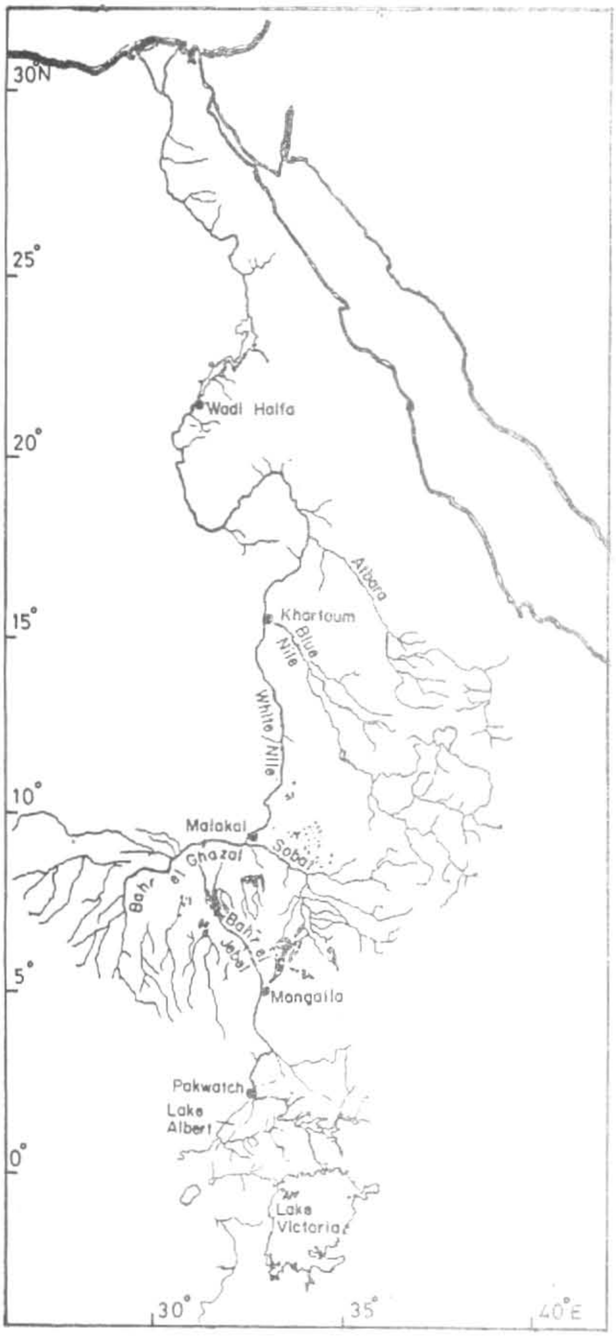


Fig. 1. The river *Nile*

negative correlated with sunspot number (Herman and Goldberg 1978). Also in the equatorial belt is the *Nile* river, which flows out of lake Victoria. The mean height of this river in Egypt for the years 1737-1908, almost two centuries was analyzed by Clayton (1923) in relation to sunspot activity. For his first group of data (1737-1800), he found maximum height about 1 year before sunspot minimum. In the second data set (1825-1908) the maximum river height lagged sunspot maximum by about 2 years. This variation again implies greater rainfall in the equatorial belt in years near solar maximum. A correlation of +0. 36 was found by Shaw (1928) between *Nile* flooding and sunspot number.

Brooks (1926, 1949) has drawn attention to the possible relation of the secular variation of *Nile* levels to solar activity. Verner (1972), assuming that the *Nile* level variations are related to solar activity, approximated these variations in terms of periodic components and extra plotting these periodic variations back to the times of the first Egyptian dynasties, he attempted to explain the characteristic changes in the development of the ancient Egyptian society.

Leftus (1986) found that, secular variations of the river *Nile* levels, regularly measured from the 7th to 15th century A. D., clearly correlate with the solar variations, which suggests evidence for solar influence on the climatic changes in the east African tropics. The decline of the kingdoms in ancient Egypt and occurrence of the intermediate periods are generally explained by very low *Nile* floods and prolonged droughts followed by severe famines and the destruction of the political structure. But the radiocarbon data show that at least the first and second intermediate periods coincide with the secular maxima of solar activity and the middle kingdom with minimum. This contradicts the positive correlation found from the eight centuries of measurements of river *Nile* levels made by Arabs. It seems that the influence of solar activity on the secular climatic changes has an episodic character. The motivation for this paper follows the recent findings that solar constant is variable. The purpose of this paper is to answer two questions. First, given that the solar constant has experienced periodic variations, can an investigation of the solar activity yield information on the suspected secular variations of the solar constant ? Second, given that river *Nile* floods has experienced periodic variations, can an investigation of the solar activity yield information on the suspected long-time variations of the river *Nile* flood ?

2. Data and material

2.1. *Data of the river Nile floods*

The role of the river *Nile* and its regular yearly floods in economic, political and cultural development of ancient Egypt is very well known (Bell 1971, 1975). Records of flood levels which were handed down in fragments to the present and which already began during the first dynasty around 3100 B. C. (Bell 1970, 1975), are indeed extraordinary. Significance of the floods for agriculture had been known from very beginning of evolution of the ancient Egyptian society.

Chronicle records of yearly observations of *Nile* levels exist from 622 A. D. Low *Nile* levels were recorded around 30 June, so called old water, which represent approximately the minimum levels of the river throughout the year and maximum flood values regardless of the calendar date. The continuous series of *Nile* records continues until 1470 A. D., after which there are great gaps in the records, and the uninterrupted series continues again from 1838 A. D. All records from the beginning to 1921 A.D. were collected and published by Toussoun (1925), and Sami (1916). A detailed analysis of all accessible data was made later by Popper (1951).

The lower *Nile* is supplied by two main branches: the *White Nile*, which drains a large area of equatorial Africa and emerges from lake Victoria, and the *Blue Nile*, which rises in lake Tana in the Ethiopian Highlands (*see* Fig. 1). After the confluence of these two rivers at Khartum, only the river *Atbara*, flowing from the Ethiopian plateau, joins the *Nile*. The flow of *White Nile* is nearly constant throughout the year and reflects the rainfall regime in the African tropics. It determines the low levels of the lower *Nile* during a great part of the year. The *Blue Nile*, in other seasons a minor contributor, rises rapidly in July and is high through to late August and September: in this period it becomes the dominant contributor to the lower *Nile* flow (Balek 1977). The source of *Nile* floods are heavy rains in the catchment area of the *Blue Nile* during the summer monsoon. In this way the records of *Nile* levels provided important information about the time behaviour of rainfall in the tropical region of east Africa.

The used data in the present work about the river *Nile* floods are available from "*The Nile Calendar*" by Sami (1916). Also, the calendar contains a table for the *Nile* floods records cover the period (1798-1801) collected by M. Lepere, one of the scientists of the Franco-army of Napoleon Bonaparte at Egypt during the period (1798-1801).

2.2. *Data of solar constant*

The daily mean value of solar constant during the period (1925-1952) measured from the earth's surface are obtained on a magnetic tape from the Atmospheric and Environmental Inc., USA. Most of the data are measured under the supervision of Prof. Abbott, the Director of the Astrophysical Laboratory of the Smithsonian Institution, USA in that time. Apparent correlations were found between the magnitude of solar constant as measured at the earth's surface and sunspot number by Abbott (1958), and this would seem to supply the needed mechanism to explain many of historical correlations between solar activity and the weather.

Also, the daily mean value of the solar constant measured by the artificial satellite Nimbus-7 (channel 10 C of Epply Laboratory, Inc.) are published for the period (Nov 1978-Dec 1984) in Solar-Geophysical data, No. 499, part II, 1986. The bulletin is received from the National Geophysical Data Center, Boulder, Colorado, USA.

2.3. *Data of the solar activity*

The umbra is the dark central core of a sunspot with a brightness average over all wavelengths of about one quarter of that of the surrounding photosphere (Bray and Loughhead 1964). The penumbra is a somewhat less dark region which surrounds the umbra. It has a brightness about three quarter that of the surrounding photosphere (Tandberg 1967). The umbra and penumbra have rather sharp boundaries and can easily be distinguished from one another and from the quiet photosphere. Consequently, one can measure the area of the solar disc which is covered by umbrae or penumbrae.

The sunspot number R (Wolf number or sunspot relative number) is defined by :

$$R = k\ (10g + f) \qquad (1)$$

where f is the total number of spots on the visible disc (irrespective of their size); g the number of spot groups; and k an individual reduction coefficient depending on the observer and observing instrument (Kruger 1979). Yearly averages of sunspot numbers exhibiting the periodic nature of solar activity.

Faculae or plages are bright structured regions which are detectable in monochromatic light (H-alpha, L-alpha, K-line of Ca, He I, He II, ...) at chromospheric heights. In integrated light they can be detected close to the solar limb, also at the photospheric level (Kruger 1979). Faculae represent hotter parts in the solar atmosphere surrounding sunspots but having weaker magnetic fields (<10 G) and greater life times than spots.

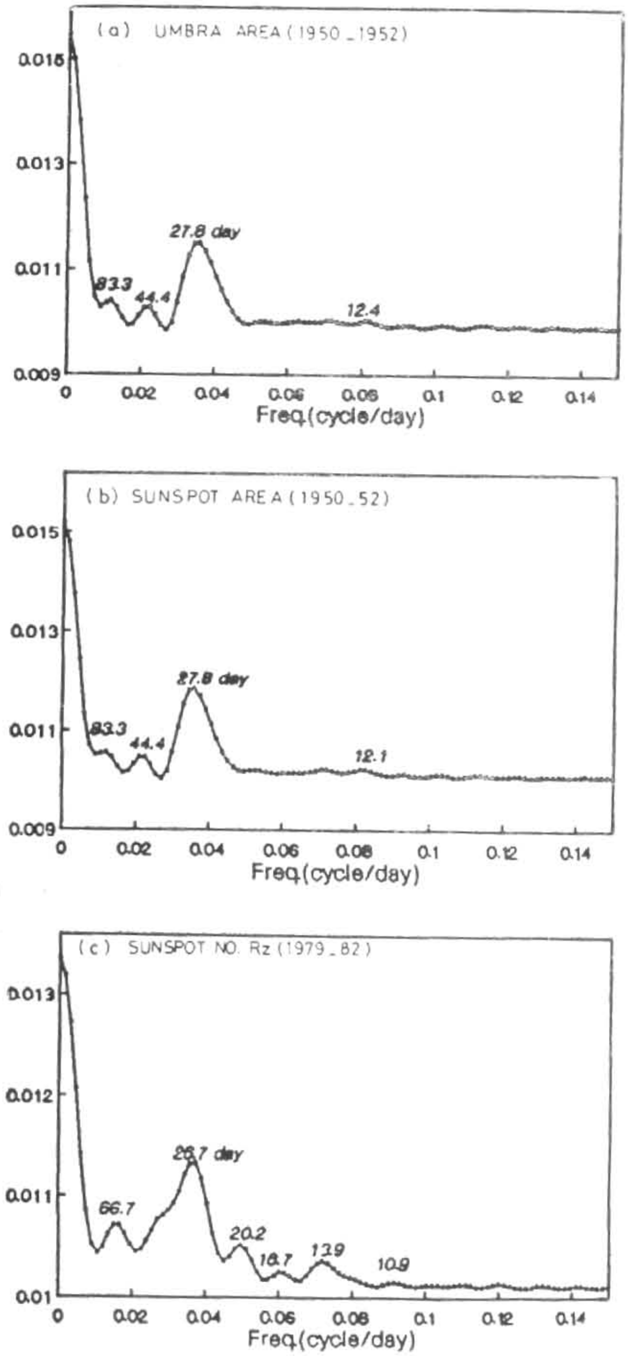
Above the top of the chromosphere, where hydrogen is ionized and so we no longer see H-alpha light emitted, lies the outermost part of the solar atmosphere (Protheroe *et al.* 1984). It is seen as the pearly white crown of light surrounding the darkened sun during a total solar eclipse, this is called the corona. It radiates radio emissions on different frequencies from microwave to kilometre wavelengths. The solar radioflux measured at 2800 MHz (10.7 cm wavelength) have highest correlation with the sunspot number. It is a good index for the solar activity.

The daily value of umbra area, sunspot (umbra and penumbra) area and faculae area are measured by the Astrophysical Observatory of the Smithsonian Institution (USA) during the period, 1925-1952. This data was obtained from the Atmospheric and Environmental Inc. (USA) on magnetic tape.

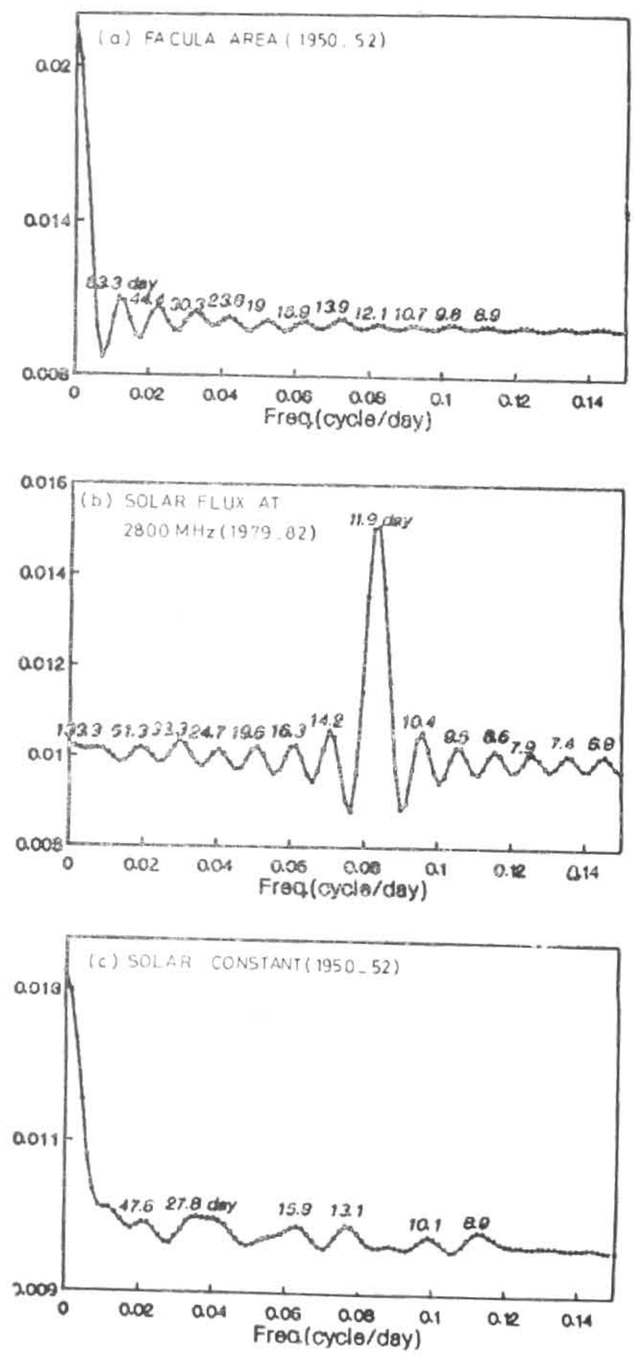
The sunspot numbers for the period (1610-1960) are published in "*The Sunspot Activity in the Years* 1610-1960" by Professor M.Waldmeier, Copy right 1961, Swiss Federal Observatory, Zurich, Switzerland. In 1987 Waldmeier's text has been revised and edited by John A. Mckinnon and published in new text of the name " *Sunspot Numbers : 1610-1985*" as Report No. UAG-95 from World Data Center A for Solar-Terrestrial Physics, Boulder, Colorado, USA.

Wolf numbers from 1700 to 1748 are poorly known; those from 1749 to 1817 are questionable, and from 1818 to 1847 are good. The sunspot data from 1848 to the present are the most reliable.

The daily solar flux values at 2800 MHz adjusted to one Astronomical Unit, are reported by the Algonquin Radio Observatory (ARO) of the National Research Council near Ottawa, Canada. These data are published regularly in "*Solar-Geophysical Data*" prompt reports of NOAA, National Geophysical Data Center, Boulder, Colorado, USA.



Figs. 2 (a-c). Power spectra of daily (a) umbra area (1950-1952), (b) sunspot area (1950-1952) and (c) sunspot numbers R_z (1979-1982)



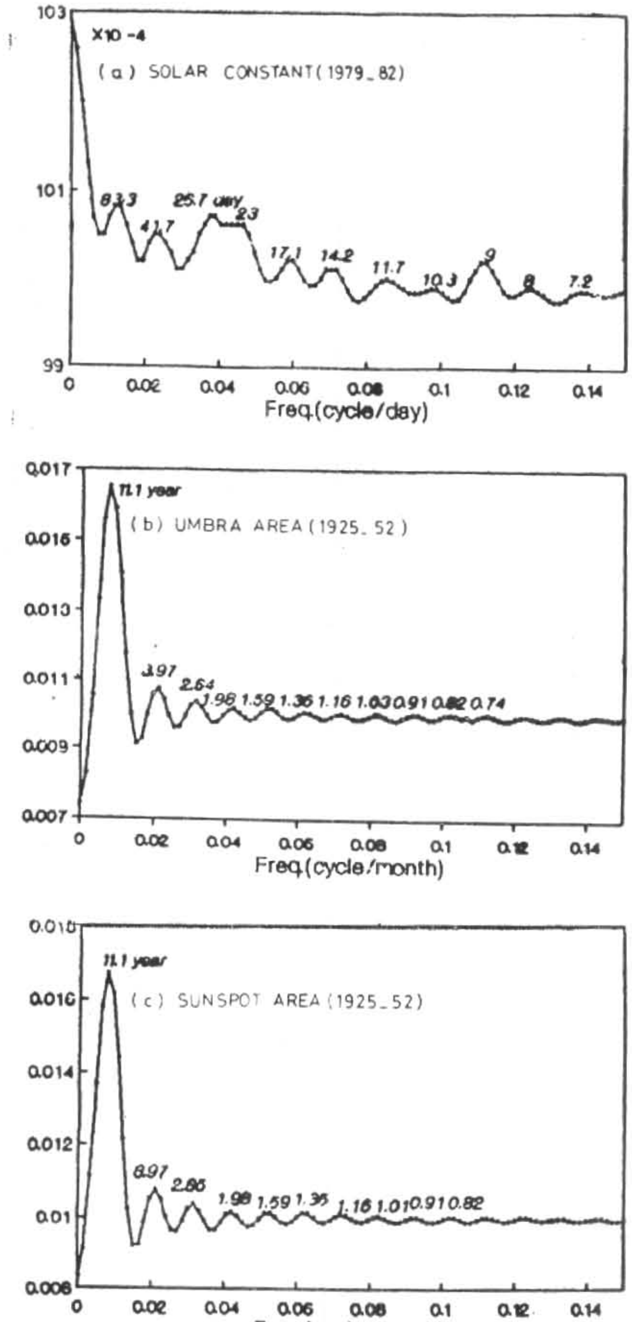
Figs. 3 (a-c). Power spectra of (a) daily facula area (1950-1952), (b) solar flux at 2800 MHz (1979-1982) and (c) daily solar constant (1950-1952)

3. Method of computation

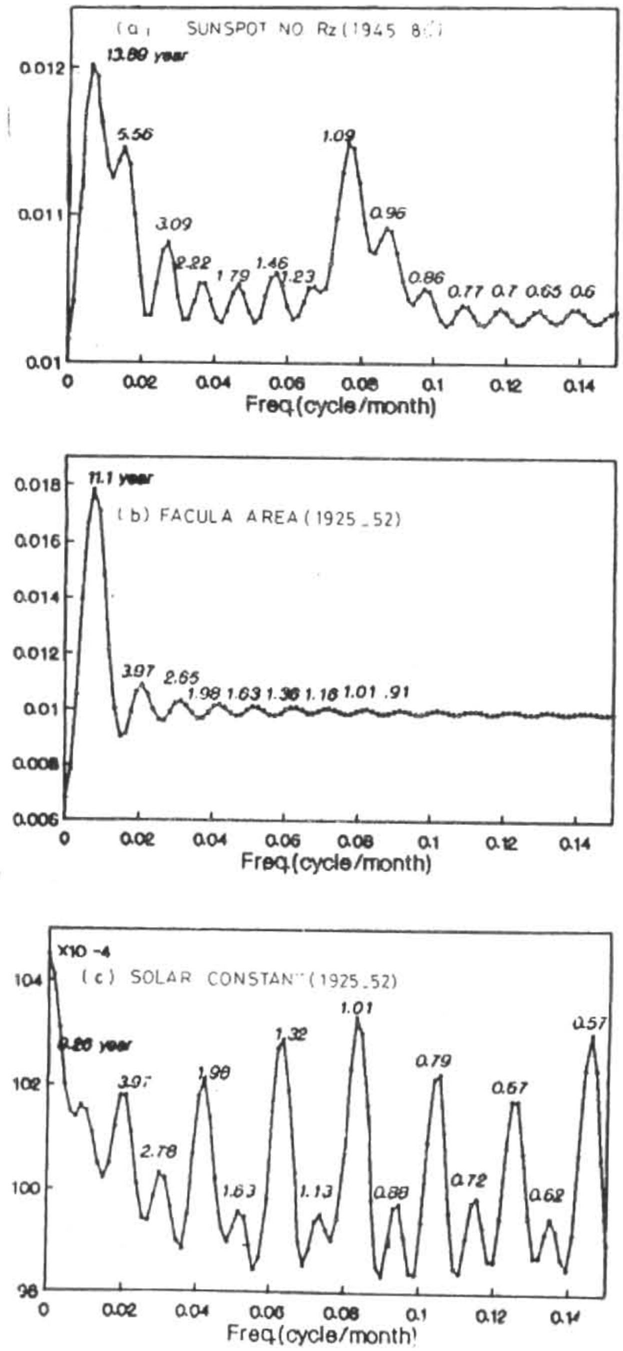
To study the variations in the solar activity, irradiance and the river *Nile* floods. The time series for short and long period must be analysed by the power spectrum technique. The calculation of the power spectrum density (PSD) depends on the following steps (Badawy and Tadros 1984).

3.1. Calculation of the autocorrelation function $C(T)$ as a function of the lag number by :

$$C(T) = \frac{1}{N-T} \sum_{t=1}^{N-T} [X(t) - \bar{X}][X(t+T) - \bar{X}] \quad (2)$$



Figs. 4 (a-c). Power spectra of (a) solar constant (1979-1982), (b) umbra area (1925-1952) and (c) sunspot area (1925-1952)



Figs. 5 (a-c). Power spectra of (a) sunpsot numbers R_z (1945-1988), (b) facula area (1925-1952) and (c) solar constant (1925-1952)

where, N is the total number of data points, T is the lag number ($T = 0, 1, 2, ..., T_m$), T_m is the maximum lag, $X(t)$ and $\bar{X}$ are the single and average value of observations.

3.2. The PSD $P(L)$ is computed from the following relation :

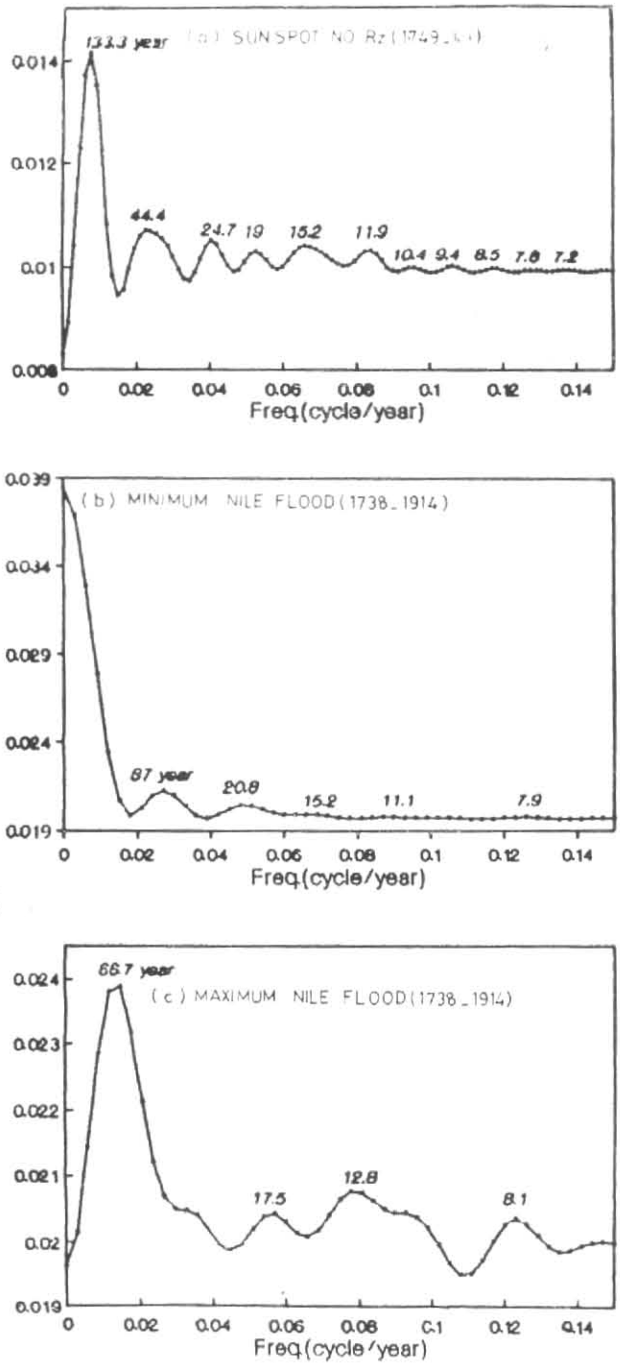
$$P(L) = \frac{1}{T_m}\left[C(0) + 2\sum_{T=1}^{T_m-1} C(T).W(T).\cos\left(\frac{L\Pi T}{T_m}\right) + C(T_m).W(T_m).\cos(L\Pi) \right] \qquad (3)$$

where $0 < L < T_m$, $W(T)$ is known as the lag window.

The lag window may be considered as cosine window in the following form :

$$W(T) = \begin{cases} [1/2\,T_m]\,[1 + \cos(T/T_m)] & ; \; 0 \leqslant T \leqslant T_m \\ 0 & ; \; T > T_m \end{cases} \qquad (4)$$

which is known as Hanning Window (HW) (Blackman and Tukey 1958, Markus 1974).



Figs. 6 (a-c). Power spectra of (a) sunspot number R_z (1749-1985), (b) minimum *Nile* flood (1738-1914) and (c) maximum *Nile* flood (1738-1914)

The cosine lag window may be used in the following form :

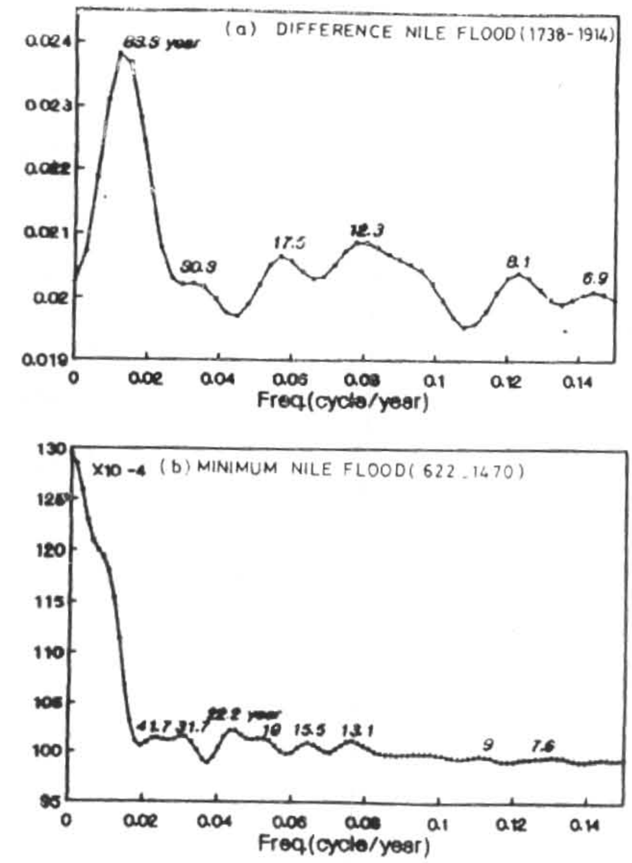
$$W(T) = \begin{cases} [1/T_m]\,[0.54 + 0.46 \cos\ (T/T_m)]\,; & 0 \leqslant T \leqslant T_m \\ 0 & ;\ T > T_m \end{cases} \quad (5)$$

which is known as Hamming window (Blackman and Tukey 1958, Markus 1974).

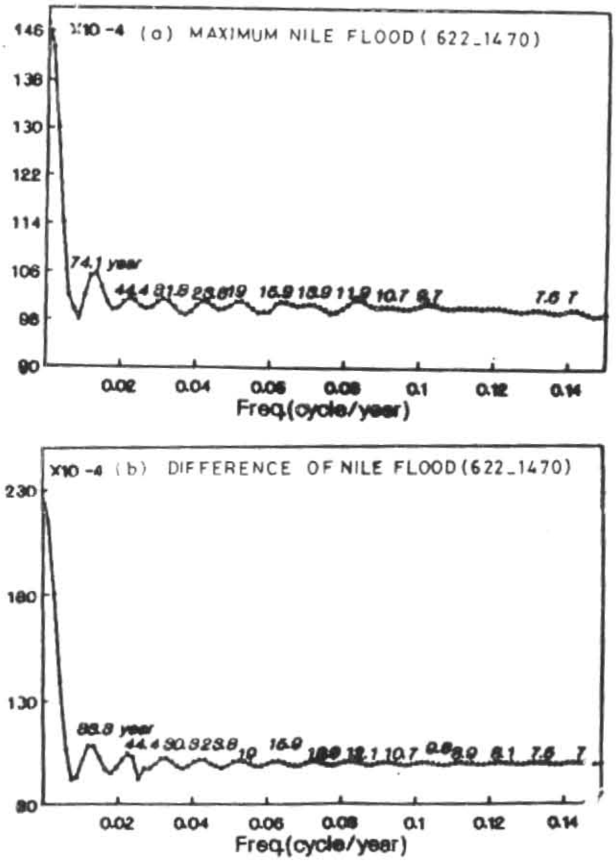
Actually, the general nature of the spectral windows in these two pairs is the same (Blackman and Tukey 1958).

The consideration of the exponential form for the lag window is known as Parzen Window (PW) given by the following form (Badawy and Tadros 1984, Markus 1974) :

$$W(T) = \begin{cases} [1/T_m]\,[1 - 6(T/T_m)^2 + 6(T/T_m)^3]\,; & 0 \leqslant T \leqslant T_m/2 \\ [2/T_m]\,[1 - (T/T_m)]^3 & ;\ T_m/2 \leqslant T \leqslant T_m \\ 0 & ;\ T > T_m \end{cases} \quad (6)$$



Figs. 7 (a & b). Power spectra of *Nile* floods : (a) difference (1738-1914) and (b) minimum (622-1470)



Figs. 8 (a & b). Power spectra of *Nile* floods : (a) maximum (622-1470) and (b) difference (622-1470)

Determination of the real frequencies in the input data depends on obtaining the power spectrum by the previous steps after filteration, using Kalman filter given by the following mathematical model (Badawy and Tadros 1984, Tadros and Shaltout 1989) :

$$P_k^* = e^{2(t_k - t_{k-1})} P_{k-1} + \sigma_h^2$$

$$X_k^* = e^{(t_k - t_{k-1})} \hat{X}_{k-1}$$

$$B_k = P_k^* / (P_k^* + \sigma_v^2)$$

$$\hat{X}_k = X_k^* + B_k (Y_k - X_k^*)$$

$$P_k = (1 - B_k) P_k^* \qquad (7)$$

where σ_h^2 and σ_v^2 are the variances of the system and the measured noise respectively.

The estimated value $\hat{X}_k$ at any time t_k can be evaluated once the prediction of that value is calculated according to the first two relations of Eqn. (7). The determination of σ_h^2 and σ_v^2 depends on the knowledge of the autocorrelation and power spectrum density of the observed data (Badawy and Tadros 1984).

According to Tadros and Mosalam Shaltout (1989), the PSD using HW was greater than that when PW was used. Moreover, HW was favourable for the identification of more frequencies than PW, which may help in determination of more different cycles. For the identification of the real frequencies, PSD was determined before and after filteration using Kalman filter. Therefore, the power spectra after filteration, using HW, will be determined for all different data in this work.

4. Results and discussion

4.1. *Short-term periodicities (days)*

For estimating the short term periodicities, the autocorrelation and the power spectra analysis are applied on the following time series :

(a) The daily area of sunspots umbra for the period (1950-1952).

(b) The daily area of sunspots for the period (1950-1952) .

(c) The daily sunspot number R_z for the period (1979-1982).

(d) The daily area of faculae for the period (1950-1952).

(e) The daily value of the solar radio flux on 2800 MHz for the period (1979-1982).

(f) The daily value of the solar constant measured at the earth's surface for the period (1950-1952).

(g) The daily value of the solar constant measured by the artificial satellite Nimbus-7 for the period (1979-1982).

The power spectra are given in Figs. 2(a)-4(a) for 4.1(a-g) respectively. From these figures we can notice that :

(*i*) The period of rotation of the sun about its axis is the prominent peak in the power spectra of the sunspot activity. It is equal to 27.6 days in Figs. 2 (a & b) and to 26.7 days in Fig. 2 (c).

(*ii*) The period of 27.6 days can be seen in the power spectra of faculae area (Fig. 3a) as 30.3. But, in the same figure, periodicities of 83.3 and 44.4 days are more prominent than 30.3 days periodicity.

(*iii*) The most prominent peak in the power spectra of solar radioflux on 2800 MHz (Fig. 3b) is that corresponding to periodicity of 11.9 days.

(*iv*) The period of solar rotation can be seen in the power spectra of the solar constant as 28.6 days periodicity for earth's surface measurements (Fig. 3c), and 27.6 days periodicity for Nimbus-7 measurements.

Also, from Figs. 2(a)-4(a) we deduce that the short term power spectra of the solar constant showing remarkable similarity with that of photospheric phenomena (sunspots), and chromospheric phenomena (faculae), than that of coronal phenomena (coronal condensations are the origin of the most of the solar radioflux on 2800 MHz).

Most of the solar radiation emit from the photosphere of the sun. For that, its correlation with the photospheric phenomena is a natural result. Where, the value of the solar constant increase with decreasing the sunspots area (Wilson *et al.* 1982, Pap 1985). Because, the sunspots are cold area in the photosphere (2000 K cooler than the effective photospheric temperature) as mentioned by Herman and Goldberg (1978). Such studies indicate that the deepest photospheric layers contributing to the light received from the sun are at about 8000 K (Protheroe *et al.* 1984).

We must mention here, the power spectra lead to different values for the period of the solar rotation. It is 27.6 days in Figs. 2 (a & b), 26.7 days in Figs. 2 (c), 3 (a) & 4 (a) and 28.6 days in Fig. 3 (c), this result depends on the location of active regions in the solar latitudes. Because the solar rotation is a differential rotation from the solar equator to the two poles of the sun, the period of rotation is 25.8 days at the equator and about 40 days at the poles (Protheroe *et al.* 1984).

4.2. *Long-term periodicities* (*years*)

For estimating the long term periodicities, the autocorrelation and power spectra analysis are applied on the following time series :

(a) The monthly mean area of sunspots umbra for the period (1925-1952).

(b) The monthly mean area of sunspots for the period (1925-1952).

(c) The monthly mean sunspots number R_z for the period (1945-1986).

(d) The monthly mean area of faculae for the period (1925-1952).

(e) The monthly mean value of solar constant measured from the earth's surface for the period (1925-1952).

The power spectra are given in Figs. 4(b)- 5(c) for 4.2 (a-e) respectively, from these figures we can notice the following :

(*i*) The eleven-year cycle of the solar activity are prominent peak in the power spectra of the area of umbra, sunspots and faculae (Figs. 4b, 4c & 5b). It is equal to 11.1 years.

(*ii*) The power spectra of sunspot numbers R_z show two significant peaks, one is equal to 13.9 years and the other is equal to 1.09 years (Fig. 5a).

(*iii*) The most prominent peak in the power spectra of the solar constant (Fig. 5c) is of 1.01-year periodicity.

From these results, we can deduce that, the period of revolution of the earth about the sun (1 year) is the more effective on the variability of the solar constant than the eleven-year cycle of the solar activity. This occurs due to change the distance between the earth and the sun during the revolution of the earth about the sun in elliptical orbit (Robinson 1966).

The periodicity of 13.9 years in sunspot number R_z for the period (1945-1986) is the eleven-year cycle, because the time interval from one maximum activity to the next varies from cycle to cycle. The shortest interval ever noted is 7.5 years & the longest, 16 year (Protheroe *et al.* 1984). Also for the same reason, we consider the periodicity of 9.3-year in the power spectra of the solar constant (Fig. 5c) is the eleven-year cycle. But, it is less prominent than the period of earth's revolution about the sun.

4.3. *Very long-term periodicities* (*tens years*)

To estimating, the very long-term periodicities in solar activity and *Nile* floods the autocorrelation and power spectra analysis are applied on the following time series :

(a) The annual mean value of sunspot number R_z for the period (1749-1985).

(b) The annual value of the old water (minimum level of the river *Nile* at Cairo) for the period (1738-1914).

(c) The annual value of the maximum *Nile* flood for the period (1738-1914).

(d) The annual difference between the old water and the maximum *Nile* flood for the period (1738-1914).

(e) The annual value of the old water of *Nile* for the the period (622-1470).

(f) The annual value of maximum *Nile* flood for the period (622-1470).

(g) The annual difference between the old water and maximum *Nile* flood for the period (622-1470).

The records of the old water and maximum *Nile* flood for the period (1801-1818) are calculated and deduced by authors from the historical description of the *Nile* at Cairo during this period by Egyptian historiographer El-Gaperty, according to Sami (1916).

The power spectra are given in Figs. 6(a)-8(b) for 4.3 (a-g) respectively. From these figures we can notice the following :

(*i*) There are periodicities in sunspot numbers ranging between 7.2 & 133.3 years, as shown in Fig. 6(a). The eleven-year cycle is clear as 11.9-year periodicity.

(*ii*) There are periodicities in the old water of *Nile* ranging between 7.9 and 37 years. The eleven-year cycle is slightly clear as 11.1-year periodicity in Fig. 6(b). The same result confirm from Fig. 7(b), where the periodicities range from 7.6 to 41.7 years, and the eleven-year cycle is clear as 13.1-year periodicity. The 20.8-year periodicity in Fig. 6(b), and 22.2-year periodicity in Fig. 7(b) may be related to 22-year cycle of the solar magnetic field.

(*iii*) There are periodicities in the maximum *Nile* flood ranging from 8.1 to 66.7 years in Fig. 6(c), and from 7 to 74.1 years in Fig. 8(a). The eleven-year cycle is clear as 11.9-year in Fig. 8(a), and 12.8 in Fig. 6(c). Also, the 22-year cycle and its multiple are clear in Fig. 8(a) as 23.8 and 44.4 years respectively.

(*iv*) There are periodicites in the difference between old water and maximum *Nile* flood ranging between 6.9 & 83.3 years in Fig. 7(a), and 7 & 83.3 years in Fig. 8(b). The 11-year cycle is clear as 12.3-year periodicity in Fig. 7(a) and 12.1-year periodicity in Fig. 8(b). But the most prominent periodicity is the 66.7 years, which may be the third multiple of the 22-year cycle.

(*v*) It is clear from Fig. 8(a), there are two peaks at 74.1 and 44.4 years. In 1916 and 1946 the level of the *Nile* flood was very high. Therefore, if these two peaks are taken into consideration, then, it is predicted that the year of 1990 may be also have a very high level.

Generally most of the periodicities in the *Nile* records may be related to the 11-year or 22-year cycles or their multiples.

Also, we must mention here, Figs. 6(a), 7(a), 8(a) & 8(b) show periodicity of 19-year. During many centuries, from the ancient Egyptian time till now, some historiographers and scientists spoke about 19 years periodicity in the *Nile* flood or its multiples (Sami 1916). But, this is not the prominent peak as shown in the figures. The 19-year periodicity is attributed to the lunar tide of 18.6 years which has been previously detected in precipitation records from North and South America, India and China (Hameed 1984).

5. Conclusions

From our present results and discussion we conclude the following :

(*i*) Short and long-term variations of solar activity yield informations on the suspected short and long-term variations of the solar constant.

(*ii*) Annual and secular variations of solar activity yield informations on the suspected annual and secular vatiations of the river *Nile* flood.

(*iii*) Solar activity affects the solar constant. Consequently, the solar constant changes the weather and climate (or at least forcing the change). Then, fluctuations in the rainfall of the tropic regions occur. The oscillations in the *Nile* flood is indirect indicator for the variability of the rainfall on the tropic of east Africa.

(*iv*) The periodicities in the *Nile* flood are correlated with the 11-year cycle of solar activity or its multiplies.

(*v*) Only solar activity cannot be used to predict the level of *Nile* flood, we can make a long-term prediction for the level of the *Nile* flood in the future.

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