S. Yousef et al. / ICEHM2000, Cairo University, Egypt, September, 2000, page 209- 221

ALERT El SAHEL COUNTRIES; DROUGHT IS APPROACHING

Shahinaz Yousef
Astronomy and Meteorology Dept, Faculty of Sciences
Cairo University, Cairo Egypt
e.mail: Shahinaz@sci-astro.cairo.eun.eg Fax: 5818063

Limam Ould Mohamed Ghilly
Islamic Republic of Mauritania
Institute of Arab Research & Studies - Cairo
E- mail: lymam@maktoob.com

ABSTRACT

Based on Senegal river cycles, precipitation cycles of various El Sahel stations which are related to Solar Wolf-Gleissberg cycles, and on relations to Nile floods and Equatorial lake levels, It is anticipated that there is a considerable probability that drought is approaching El Sahel Zone.

There is a likelihood that the coming drought will be harsh due to presence of Pacific decadal oscillations which is expected to enhance the effect of El Nino events.

It seems likely that drought will not start in El Sahel zone at the same time but will rather migrate in space and time.

It is advisable for El Sahel countries to make the most of the present high precipitation, which are due to La Nina phenomena and save food for the expected drought years.

El Sahel was subjected to drought conditions several times during this century, in 1913/14, 1941/42, 1968/69, 1972/73. The last and worst drought in Senegal river Basin was the 1984/85 when the river could be crossed on foot in some points and a large number of animals and human beings perished.

It is rather wise to store wheat, corn and other similar plants in their spikes for the time of drought; seeds for human consumption and crust for animal consumption.

1-INTROCUCTION

Important climatic features ,such as droughts and unusually growing seasons, are dependant on the solar cycle to such an extent that significant progress could be made in forecasting the occurrence of these features if some account were taken of the expected levels of solar activity in the future(King 1973). It is the purpose of this paper to outline the present and future solar activity and to study droughts in El Sahel as well as other countries at similar levels of the present and future solar activity with the intention of predicting droughts in El Sahel zone.

2-EL SAHEL ZONE

The Sahel is a belt on the southern edge of the Saharan desert, passing from Senegal through Mauritania, Mali, Burkina Faso, Niger, and Chad, and blends seamlessly into less arid Sudano-Sahel belt to its southern edge. In other words, El Sahel is an unstable dry land separating the great Sahara from the Sudanese agricultural zone. It expands or shrinks according to the annual rainfall. For instance when precipitation in 1941-1942 was below 100mm over a region of 340 000 km in Mauritania which is equivalent to one third of the its area, it became a ver dry Sahara. Ten years later, annual precipitation exceeded 100 mm, cattle appeared in this land, then the situation reversed again with a new change in the climate balance. In the seventies, the great Sahara extended southward a distance of 150 km.

James L. Webb in his book ,Desert Frontier: Ecological and Economic Change along the Western Sahel, 1600-1850, documents the increasing aridity of the transitional zone between the full desert of the Sahara and the open grassland of western Africa, the border moving 200-300 kilometers south during a brief two and half centuries; and the political and economic changes as pastoral nomads of the desert edge followed the shift south, and the agricultural communities in their way had to abandon their villages or face subjugation.

The 50 million people of the Sahel pursue diverse livelihood strategies including agriculture, livestock herding, fishing, short and long-distance trading, and a variety of urban occupations. Farming in this region is almost entirely reliant on three months of summer rainfall, except along the banks of the major rivers, lakes, and other seasonal water courses (Batterbury 1998).

3-PRECIPITATION IN WEST AFRICA

The climate of west Africa has several unique features. The annual rainfall is almost constant along each latitude. However, annual rainfall decreases sharply from south to north with a gradient of about 1mm per kilometer, from about 1500mm near the coast at 5° N to about 100 mm at the border with the Sahara Desert at about 20° N (see fig 2). The rainy season occupies roughly the months of June, July, August and September(El Tahir and Gong 1996).

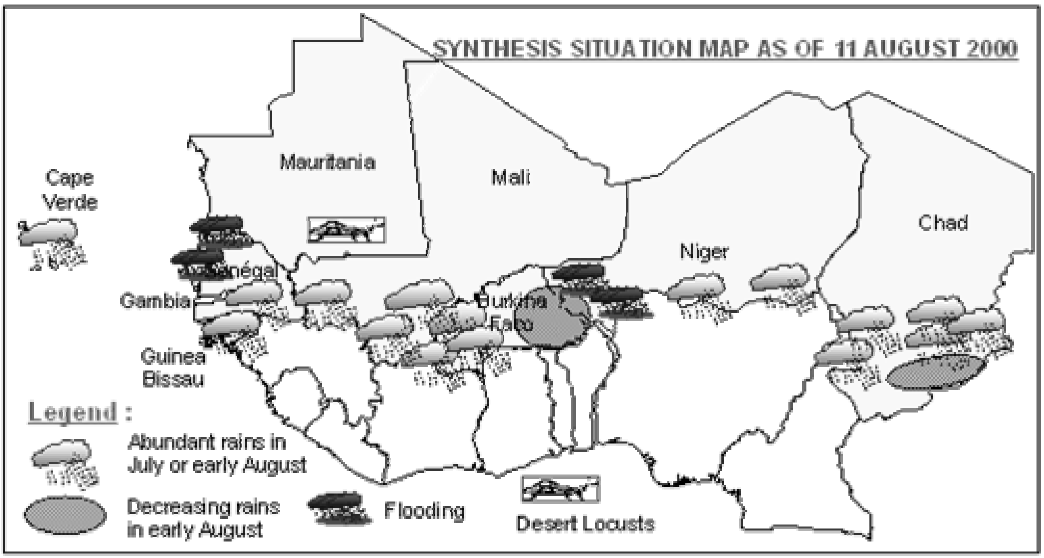
4- DROUGHTS IN EL SAHEL

Three major droughts in El Sahel have occurred this century, in 1910-1916(with rainfall drop starting in 1907), 1941-1945, and a long period of below average rainfall that began in the late-1960s and continued, with some interruptions, into the 1980s. Absolute minimum rainfall level were recorded at many stations in 1983 and 1984. The period of poor rainfall in the 1970s struck particularly hard there were an estimated 100,000 drought-related deaths.
Sahelian droughts and their effects have been studied intensively since the 1970s, as part of the international response to "environmental emergency".
Since the early 1970s the international community has acquired an increasing capability to prevent the onset of drought-induced food shortages. Early warning systems are one aspect of this. These provide the data necessary to predict or assess potential crop loss and animal shortfalls, based partly on remotely-sensed data of vegetation cover and rainfall patterns and partly on food market surveys. The FEWS (Famine Early Warning System) developed by the American aid program (USAID) for example, alerts policymakers and governments to rapid price hikes for the staple foods at local markets, and unusual land cover changes, that may signal an impending food.
The premise was that, if rainfall was unreliable, then what fell should be captured and used more effectively. A third group of proposed adjustments was focused on improved production technologies, such as higher-yielding drought-resistant crops, irrigation, or improved ranching and grazing schemes.
Drought is but one of a set of overwhelming problems affecting the Sahel, which has some of the poorest nations in the world. Organizations like the International Institute for Environment and Development's Drylands Program, the Club du Sahel, Denmark's DANIDA, and the Institut du Sahel in Mali.are helping with this enviromental emergency.

5-SAHEL WEATHER AND CROP SITUATION REPORT

According to the FAO Global Information and Early Warning System on food and agriculture Report No.3 - 11 August 2000, rains have been generally widespread and abundant over the main agricultural zones of the Sahel in July. They have been particularly abundant in early and mid-July over Mali and Niger, in late July/early August over Senegal, The Gambia and southern/western Mauritania, and during the entire month of July in Chad. Precipitation was more limited in Burkina Faso but improved significantly over the western half of the country in early August. Rainfall was abundant in Guinea-Bissau. Significant rains were registered on all the islands of Cape Verde in late July. Flooding was reported following heavy rains in mid July in Niger, in late July/early August in northern Senegal and Mauritania and in early August in northern Burkina Faso. Satellite images for the first decade of August shows that cloud coverage remains present over all the agricultural zones of the Sahel. Precipitation has been particularly abundant over southern Mali and the Sahelian zone of Chad, but more limited over western and eastern Niger and southern Chad.
Following these good rains, plant water needs have generally been covered and crops are developing satisfactorily. Recently planted millet and sorghum crops are emerging satisfactorily in northern Senegal, Mauritania, Niger, northern Burkina Faso, Mali and Chad. Elsewhere, crops are growing normally, except in eastern Burkina Faso where more rains are needed to prevent water stress.

Fig 1: Abundant rain in Summer 2000.



6- SENEGAL RIVER

Sénégal river, western Africa, is forming the boundary between Senegal and Mauritania. The river is 1,800 km in length. Two of the river's three head streams rise in the Fouta Djallon highlands in Guinea .According to the Encarta Encyclopedia ,it has two main sources, the Bafing and the Bakoye, which meet at Bafoulabé, in Mali. From there the Sénégal flows northwest, west, and southwest, reaching the Atlantic Ocean near Saint-Louis, Senegal. Floods come in early September at Bakel, reaching Dagana by mid-October. During the flood season the water level rises 3.5 metres, the flow is some 300 times greater than in the dry season, and the river occupies the entire valley.

The major rivers that flow through the Sahel , the Senegal , the Niger and Chari are shown in Fig (2), Those rivers and partly the Nile , reflect the general annual and seasonal rainfall over a vast area of the Sahelanian and Sudanian climatic zones. The variation of the annual discharge for the various rivers shows a similar striking pattern.(Fig 3) three drastic droughts clearly separated by two longer periods of humid double peaks conditions.

The River Senegal has been taken as a typical example as shown in Fig(4) after Faure and .Gac 1981) . Notice the 1913 drought, which is coincident with the lowest Nile River discharge, recorded since discharge measurements in recent records Fig (5). It seems that 1912- 1913 were a global drought period, e.g. 1912 was the midpoint of contemporary severe Great Plains North American drought. It .was also sunspot minimum (Roberts 1976). As a matter of fact 1913 was the end of the 12 yr. weak solar cycles intermediate between two Wolf- Gleissberg (see section 7 below). The mean interval between the last three droughts in the river Senegal is 31.3 yr. with extreme conditions every 10.3±4 yr (i.e of the order of sunspot cycle) if the same pattern continues, Faure and Gac predicted that a severe drought will occur towards the beginning of the third millenium; centered at 2005.

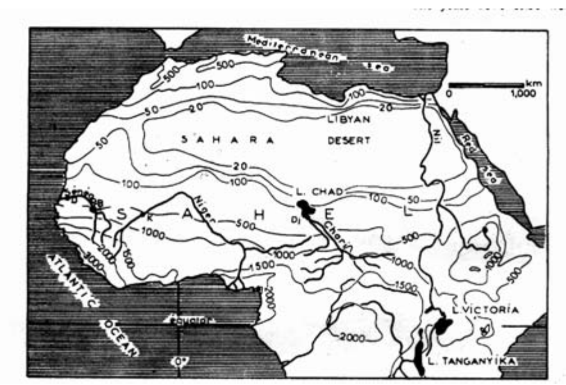


Fig2: Map showing the main four rivers flowing in El Sahel. Isohyetes are also shown(after Faure and Gac 1981 and references therein).

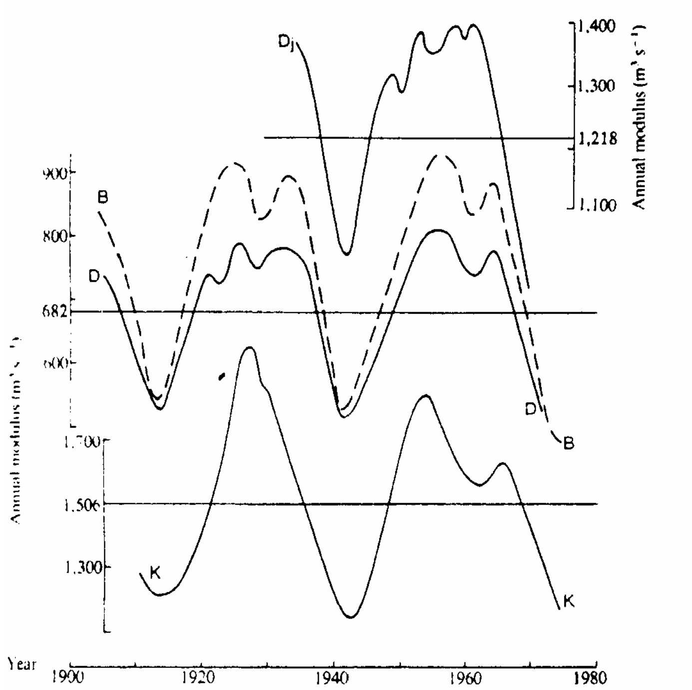


Fig. 3 Comparison of the pattern of river runoff in Sahel (7-yr running mean): Sénégal at Bakel (B) and Dagana (D), Niger at Koulikoro (K) and Chari at Djamena (Dj).

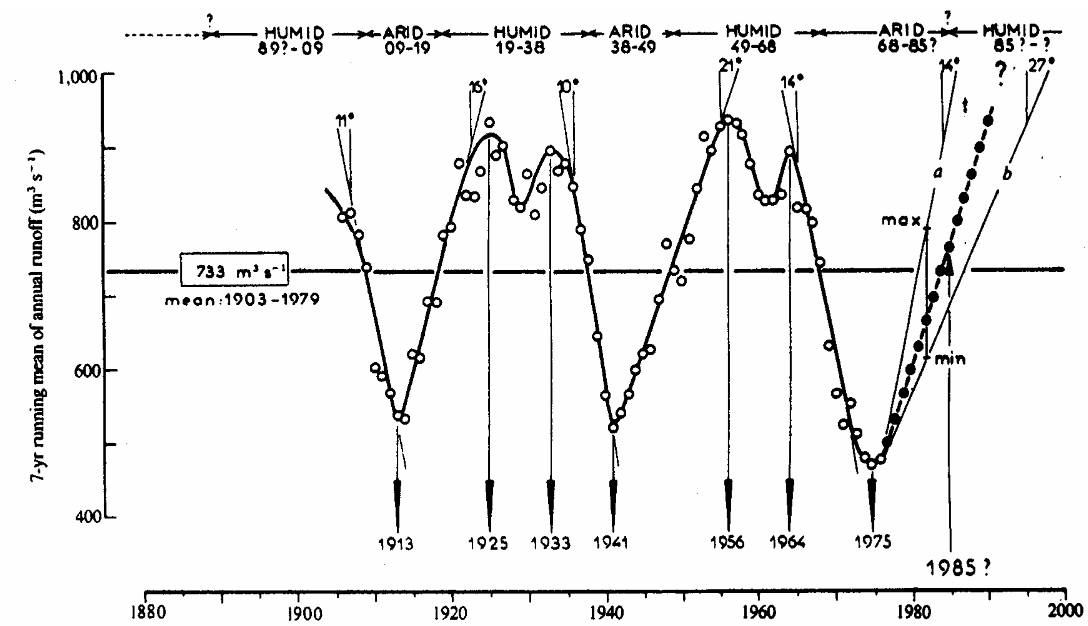
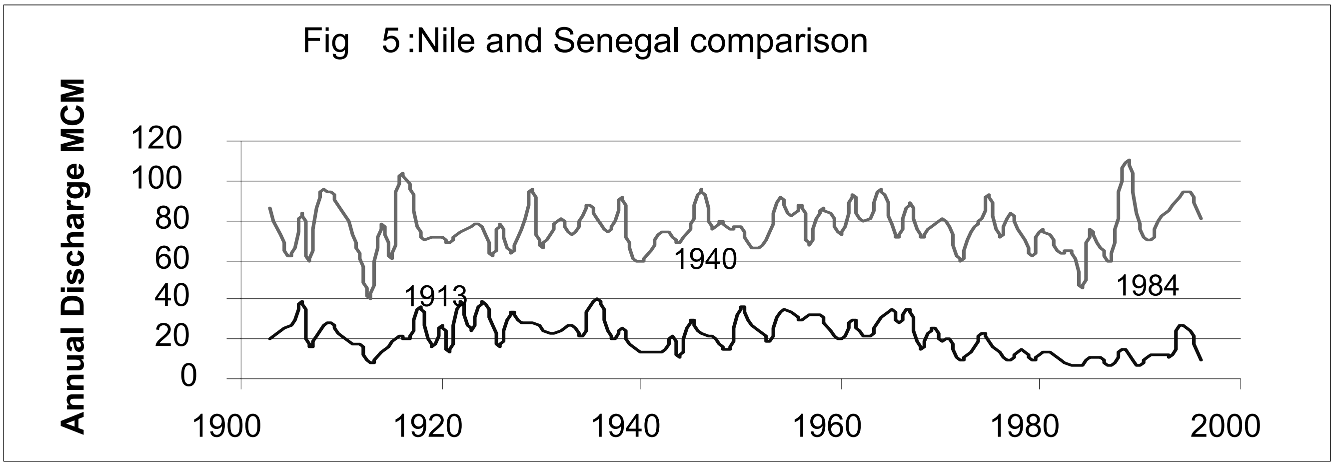


Fig 4: 7-yr. running mean of annual runoff of river Senegal (after Faure and .Gac 1981). Notice that the return to humid is slower than the humid/arid transition. Expected drought period is centered at 2005.

Fig 5: Comparison of time series of River Nile (upper) and River Senegal (lower). Note the cyclic pattern of River Nile with troughs at 1913,1940, 1970s and 1984 in coincidence with drought conditions in River Senegal.



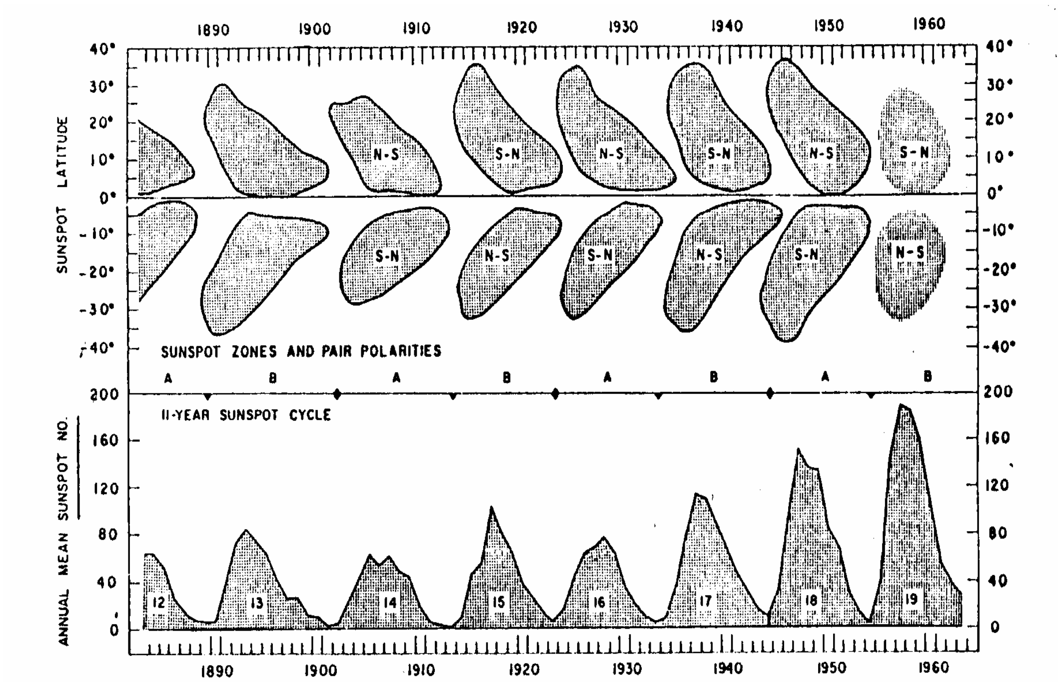


Fig 6: The Maunder Butterfly diagram of sunspots and the associated 22 and 11yr. cycle(after Chernosky 1966). Notice the weak intermediate sunspot cycles number 12,13 and 14.

Cycle 19 is the maximum of all cycles since start of observation. Notice that the latitudinal distribution of sunspots of cycle 19(10 yr durarion).) is quite different from previous cycles as the spot appear at much lower latitude than usual. In addition the length of cycles 18 and 19 is 10 yr. each while the length of cycles 17 and 20 is 12 years.

7-SOLAR-WOLF-GLEISSBERG CYCLES

Besides the well known 11 year sunspots cycles (Fig 6) where the number of sunspots reaches maximum every (10-12) years, a solar cycle of length between (60-121) years known as Wolf Gleissberg cycle exists. Such cycles including some projection into the future are shown in Figure (7)

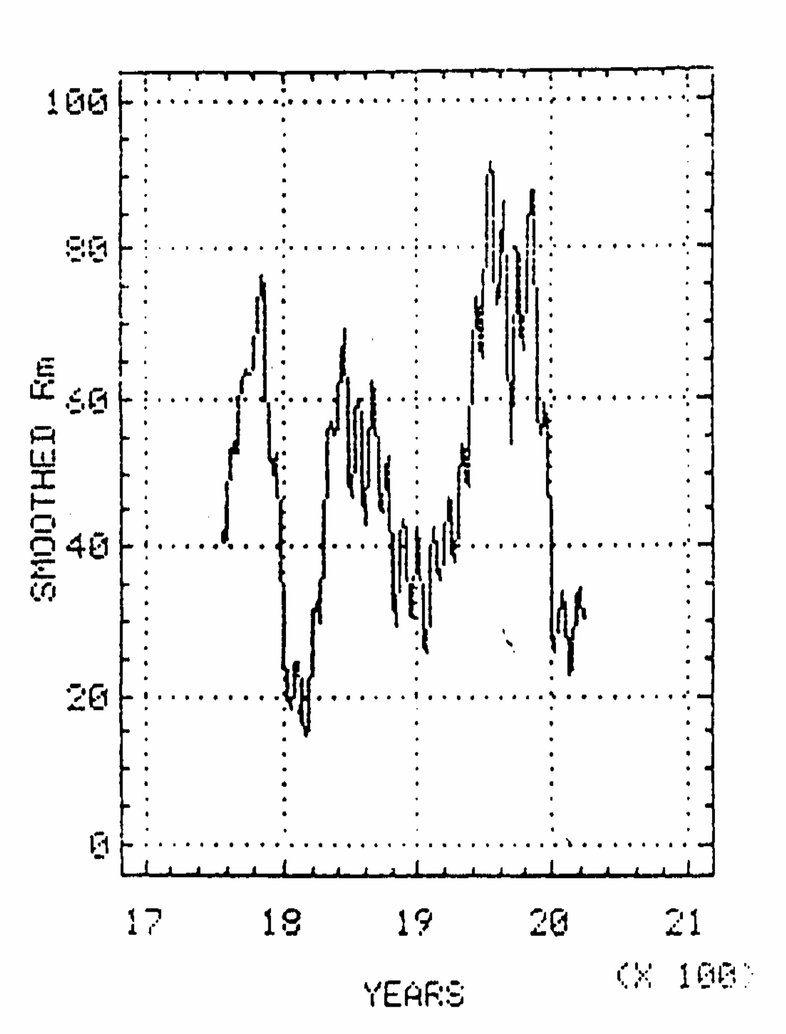


Fig 7: The last three Wolf-Gleissberg cycles, super-imposed on them ,are the 11yr.solar cycles. Note the intermediate weak 12 yr. solar cycles after Yousef (1995).

The start of the last Wolf-Gleissberg occurs at 1913, it attained maximum at 1957-59 and a secondary maximum at 1981and ended 1997 with an 84 yr. duration.

Cycles 12,13,14 are intermediate weak solar cycles in between the last two Solar Wolf-Gleissberg cycles. The levels of Lake Victoria showed sympathy with those cycles with drought years coincident with solar cycles minimum. In addition cycle 15, the first of the series of the last Solar Wolf-Gleissberg cycle also showed such sympathy

The 1997-98 sharp rise in Equatorial Lakes level confirms the end of the last Wolf-Gleissberg cycle and the start of a new intermediate era of weak sunspot cycles (Yousef et al 2000). An Era of frequent intensified natural hazards.

8-THE OCCURRENCE OF DROUGHTS WITH REFERENCE TO SOLAR ACTIVITY

Major Famines and droughts during the past 300 years have been correlated by Nicholson (cited in Faure and Gac 1981) who found they are repeated at intervals of 72 ± 16 yr. This period is of the order of Wolf- Gleissberg cycle (see section 7).

In earlier papers, we have addressed ourselves to a very important question of solar terrestrial effect namely: What is the effect of solar Wolf- Gleissberg cycles on precipitation and droughts in various parts of the world? This was started by studying long range smoothed rain cycles in England-Wales and India (Yousef (1995b, 1996, 1998, Yousef and Al Kuhaimi (1996). It was found that ,for those countries, there are two precipitation cycles within one solar Wolf-Gleissberg cycle.

The above study is now extended to cover some stations in El Sahel zone, however the data here covers only part of the Wolf Gleissberg cycle.

Figure (8) shows the precipitation stations considered (for further details see Yousef and Hafez 1988)The National center for Atmospheric Research is the source of rainfall data. Smoothed precipitation cycles for the stations studied are shown in Figs (9 to 12).

During the present study, it is found that: in the case of Ilorin (lat. 8.48º) in Nigeria, the precipitation cycles have two precipitation cycles within the studied part of the Solar Wolf Gleissberg cycles and can be fitted to a polynomial of the tenth order. Ilorin precipitation cycles are identical to the Niger, Senegal and Chari runoff cycles and hence lake chad (consult Fig 2). This reflects the unity of the rainfall regime in the area. The first root of the precipitation cycle due to the 1913 severe drought is

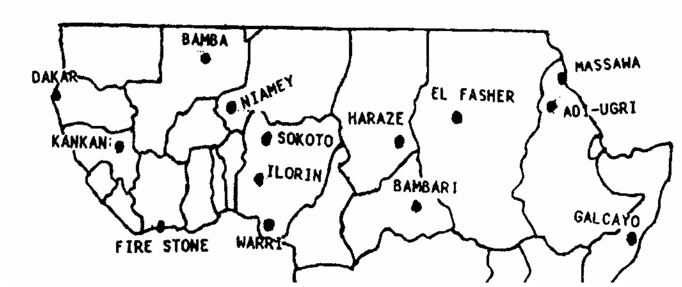


Fig 8: Selected meteorological stations including El Sahel zone

coincident with the weak solar intermediate cycles , ten years before the start of the Wolf- Gleissberg cycle ,and an expected drought around 2005± 4 yr. should mark the end root. Hence, for this part of the world, there are three precipitation cycles almost within the last Wolf-Gleissberg cycle.
Precipitation cycles for Warri (lat 5.52º) and Dakar(lat 14.73º) presented in fig 12, are very interesting. The first two rain cycles were forced by two sunspot cycles No 14 and 15 as rainfall sympathized with the two solar cycles in the same fashion as the level of Lake Victoria did (Yousef et al. 2000).
According to Said (1993 and references therein), generally speaking, El Sahel zone has been subjected to several droughts during the period of study; 1911-1915, 1940-1944, 1968-1972 and 1982-1987.
Series of dry years have also been reported in El Sahel for 1900-3, 1909-16(especially 1913-14),1931,1940-4 ,and then 1968-73 (.Lockwood 1979 and references therein).
Each of these famine years will be studied on the light of solar activity and related El Nino events.

A-Droughts 1900-3

1900-3 years of droughts occurred at the minimum of sunspot cycle in-between cycles 13&14 (see fig 6). Contemporary strong El Ninos occurred in 1899-1900, medium El Ninos at 1902,4-5(Quinn and Neal 1992). Those years were also drought years in Lake Victoria.

B-Droughts In 1911-1915

Contemporary droughts occurred in Nile and Senegal River as shown in Fig 5**.** 1913 is the worst drought in recent Nile records. Lake Victoria also experienced a period of droughts at that time.
1912 was the midpoint of severe Great Plaines American droughts and was associated with sunspot minimum (Roberts 1976).
1913 marked the end of the weak 12 years intermediate sunspot cycles and the beginning of a the last Wolf-Gleissberg cycle (consult figs (6 and 7). This period was a drought period worldwide. Unusual three years of El Ninos took place in 1911-14 (Greenpeace Climate Impacts Database). Droughts in Dakar and presumably in El Fasher were not severe in 1913.

C-Droughts in the thirties

It looks that while Kankan (lat. 10.30º, Fig 10) had increased precipitation in the thirties, Bamba (lat. 17.00º) had droughts. This means that precipitation over Kankan was negatively correlated with sunspot cycle No 16 with its minimum at the early 1930s. On the other hand, Bamba was positively correlated with the same sunspot cycle. Niamy showed a minor precipitation cycle in positive correlation with solar cycle 17 with droughts in the early thirties and about 1945,i.e similar to Bamba but at a reduced rate. This implies that sun- precipitation correlation reversed sign about the latitude of Niamy and showed quite distinct positive correlation with sunspot 17 leading to drought conditions at Bamba on the border of the Sahara in the early 1930s.
Three years of El Nino also occurred between 1930-32. The first two years where moderate Ninos while the third was a strong one.

D-Droughts in the Forties.

Droughts in the forties in Illorin (Lat.8.48º) are of the same magnitude as those in 1913. The mid point at 1945 coincided with minimum between cycles 17 and 18. As for Sokoto (Lat.13.2º) and Niamy (Lat.13.48º) further north, droughts in the forties were milder than the previous ones and in Niamy they persisted much longer.
Precipitation cycles for Bamba, Bambari and Kankan are shown in Figure (10). The partial precipitation cycles for Bambari in C.A.R. can also be compared with those in Figure(9) with the following

remarks: the general droughts in the forties started around 1938 in Bambari then migrated to Kankan (1940) and then to Bamba(1945-1946) at the west, few years later, some drop in precipitation started at

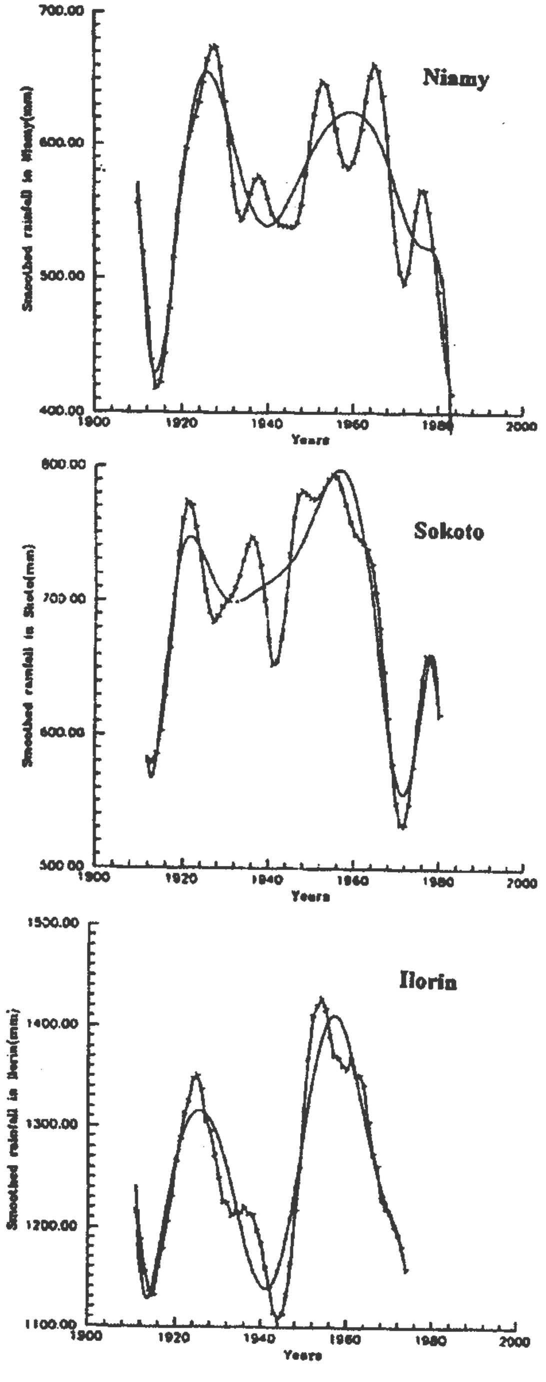


Fig. (9): Ideal precipitation cycles for Ilorin, Sokoto and Niamy. Note their polynomial fitting of the tenth order.

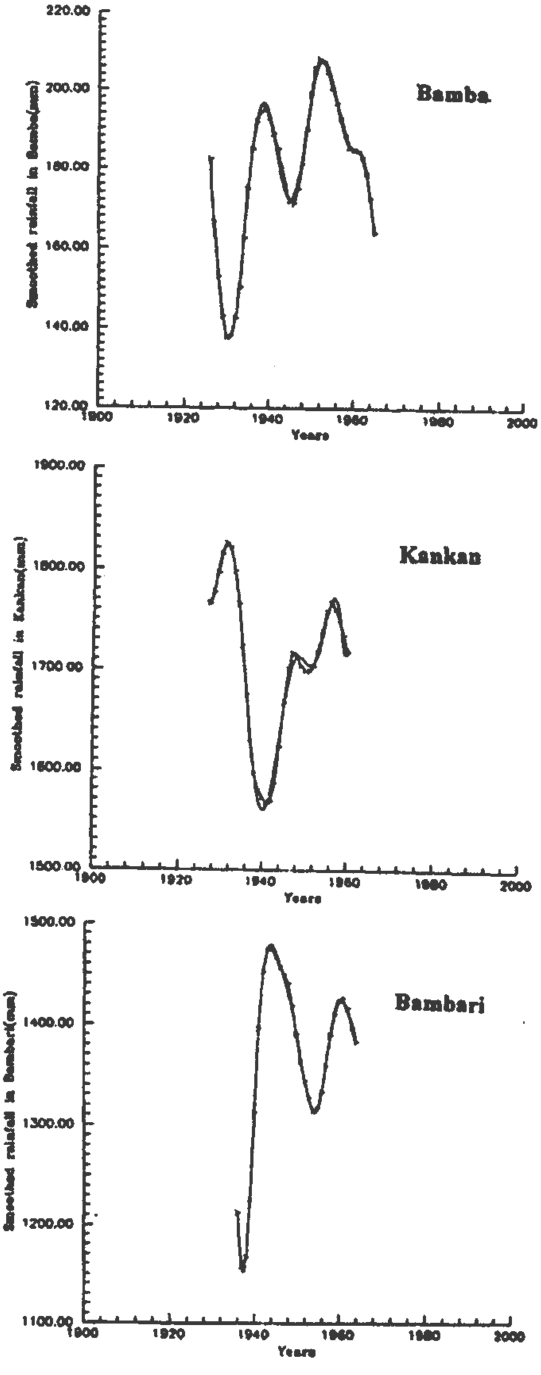


Fig. (10): Partial precipitation cycles for Bamba, Kankan and Bambari. Note their polynomial fittings of the tenth order.

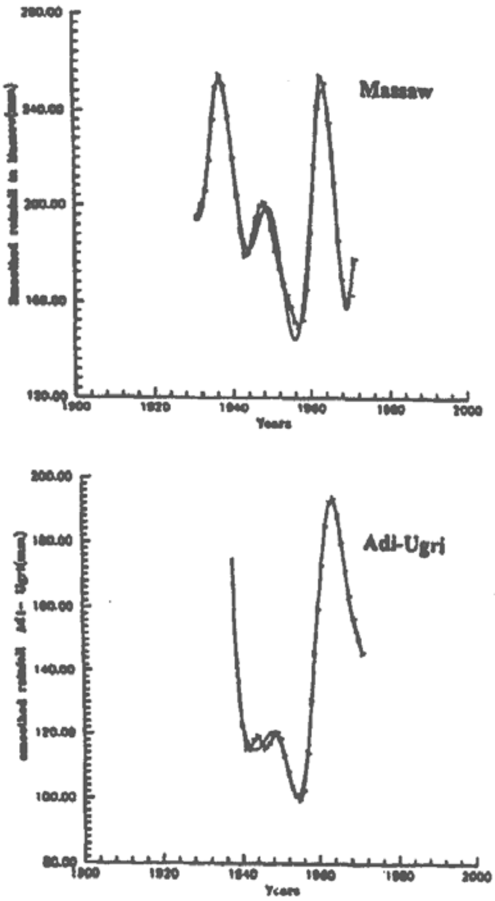


Fig. (11): Partial precipitation cycles for Massaw and Adi-Ugri. Note their polynomial fittings of the tenth order.

Fig. (12): Smoothed precipitation for Dakar, El Fasher and Warri.

the late fifties in Bambari and was later distinguished mostly in Niamy and to a lesser degree in Ilorin and was hardly distinguished in Sokoto.
Mild droughts occurred in the forties in England-Wales. Unusual three successive years of El Nino occurred in 1939-42.

E-Precipitation Rise In The Sixties

Smoothed Senegal river cycles (fig 4) show flat maximum at1955, 56,57,58 in response to the maximum of Wolf –Gleissberg cycles.
The pattern of precipitation cycles in both Massaw and Adi-ugri in Ethiopia are quite similar (see Figure(11). Adi-ugri had a prolonged drought of about 12 years. Those stations are very interesting, they showed positive correlation with solar cycle 17 with maximum in the late thirties (maximum sunspot 1937-38), and then the level of precipitation dropped to drought conditions with the drop of cycle 17(see fig 7). Precipitation stayed at drought conditions for about 12 years but showed solar cycle sympathy with solar cycles number 18. Most important is the switch from positive sun-precipitation response to negative response with cycle 19 which is the maximum of the Wolf- Gleissberg cycle. Drought conditions intensified with its maximum but the amount of precipitation afterwards almost doubled by the decline of this solar cycle.
This sharp rise in the 1960s is a global climate change. In the case of Lake Victoria the sharp rise occurred in 1961-62. This negative correlation persisted for solar cycle 20 as drought conditions persisted with its maximum in Massaw and Adi-Ugri. The reversal to negative sun-precipitation correlation in the 1960s is also evident from comparison of Lake Victoria level in response to solar forcing(Eddy 1972 cited in Hoyt and Schatten 1997). Generally speaking, the 1960s was a prosperity period in the area studied.

F- Droughts 1968-72

During the period 1968-72 rainfall along the desert fringe was only 40 to 60 per cent of the 1931-60 average. The discharge of the Niger and Senegal river declined by 50 and 70 % respectively. and Lake Chad was reduced in area by 65 per cent. The annual floods on the inland deltas of the Niger and the Senegal Rivers virtually disappeared. In 1974 , rainfall became sufficient again (.Lockwood 1979 and references therein).
Six years of droughts have brought the sub-Saharan areas of the El Sahel ,parts of Ethiopia , and Somalia to nothing short of catastrophe. More than 25 million people have been affected and initial estimates for west Africa that more that 100,000 have died. Cattle losses are placed around 75 per cent in Mauritania,50 in Senegal , 50-80 in Mali,50-100 percent in Upper Volta ,80 per cent in Niger and 90 percent in chad (.Lockwood 1979 and references therein).
The 1968-1972 droughts are clearly distinguished in Sokoto than Niamy followed by a brief spell of rain then a drop to the 1982-1987 droughts. 1975 was mid drought in Senegal River (fig 4).
Medium El Nino occurred in 1996 followed by a strong event in 1972-73,and a medium one in 1976 (Quinn and Neal 1992).

G-Drought In The Eighties

Most distinct in El Fasher(Lat.13.62) and Dakar(Lat.14.73 as seen in Fig 12 coinciding with solar cycle 21 forming the second maximum of the Wolf-Gleissberg cycle.
The negative sun-precipitation correlation that persisted for solar cycle 20 ,turned to positive correlation for cycle 21(start 1976, maximum 1979-81 and declining phase 1982-86). This is evident in the small peak in precipitation particularly in the case of Sokoto and Niamy(Fig 9) and the drought conditions that prevailed during the period 1982-87. This drought was so severe in El Fasher (Sudan), Dakar (Senegal) where it was severer than the 1913 drought. However in Sokoto and Illorn in Nigeria, Niamy in El Niger,it was comparable with the 1913 drought.
The Effect of latitude variation can be found on comparison of Warri(Lat 5.52), Illorin(Lat 8.48), Sokoto(Lat 13.02) and Niamy (Lat 13.48).
Figures(9)and (12) show the precipitation cycles for the above mentioned stations located on nearby longitudes as shown in figure(8). Near the equator (Warri), precipitation variability is rapid. Precipitation cycles in Sokoto(Nigeria) and Niamy(Niger) are simmilar to that of Illorin, however the droughts in the forties for Sokoto and Niamy are about half milder than Illorin.
It is important that the start of 1982 drought was caused by the 1982-83 very severe El Nino that was followed by 1986-87 El Nino predicted by Stephen Cane and Stephen Zebiak of Columbia University

in 1985 one year in advance, using wind and ocean measurements in the Pacific(Greenpeace data base-internet).

9-ON THE PROBABILITY OF FORTHCOMING DROUGHTS

A drop in solar activity between the two solar Wolf-Gleissberg cycles occurred around 1878-1913(Yousef 1995a, b). On one hand, droughts in England and Paris occurred few years before 1900, few years after 1900 in India and on the other hand they occurred at 1900-3 and 1911-1915 in El Sahel i.e. at the middle and end of the period of solar activity drop. Table 1 summarizes the recurrence of droughts with relevance to the intermediate drops between Wolf-Gleissberg cycles. It seems likely so far, that present droughts at the start of drop are recurrent of those during the 1794-1823 drop as seen in the case of British Colombia which was readily expected by the first author (lakes in British Colombia were dried up for two years). Indian droughts came in due time after 5 years of drought alert to India (see Yousef 2000 in this volume).

Droughts in El Sahel occurred in 1791-1800 at the beginning of the drop of Wolf-Gleissberg cycle. On the other hand, droughts occurred at 1900-3 and between 1911-1915 in El Sahel at the end of the drop between Wolf-Gleissberg cycles. This alternative occurrence of droughts at the beginning and end of solar Wolf-Gleissberg cycles was also observed in Nile floods. During the drop in between Wolf-Gleissberg cycles near 1800, Nile floods were low at the beginning of drop then they were followed by high destructive floods. In the following drop around 1900, high floods prevailed in the beginning followed by low floods.

From the above and from Senegal river runoff cycles (Faure and Gac 1981) and from expectation of strong El Nino events in the near future there is an increased probability of El Sahel and Ethiopian drought during the coming few years and God knows best.

Table 1
Comparison of recurrence of droughts in different places with relevance to intermediate drops between Wolf-Gleissberg cycles

Cycle	Drop 1794-1823		Drop 1877-1913		Drop 1997-2022(33?)	
Country	**Start**	**End**	**Start**	**End**	**Start**	**End**
British Colombia	1795-99			1900-03	1994-96?	
England-Wales	1782-88 1806-12			1892-1901	1995-97	
India				1898-1907	2000	
Morocco	1794-98				1995-99	
El Sahel	1791-1800	1828-39		1910-16	Expect Drought 2005±4	Expect Drought
Nile	1803-4	1812		1912-18	Expect Drought 2005±4	Expect Drought

Conclusions

The importance of studying droughts in El Sahel zone for us people of the Nile basin lies in the fact that there is a clear positive connection between the discharge of the river Nile and meteorological conditions in El Sahel zone(refer to fig 5). Previous contemporary droughts linked with El Nino events occurred in both regimes. The ability of long range forecasting of droughts in El Sahel will thus be reflected on forecasting of Nile floods.

The influence of solar activity as manifested by long range (80-121) years Wolf-Gleissberg cycles is quite clear in England-Wales, Paris, India as well as El Sahel zone. Precipitation cycles in Ilorin, Sokoto and Niamy are ideal. Such precipitation cycles which have their original roots at the periods of weak solar activity in between solar Wolf-Gleissberg cycles, can be used in long range forecasting for droughts and wet periods. It is evidenant that within one solar Wolf-Gleissberg cycle,there are two precipitation cycles for England-Wales, Paris and India while there are three precipitation cycles for

Ilorin, Sokoto and Niamy etc. It is useful to study such rain cycles in different parts of the world in conjunction with El Sahel as it seems that droughts originally have their dependence on solar Wolf Gleissberg cycles and that droughts migrate from place to place. It is anticipated that several years of droughts will prevail in El Sahel and Ethiopia in the near future. Earlier alerts of El Sahel and Nile droughts were given in Yousef and Hafez (1998) and Yousef (2000 a&b).
Attention to the current early forecast of droughts is made to all El Sahel and west African governments mentioned in this paper and international organizations to be ready in order to coup with the expected drought and God knows best.

Acknowledgements
My sincere thanks are due to my mother Mrs. Ikram El Attar for help and encouregements.

References
Batterbury Simon 1998: The Sahel region; assessing progress twenty-five years after the great drought. A shorter version is in The Geographical (London) May 1998.

Chhernosky,E.J 1966:Double sunspot cycle in terrestrial magnetic activity,1884-1963.J,Geophysical Res.,71,965-974.

El Tahir, A.B. and Gong, Culining 1996: Dynamics of wet and dry years of west Africa, J. climate 9, 1030-1042.

Faure, Hugues and Gac, Jea-Yves 1981: Will the Sahelian drought end in 1985.Nature 291, 475-478.

GREENPEACE Climate Impacts Database(internet): after("Fire and flood greet El Nino's third year", New Scientist, p.15, 15 January 1994).

Hoyt D.V. and Schatten, K.H 1997: The Role of the Sun in Climate Change.

King, J. W. 1973: Solar radiation changes and the weather. Nature 245,443-446.

Lockwood J.G. 1979: in causes of climate . Edward Arnold publishers Ltd, London.

Quinn, W.H., V.T. Neal: The Historical Records of El Nino Events. In Climate Since A.D. 1500. Editedby, r. Bradley and P. Jones.

Roberts,W.O., Sun-Earth Relationship and Extended Forecast Problem. Science, Technology, and the Modern Vavy, thirtieth Anniversary 1946-1976.

Said, R. (1993): The river Nile.Dar El Hilal, Cairo, Egypt (in Arabic).

Webb James L. :Desert Frontier: Ecological and Economic Change along the Western Sahel, 1600-1850.Annotation c. Book News, Inc., Portland, OR (booknews.com).

Yousef, S.(1995 a): The downturn of solar activity during the coming three solar cycles. Bull. Fac. Sci., Cairo University, 63, 185.

Yousef, S. (1995b):The possibility of forecasting Nile floods during the coming forty years. The first scientific congress on science in service of sustained development in Nile Basin countries. Cairo 22-24 May.

Yousef, S. (1996a): Nile flood-drought hazards 1996-2031.International commission on irrigation and drainage ICID. Cairo;Sept. Cairo, Egypt.

Yousef, S. (1996b): A warning of African droughts during the coming 35 yearBig. Cities world conference on national disaster mitigation, Cairo, Egypt.Jan 5-9.

Yousef, S. (1998): A warning of solar inactivity during the next few decades and its influenceon IMF and cosmic rays.Third SOLTIP symposium on solar and interplanetary transient phenomena.,Editors Xueshang Feng, Fengsi Wei and Murray Dryer. International Academic publishers. pp 569-575.

Shahinaz Moustafa Yousef 1999: Long Range Forecast Of Nile Floods During The Twenty First Century. Seventh Nile 2002 Conference , Comprehensive Water Resources Development Of Nile Basin : The Vision For the Next Century. Cairo , March 15-19.

Shahinaz Moustafa Yousef 2000a :An Overview Of Flood-Drought Hazards In The 21st Century. WMO International Workshop On Long Range Forecasting and Its Applications. Cairo ,January 23-27.

Shahinaz Moustafa Yousef 2000b: Call For Drought Strategy Workshop. Proceedings Of the International Conference On Water Africa North 2000. P. 46 Cairo 9-11 May.

Yousef, S.and El Kuhaimi, S.(1996):Expected drop in the solar constant and considerable variation in duration of sunshine during the coming three decades.
Fourth conference on renewable energy and workshop, April 14-18.

Yousef Shahinaz and Hafez, Y. 1998: On the Role Played by El Nino Strength and Solar Activity on the Rainfall in El Sahel Zone. In Proceedings of the International Conference on Water Problems in Africa. 26-27 Oct., 133-157.

Yousef, Shahinaz, M. Amer and M Abdel Aty 2000: The sharp Rise of Lake Victoria, a Positive Indicator to Solar Wolf- Gleissberg Cycles Turnning Points. Paper I,this Volume