S. Yousef et al. / ICEHM2000, Cairo University, Egypt, September, 2000, page 250- 262

THE GREAT NILE FLOODS OF 1998 AND 1999 ; SUCESSFUL FORECASTS USING SOLAR TERRESTRIAL RELATIONS AND REAL DATA

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ABSTRACT

In 1995,in a paper on long range forecasting of Nile floods , the first author stressed the possibility of successive high floods and called upon the Egyptian authorities to be ready with the Tushka canal. Indeed , the 1996 was the first high flood in the series and there was a spillage for the first time in the Tushka canal.

Early in 1996, in the Big Cities Conference on Natural Disaster Mitigation, It was also forecasted that the 1997 Nile flood will be low while the 1998 Nile flood will be destructive. This successful forecast was based on solar terrestrial studies in connection with Nile floods and El Nino events. In the same 1996 paper, it was also forecasted that El Nino is expected to occur in 1997±1 year. Eventually a very strong Nino occurred in 1997-1998.

In an earlier paper, it was also anticipated that the 1999 Nile flood would be rather high.

The present paper outlines the long-range solar-terrestrial forecasting method involved and documents the real data of the 1998 and 1999 great Nile floods. There is some increased probability that drought is approaching the Ethiopian Nile sources in the near future due to the our forecast of El Nino events which may last for a couple of years at least and which will be intensified due to the presence of Pacific decal oscillations.

1-INTRODUCTION

Advanced flood forecasting can reduce loss of human lives and movable properties to a considerable extent. Necessary action can be taken for disaster preparedness.. Flood forecasting in particular play an important role in optimum utilization of water resources. In the context of reservoir operations and management , flood forecast helps in planning the regulation of water in the downstream channel and at the same time retaining sufficient water in reservoir for irrigation and power generation (Sharma &Sharma 1997).

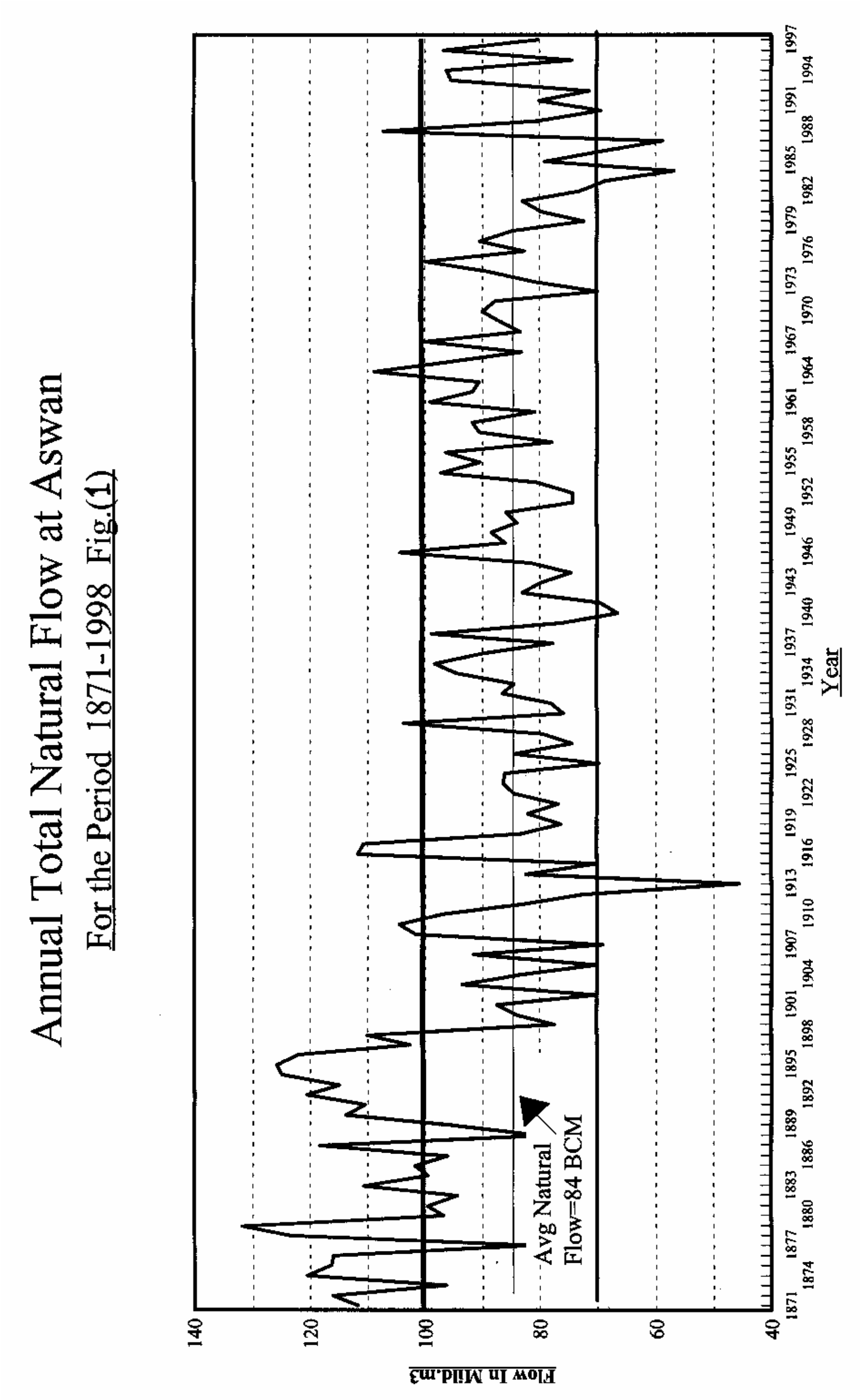
As long as the river flows close to the average, there is no hazards .. When the river flow exceeds some permitted threshold of local significance and extends outside the band of tolerance, it will cease to be beneficial and be perceived as a hazard. Thus very low and very high flows will be considered to create a drought hazards or a flood hazards respectively. The impact of the hazard will, in part, be determined by the magnitude of the event (expressed by the peak deviation beyond the threshold on the vertical scale) and the duration of the event (expressed by the length of time the threshold is exceeded on the horizontal scale.

In the case of the river Nile ,the average discharge is 84.5 billion cubic meters, the lower limit of the Damage threshold is 70 Billion cubic meters. 100 cubic meters is the upper limit of the damage threshold (Fig 1). Higher discharges can cause damage in some parts of the river such as the 1998 great flood which caused considerable damage in Sudan up till Wadi Halfa. The damage threshold can be tolerated due to the storage capacity of the high Dam and the hydrology policy of handling the flood which saved Egypt from a flood disaster.

Flood prediction is very important in increasing the range of tolerance by either evacuating the dam to a certain level beforehand in the case of extremely high floods and keeping the level of the dam high in the case of low floods.

2-EARLY FORECAST OF THE 1998 DESTRUCTIVE NILE FLOOD

Long range solar activity is a key factor in flood -drought forecasting. The close resemblance of solar activity envelope and Nile floods and the level of lake Qarun since 9000 BC proved beyond any doubt that solar terrestrial relations is a dominant factor in flood - drought phenomena (Yousef 1999a). On a still shorter scale of the order of 250 years or more of real data, precipitation cycles were found to be coherent with the 80-120 years of solar Wolf- Gleissberg cycles as evident in Figure 2 with two


Annual Total Natural Flow at Aswan
For the Period 1871-1998 Fig.(1)
Avg Natural Flow=84 BCM
Flow In Milld.m3
Year
140
120
100
80
60
40
1871 1874 1877 1880 1883 1886 1889 1892 1895 1898 1901 1904 1907 1910 1913 1916 1919 1922 1925 1928 1931 1934 1937 1940 1943 1946 1949 1952 1955 1958 1961 1964 1967 1970 1973 1976 1979 1982 1985 1988 1991 1994 1997

precipitation cycles within one solar Wolf Gleissberg cycle (see Yousef 1996,1997,1998b). Our understanding of such backward rain cycles can be reflected into the future. In the case of the river Nile , Yousef and El Rae (1995), found three Nile cycles for the period 622-1466 .

Right now we are just entering a period of solar inactivity in between Wolf Gleissberg cycles as shown in figure 2(lower-right) predictions of the forthcoming solar cycles can be found in Yousef (1995).

Such fast drop in solar activity in my opinion is the cause behind the wide spread instabilities in the world. Droughts in England-Wales, Paris and India occurred in relevance to such fast drops. This statement is based on studying flood drought hazards and El Nino phenomena during previous similar drops of solar activity around 1800 and 1900.

Figure 3 shows the natural Nile flood discharge for the period 1872-1918 i.e. during the period of the previous solar activity drop intermediate between Wolf -Gleissberg cycles. Cycles. Note also sunspot number as an indicator of solar activity during the same period when weak sunspot cycles occurred.

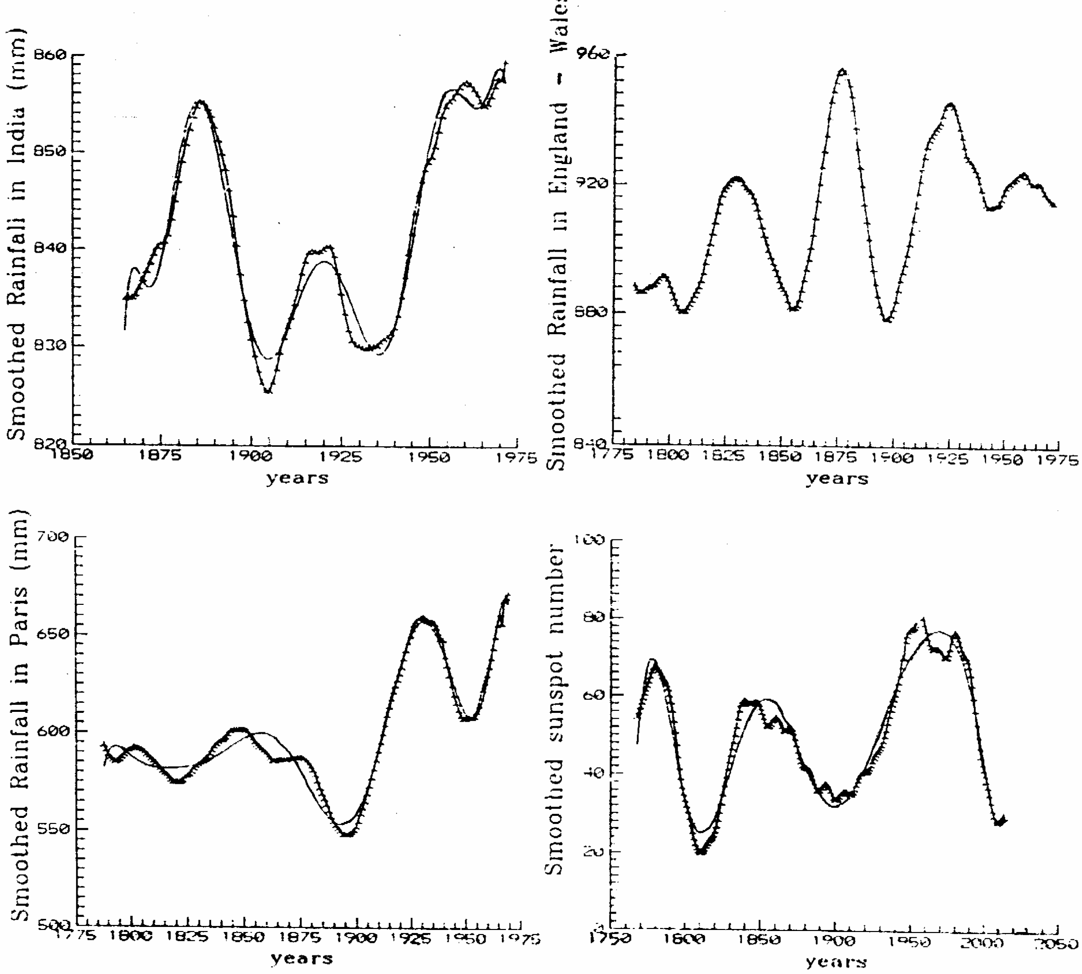


Fig 2 Coherence between Solar Wolf-Gleissberg cycles and Precipitation cycles for England-Wales, Paris and India. Note their polynomial fittings of the tenth order. Droughts occurred around 1880,1900 and 2000 coinciding with solar minimum between Wolf-Gleissberg cycles.

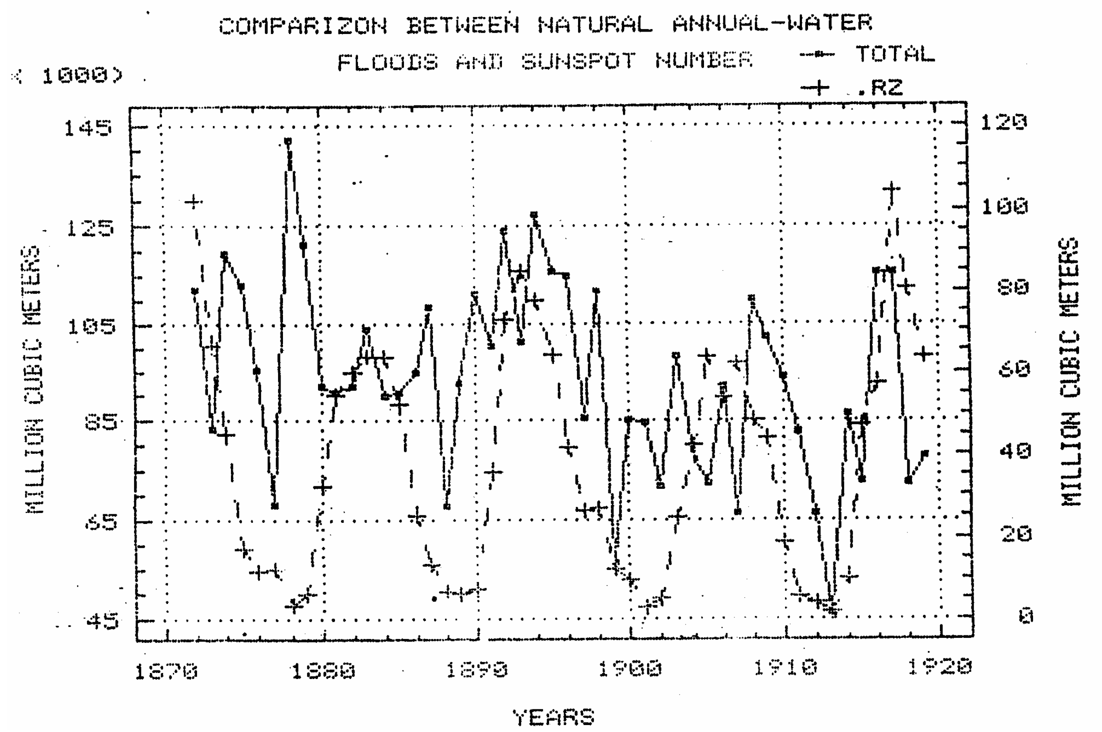


Fig.3: The effect of solar forcing on natural Nile floods discharge during period of weak solar cycles around 1900. Upper and lower curves represent Nile floods and sunspot cycles respectively. Note that low Nile floods attributed to El Nino events, occurred at sunspot minimum, and were followed by destructive to high floods owing to La Nina. In addition between 1888and 1901 Nile discharge followed the solar cycle closely.

Using this particular diagram, several predictions were made on the basis of the following facts:

1) 1877-1878 was a very strong El Nino event (Quinn and Neal 1992). This event was contemporary with very low Nile flood causing great scarcity of food in Egypt and indicating severe droughts in Ethiopia. In 1877, much of China was subjected to a terrible famine, Nine to thirteen million people perished from hunger, disease or violence. Drought was the immediate cause of the north of China famine of 1877-78. Severe droughts in other countries in these years also led to famine. In India , during the 1877 severe drought, the percentage of country's affected area was 64 (Upadhyay 1995) One estimation is that over eight million deaths could be attributed to the Indian famine and epidemic diseases. This year was also a famine year in northeastern Brazil. Estimates of the number of deaths it caused there range from 100,000 to more than one million .There was a severe drought in Australia and south Africa. Droughts also occurred in Java (Indonesia) (after Quinn et al (1978) cited in Allan 1991). Climatic problems that accompany ENSO events were : droughts in India, Ethiopia, Australia, southern Africa, northeast Brazil, northern China and floods in Ceylon and Australia after the end of the ENSO event. There was a major ENSO episode during 1877-78 with very heavy rains and flooding along the Pacific coast of South America (Nicholls 1991 and references therein).

2) The low Nile flood of 1877 was followed by a destructive flood the next year accompanied by disease and famine. This was the highest flood ever recorded since the start of the Aswan discharge measurements . After the terrible drought of Australia, disastrous floods have followed causing great destruction of life and property and a terrible hurricane struck Tahiti in February 1887. In the case of India , the year 1878 was a year of severe floods in several states (Upadhyay 1995).

3) The 1888 drought was attributed to ENSO. There was a low Nile flood in 1888.
The year 1888 in Ethiopia, was excessively hot and dry .On 16 November 1888 there were reports that lack of rain had caused a large portion of the crops to perish. By 8 January 1889 in certain areas all the

crops had been burned by the sun. The Ethiopian Famine was accompanied by epidemic and believed to have resulted in the death of one third of the entire population . In certain areas perhaps 80 percent of the total population was lost (Nicholls 1991 and references therein).
In India, a late and scanty monsoon resulted in about 1.500.000 deaths. Drought and famine struck northern Brazil. Droughts again occurred in Indonesia and Australia. The Australian drought did not cause famine but in January 1889 floods at the end of the event caused some deaths.

4) 1899 -1900 are also strong El Nino years (Quinn and Neal 1992).
5) Notice the close resemblance of Nile floods to the corresponding solar cycle between 1888-1901 indicating positive solar forcing on Ethiopian precipitation.
6) 1913 was the lowest Nile flood in record . Three-year El Ninos took place in 1911-14 and 1939-42(Greenpeace Climate Impacts Database (by internet and an 1994 reference therein). Notice that 1913 marked the end of the Wolf-Gleissberg cycle.
7) Notice that the above mentioned biannual El Nino events occurred during the minimum of the 12 years weak sunspot cycles thus causing a low flood followed by two very high to destructive floods. Generally speaking, i.e El Nino events were abundant around 1800 and 1900 (Sharp1992 and references therein) i.e. during the drops intermediate between the previous two Wolf-Gleissberg solar cycles.

Figure (4) illustrates three Nile flood hydrographs; the 1877-1878 low Nile flood's hydrograph , the destructive 1878-1879 Nile flood hydrograph and the following year(1879-1880) very high hydrograph. Note that each of the three hydrographs can be fitted to a polynomial of the 7^{th} order. Notice that the 1877 hydrograph started in August while the 1887 destructive flood started in July. The 1879 very high flood started as early as June. The general level of the Nile remained high after the end of 1878 destructive flood and also following the 1879 very high flood.

Yousef (1998) estimated the discharge of Nile floods during the similar period of solar inactivity in between solar Wolf-Gleissberg cycles around 1800 AD and found that low floods were common during the early period and destructive during the late period. This observation is in opposition to the fact that during the following period of solar inactivity around 1900, high floods were frequent at the beginning while low floods were frequent at the end of the period .

It is thus anticipated that Nile floods during the present drop of solar inactivity will to some extent be similar to those around the 1800 drop. It was also anticipated from point 7 that the 1997 Nile flood occurring at the start of the inactivity period will be low due to an ENSO event while the 1998 and 1999 floods will be higher to destructive. due to La Nina .

3-TELECONCTIONS

ENSO occurrences are global climatic events that are linked to various climatic anomalies.. Extreme anomalies such as severe droughts, flooding and hurricanes have strong teleconections. Teleconections are defined as the linkages over great distances of seemingly disconnected weather anomalies (Glantz 1991). Understanding these connections can help in forecasting drought, floods and tropical storms (hurricanes).

It was the knowledge of such teleconections particularly during the previous periods of solar inactivity, which is similar to the present anticipated drop in solar activity, which allowed the successful prediction the 1997-1998 very strong ENSO event and the related droughts in various parts of the world including Ethiopia , the destructive Nile flood and other floods in 1998.

During an ENSO event, drought can occur virtually any where in the world, though researchers have found the strongest connections between ENSO and intense droughts in Australia, India, Indonesia, the Philippines, Brazil, parts of east and south Africa, the western Pacific islands (including Hawaii), central America and various parts of the U.S.A. Drought occurs in each of the above regions at different times (seasons) during an event and in varying degrees of magnitude.

Yousef (1966a,b)**,**in the Big Cities Conference on Natural Disaster Mitigation have successfully predicted several Natural Hazards several years beforehand. These are considered an achievement in the field of long-range forecast (1996-2032) and should have a great effect in saving lives and in the economy of the countries concerned. These successful predictions left no doubt on the effect of solar activity on terrestrial events.

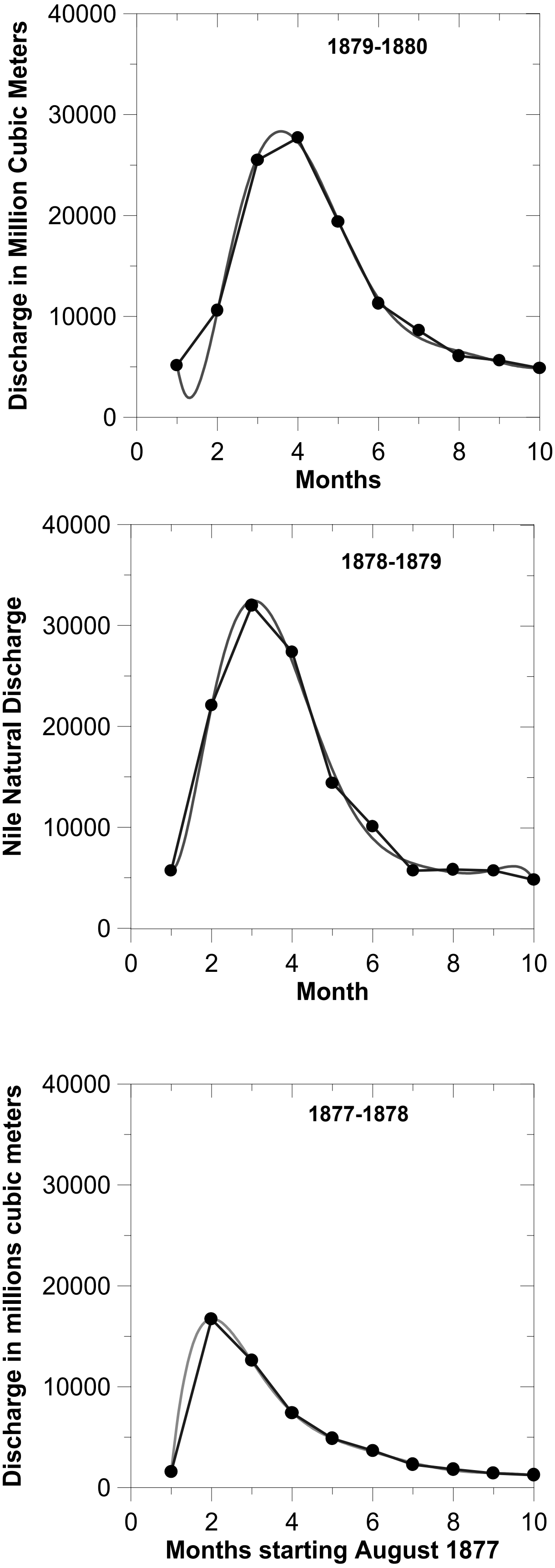


Fig 4: Three Nile Flood Hydrographs :
1877-1878, 1878-1879, 1879-1880
Note the polynomial fitting of the 7th order to the three hydrographs

3.1Some predicted Natural Hazards

1) Being at minimum of the predicted solar activity cycles (Yousef 1995a,b) the years 1997, 2009,2021 and 2032 ± 1 were predicted as ENSO years (i.e. El Nino plus southern oscillation). The 1997-1998 EL NINO is the El NINO of the century.
2) 1997 was predicted as a year of low Nile flood to be followed by a destructive flood. These predictions came almost true as 1997 Nile flood was below average while 1998 was destructive. The 1999 Nile flood was also expected to be very high.(Yousef 1998,Yousef and Osman 1999, and Yousef 1999b).These prediction were made from studying the sequence of natural Nile floods at the beginning of entering the drop of Solar Wolf- Gleissberg cycles at 1797, 1877 and 1997. The start is El Nino year to be followed by two La Nina years causing droughts over Ethiopia followed by two destructive Nile floods.
3) In the case of China, It has been indicated that Ethiopia and the North of China are teleconnected and that a mixture of severe droughts followed by severe destructive floods will occur and specified that droughts were to be expected around 1997. Indeed ,this expectation came true as droughts occurred in the north and north east of China in 1997. In August 1998, China floods surged toward record levels. Unusually heavy seasonal rains fed the worst flooding in 50 years in China's northeast provinces ,and floods along central China's Yangtze river are the worst since 1954,when more than 30,000 people were killed. Tens of millions of people have been left homeless in the 1998 floods (CNN).
4) The papers also forecasted droughts in North of Brazil. It was also anticipated that floods will follow the droughts. According to the CNN in April 1998, drought heightens tensions in Brazil's Northeast. According to the National Drought Mitigation Center, drought continued in northeastern and central Brazil. After the writing of this statements floods occurred in Brazil on the 3rd of March 1999.
5) In page 357 of the first paper , it is stated that droughts are likely to occur in British Colombia. The National Drought Mitigation Center in August -Sept 1998 indicated that drought codes remained extreme for most of western (i.e. British Colombia) and northern Canada.
6) The paper also expected droughts to affect Australia. Droughts prevailed in east-central and southeast Queensland and southwest New South Wales. Such droughts ought to be followed by severe floods and since the writing of the drought statement, the worst floods in 100 years attacked northeastern Australian states and cyclone floods hit north Australia in February 1999. In Newzeeland, prolonged drought occurred in 1997 and July 1998 was the warmest since 145 years. Floods then attacked the northern island of Newzeland on January 1999(CNN).
7) This paper predicted the occurrence of hurricanes and indeed according to the university of Colorado hurricane forecast team, the four years period from 1995-1998 was the most active four consecutive years of hurricane activity on record, i.e. during the downturn of solar activity . 1998 was extremely active and it seems that we are embarking a new era of enhanced major hurricane activity.
8) The title of other paper by Yousef 1996 (page 349-358) is " A serious warning of wide spread drought-flood hazards (1996-2032). And indeed floods were destructive in China, California, Bangladesh, India, Indonesia, Britain, Germany, and Holland among others. North Korea was ravaged by four straight years of floods, droughts and other natural disasters.

According to the National Drought Mitigation Center, extreme droughts occurred for most of western and northern Canada, In Cuba the drought which began early 1998 was the worst in forty years and ended by flood due to Hurricane George, Jamaica was also subjected to a severe drought. In central America , Honduras suffered from the worst drought conditions of the past decade followed by Hurricane Mitch which destroyed also Guatimala, El Salvador causing the death of 11,100 persons and is called the disaster of the century.

In south America, Bolivia, north eastern and central Brazil, Central Chile and Equador were affected by droughts. According to the CNN, Colombia sufferred also from droughts. On the other hand Mexico had the worst floods in forty years.

In Newzeeland , prolonged drought occurred in 1997 and July 1998 was the warmest since 145 years. Floods also attacked the northern island of Newzeeland.

In the case of the Pacific Islands, a prolonged drought, the worst in record occurred in American Samoa. According the CNN, a prolonged severe drought parching the South Pacific Island of Fiji and as Yousef (1996a) expected floods should follow and they did on January 1999. Hawaii also faced severe drought starting January 1998. In Asia, Cambodia sufferred from droughts and floods. By the end of February 1999, Colombia was hit by floods.

Israel was also having droughts and I feared that drought may migrate to other Middle East countries e.g. parts of Saudi-Arabia (probably Naged, according to some investigation which is to be published elsewhere). [1]

In Russia, the 1998 drought was the worst in 100 years. The former Yugoslavia was also facing severe drought. Ukraine was threaten by floods on February 1999 the fifteenth.

In 1999 ,the worst floods in memory attacked Hungry on the 2nd of March. Rhine floods occurred in February .

In Africa, Ghana was having the lowest rainfall in 30 years. Mozambique was having a mixture of droughts and floods. The South of Sudan and Somalia were having droughts.

The importance of such knowledge of teleconections ,is that it can be used as indicators of drought -flood hazards. To us people of the Nile ,it can be used to forecast Nile floods a long time in advance. We would like to stress here, the strong teleconection between the North of China and Ethiopia. This strong connection allowed the first author to give Alert of the 1996 high Nile flood and to call upon the Egyptian authorities for the preparation of the Tuscha canal (Yousef 1995b). Thanks are due to the Egyptian authorities for immediate response for this call. It also allowed the first author to forecast the 1998 great Nile flood with confidence.

Tables 1&2 summarize the 1998 and 1997 Natural hazards.

TABLE I
Natural Hazards 1998

MONTH	DROUGHT	FOREST FIRE	FLOODS	CYCLONES	TYPHOON	HURRICAN
JAN				TONGA		
FEB			Zambia			
MAR	Micronesia Guvana	Brazil	Pakistan			
APR		Phillippine	Uruguav Iran	Vanuatu		
MAY				Banglade Sh		
JUNE			Russian Federation Romania China	India		
JULY			Bangladesh Korrea			
AUS	Viet Nam India Cuba		Turkey Nepal			
SEP	Fiji	Russian Federation	Sudan Korea Slovakia Phillippine Benin			Caribbean Georges
OCT			Iran			Mitch
NOV			Vietnam	Bangladesh		
DEC					Philippine	

Since the writing of this statement, Saudi Arabia and Yemen faced droughts in the year 2000 [1]

TABLE II

Natural Hazards 1997

DATE	DROUGHT	FOREST FIRE	FLOODS	CYCLONE	TYPHOON	HURRICAES
JAN				Madagascar		
FEB	Kenya Ecuador		Mozambiqu e Malawi Bolivia			
MAR			Ecuador	Tonga New Guinea Fiji		
APR	Ethiopia		Tanzania			
MAY			China Afghanis Tan	Bangladesh		
JUNE			Romania Chile Benin Azerbaijan Armenia			Belarus
JULY			Poland			
AUS			Mldova India		China	
SEP	New Guinea Indonesia Nicaragus			Bangladesh		
OCT		Tanzania	Ecuador			
NOV	Solomon Honduras		Uganda Somalia Kenya Ethiopia	Cook Islands	Vietnam	Mexico
DEC			Peru Paraguay Congo			

4-THE 1998 NILE FLOOD

According to the UN Office for the Coordination of Humanitarian Affairs (OCHA), in August and September 1998 floods and heavy rains occurred in 18 of Sudan's 26 States. The combined results of heavy rains in Ethiopia and southern Sudan resulted in the highest river levels along parts of the Nile and tributaries since records began. Flooding affected about one million people. Of whom over 100,000 were displaced. It resulted in a dramatic increase in the incidence of malaria and other water related diseases, primarily because of the flood latrines, polluted wells, and destroyed water systems. Production in the irrigated agricultural sector was seriously reduced up to 20% of the country's date palm trees were destroyed.

The Northern and River Nile States were the most affected, floods in the area displaced over 7000 persons and schools were severely damaged.

According to the CNN in Sep 1998, floods and heavy rain destroyed 119,000 houses on Tuti Island, located in the Blue Nile, a few hundred meters from where the river meets the White Nile, more than 10,000 inhabitants have been battling the surging river. 2.5 mile long walls of sandbags were erected to save thousands of homes. 1998-99 and 1999-2000 Nile hydrographs are shown in figures 5(a &b).

5-REAL DATA OF 1998/1999 AND 1999/2000 HIGH NILE FLOODS

A synoptic of the River Nile and its tributaries is shown in fig (5).it shows the positions of the guage reading stations :

Malakal	:	North of the connection of the Sobat River to the White Nile.
El Diem	:	On the Blue Nile upstream Rosseres Dam.
Khartoum	:	On the Blue Nile before its connection with the white Nile.
Atbara	:	On the Main Nile, North of the connection of Atbara River and the Main Nile.
Dongola	:	On the Main Nile, South of the High Aswan Dam.

The following hydrographs show daily water levels of the above five main stations. In each station a comparison between 1998/1999, 1999/2000 high flood years hydrographs with the absolute max, min and average level measurements.

Deim, Khartoum, Atbara and Dongola hydrographs show that years 1998/1999, 1999/2000 are high years and water levels of 1998/1999 are over than that of year 1999/2000. They show also that there are two peaks of the flood, the first one at August, beginning of September and the second at October.

From Malakal gauge reading, it can be said that the years 1998/199 and 1999/2000 are above average and the year 1999/2000 water levels is over than year 1998/1999 for most of the year, in spite of the fact that the total natural Nile discharges in 1999/2000 is less than that of 1998/1999, This means that the Equatorial and Ethiopian water shed areas are separate.

The hydrolgic characteristics of flood 1998/1999 and flood 1999/2000 are shown in table III.

Table III

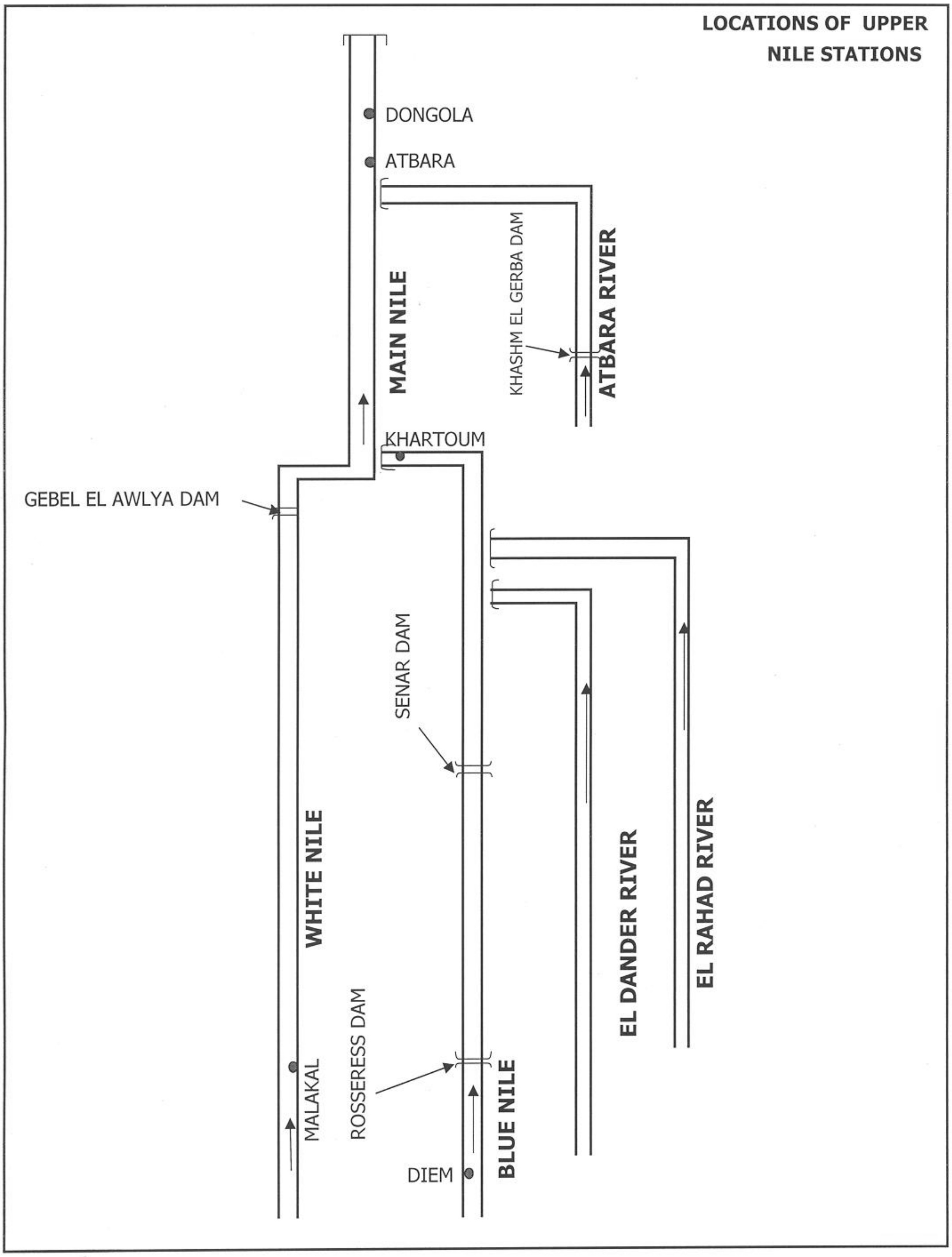
Hydrologic Characteristics of flood 1998/1999

Levels :		
High Dam U.S.W.L. on 31/7/1998.	= 174.75	m.
High Dam U.S.W.L. on 31/7/1999.	= 175.79	m.
Total Excess in High Dam U.S.W.L.	= 1.04	m.
Max. High Dam U.S.W.L.	= 181.30	m.
Contents :		
Contents of Lake Nasser on 31/7/1998.	= 120.000	Mild m^3.
Contents of Lake Nasser on 31/7/1999.	= 125.408	Mild m^3.
Excess in contents of Lake Nasser.	= 5.408	Mild m^3.
Max. contents of Lake Nasser.	= 157.750	Mild m^3.
Discharges :		
Total discharges D.S. Aswan.	= 71.435	Mild m^3.
Egypt water requirements.	= 55.500	Mild m^3.
Excess discharges to the Nile.	= 15.930	Mild m^3.
Discharges through Toshka Canal.	= 12.596	Mild m^3.
Water arriving Aswan.	= 89.439	Mild m^3.

Hydrologic Characteristics of flood 1999/2000

Levels :		
High Dam U.S.W.L. on 31/7/1999.	= 174.79	m.
High Dam U.S.W.L. on 31/7/2000.	= 175.85	m.
Total Excess in High Dam U.S.W.L.	= 0.06	m.
Max. High Dam U.S.W.L.	= 181.60	m.
Contents :		
Contents of Lake Nasser on 31/7/1999.	= 120.408	Mild m^3.
Contents of Lake Nasser on 31/7/2000.	= 125.720	Mild m^3.
Excess in contents of Lake Nasser.	= 0.312	Mild m^3.
Max. contents of Lake Nasser.	= 159.700	Mild m^3.
Discharges :		
Total discharges D.S. Aswan.	= 67.060	Mild m^3.
Egypt water requirements.	= 55.500	Mild m^3.
Excess discharges to the Nile.	= 11.560	Mild m^3.
Discharges through Toshka Canal.	= 11.560	Mild m^3.
Water arriving Aswan.	= 81.460	Mild m^3.

Fig 5: A synoptic of the River Nile and its tributaries showing the positions of the guage reading stations.



Conclusion

Based on backward study of Nile floods during two solar low activity periods similar to the predicted (present) solar activity , the author was able to forecast the EL Nino 1997-1998 event of the century. As a consequence of this event, Low Nile flood was forecasted for 1997 to be followed by two destructive to high floods in 1998 and 1999.
It is also anticipated that a sequence of low floods will prevail in the near future to be followed by a series of high to destructive floods similar to the sequence of Nile floods in the drop of solar activity periods around 1800.
A flexible cultivation policy is advisable in the coming period i.e. during high flood years, no restrictions should be put on the high water consuming crops ,e.g. rice and sugar cane .In fact such crops should be encouraged during high flood years and stored for the anticipated low flood years. However during low flood period, governmental control on crops is advisable.
Confirmation of flood teleconctions between Ethiopia and the North of China allows early forecasting of the level of the Nile floods as the latter preceded the former by about one month. A study of such teleconctions over long period will be done elsewhere.
The Natural discharge of the river Nile in the water years 1996 ,1997,1998 and 1999 are 96,80, 120 and 110 Milliard cubic meters (cumecs) respectively.

Acknowledgment

I greatly appreciate my mother's support. My sincere thanks are also due to Dr. .Mahmoud Abu Zeid for great encouragement.

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