Nile Flooding fluctuations and its possible connection to the long solar variability

Basurah, H. M.
Astronomy Department, Faculty of Science,
King-Abdul Aziz University, Jeddah, Saudi Arabia.
hbasurah@kau.edu.sa

ABSTRACT

In the present paper, data of the Nile River flooding, from mid of the seventh century to the end of the ninth century, which collected from different Islamic history books, has been used to investigate the cycles of its level variability. This is considered as the longest direct instrumental climatic record available up to now. It also could provide information, dating back to hundred years, which make it suitable for analyzing climate variations and their possible correlation with the solar activities. The most significant periods were found corresponding to the Gleissberg and Schwabe solar cycles. Also centennial and multidecadal cycles have been found, but at low confidence level. We had found some of these cycles are similar to the solar variability cycles, while others are typical for terrestrial climate that may be considered as possible indication of solar-climate relationship. The results obtained in the work are consistent with other work (Hameed 1984, Shaltout and Tadros 1990, Putter et al 1998) where they had used different version of Nile river flood-level time series.

KEY WORDS: Solar activities, Nile Flooding, solar Cycles

1. INTRODUCTION

It is known that the sun controls the Earth's climate system. Thus, variations in the solar output and its activity may provide a means for climatic changes. The main reliably-established modes of solar variability are: (a) the quasi 11-year cycle (the cycle of Schwabe), (b) the century-type cycle, revealed by (Gleissberg 1944), (c) solar variation with period ca 200 years, which was found by (Suess 1965, 1980). Although the period of the cycle of Gleissberg is often considered as 80-90 years, (Ogurtsov et al. 2002) showed that Gleissberg variation likely has a wide frequency band, with a double structure consisting of 50-80 years and 100-140 years periodicities. Many articles indicate that the variations in the solar emitted energy could be responsible for the sensitivity of the Earth's global climate. There are some evidences that the climate fluctuations follow the solar activity for hundreds of years (see e.g. Lean and Rind, 1998). Distinct correlation between solar cycle lengths and Northern Hemisphere temperature has been reported by (Friis-Christensen and Lassen 1991) as well as (Thejll and Lassen 2000). Also, (Alnaser and Merzaa, 2003) found that the temperature variations at Bahrain, were associated with the Schwabe solar cycle (sunspot number cycle). (Marsh and Svensmark 2000) have demonstrated significant correlation between low cloud cover and the galactic cosmic ray intensity.

While, (Reid 1987) examined the record of the globally averaged sea surface temperature and found that it has a long term cycle of 80-90 years, which may be a manifestation of the solar Gleissberg cycle. (Mouradian 2001), also showed that the century-scale solar periodicity is important for the Sun-Earth relationship.Moreover, investigation of the North Atlantic climate over the last two millennia shows cycles of 72-97 years, (Proctor et al. 2002). Also, the 80 year cycle was found in the Australian varves (Williams 1981), while varved sediments thickness of meer lakes in Germany showed variability similar to the solar Schwabe cycles (Vos et al. 1999). A study of tree rings also demonstrated presence of Suess and Gleissberg cycles (Kartavykh 2002).

(Lassen and Friis-Christensen 1995), reported a good correlation between the solar activity and Northern Hemisphere land temperature as a result of presence of 400 years cycle in both records. However, despite all these evidences, the exact physical mechanism of the solar-climate link is still being actively debated (Jorgensen and Hansen 2000), and (Laut 2003). Further research of the solar-climate relationship is necessary and reliable information about climatic changes over the long time scales is needed. That is why the Nile flooding record is of great importance. It covers more than millennium and thus its variability would expect to reflect the majority of the Sun's variations.

Early in the twentieth of the last century, the Nile flooding levels were used as an indirect indicator for the solar effect on the climate through a correlation of 0.36 between the sunspots number and the variability of (the Victoria Lake) the Nile level, (Shaw 1928).

In the present paper, the Nile floods have been used as a means to investigate cycles of its levels, which could be affected by solar activities.

2. DATA ANALYSIS

The Nile flood level record set is longest direct instrumental climatic record available now. It covers the period 640 up to 1891 AD, and have been published in many Arabic history books, e.g. (Al-Magrizi 1972), (Al-Dahabe 1994), (Ibn Tagryhribirdi 1970), (Al-Ayni 1988), and (Ibn-Gade Shohba 1997). Furthermore, all the data have been collected and compiled by (Basha 1890) and (Basha 1916), and the compilation has 1119 data points.There were many Nilometers since old kingdom, all of them used the same scale, Ell - which is called "Theraa" in Arabic - is equal to 54.04 cm, (Al-Glgashandi 1987). The data are taken from the Al-Rodah Nilometer, (Basha 1890) and (Basha 1916). The Nilometer at Al-Rodah is the oldest structure in Egypt built after the Arabs to measure the annual Nile flood. It was built in 861 AD by the order of the Abbasid Calipha Al-Mutawakkil (847- 861AD), under the direction of Ahmad ibn Muhammad Al-Hasib and devised by Ahmad ibn Muhammad Al-Farghani (Alfraganus). It is in the form of an octangular marble pillar, with twenty two Ell marks. The structure consists of a 2 m square stone-lined pit, 13.14 m deep, connected to the Nile by three tunnels; for more details refer to (Abouseif 1992) and (Hill and Golvin 1976). From the point of view of the agriculture, a level of sixteen Ells is good, and less than this figure points out to drought and hunger, and more indicates to the danger of flood capable of destroying the agriculture, (Al-Noayray1988).

Figure 1, illustrates the distribution of the Nile flood for a period of about 1250 years, starting by 640AD. It is seen that the average rate of the flood was approximately constant up to the mid of the fourteenth century and after that it started to increase gradually until the twentieth century. First historical announcement for the extreme increase of the flooding was by historian Ibn-Gade Shohba was in 784H (Hejra, Islamic calendar), corresponding to 1382 AD, indicated by the arrow in Figure 1. He said that an increase of this magnitude has never seen or heard before, it was more than twenty Ells.

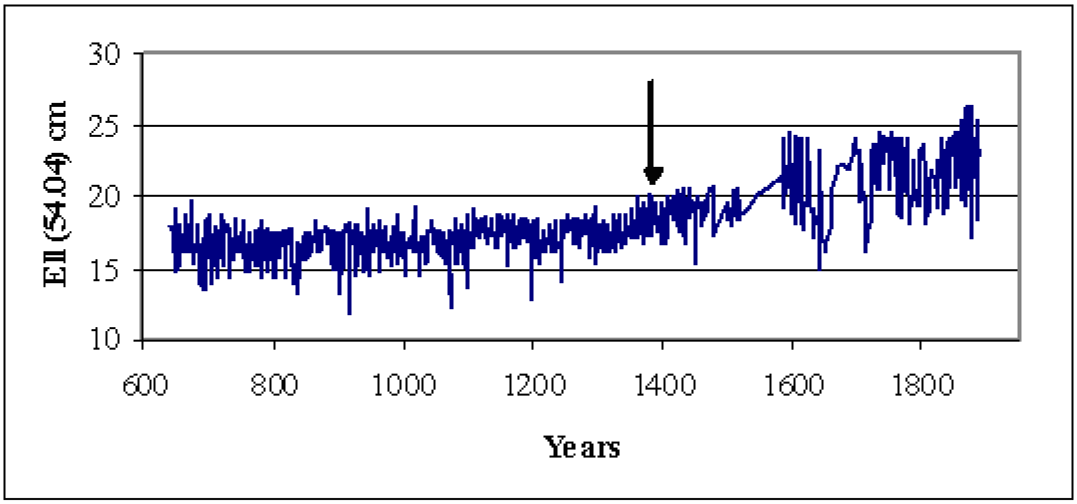

Figure 1. Yearly rate of the Nile river-flooding, between year 640 and 1891, based on Al-Rodah Nilometer. In 1382, the Nile level was over than twenty Ells, as mentioned by the Islamic historian Ibn-Gade Shohba.

Fourier spectrum of the data illustrates the presence of significant periodicities with confidence level above 95% for periods of 125, 74, 60 and 10.7 years, and with confidence levels of 81 and 87% for 420 and 210 years variations respectively, see Figure2.

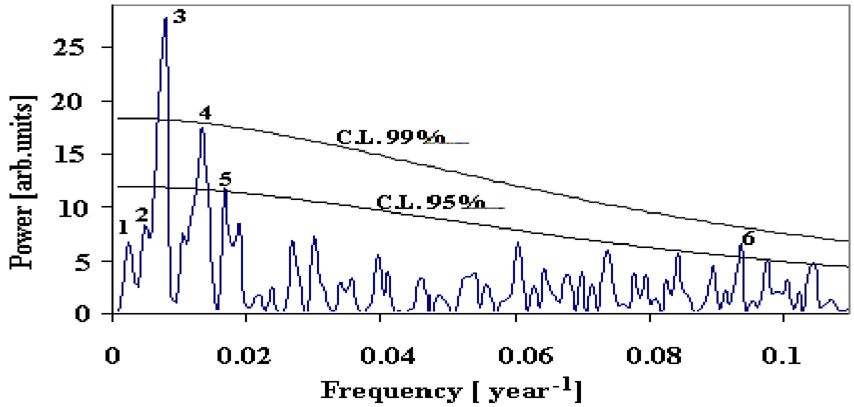

Figure 2. The amplitude spectrum of the Nile River flooding rate, presented in figure1. The first two peaks are for cycles of 420 and 210 years, while peaks 3, 4 and 5 correspond to cycles 125, 74 and 60 years, respectively. The last (no. 6) is for 10.7 years.

Few peaks around cycle 10.7, at the range of Schwabe frequency band(8-12 yrs),may be attributed to the influence of quasi 11-year solar Schwabe cycle. The cycles of 60 to 125 are within the frequency band of the Gleissberg solar cycle (it ranges from 50 to 140 years, according to (Ogurtsov et al 2002).The 210year and 420year periodicities may be a manifestation of longer-scale solar variability.

3. CONCLUSION

The climate variations prior to the industrial era may be strongly influenced by the variation in solar activity. One of the main difficulties in the solar-climatic analysis is indeed due to the scarcity of available experimental data sets. Thus, the information about the Nile water level since the seventh century is valuable for understanding the long-term climatic variations. The power spectrum analysis of the Nile River flooding shows different groups of centennial and multidecadal cycles. The majority of these cycles are typical both for terrestrial climate and for solar activity that may reflect the solar-climate relationship.

In fact, this study may be considered as an attempt for a better understanding of the ancient climate, its variability and possible connection with the changes in the solar activity. Further investigation is necessary for the clarification of this relation.

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تذبذبات فيضان نهر النيل واحتمال ارتباطها بالتغيرات الشمسية طويلة المدى

حسين باصرة
قسم الفلك، كلية العلوم، جامعة الملك عبد العزيز، جدة المملكة العربية السعودية

ملخص

تم في هذا البحث جمع البيانات الخاصة بفيضان النيل السنوي خلال الفترة الواقع ما بين القرن السابع إلى نهاية القرن التاسع عشر الميلادي من العديد من كتب التاريخ الإسلامي. وتعتبر هذه البيانات أطول تسجيل حضاري مناخي موجود حتى يومنا هذا. ثم عملت دراسات إحصائية لمعرفة الدورات التي حدثت لتغير مستوى نهر النيل خلال القرون الماضية حيث يتم الاعتماد على كثير من المعلومات والدراسات التاريخية للتوصل إلى حالة المناخ في تلك العصور الغابرة وإلى وجود روابط طبيعية لما يحدث من تغيرات مناخية وإمكانه ارتباطها بتغير نشاطات الشمس الدورية.وقد أشارت التحاليل الرياضية التي طُبقت على بيانات النيل إلى وجود تغيرات دورية مشابهة لدورات النشاط الشمسي. وقد كانت دورات شواب و فليسبرغ موجودة بنسبة تفوق 95%. وبدقة اقل الدورات الطويلة والمتوسطة. هكذا فان التشابه ما بين التغيرات الشمسية والتغيرات المناخية التي أثرت على الحالة الجوية لمنابع النيل يشير إلى احتمالية وجود علاقة مابين التغيرات الطبيعية التي تحدث في الشمس والتغيرات المناخية الحاصلة على كوكب الأرض، كما أن نتائج هذه الدراسة تتفق مع بعض الدراسات التي كان فيها البحث عن الدورات بنطاقات ترددية.