Climate Change: Global, Regional and National Dimensions

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Abstract

Solar activities have had notable effect on palaeoclimatic changes. Contemporary solar activities are so weak and hence expected to cause global cooling. Prevalent global warming, caused by building-up of green-house gases in the troposphere, seems to exceed this solar effect. This paper discusses this issue.

River Nile is the principal source of water to Egypt. Hence the climates of the Nile Basin are of special importance. Egypt and the 9 countries that share the Basin need to develop a regional circulation model that would enable them to forecast future climate changes.

Recent changes in climate parameters over Egypt and its impacts have been assessed, and efforts towards mitigation and adaptation to climate change were reported in the national communication to COP, 2009.

1-Introduction

The United Nations Secretary General Ban –Ki moon at COP-14, in Pozna, (Dec.2008)* stated that "Climate change has long since ceased to be a scientific curiosity, and is no longer just one of many environmental and regulatory concerns. It is the major, overriding environmental issue of our time, and the single greatest challenge facing decision makers at many level". Climate change has become a prominent item on the agenda of world concerns. It is a growing crisis with economic, health and safety, food production security, and other dimensions. There is alarming evidence that important tipping points, leading to irreversible change in major earth systems and ecosystems, may already have been reached or passed. The change of climate is pushing many earth systems towards critical thresholds that will alter regional and global environmental balances and threaten the world at multiple scales.

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* The fourteen session of the conference of parties of the UN framework convention on climate change

Questions are being asked, hypotheses are being proposed, trying to identify the real forces that drive the global climate change. Is it a geological issue or cosmological issue or an issue of social behavior? In this paper we try to discuss the solar activities and its effects on the climate changes. The regional and recent changes in climate parameters over Egypt and its impacts will be addressed in this paper.

2-Deep Solar Minimum of Cycle 23

Solar activity affects the climate but seems to plays only a minor role in the current global warming. For example the Earth's temperature has risen perceptibly in the last 30 years while the solar brightness has not appreciably increased in this time (Krivova and Solanki 2003, Krivova and Solanki 2004). The average solar activity has declined rapidly since 1985 and cosmogenic isotopes suggest a possible return to Maunder minimum conditions within the next 50 years.

The present part of this paper examines the deep minimum of solar cycle 23 and its likely impact on climate change. In addition, a source region of the solar winds at solar activity minimum, especially in the solar cycle 23, the deepest during the last 100 years, has been studied. Is this episode comparable to the Maunder Minimum or is it like the Dalton Minimum? Furthermore, the near future solar cycle 24 and prediction of its conditions are presented. The solar cycle 23 started in April 1996 and had its peak in early 2000, 2001. The decline phase of this period extended from 2002 until December 2009, which is the longest decline phase in the last 23 solar cycles. Solar cycle 24 started in 2009, it was a late starter, about three and a half years later than the average of the strong cycles in the late 20th century and almost three year later than the weak cycles of the late 19th century. For more details about solar cycle 23 activities and its statistics, see for example Hady (2002), Hady and Shaltout (2004) , and Hady (2009). Figure (1) shows the length of the last 5 solar cycles 19, 20, 21, 22,23, in the left hand side part and the cycle 23 behavior and the cycle 24 prediction according to Marshall space flight center, NASA. We may observe the length of solar cycle 23 that extended for 13.5 years starting from April 1996, and it is a very weak cycle compared with solar cycle 19, Hathaway (2010).

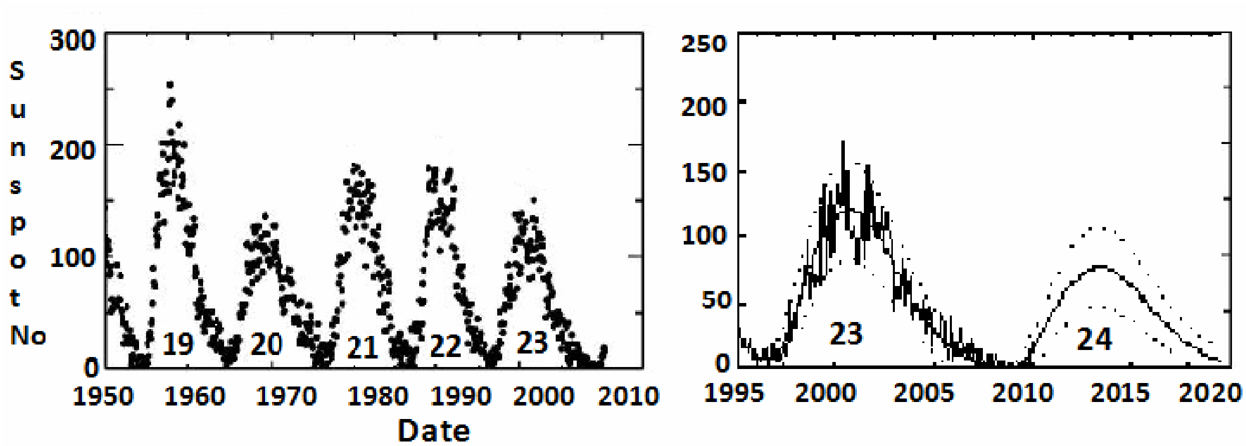

Figure (1): sunspot cycles, and cycle 24 prediction.

The monthly and yearly mean of sunspots during the solar cycle 23 and its decline phase until December 2009 are given in table (1). The data used to prepare table (1) and table (2) were obtained from Kandilli Observatory, Bogazici University, Turkey.

Table (1): Monthly and yearly means of sunspot numbers of solar cycle23

Year 2001 is the maximum solar activates of cycle 23:
Monthly means: 95.6 80.6 113.5 107.7 96.6 134.0 81.8 106.4 150.7 125.5 106.5 132.2
Yearly Mean: 110.58

Year 2003 is the year of starting decline phase of cycle 23
Monthly means: 79.7 46.0 61.1 60.0 54.6 77.4 83.3 72.7 48.7 65.5 67.3 46.5

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Yearly Mean: 63.57
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Year 2006 is the year of staring solar minimum of cycle 23
Monthly means: 15.3   4.9   10.6   30.2   22.3   13.9   12.2   12.9   14.4   10.4   21.5   13.6
Yearly Mean: 15.16
------------------------------------------------------------
Year 2007 continuous of minimum of cycle 23:
Monthly means: 16.8   10.7   4.5   3.4   11.7   12.1   9.7   6.0   2.4   0.9   1.7   10.1
Yearly Mean: 7.5
Spotless Days 149 of 365 days ( 41% spotless days)
------------------------------------------------------------
Year 2008 continuous of minimum of cycle 23:
Monthly means:  3.3   2.1   9.3   2.9   3.2   3.4   0.8   0.5   1.1   2.9   4.1   0.8
Yearly Mean: 2.85
Spotless Days 266  of 366 days ( 73% spotless days)
------------------------------------------------------------
Year 2009 continuous of minimum of cycle 23
Monthly means: 1.5   1.4   0.7   0.8   2.9   2.9   3.2   0.0   4.3   4.6   4.2   10.6
Yearly Mean: 3.1
Spotless Days  274 of 365 days (75% spotless days)
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From the table (1) we note the spotless days during years 2007, 2008, 2009. During 2008 there were no sunspots observed on 266 days of the year's 366 days (73%), during 2009 the spotless days were 274 of 365 days (75% spotless days). These represent the deepest minimum compared with records of the 20th century. The sun is in a phase of unusually low activity, as indicated by sunspots numbers and spotless days; this depends on recorded observations to detect this change of the sunspot numbers for a long period during the 20th century. Figure (2) shows the spotless days in years of the 20th century.

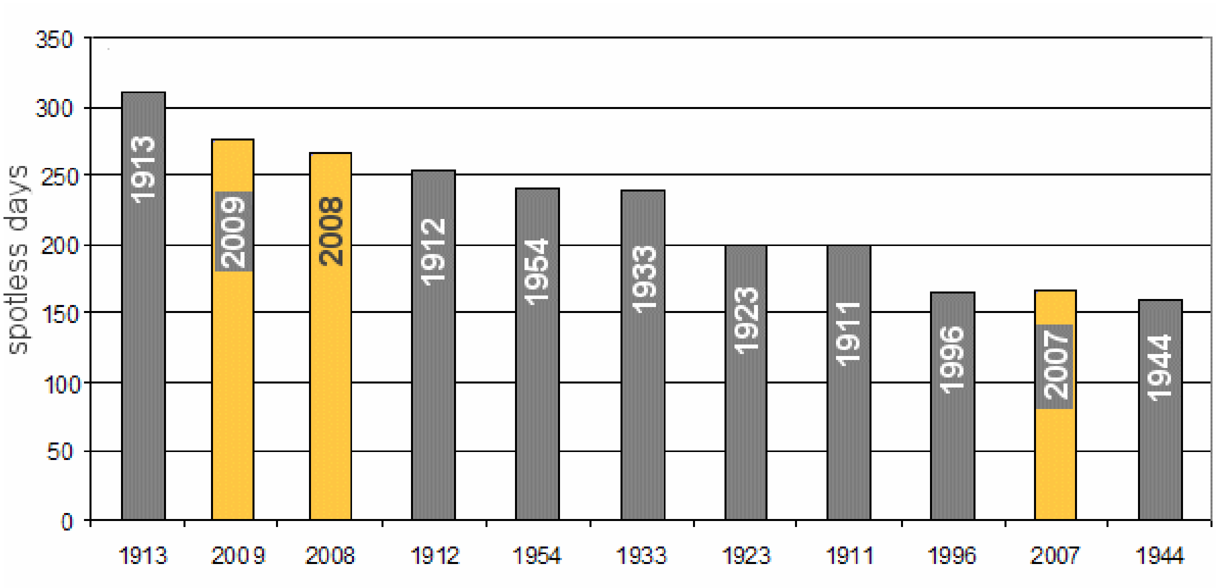

Figure (2) Sunspot counts for spotless years during the 20th century. The years 2007, 2008, 2009 are the years of minimum of solar cycle 23.

Monthly and yearly means for the flare index during the maximum activity of the solar cycle 23, and its decline phase until December 2009 are given in table (2). Data in table (2), show that the yearly means of flare index are less than 0.5 starting from year 2006 , which means that reduced solar activity appears starting from year 2006.

Table (2): Monthly and yearly flare index of solar activity full disk of the solar cycle 23

Year 2001 is the maximum solar activates of cycle 23 Yearly Mean = 6.80 Monthly Means: 2.76 1.25 7.65 10.20 2.89 4.86 1.84 6.38 11.77 9.50 10.95 11.39 --- **Year 2003 is the year of starting decline phase of cycle 23:** Yearly Mean = 3.46 Monthly means: 2.69 1.55 3.33 2.62 4.35 4.54 2.55 1.59 0.77 12.11 4.53 0.68 --

Year 2006 is the year of staring solar minimum of cycle 23
Yearly Mean = 0.54
Monthly means: 0.03 0.00 0.11 0.53 0.03 0.01 0.28 0.14 0.19 0.05 0. 4.89

--- **Year 2007, continuous of minimum of cycle 23**
Yearly Mean = 0.47
Monthly Mean: 0.49 0.01 0.01 0.02 0.24 1.53 1.16 0.21 0.00 0.00 0.01 1.88

Year 2008, continuation of minimum of cycle 23
Yearly Mean = 0.03
Monthly Means: 0.05 0.00 0.20 0.06 0.00 0.00 0.00 0.00 0.00 0.00 0.03 0.00

Year 2009, continuation of minimum of cycle 23
Yearly Mean= 0.027
Monthly Means: 0.04 0.00 0.03 0.06 0.00 0.00 0.00 0.00 0.00 0.00 **0.03** **0.20**

Prediction of the behavior of a sunspot cycle is fairly reliable once the cycle is well underway. A number of techniques are used to predict the amplitude of a cycle during the time near and before sunspot minimum. Relationships have been found between the size of the next cycle maximum and the length of the previous cycle, the level of activity at sunspot minimum, and the size of the previous cycle. The method used for solar cycle predictions depends on Feynman and Wilson methods see for example (Hathaway et al. 1994, 1999, and Wilson et. al. 2009). We shall show only the statistical results of our solar cycle predictions compared with all solar cycles as given in table (3).

Table (3): Minimum and maximum of sunspot in the series of solar cycles

Sunspot Cycle Number	Year of Min	Smallest Smoothed Monthly Mean	Year of Max	Largest Smoothed Monthly Mean	Rise to Max (Yrs)	Fall to Min (Yrs)	Cycle Length (Yrs)
1	1755.2	8.4	1761.5	86.5	6.3	5.0	11.3
2	1766.5	11.2	1769.7	115.8	3.2	5.8	9.0
3	1775.5	7.2	1778.4	158.5	2.9	6.3	9.2
4	1784.7	9.5	1788.1	141.2	3.4	10.2	13.6
5	1798.3	3.2	1805.2	49.2	6.9	5.4	12.3
6	1810.6	0.0	1816.4	48.7	5.8	6.9	12.7
7	1823.3	0.1	1829.9	71.7	6.6	4.0	10.6
8	1833.9	7.3	1837.2	146.9	3.3	6.3	9.6
9	1843.5	10.5	1848.1	131.6	4.6	7.9	12.5
10	1856.0	3.2	1860.1	97.9	4.1	7.1	11.2
11	1867.2	5.2	1870.6	140.5	3.4	8.3	11.7
12	1878.9	2.2	1883.9	74.6	5.0	5.7	10.7
13	1889.6	5.0	1894.1	87.9	4.5	7.6	12.1
14	1901.7	2.6	1907.0	64.2	5.3	6.6	11.9
15	1913.6	1.5	1917.6	105.4	4.0	6.0	10.0
16	1923.6	5.6	1928.4	78.1	4.**8**	**5.4**	**10.2**
17	**1933.8**	**3.4**	**1937.4**	**119.2**	**3.6**	**6.8**	**10.4**
18	**1944.2**	**7.7**	**1947.5**	**151.8**	**3.3**	**6.8**	**10.1**
19	**1954.3**	**3.4**	**1957.9**	**201.3**	**3.6**	**7.0**	**10.6**
20	**1964.9**	**9.6**	**1968.9**	**110.6**	**4.0**	**7.6**	**11.6**
21	**1976.5**	**12.2**	**1979.9**	**164.5**	**3.4**	**6.9**	**10.3**
22	**1986.8**	**12.3**	**1989.6**	**158.5**	**2.8**	**6.8**	**9.7**
23	**1996.4**	**8.0**	**2000.3**	**120.8**	**4.0**	**10.0**	**13.5**
Author's estimation of cycle 24							
24	**2009.96**	**9.0**	**2015.2**	**105.0**	**5.24**	**7.8**	**13.o4**
Mean Cycle Values:		**6.1**	**113.2**		**4.7**	**6.3**	**11.0**

From the tables and figures we can conclude that the solar activity are rapidly inclined downward from about 30 years ago and will continue for the next 50 years. Solar activities have had notable effect on palaeoclimatic changes. The surface warming and the solar cycle in times of high solar activity are on average 0.2°C warmer than times of low solar activity. Prevalent global warming, caused by building-up of green-house gases in the troposphere, seems to exceed this cooling solar effect. Figure (3) compares the changes during last 150 year for solar cycle variations, earth surface temperature, and CO_2 variability. We notice that agreement for the parameters variation occurred until the year 1960. There is no agreement between solar cycle variations and Earth surface temperature after the CO_2 increasing dramatically from the year 1960.

The scientific consensus is that solar variations do not seem to play a major role in determining present-day observed climate change, but have played a major role in palaeoclimatic changes, for example, the climate cooling during the Maunder minimum (from year1645 until 1710), and Dalton minimum (from year 1797 until 1825) was due to the solar activities collapse.

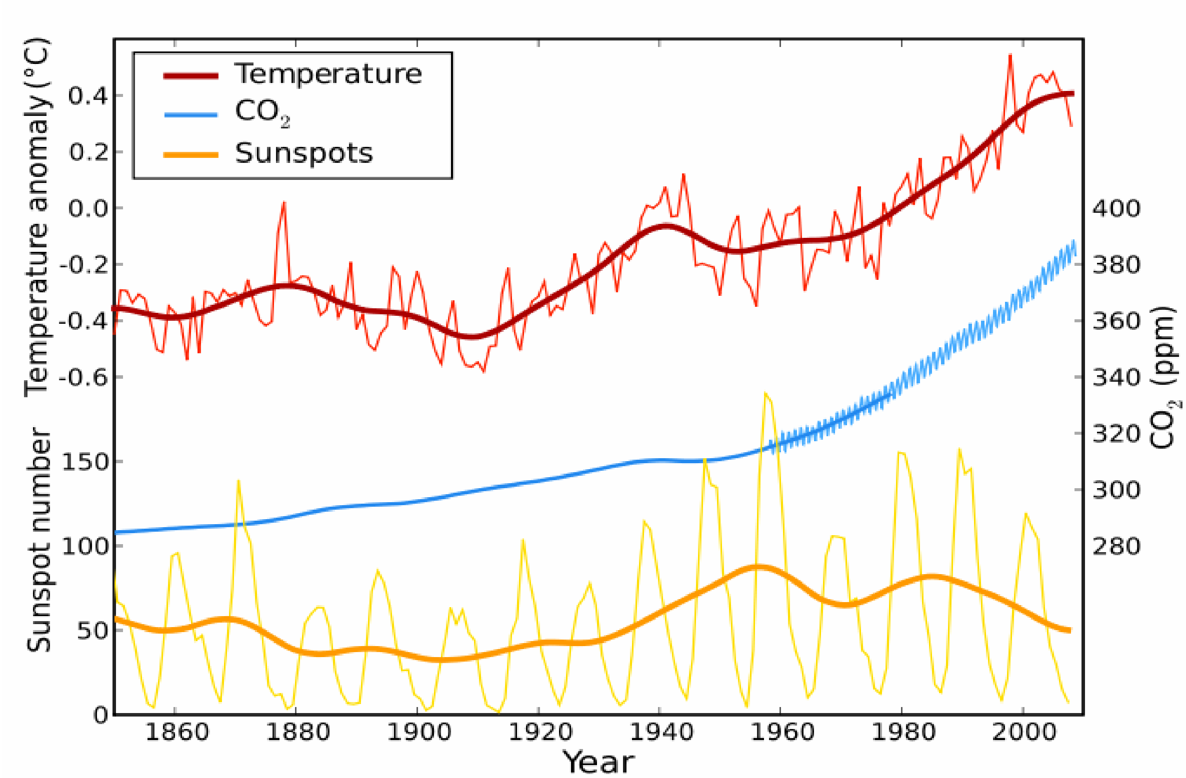

Figure (3): Temperature, Co_2 concentration in the troposphere, and sunspots variations starting year 1850 until 2010.

Due to the paucity of sunspots in the Maunder Minimum (1645 – 1710), ^{14}C data provides evidence for the presence of solar cycles and their length. According to Makarov and Tlatov (2007), solar cycles averaged 20 years long in the Maunder (See Callebaut 2008). In Figure (4), ^{14}C Count Variation in the bi-annual rings of the pine-trees from south Urals for 1600-1730 are shown, the solar minimum marked with vertical lines. The numbers along lower part of the figure are the length of the solar cycles from minimum to minimum measured in years.

To compare the start of the Maunder Minimum with current day minimum, Watts Anthony (2009) marked that the maximum of Solar Cycle 24 would be in 2015, that is, 15 years after the peak of the preceding cycle. There is also a parallel in the way that the ^{14}C is climbing above the peaks of previous minimum, as it is today with the Oulu neutron count. Neutron count tends to peak a year after solar maximum, so a neutron peak in 2010 is consistent with solar minimum in 2009. From Figure (4), a repeat of the Maunder Minimum can be expected; the neutron flux will remain well above the levels reached in the minimum of the second half of the 20th century. Activity and timing of the current minimum, as well as the timing of the Solar Cycle 24 maximum in 2015 compares with the start of the Maunder Minimum. There is no data to date which diverge from the pattern of the start of the Maunder Minimum, Hathaway (2008).

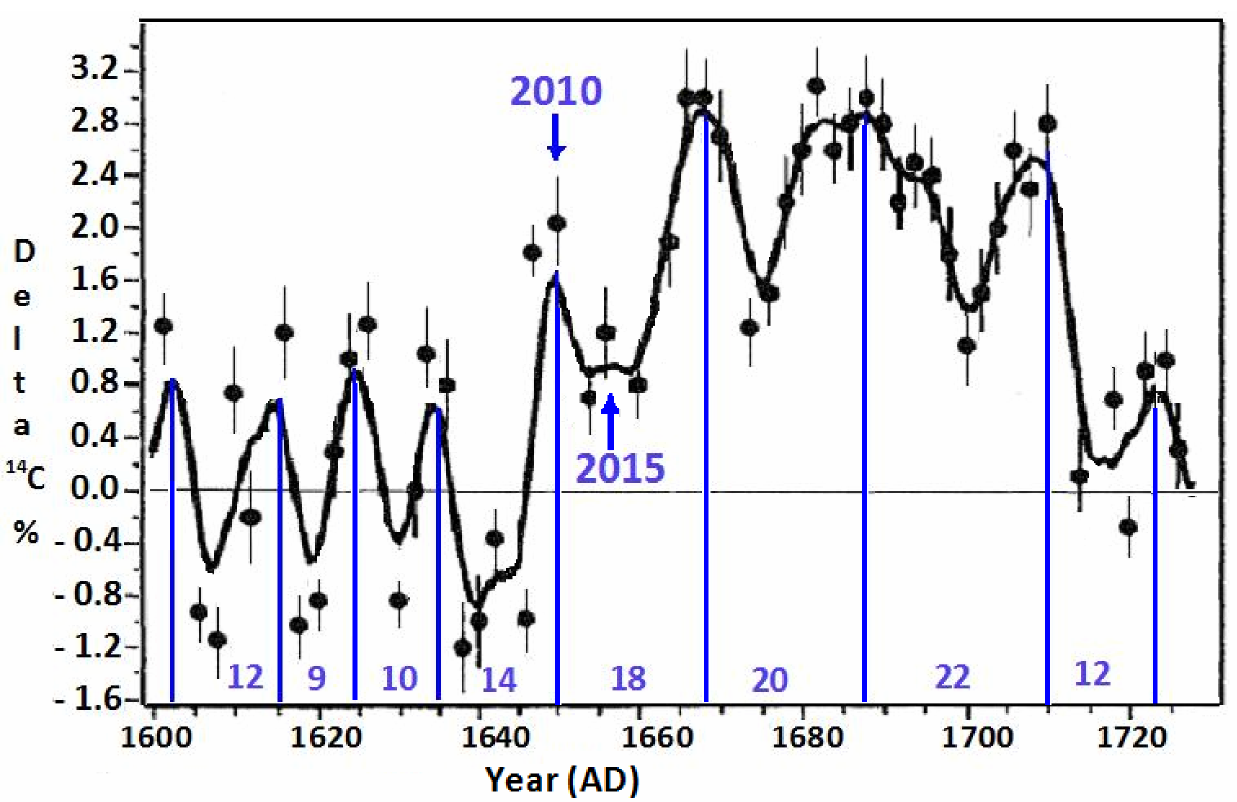

Figure (4): Solar cycles during the Maunder minimum, the solar minimum marked with vertical lines. The numbers along the lower part of the figure are the length of the solar cycles from

minimum to minimum in years. The suggested comparison with years 2010, 2015 was marked by Watts A. (2009).

Is the Dalton minimum repeat possible? This question was asked after the deep solar minimum of cycle 23 and ending up at 13.5 years long. The Solar Cycle 24 was a late starter, about three and a half years later than the average of the strong cycles in the late 20th century and almost three year later than the weak cycles of the late 19th century. Figure (5) shows the similarity of the solar cycles behavior during Dalton minimum years and the last two solar cycles 22 and 23, the prediction of solar cycles 24, 25,26 agree with this supposition, Callebaut (2008), Watts A. (2010).

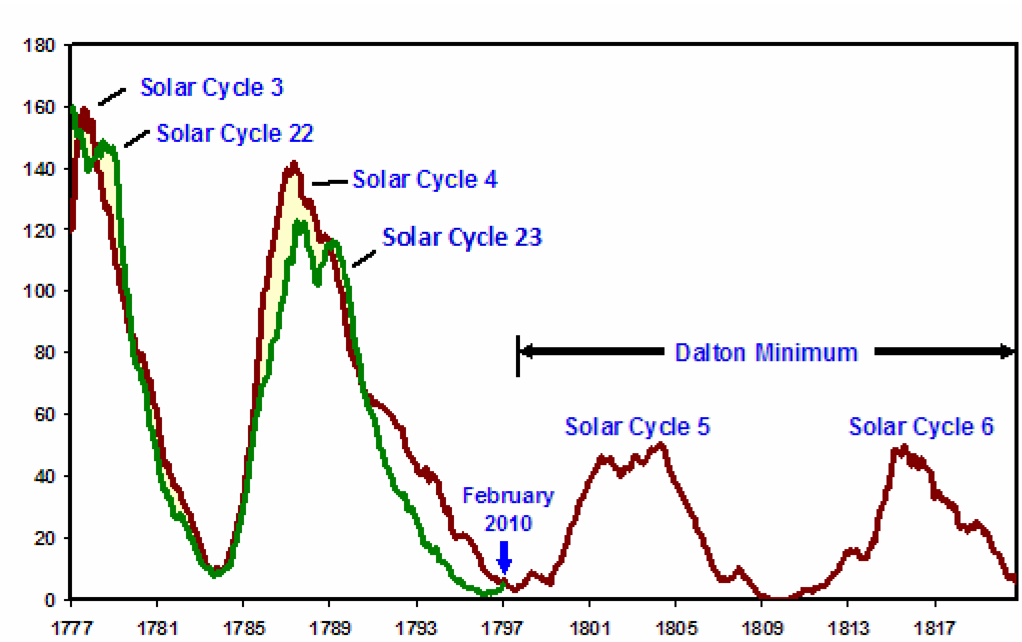

Figure (5): show the Dalton minimum era and the Solar Cycle 22 and 23 are overlaid on solar cycle 3 and 4 above to show similarity

We can conclude the following: Solar activities have had notable effect on palaeoclimatic changes. Contemporary solar activities are so weak and hence expected to cause global cooling. Prevalent global warming, caused by building-up of green-house gases in the atmosphere, seems to exceed this solar effect.

3- Regional climates of the Nile basin: past and future

The river Nile runs in a south to north alignment for 35^{o} of latitude: from Lake Tanganyika (Lat 4^{o}S) to the Mediterranean (Lat 31^{0}N). Its basin is shared by 10 countries: Zaire, Burundi, Rwanda, Tanzania, Uganda, Kenya, Eritrea, Ethiopia, Sudan and Egypt, and spans a very wide spectrum of climates from humid tropics to deserts, see Kassas (2001).

The Nile has a very complex geological history, but its present form with it summer floods and its diverse sources is relatively recent (10-20 thousand years, see Said, 1993, for details). Climate changed during that period dramatically. From 16000 B.C.E. until now the climate has been changed a few times. Figure (6) shows the maps of the expansion of the Sahara around 16000 - 7000 B.C.E., see Combaz A. (1985), great lakes that previously existed in the present-day desert regions of Mauritania, Chad, northeast Ethiopia or southern Africa dried up within one or two millennia, the dune massifs advanced several hounded kilometers southwards to the regions where precipitation currently borders on 800 mm/yr.

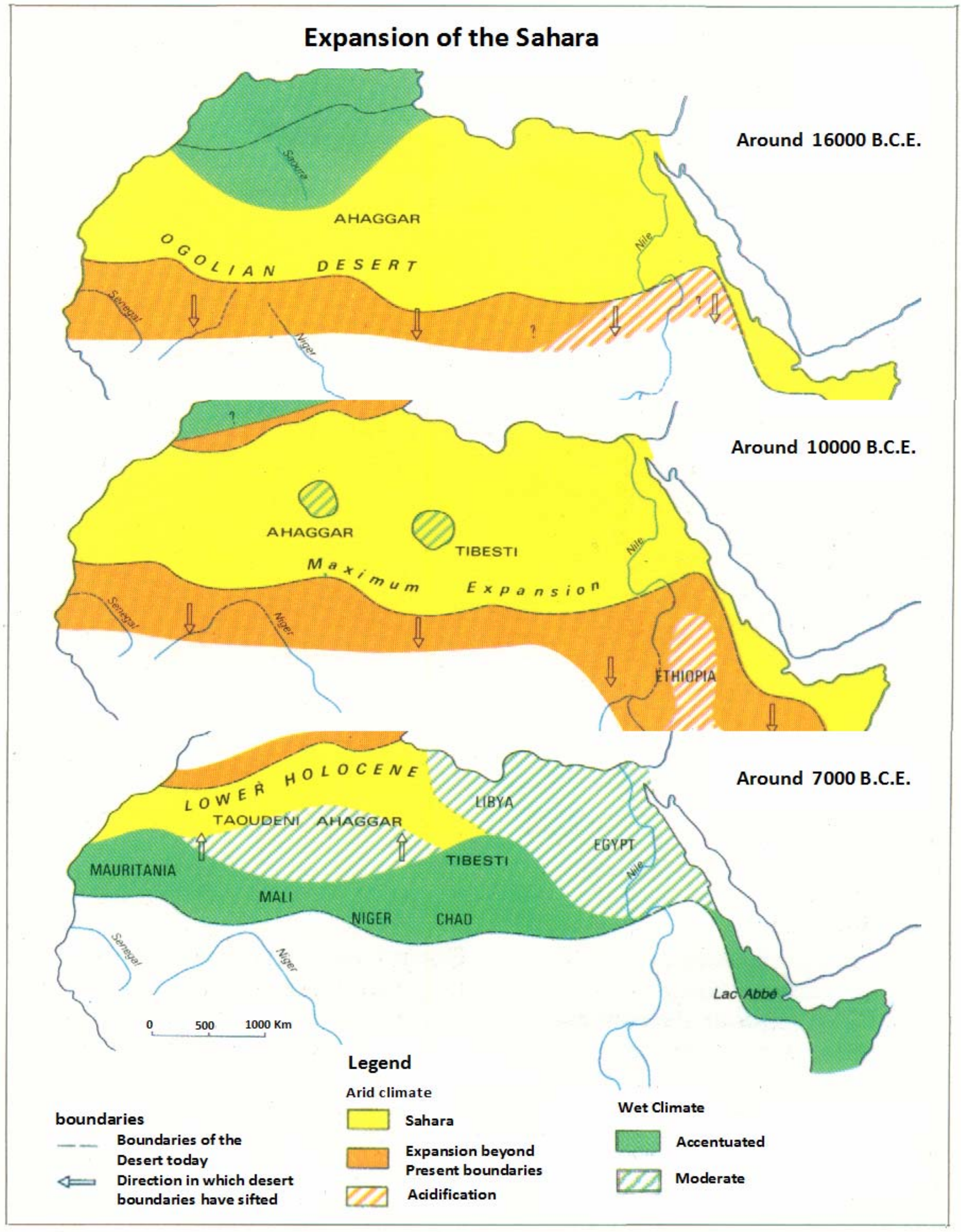

Figure (6): The expansion of the Sahara around 16000 - 7000 B.C.E., (Combaz 1985).

The human history associated with the river Nile provided part of the world cultural heritage, especially during the Pharaonic history. Climate controlled occupation in the Eastern Sahara during the main phases of Holocene. Rainfall zones are delimited by best estimate isohyets on the basis of geological and archaeological data, as shown in figure (7). In the part (A) of the figure is shown the abrupt arrival monsoon rains 8500 B.C.E. , part (B) after 7000 B.C.E., human settlements became well established all over Eastern Sahara, fostering the development of cattle pastoralism. In part (C) Retreating monsoonal rains caused the onset of desiccation of the Egyptian Sahara at 5300 B.C.E. prehistoric populations were forced to move to the Nile valley as ecological refugees. The return of full desert conditions all over Egypt at 3500 B.C.E. coincided with the initial stages of Pharaonic history in the Nile Valley (Kuper &Kroperlin 2006).

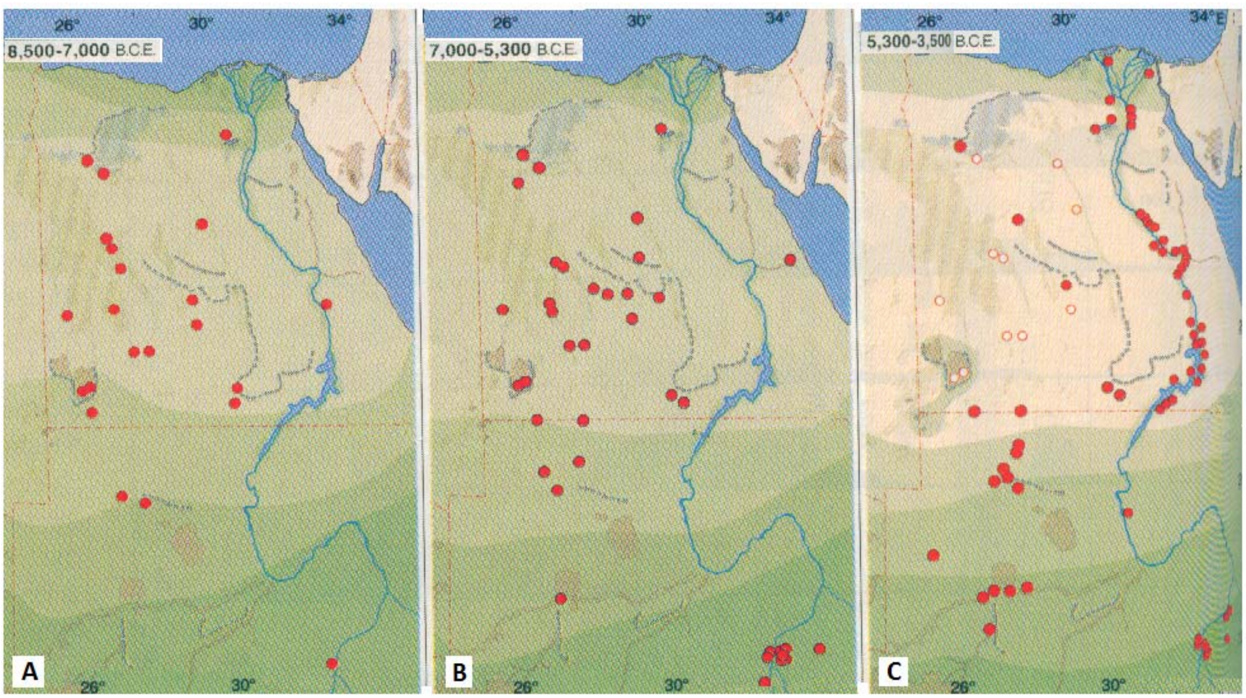

Figure (7) shows map of the archaeological sites in the western Desert in 8500-700 B.C.E. (part A), 7500-5000 B.C.E.(Part B) and then during 5300- 3500B.C.E.(Part C). Red (gray) dotes indicate major occupation areas, white dots indicate isolated settlements in ecological refuges and episodic transhumance. The Saharan desert was void of any settlement outside of the Nile valley and extended about 400 Km farther south than it does today (Kuper &Kroperlin 2006).

With the pending climate changes that seem likely to prevail later in the 21st century, the countries of the Nile Basin need to be able to forecast the manifestations of these changes in the basin. The available GCM seem unable to do this forecast (IPCC, 1998, pp 47-48). A regional circulation model, or a series of sub-regional models, each addressing one of the 5 climate systems prevalent within the Basin (Kassas, 2001), need to be developed. This would be a major undertaking that requires region-wide collaboration and substantial technical assistance.

4- National needs

Due to the impact of climatic change on industry, agriculture, energy use and all other aspects of human life, a national research program in Climate change is very important.

General climate of Egypt is dry, hot, and desert type. During winter, climate of Lower Egypt (the Northern part) is mild with some rain showers, mainly over coastal areas. Upper Egypt is practically rainless with warm sunny days, but rather cool nights.

The data collected by Egypt Meteorological Authority and local universities for the period 1961-2000 have been analyzed and the following results were deduced (El-Shahawy, 2007).

1. The mean atmospheric pressure has positive trend +0.026 hPa/year.

2. The mean maximum air temperature has positive trend of +0.34 ^{0}C /decade

3. The mean minimum air temperature has positive trend of +0.31 ^{0}C /decade

4. Positive trend in mean annual relative humidity of air of + 0.18% /year.

5. Negative trend in sunshine duration of – 0.01 hours per year.

6. Negative trend in mean annual total radiation of – 0.09 MJ/m2

These data indicate that there is a climate change trend associated with the global warming. It is also concluded that there are increases in the number of hazy days, misty days, turbidity of the atmosphere, frequency in sand storms and incidents of hot days (over 45 ^{0}C). The frequencies of events of rising sand, sand storm, haze, thunder storm and flash floods in Egypt are taken as indicator of enhanced climatic variabilities. Extreme weather events in the last three decades have been studied from two points of view, frequencies and severity. The number of days of maximum temperature equaling or exceeding 45 ^{0}C have increased in Upper Egypt from 50 days in the first decade to 52 in the second and reached 69 days in the last decade of the 20th century. In the Western Desert, the extreme hot days were 37 in the last decade, while it was only 22 days in each of the previous decades. The rest of Egypt did not experience increase in the number of days with peak temperature 45 ^{0}C or more. The Mediterranean coast of Egypt experienced successive increase in the amount of annual rainfall during the last three decades. The mean trend over the area is + 0.76 mm. per year. (El-Shahawy, 2007). The potential social and economic impacts of climate change would be serious on the country's future. The main key sectors relevant to climate change are; energy, transportation, industry, agriculture and wastes. Their activities produce GHG emissions.

To mitigate climate change, Egypt need to develop renewable source of energy, to use it as fuel in industry and transport, domestic and industrial programs, energy-efficient buildings, and agriculture. Promotion of energy efficiency is to develop environment-friendly energy and to reduce GHG emissions. Further reductions of GHG emissions from the energy sector up to the year 2027, can be achieved through many actions. These actions as prioritized for Egypt's mid-term strategy include renewable energy, energy efficiency, lower carbon fuels, nuclear power and improved transportation fleets. In the area of mitigating industrial GHG emissions, the sector of cement in Egypt is responsible for 17 Million tons of CO_2 emissions per year, which is about 68% of the total GHG emissions of the industry sector. Egypt's Industrial Development Strategy issued in 2006 integrates climate change into national development priorities, and creates market for the climate and environment friendly technologies. (From Egypt second national communication, 2009, and Egyptian Environmental Affair Agency report 2001).

The Nile Delta region is presently subject to changes; including shoreline changes due to erosion and accretion, subsidence and sea level rise due to climate changes. It is well known that the delta suffers from land subsidence that increases from west to eest. Hence it is highly vulnerable to potential impacts likely sea-level rise. A national research program on climate change is very important now. This program may include exploring means for protecting the sea coasts against likely sea-level rise.

5 – Conclusions

From this paper, we can conclude the following:

1- Although the solar activity during the last 30 years has a deep minimum there is a global warming. The solar variations of it activities do not seem to play a major role in determining present-day observed climate change, Prevalent global warming, caused by building-up of green-house gases in the atmosphere, seems to exceed and hence mask this solar effect, but it played a major role in palaeoclimatic changes, for example, the climate cooling during the Maunder minimum and Dalton minimum was due to the solar activities collapse.
2- To manage the water resource of Nile Basin and to forecast possible changes to be associated with rending climate changes, we need to develop a regional circulation model, or a series of sub-regional models, each addressing one of the 5 climate systems prevalent within the Basin. This would be a major undertaking that requires region-wide collaboration and substantial technical assistance.

3- In the local side, high effects of the climatic change are expected on industry, agriculture, energy use and all other aspects of human life in Egypt. To mitigate climate change, Egypt need to develop renewable source of energy, to use it as fuel in industry and transport, domestic and industrial programs, energy-efficient buildings, and agriculture. A national research program on climate change is very important now. This program may include exploring means for protecting the sea coasts against likely sea-level rise.

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