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80–120 yr Long-term solar induced effects on the earth, past and predictions

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Abstract

The 80–120 year solar Wolf-Gleissberg cycles have wide effects on the Earth's environment. Studying past effects can throw light on future predictions of solar terrestrial relations at similar solar activity levels. Solar induced climate changes do happen at the turning points of such cycles when changes in solar spin rates occur. Reversing of North Atlantic Oscillations can be interpreted in terms of solar stimuli. The sudden abrupt rises of lakes levels and closed seas are solar forced. It is anticipated that the Aral and the Dead Sea will recover in the near future. Following drought conditions in African Equatorial lakes by the end of cycle 23 around 2008 ± 2 yr, cyclic rises and falls of lakes level are expected to be coherent with the weak cycles 24 to perhaps 26 when solar forcings will reverse or cease to exist.

The Atlanto Canadian fish disappearance dilemma is a natural Wolf-Gleissberg cycle induced effect and is expected to recover in due time.

Keywords: Wolf-Gleissberg cycles; NAO; Lakes levels; Fish disappearance; El nino

1. The Wolf-Gleissberg cycles, (WGCs)

The Sun has three types of solar magnetic cycles (Nesme-Ribes et al., 1994); the Maunder minimum type, the normal 11 yr cycles and the weak magnetic cycles mostly of 12 yr duration. Those weak cycles occurred around 1800 (cycles 5–7), 1900 (cycles 12–14 and possibly 15) and 2000 (cycles 23–25 and possibly 26), see Yousef (1995, 1998, 2003). Different types of solar cycles are shown in Fig. 1. On smoothing, larger scale (80–120 yr) solar magnetic cycles. known as the Wolf-Gleissberg cycles (WGCs) become distinguished (Fig. 2).

A series of weak cycles occur intermediate between two successive WGCs. Those WGC cycles generally have two maximums of strong normal cycles separated by one or two weak cycles, e.g. the strong solar cycles 19 and 21 were separated by the weak cycle number 20.

The solar spin rate is generally faster during the start of weak cycle series as evident from Fig. 3 for the weak cycles earlier than 1900 and for cycle 20 in the 1960s (Hoyt and Schatten, 1997). This faster rotation rate leads to a reduction in solar energy budget emitted from the sun in all wavelengths as well as solar wind.

Solar induced climate change do occur at the turning points of those WGCs whenever there is a change in the solar spin rate. Solar induced climate changes do occur at the start, end of those weak cycles and following the WGC maximums (Yousef, 2000b).

The present solar cycle number 23 is the first of weak cycle series, the last solar induced climate change did occur around 1997 with the start of those weak cycles at the end turning point of WGC (Yousef, 2003).

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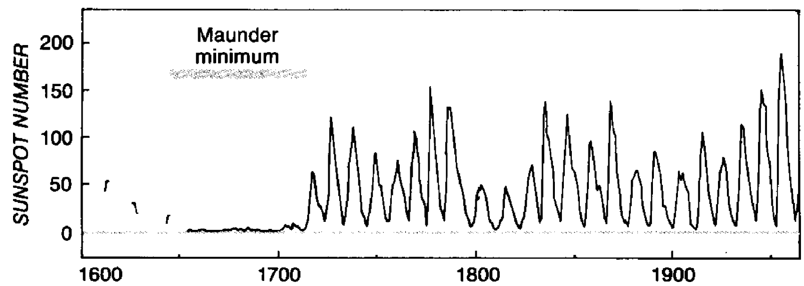

Fig. 1. Time Series of Sunspot number. Notice the weak cycles number (5, 6 and 7) around 1800 and (12, 13, 14 and 15) around 1900.

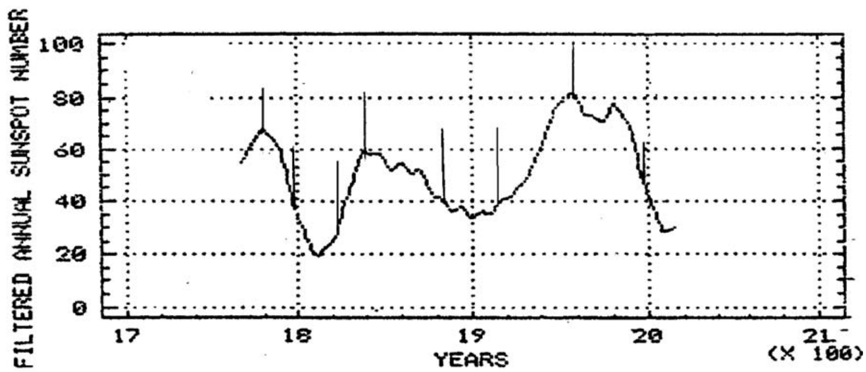

Fig. 2. The 80–120 yr solar Wolf-Gleissberg cycles for the period (1770–2010). They are evident on smoothing of Fig. 1. Note some of the turning points of those cycles indicated by vertical lines. Climate changes do occur at those turning points. Note the 1878 end turning point when weak cycles started. Start turning points occur at the termination of weak solar cycles at the start of WGCs. Note also the Maximum turning point 1957–1959 (maximum of cycle 19) followed by the weak cycle number 20. Climate change did occur in the 1960s. The secondary maximum occurred around 1980. Note also the 1997 start of weak cycle number 23 which is the first weak cycle of a series thus caused the 1997 solar induced climate change.

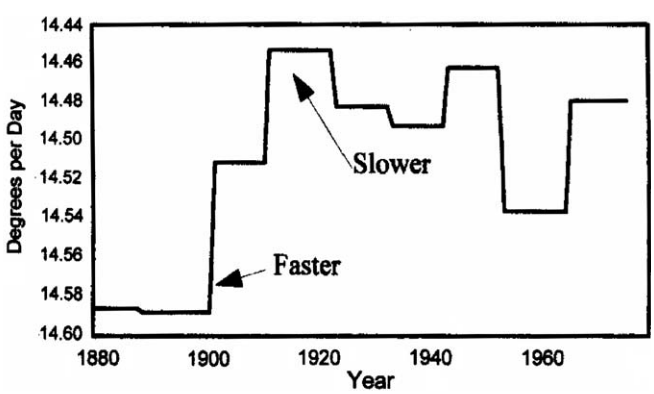

Fig. 3. The Solar equatorial rotation rate: 1880–1900 faster rotation rate is due to the first two weak cycles of the weak series. Slower rotation rate happened for the following weak cycles. Solar induced climate changes occur whenever there is a change in the rotation rate. This change in rotation rate is deeply rooted in the layers underlying the photosphere. Faster rotation (weak cycles) means lower energy budget emitted from the sun (Hoyt and Schatten, 1997). Slower rotation means higher flux emitted irradiance in all wavelengths.

2. Effects of Wolf-Gleissberg cycles on earth

2.1. Effects on pressure

(a) Effect on North Atlantic oscillations
(b) Effect on El Nino southern oscillations

These effects would lead to changes in the general wind circulation at Wolf-Gleissberg cycles turning points. Note that coronal mass ejections collide with the Earth's atmosphere, induce magnetic storms and increase pressure in some locations and reduce it in others.

2.1.1. North Atlantic oscillations

It is measured in terms of the normalized pressure difference between the area of low pressure that usually occurs over Iceland and the high pressure region in the vicinity of the Azores (Burroughs, 2003). It is of particular interest in winter (from November to March). When the Icelandic low is particularly deep and the Azores high is well defined, then the circulation is strong and the NAO index is positive. Conversely, when the gradient is reduced or even reversed with high pressure near Iceland and low pressure near the Azores, the index is negative. When NAO index is positive, it produces strong westerly winds over the North Atlantic and the reverse pattern with much weaker circulation.

The pattern of NAO can be interpreted in terms of solar forcings:

(a) 1880–1900, with the start of the first two weak solar cycles in the series of faster rotational rate, the smoothed NAO index alternate signs.

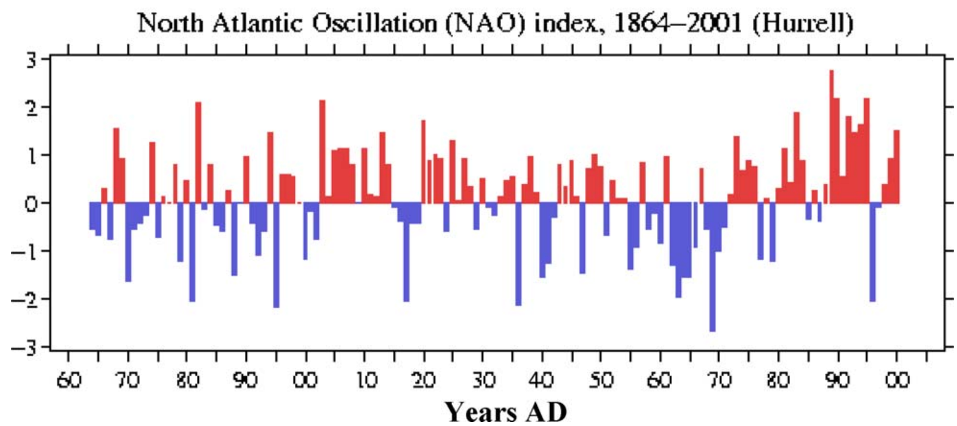

Fig. 4. The North Atlantic oscillation index. It is a measure of pressure difference between the area of low pressure that usually exists over Iceland and the high pressure region in vicinity of the Azores. It has a positive value for low pressure over Iceland and a negative value for high pressure over Iceland. The pattern of NAO switches polarity due to solar forcing. The period 1900–1933 is predominately positive during this time solar forcing of weak cycles caused cyclic rise and fall of lake Erie. 1960s maximum negative caused a solar induced climate change.

(b) A switch to positive NAO index happened for the next three weak cycles of the series as seen in Fig. 4. The spin rate of the sun slowed down during those cycles as seen in Fig. 3.
(c) With the strong first peak of Wolf-Gleissberg cycle, and the following weak cycle number 20, the NAO index was highly negative, induced the climate change of the 1960s and changed the general wind circulation.
(d) A change of NAO from −ve to +ve occurred in the 1980s, again with a slowing down of solar rotation rate at the secondary maximum of Wolf-Gleissberg cycle.
(e) In 1997, the NAO was switched from +ve to −ve and back to +ve in 1999 confirming that 1997 is a climate change year.

2.1.2. Solar modulation of El nino sourthern oscillations

Combining the estimates of El Nino frequency and sunspot numbers (showing the Wolf-Gleissberg cycles), Anderson (1990) cited in Sharp (1992) showed that the records for the last 300 or so years are strongly negatively correlated as seen in Fig. 5, from which he concludes that solar energy may modulate ENSO frequencies.

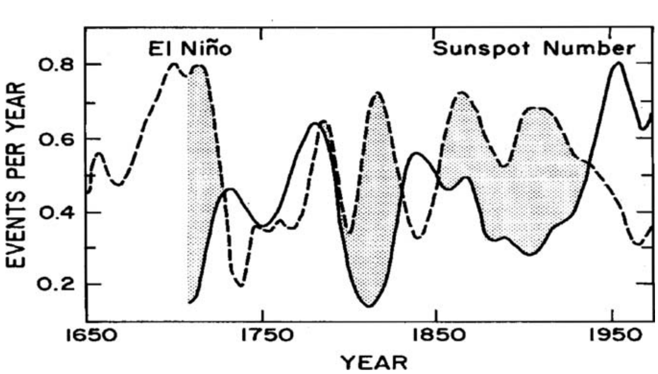

Fig. 5. The effect of Wolf-Gleissberg cycles (continuous line) on the modulation of El Nino frequency (broken line) for more than 300 years.

2.2. Effect of Wolf-Gleissberg cycles on lake levels

Lake and closed sea levels are forced up and down in response to solar stimuli at the turning points of Wolf-Gleissberg cycles (Yousef and Amer, 2000). The same turning point can raise the level at some location and reduce it at others. The rise and decline of few lakes; Lake Victoria as an example of the Equatorial African lakes, the Aral Sea and the Dead Sea in Asia as well as Lake Erie as a sample of the American Great Lakes, are to be considered.

2.2.1. Maximum turning point of Wolf-Gleissberg cycle (1959–1960s)

This turning point induced the 1960 climate change with the following effect

(a) Lake Victoria rose by about 3.6 m. This rise is reflected in the discharge of the White Nile at Malakal (Fig. 6b).
(b) Lake Erie showed considerable rise (Fig. 6a).
(c) The Aral Sea declined ever since this climate change. The shrinkage is severe that at some locations, the present shore is more than 120 km far from the preshrinkage state. It has been divided into two divisions, the big and the little Arals. The Little Aral is fed by the Syr Darya river.
(d) The Dead Sea declined since 1957–1959 (Fig. 7 up).

2.2.2. End turning points of Wolf-Gleissberg cycles at the start of the first weak solar cycle of the series

First case 1878: Lake Victoria rose considerably in few years, then declined till the end of cycle number 12.

Second case 1997:

(a) Lake Victoria rose by about 1.55 m.
(b) Lake Erie is declining.

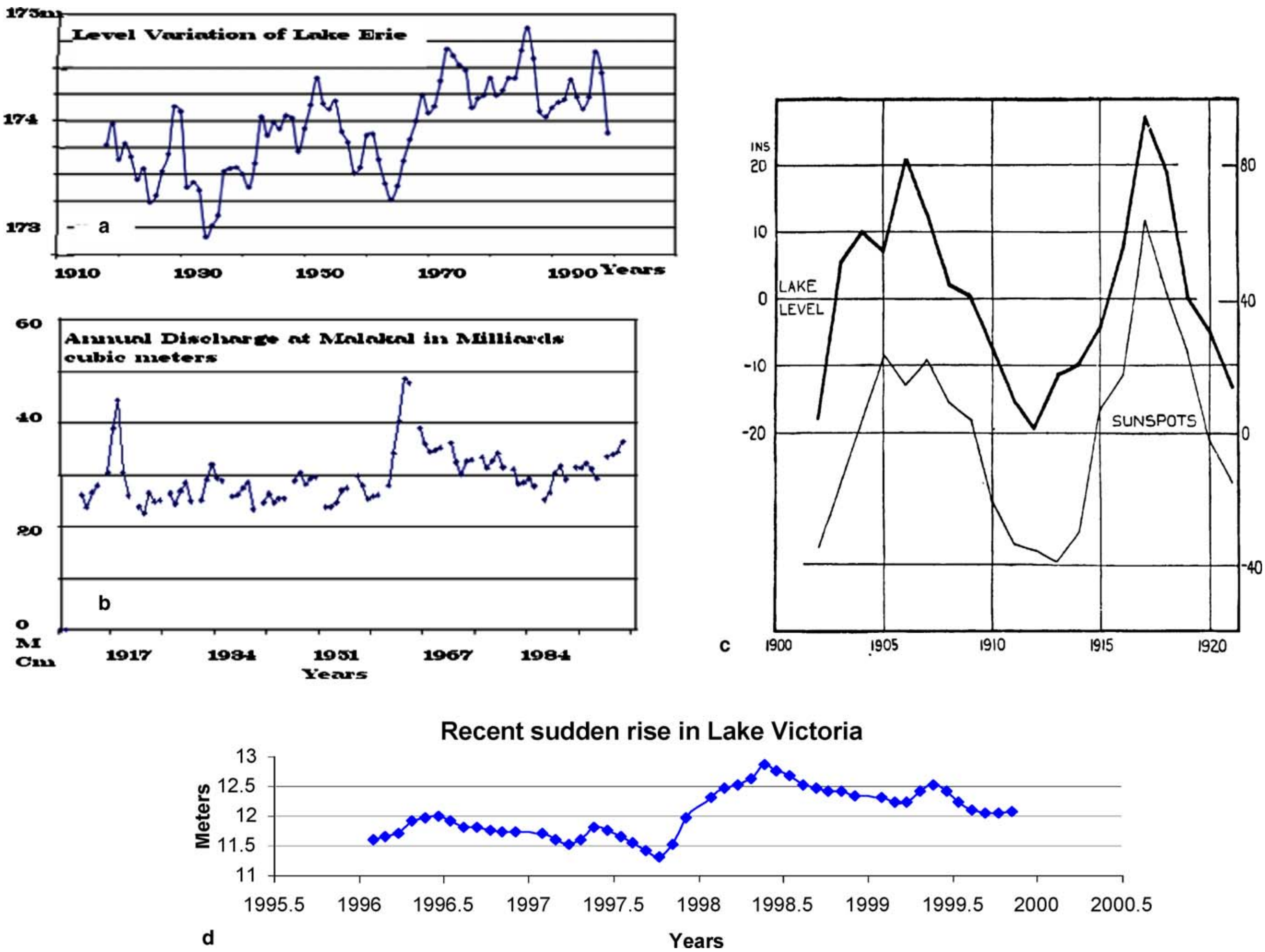

Fig. 6. (a) Time series of Lake Erie showing the cyclic level variations in sympathy with solar cycles 15 and 16 prior 1930s. (b) The annual discharge of the White Nile at Malakal showing the cyclic rise and fall in sympathy with solar cycle 15. Note also the sudden rise in the early 1960s following the maximum of Wolf-Gleissberg cycle. (c) The rise and fall of lake Victoria in sympathy with the weak solar cycles 14 and 15 (after Shaw, 1933). Such solar forcings was terminated after 1922 and is expected to return with solar cycle 24. (d) The 1997 climate change induced 1.55 m sudden rise in Lake Victoria level. with the start of solar cycle 23. Cycle 23 is the first of weak cycles series. Earlier similar rise occurred in 1878 with the start of solar cycle 12 which was first of the previous weak solar cycles series.

(c) Only the little Aral Sea (not the big Aral Sea) showed about 3 m rise due to increased inflow of Syr Darya flowing from the Tian Shan mountains north of Tibet.

1. *The 1960s solar induced climate change:* Forced both of the Equatorial African Lakes and the American Great Lakes to rise.
2. *Coherent forcing on lakes level.*

The first weak cycle of the series (cycle 12) caused abrupt rise of lake Victoria level, cycles 13–15 forced the Equatorial lakes levels to rise and fall coherently (Fig. 6c). On the other hand, cycles 14–16 forced Lake Erie to rise and fall in sympathy (Fig. 6a).

Forcast: Lake Victoria is expected to experience cyclic rises and falls with the weak cycles 24–26. Lake Erie is to show this effect with cycles 25–27.

3. Cyclic Lake level variations in coherence with the following weak solar cycles

(a) Lake Victoria and other Equatorial African lakes at the Nile Source: All showed this strong solar forcing that forced the lakes level to show cyclicity in coherence with solar cycles number 14 and 15 (1901–1922), see (Fig. 6c) and the extreme left of Fig. 6b. It is possible that solar cycle 13 (1889–1900) also showed such cyclicity however the data are not available.
(b) Lake Erie: Data showed this cyclic rise for cycles 15 and 16 (1914–1933), possibly the lake also showed this cyclic rise since cycle 14 (as the data are not available).
(c) The strong solar cycle forcing that raised the Equatorial Lakes levels in sympathy ended in 1922 at the Equator as evident in Fig. 6b at the extreme left

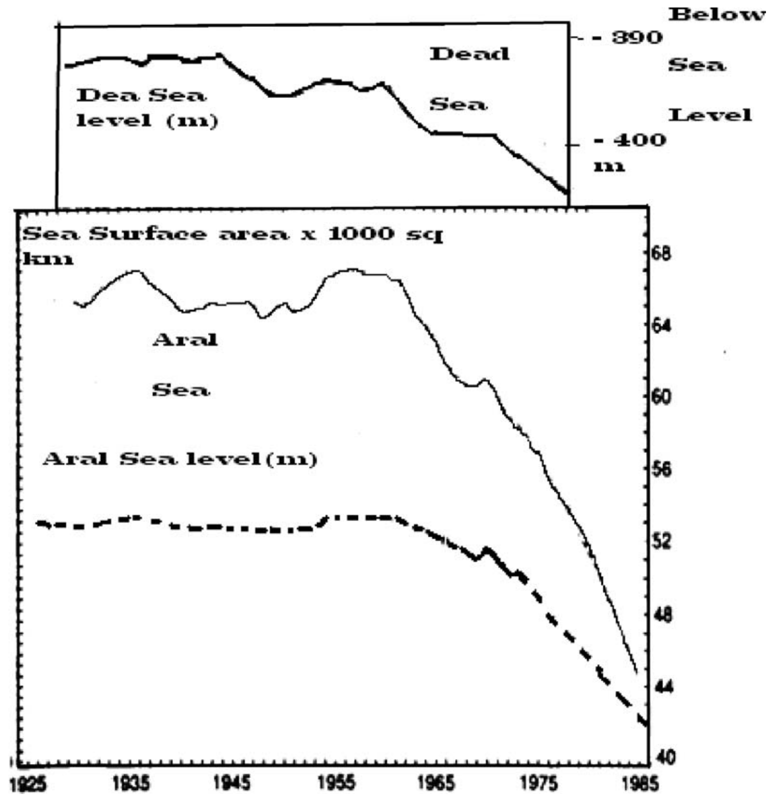

Fig. 7. The late 1950s early sixties coherent decline of the Dead Sea (top) and the Aral Sea (bottom) due to the maximum turning point of the Wolf-Gleissberg cycle. This Decline is natural. Recovery of both seas are to be expected not very far in the future (possibly with the start of cycle 24). Plans for Joining the Dead Sea with the Red and or the Mediterranean Seas should be abandoned as they are dangerous to the environment and a waste of money. The Little Aral sea showed a 1997 3 m up rise (not shown here). Hopefully the Big Aral will rise perhaps in 2008 ± 2 yr with the rise of solar cycle 24 or may be with cycle 25).

and c. This strong solar forcing ended in 1933 at the Northern latitudes as seen in Fig. 6a showing the variation of level of Lake Erie.

4. Forecast for the lakes levels variations

(1) Strong solar forcing due to the second to the last of the weak cycles cause the lakes levels to rise in coherence with the cyclic variations of the weak sunspot.
(2) The Great American Lakes (Lake Erie and the others) were influenced by an additional weak solar cycle. However it is suggested that lake Erie started this cyclic variation one solar cycle later than lake Victoria and other Equatorial Lakes. In other words Lake Victoria was subjected to level cyclic variations in response to three solar cycles number 13–15, while Lake Erie showed cyclicity in response to cycles 14–16.
(3) This is in agreement with the chart of North Atlantic oscillations as the positive index occurred between around 1900–1933, i.e. with solar cycles 14–16.
(4) Forecast of cyclic variations.
(a) Because of the 200 yr solar cycle, the Equatorial African Lakes are expected to show cyclic level rises and falls beginning with the start of the second weak cycle number 24 around 2008.
(b) Lake Erie and other American Great lakes are expected to show this cyclic variation with the start of solar cycle 25 around 2020.
(c) The NAO is expected to reverse sign in 2020 and this will last for at least two solar cycles.
(5) Recovery of the Aral Sea is likely to start in the near future. The Caspian Sea is also suffering from shrinkage effect. Recovery of the Caspian Sea is also to be expected due to solar forcings not far in the future.

4.1. Effect of the Wolf-Gleissberg cycles on fishery

4.1.1. The Atlanto-Scandian herring fishery case

The Baltic and North Sea herring fisheries underwent sharp changes alternating with each other in a way that had obvious climatic significance (Lamb, 1982).

The Atlanto-Scandian herring fishery began about one thousand years ago. Traditionally the main fishery of adult herring had been a winter fishery along the Norwegian west coast. Fig. 8 (bottom) shows the catches of winter herring off the western Norway. It is evident that the number of catches follow two Wolf-Gleissberg cycle closely.

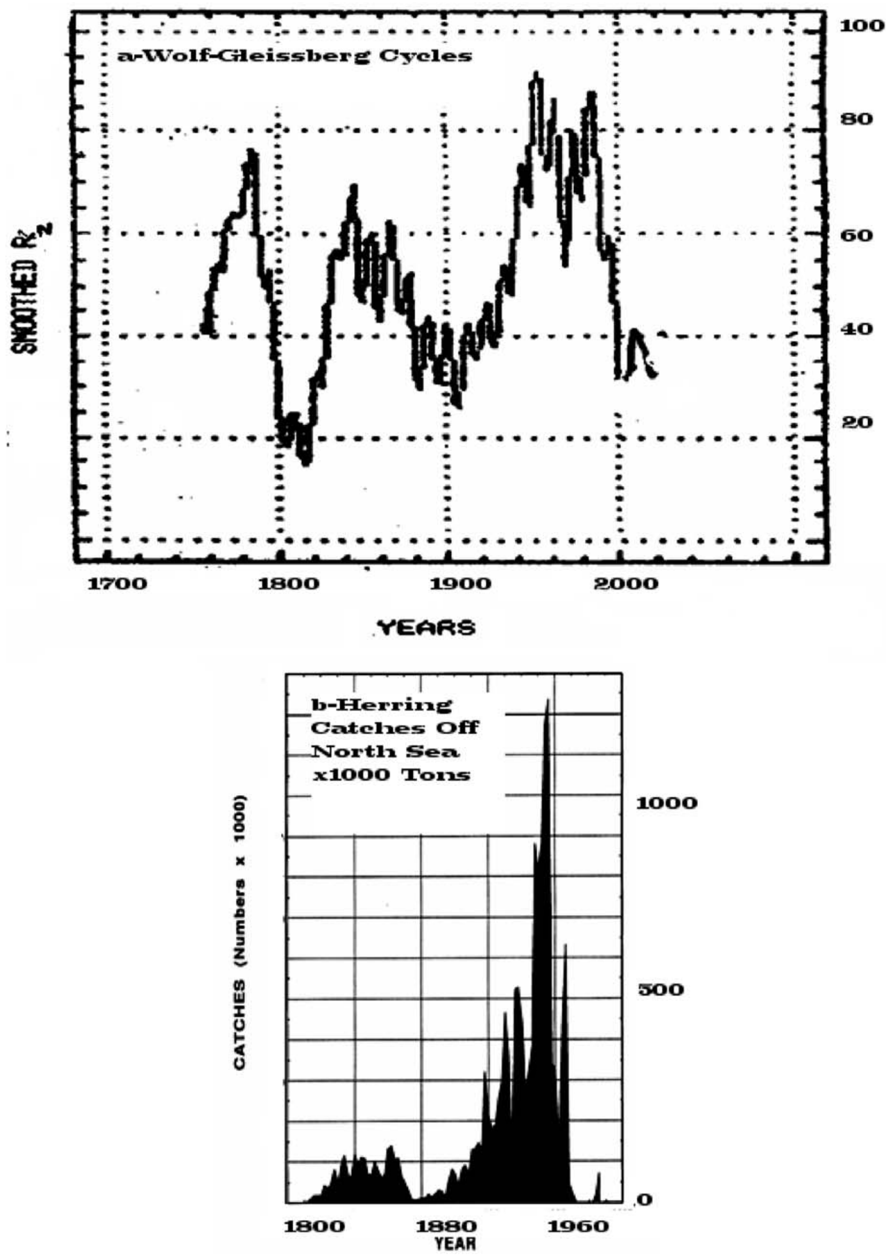

Fig. 8. Wolf-Gleissberg cycle solar forcing (top figure) on herring in North Sea (lower figure). Notice the effect of the 1960 solar induced climate change on herring abundance. Herring disappeared from North Sea off the Coasts of Denmark and Siberia with the Maximum of Wolf-Gleissberg Cycle in 1957–1959. There might be a meteorological connection between the North Sea, the Aral Sea and the Dead Sea. Notice even the increased abundance of Herring with individual sunspot cycles. Sea Weeds also show abundance dependance on sunspot cycles. The herring figure is from Krovnin and Rodionov (1992).

The number of catches was very low around 1800 and 1900, i.e. during the weak solar intermediate cycles. The number of catches rose from several hundred metric tons in 1810–70,000 metric tons in 1830 and reached a maximum of 100,000 metric tons during the 1860 secondary maximum of Wolf-Gleissberg cycle and then declined in 1870s. In 1880s and 1890s, the annual catches totaled only 13,000 metric tons. The number of catches rose again with the development of the following Wolf-Gleissberg cycle reaching a peak of 10 million metric tons in 1957 (maximum of Wolf-Gleissberg cycle) and then declined sharply to 3 million metric tons in 1963. The decline of herring fishery extended also to USSR and Iceland ending with the collapse of the Scandian herring stock (Krovnin and Rodionov, 1992).

During the 1960s, the intensification of fishing pressure coincided with pronounced change in the regional climate. Analysis of about a thousand years of herring fishery indicated that there had been analogous situations in the past, when fishery disappeared. Before its disappearance toward the end of the previous century, the fishery tended to shift northward. A similar situation was observed in 1950–1960s. Since the herring normally inhabit waters with temperatures between 3 and 13 °C (Lamb, 1982), then the

Wolf-Gleissberg pattern evident in Figs. 2a and Fig. 8 actually is a biological temperature time series off western Norway. The northward shift of herring may be due to northward shift of warm water stream in the North Sea.

The increased abundance of herring should also reflect abundance of food necessary to sustain the fish. It is found that e.g. that the density of seaweed off the shore of Scotland follow exactly sunspot cycles for the years 1946–1955 (Hoyt and Schatten, 1997 and references therein).

4.1.2. The sardine catches case

The problem of disappearance of about 95% of the sardine fishery from the eastern basin of the Mediterranean Sea was attributed to the High Dam holding the Nile water from going into the sea by 1965. This might be the case, however it may be that the sardine fishery declined in analogy to the herring fishery. This problem can be solved if historical declines were reported in the past or the sardine disappearance is reported at the same time elsewhere.

In deed, this is evident from the title of the article of Ueber and MacCall (1992) "The rise and fall of the California sardine empire". Fig. 9 bottom reproduced from Kawasaki (1992), shows the fluctuations in three major sardine populations in the Pacific; the Far Eastern waters around Japan, the California sardine off the west coast of North America and the Chilean sardine off the Chilean coast. Around 1960, when the Japanese sardine stock was at low level, it was confined to a small coastal area along southern Japan. However in the 1980s, when the stock was abundant it spread throughout the Sea of Japan. During the decline period of Far Eastern sardine, a three-year old fish increased in length from 18 to 20 cm.

Sardin has returned to the Egyptian shores and is seen in the Markets of Portsaid, Damieta, Alexandria etc. The case of the rise and fall of the sardine is a global one and ought to be studied in the prospect of solar induced climate change. Sardine population declined with 1960s climate change but reached apex with the secondary peak of WGC in the 1980s.

The American lobster industry was subjected to a disaster in the 1920s ad 1930s (Acheson, 1992). This can be explained in terms of solar forcing around 1922 with the termination of solar weak cycles and start of new Wolf-Gleissberg cycle affecting the solar radiation reaching the Earth.

4.1.3. The mystery of the disappearance of Canadian Atlantic fish

The real disaster of the disappearance of Canadian fish off the Atlantic coasts of Canada is investigated in two cases.

1. American shad: livers partly in American Atlantic and partly in Atlantic Canada. It shed high population in the 1960s following the maximum of Wolf-Gleissberg cycle(also in agreement with the NAO −ve index) then it declined in number. Another mild peak occurred in the 1980s with the second peak of Wolf-Gleissberg cycle, also in agreement with the reverse of NAO index to +ve values.
2. Canadian cod: increased populations in the late sixties, delayed than herring fish. A minor peak happened in the 1980s before disappearance.

4.1.3.1. Outline and prediction for fishery.

1. In the cases studied, herring, sardine, cod and American shad, they all show population dependence on the solar induced climate change at the turning points of Wolf-Gleissberg cycles and also in agreement with the North Atlantic Oscillation Index.
2. Sardine showed global abundance coherence in different oceans and in the Eastern Mediterranean Sea (we have no data on sardine in the western. Mediterranean Sea in hand).
3. It is thus suggested that the population of the same Canadian species ought to be compared in different oceans and seas.
4. The Canadian Atlantic fish disaster is a solar induced one and its recovery can be expected in due time.
5. After its global disappearance in the 1960s, the Sardine population increased dramatically in the eighties, however other fish studied showed little abundance increase in the 1980s with the secondary peak of WGC. This is good for environmental balance.

4.2. Effect on the magnetosphere

Variability of Bow shock distance is expected. There is an expansion of the magnetosphere during weak cycles and compression at maximum of Wolf-Gleissberg cycle. Note that the size of the magnetosphere oscillates between the two maximums of the WGC (e.g. the 1959 and 1980s maximums are separated by the weak solar cycle number 20 in the 1960–1970s).

4.3. Effects on the ionosphere

Solar X-ray, UV and radio fluxes vary in coherence with the pattern of Wolf-Gleissberg cycles. Lean (2000) computed long-term variability in total solar irradiance and in two spectral bands in the UV and IR (Fig. 10). Note the UV drop at the period of weak solar cycles around 1800 and 1900. It is expected that the size, electron densities, temperature, etc. of the ionosphere would also follow the pattern of Wolf-Gleissberg cycles. Ionospheric models can be applied taking into consideration the computed UV Wolf-Gleissberg cycles flux variations.

4.4. Effects on galactic cosmic rays

During the present weak cycle period which is expected to last (30–40 yr) reduced solar wind flux are expected and

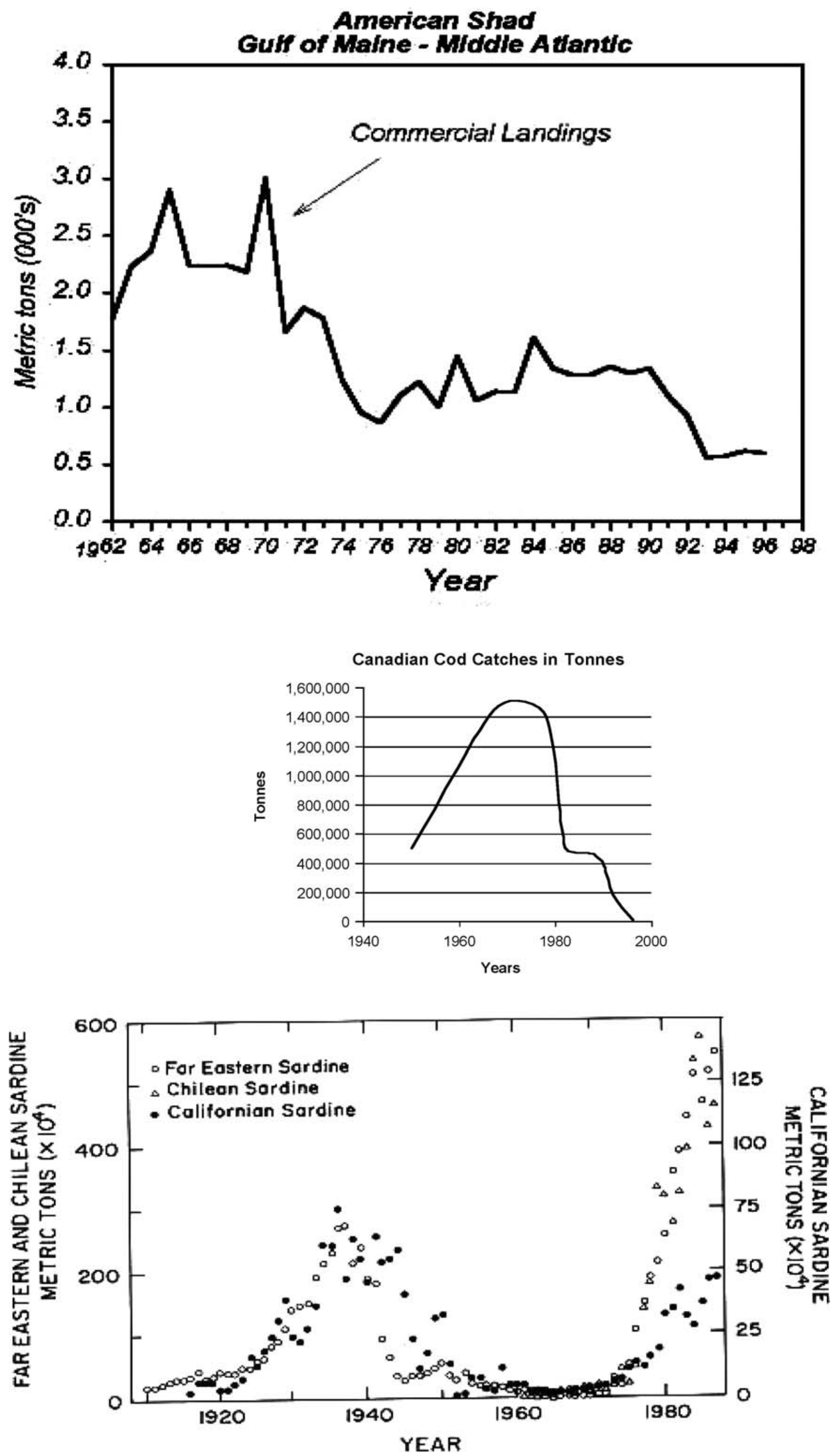

Fig. 9. The effect of solar forcing on American Shad (partly in Canada), Canadian Cod and Global Sardine. Sardine in the Eastern Mediterranean Sea also disappeared in the 1960s. Trends in the catches of sardine is reproduced from Kawasaki (1992).

a weakening of interplanetary magnetic field (Yousef, 1998). The effect will be more pronounced for the coming few weak solar cycles.

The expected result would be

(1) Increased invasion of galactic cosmic rays
(2) Hence increased cloud cover

Ion-pairs are continuously produced by radiolysis of air molecules. The ions produced are rarely single species but clusters of water molecules around a central ion. Cosmic rays are one of the contributors to radiolysis (Harrison, 2000). There is a positive correlation between cosmic ray intensity and cloud cover (Kirkby and Laaksonen, 2000 and references therein).

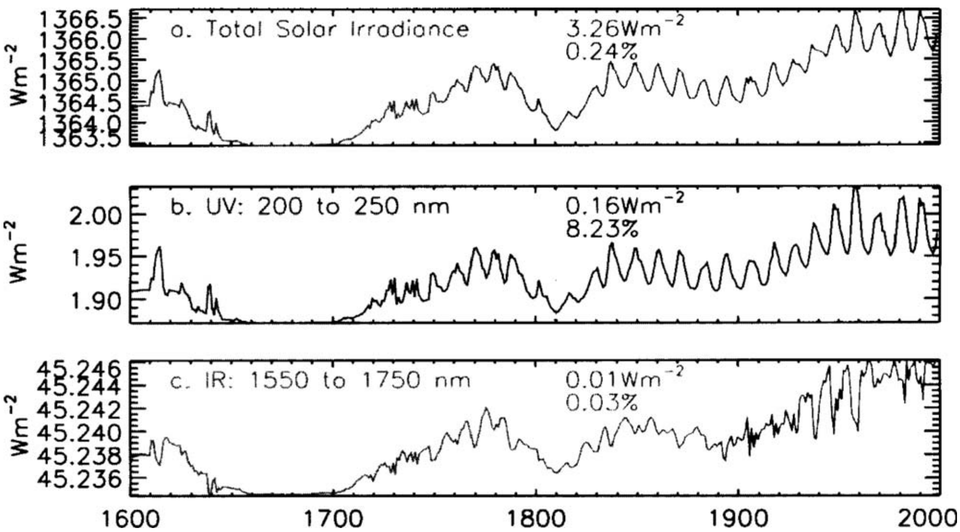

Fig. 10. Model estimate of long-term variability in total solar irradiance and in two spectral bands in the UV and IR showing the Wolf-Gleissberg cycles (after Lean, 2000).

4.5. Effect on global temperature

During the previous weak cycle series of duration around 12 yr, the global air and sea surface temperature dropped. There is a reverse correlation between solar cycle length and global mean temperature (Friis-Chrjstensen and Lassen, 1991 cited in Hoyt and Schatten, 1997).

4.6. Effect on precipitation

It is found that in several locations, the smoothed precipitation cycles follow the pattern of Wolf-Gleissberg cycles with two precipitation cycles for each Wolf-Gleissberg cycle (Yousef, 2000a).

5. Conclusions

The 80–120 year solar Wolf-Gleissberg cycles have wide effects on the Earth's environment. It has a controlling effect on space weather from the interplanetary space, to the magnetosphere, ionosphere and consequently down to the troposphere. They induce effects on global temperature, pressure and thus the general wind circulation and precipitation. It is evident that the North Atlantic Oscillations reverses sign due to solar stimuli. ENSO, El Nino and La Nina hot and cold pacific currents are solar modulated.

These effects have strong control on the biosphere. The abundance and disappearance of fish are found to follow the 80–120 yr Wolf-Gleissberg cycles (WGCs) and to be a global phenomena.

Solar induced climate changes are found to occur at the WGCs turning points. Those turning points happen whenever there are weak (12 yr) solar cycles on the sun, either in between the two maximums or in between two successive WGCs cycles. Rapid solar rotations accompany such weak cycles thus reduce the energy budget emitted from the sun. The rise and fall of Lakes levels are good signs for the occurrance of such WGCs turning points.

Studies of past solar terrestrial effects at different periods of the WGCs can reasonably be reflected into the future provided we know the current status of WGC. As a matter of fact, this can be done reasonably well because the present cycle number 23 is the first weak cycle of a 3–4 weak cycle series in between two successive WGCs. On those grounds we can make several predictions based on historical studies.

Droughts are to be expected in the Equatorial regions around Lake Victoria by the end of cycle 23 to be followed by cyclic rise and fall of Equatorial lakes levels in antisympathy with solar cycles 24–26. The present severe decline of the Aral and the Dead Sea (and Caspian Sea similarly) will stop with a nearby rise. Thus it is not advisable to interfere with the environment such as by joining the Dead Sea with either of the Red Sea or the Mediterranean Sea. The Catastroph of the disappearance of the fish from the Canadian Atlantic Ocean will end after some time hopefully. However further work has to be done in this respect. Collaborative work with the Canadian authorities is invited.

Acknowledgement

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