Solar Activity as a Possible Indicator of Global Climate Change

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Abstract : This literature study has been undertaken to investigate the possible climatic changes observed globally during centuries and the solar cycle activity during the same duration. One of the simplest observation of the Sun that one can make through a solar telescope, is in white light. On a white light image one sees sunspots, faculae, pores and granulations. The study of sunspots, which are the seat of solar activity, is of immense importance for short and long-term synoptic studies. Model simulations are limited by necessary assumptions and observations suffer from lack of sufficiently long time series of fundamental quantities. In this scenario, its a fix to decide if Solar Actitivity cycles are actually a possible indicator of the global climatic changes.

IndexTerms **- solar activity, sunspots, global climate, solar cycle.**

I. Introduction

The most obvious feature of solar variability is the change over time in the number of sunspots on the visible half of the Sun. Claims of a Sun and weather relationship can only be evaluated properly when the history of solar change is known in detail. A less visible indicator of solar change is the C-14 content of tree rings. The atmospheric C-14 levels derived from tree ring measurements can be tied to the Sun's modulation of the cosmic ray flux in the vicinity of the Earth, and thus provide a history of solar change.

SOLAR VARIABILITY

Four general factors contribute to the Sun's potential role in variations in the Earth's climate:

(i) The fusion processes in the solar core determine the solar luminosity and hence the basic level of radiation impinging on the Earth.

(ii) The presence of the star field of force, and dissipation of associated electrical currents, leads to radiation at ultraviolet (UV), extreme ultraviolet (EUV), and X-ray wavelengths which can affect certain layers of the atmosphere.

(iii) The variability of the field of force over a 22-year cycle ends up in important changes within the radiative output at some wavelengths and additionally modulates the incoming flux.

(iv) The best known feature of solar activity, i.e. the sunspot number appears to recur in cycles of 11 years, with an amplitude modulation on a time-scale of 80-90 years (Fig. 2).

SCHWABE CYCLE The most evident cycle variation in solar activity is the eleven year (or Schwabe cycle) of the sunspot number. Its existence is well confirmed since about 250 years ago as the observation of sunspots since that time has been adequately systematic. The analysis of billions of years of terrestrial climate must have demonstrated that the Sun has behaved more or less like a stationary system and also that stars like the Sun evolve on a time scale of billion of years. Thus, one ought to expect that its activity is subjected to additional or less regular oscillations.

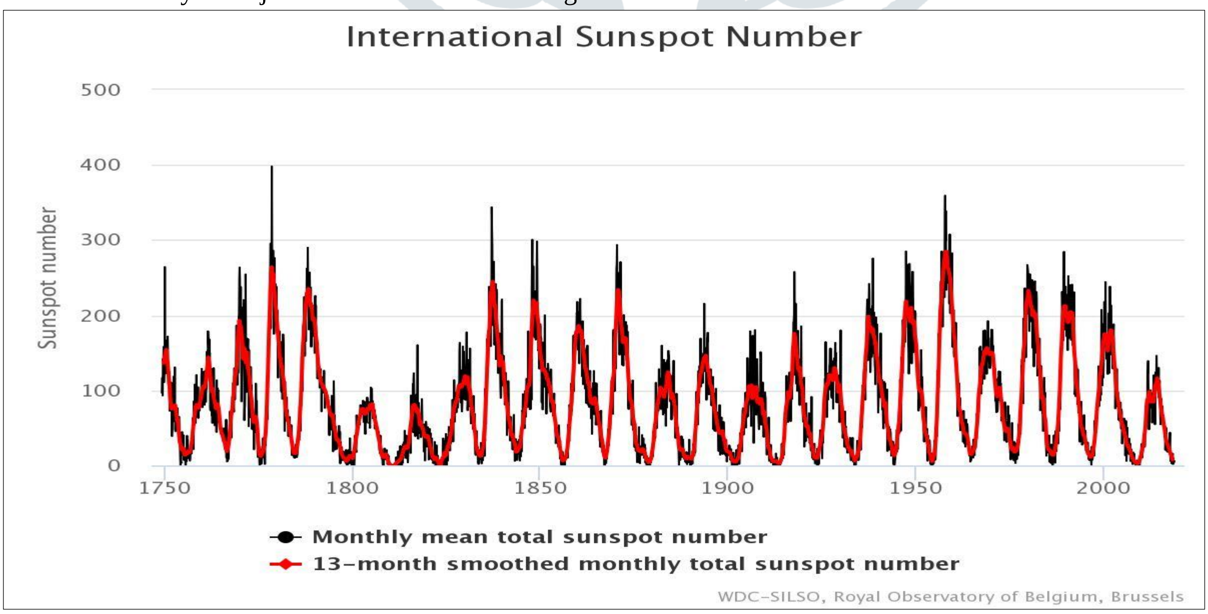

Fig.1: Sunspot data from the World Data Center SILSO, Royal Observatory of Belgium, Brussels

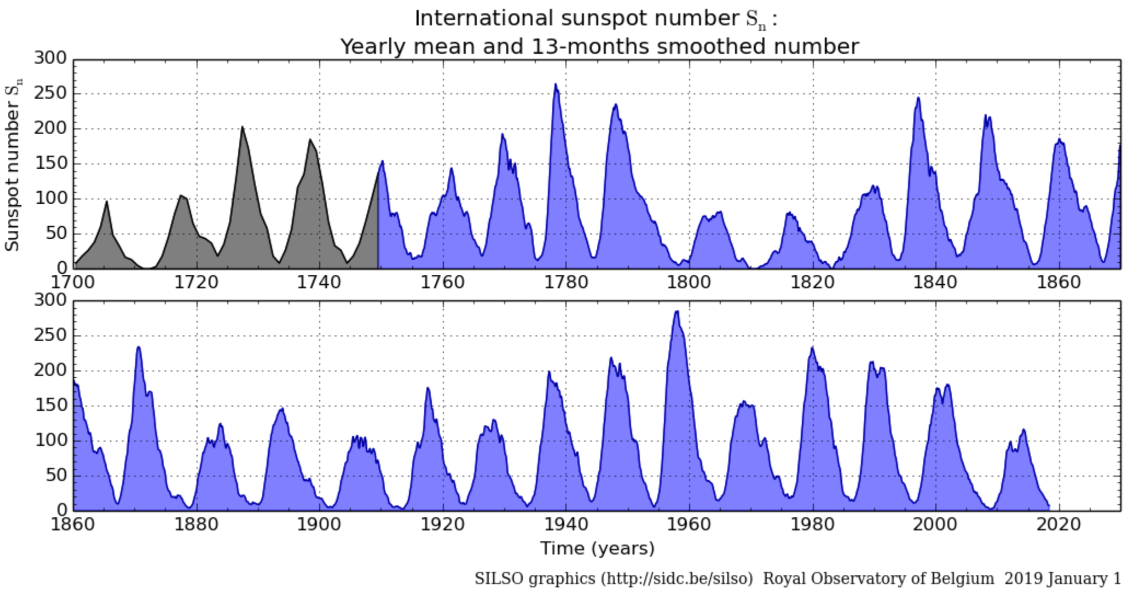

Fig.2 : Yearly mean sunspot number (black) up to 1749 and (blue) from 1749 up to the present.

SOLAR INFLUENCE THROUGH THE ATMOSPHERE

At very high altitudes (higher than approximately 200 km) variations in temperature can be estimated from measurements of density deduced from atmospheric drag on spacecraft. In this very rarefied region the large variations in short wavelength (EUV) radiation from the Sun produce solar cycle changes in temperature of more than 400 K.

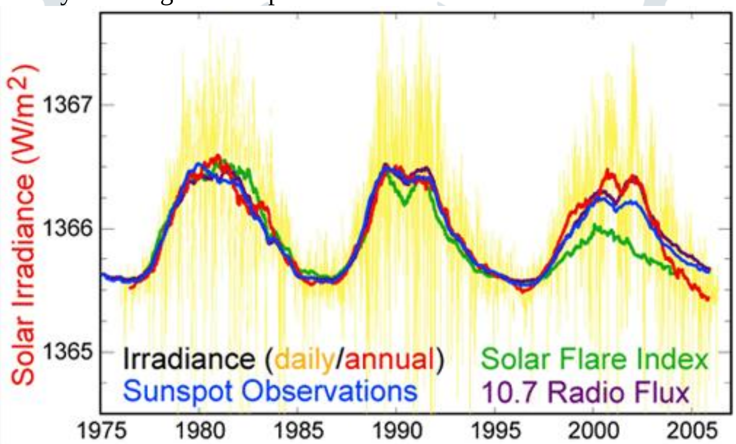

Fig. 3: Solar Cycle Variations & Solar measurements as a function of time.

(Activity cycles 21st, 22ndand 23rdseen in sunspot number index, TSI, 10.7cm radio flux, and flare index. The vertical scales for every amount are adjusted to allow overplotting on an equivalent vertical axis as TSI. Temporal variations of all quantities are tightly locked in phase, but the degree of correlation in amplitudes is variable to some degree.)

The dominant fact from the above (Fig.3) illustration is that the star output is unbelievably constant - variable solely concerning one half in 1366! But the opposite variables ar measured on a relative scale and represent abundant larger share variations, so it is possible that the solar flare index and the sunspot observations are windows to delicate influences on the Earth's climate that we do not perceive.

The total star irradiance (TSI) is that the quantity of star radiative energy incident on the Earth's higher atmosphere. TSI variations were undetectable till satellite observations began in late 1978. A series of radiometers were launched on satellites from the Nineteen Seventies to the 2000s. TSI measurements varied from 1360 to 1370 W/m2 across multiple satellites. The ACRIMSAT launched by the ACRIM group, was one of the satellites in the list. The controversial 1989 to 1991 "ACRIM gap" between non-overlapping ACRIM satellites was interpolated by the ACRIM group into a composite showing +0.037%/decade rise.

Solar irradiance varies consistently over the cycle, both in total irradiance and in its relative components (UV vs visible and other frequencies). The solar luminosity is assumed 0.07 percent brighter during the mid-cycle solar maximum than the terminal solar minimum. Photospheric magnetism appears to be the primary cause (96%) of 1996 to 2013 TSI variation. The ratio of ultraviolet to visible light also varies.

TSI varies in part with the star magnetic activity cycle with an expected amplitude of concerning 0.1% around an average value of about 1361.5 W/m2 (the "solar constant"). Variations about the average of up to minus 0.3% are caused by large sunspot groups and of +0.05% by large faculae and the bright network on a 7-10-day timescale. Satellite-era TSI variations show small but detectable trends.

TSI is higher at star most, albeit sunspots ar darker (cooler) than the common surface.This is caused by attractable structures aside from sunspots throughout star maxima, like faculae and active components of the "bright" network, that square measure brighter (hotter) than the typical surface. They put together overcompensate for the irradiance deficit related to the cooler, however less various sunspots. The primary driver of TSI changes on star motility and topographic point cycle timescales is that the varied photospheric coverage of those radiatively active star magnetic structures.

Energy changes in ultraviolet ray irradiance concerned in production and loss of ozone layer has drastic atmospheric effects. The 30 HPa Atmospheric pressure level changed height in phase with solar activity during solar cycles 20-23. UV irradiance increase caused higher atmospheric ozone production, leading to stratospheric heating and to poleward displacements in the stratospheric and tropospheric wind systems.

II. SOLAR CYCLE HISTORY

Sunspot numbers over the past 11,400 years have been reconstructed using Carbon-14-based dendroclimatology. Dendroclimatology is that the science of decisive past climates from trees (primarily properties of the annual tree rings). Tree rings square measure wider once conditions favor growth, narrower when times are difficult. Other properties of the annual rings, such as maximum latewood density (MXD) have been shown to be better proxies than simple ring width. Using tree rings, scientists have estimated many local climates for hundreds to thousands of years previous. By combining multiple tree-ring studies (sometimes with different climate proxy records), scientists have estimated past regional and global climates.

The level of solar activity beginning in the 1940s is exceptional but the last period of similar magnitude occurred around 9,000 years ago (during the warm Boreal period). The Sun was at a equally high level of magnetic activity for less than ~10% of the past 11400 years. Almost all earlier high-activity periods were shorter than the current episode. Fossil records counsel that the star cycle has been stable for a minimum of the last 700 million years.

Until 2009 it was thought that 28 solar cycles had spanned approximately 309 years between 1699 and 2008, giving an average length of 11.04 years, but research then showed that the longest of those (1784 to 1799) appears truly to own been 2 cycles, so that the average length is only averaged to 10.7 years. Since observations began cycles as short as 9 years and as long as 14 years have been observed, and in the double cycle of 1784 to 1799 one of the two component cycles had to be less than 8 years in length. Significant amplitude variations also occur.

A list of historical "grand minima" of solar activity exists (Table 1).

Table 1 : Major events and approximate dates

Event	Start	End
Homeric minimum	950 BCE	800 BCE
Oort minimum	1040	1080
Medieval maximum	1100	1250
Wolf minimum	1280	1350
Spörer Minimum	1450	1550
Maunder Minimum	1645	1715
Dalton Minimum	1790	1820
Modern Maximum	1900	present

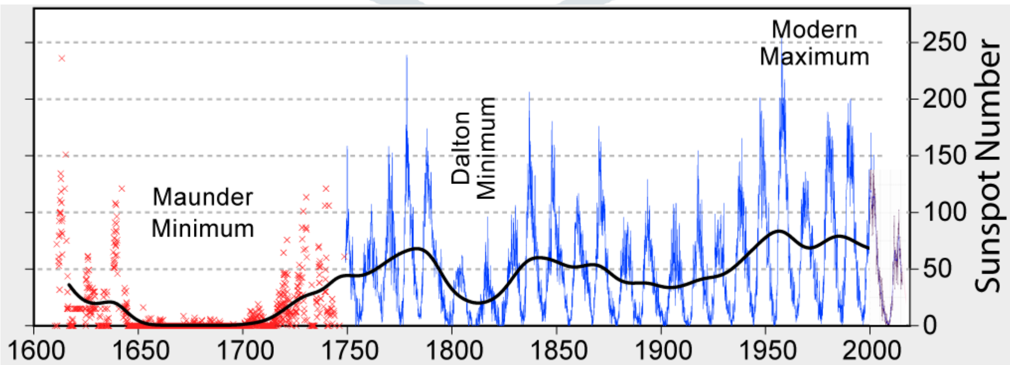

Fig. 4 : 400 years of sunspot number variations showing significant minima

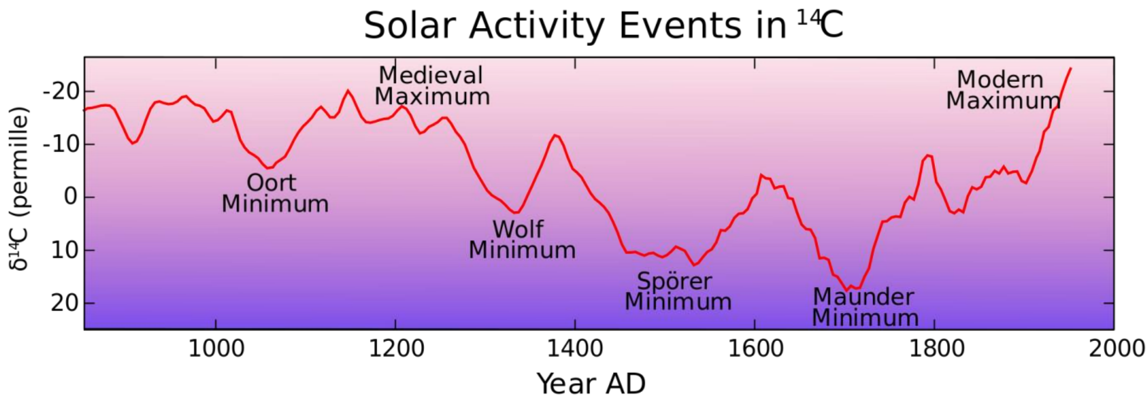

Fig. 5 : Evidence of Solar minima in C-14 activity

SOLAR SIGNALS IN SURFACE CLIMATE

Both long-term and short-term variations in solar activity are theorized to affect global climate, but it has proved difficult to quantify the link between star variation and climate. Three hypothetical mechanisms mediate solar variations' climate impacts:

a). Total solar irradiance ("Radiative forcing").

b). Ultraviolet irradiance. The UV component varies by more than the total, so if UV were for some (as yet unknown) reason having a disproportionate effect, this might affect climate.

c). Solar wind-mediated galactic ionizing radiation changes, which may affect cloud cover.

CONCLUSIONS

The place cycle variation of 0.1% has small but detectable effects on the Earth's climate. Researchers suggest that solar irradiance correlates with a variation of 0.18 K ±0.08 K (0.32 °F±0.14 °F) in measured average global temperature between solar maximum and minimum.

More statistically significant effects have to be reported and confirmed in coming days.

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