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Research Paper 1 Physics

A CORRELATIVE STUDY OF CLIMATE CHANGES AND SOLAR ACTIVITY

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ABSTRACT

The Sun is ultimate source of heat energy reaching the earth and other planets. The surface of sun is very active and is constantly changing, with huge dark sunspots appearing and disappearing over an 11-year solar cycle. The climate of earth is complexed and influenced by changes in the earth's orbit in rotation to the sun, which has driven the cycles of ice ages. Variation in the energy being emitted from the sun has also had an effect. The earth receives 174 pentawatts (PW) of incoming solar radiation at the upper atmosphere. Approximately 30 % is reflected back to the space while the rest is absorbed by clouds, oceans and land masses. Earth's land surface, oceans and atmosphere absorb solar radiation and this raises their temperature. The term 'global warming' describe an increase over time of the average temperature of the earth's atmosphere and oceans. Over the past century the global temperature has increased by approximately 0.74°C. Temperatures in the lower troposphere have increased between 0.08°C and 0.22°C per decade. Since 1980, the average temperature rise was not linear, but had risen and fallen superimposed on it due to natural variability. In this paper we have illustrated that long term variation in global temperature and solar activity has good correlation.

Key words: Sunspot number, Global warming, Solar activity, Global temperature.

Introduction:

Climate is the average pattern of weather for a particular region, usually taken over a 30-year time period. The term 'climate change' refers as remarkable change from one climatic condition to another i.e. Changes in temperature, wind, precipitation and humidity. The important feature of solar variability is fluctuations of plasma in the sun-earth space environment. The interplanetary magnetic field and energetic solar particles like solar protons, electrons emitted in the magnetosphere, vary as a result of the basic solar magnetic dynamo that drives the 11 year cycle. Lassen and Friis-Christensen (1995) have demonstrated a strong correlation between solar cycle lengths and Northern Hemisphere temperatures over the period 1860-1990.

The influence of solar variability on climate system has been a controversial subject from a long time. Maximum Solar irradiance occurs during sunspot maxima though the sunspot itself reduces radiation, excess illumination is associated with the faculae, bright regions that surround the sunspots. Climatic patterns can also be determined by cycling of water in and out of the atmosphere. Evaporation of water takes place at the surface of the earth, rises and cools, condenses into rain or snow, and falls again on the surface.

The sun changes in its activity on time scales that vary from 27 days to 11, 22, 80, 180 years and more. A more active sun is brighter due to the dominance of faculae over cooler sunspots with the result that the irradiance emitted by the sun and received by the earth is higher during active solar periods than during quiet sun periods. Space weather is significantly controlled by Coronal Mass Ejection, which can affect the earth in different ways (Tripathi and Mishra, 2005).

Sun's eruptional activity like flares, solar wind bursts from coronal mass ejections and solar wind bursts from coronal holes may also have a much greater effect on earth climate. Lockwood et al. (1999) showed how the total magnetic flux leaving the sun has increased by a factor of 2.2 since 1901. This eruptional activity may enhance warming of the atmosphere.

DATA SELECTION

Data for sunspot numbers has been taken from NOAA, National Geophysical Data Center. Earth's surface temperature data has been taken from National Aeronautics and Space Administration Goddard Institute for Space Studies.

DISCUSSION AND RESULTS

Scientists believe that variations in solar activity play a key role in earth's climate. Some scientists have predicted that there is a repeating 1,500-year solar irradiance cycle that is responsible for cyclic periods of warming and the Little Ice Age. They claim that this cycle, more than human activity, is responsible for current global warming (Haigh 2001). Current computer models

predict that by the year 2100 average surface temperature will increase by 1.4°C (Intergovernmental Panel on Climate Change [IPCC] 2001). Although many uncertainties exist in these climate models because scientists do not completely understand the process of the earth's climate system.

According to the IPCC (2007), the world's surface air temperature increased an average of 0.74ÚC in the 100 years between 1906 and 2005. During the 21st century temperatures will rise much more than they did during the past century.

During the 20th century Sea level rose 5–8 inches due to melting of glaciers and the expansion of water through increasing temperature. IPCC 2007 has predicted that in 21st Century, rise in sea level can reach up to 23 inches.

A very few sunspots were seen during the period 1600 to 1700.Between 1650 and 1700, global climates turned extreme cold (the Little Ice Age), which shows a clear correspondence between sun spots and cool climate. After 1700, the number of observed sunspots increased sharply .The Maunder Minimum was preceded by the Sporer Minimum (1450–1540 AD) and the Wolf Minimum (1290–1320 AD). Low number of sunspots were seen in these periods resulting cooler global climates. During the Maunder Minimum, almost no sun spots occurred for 50 years. The Dalton sun spot minimum, which occurred during 1790 to 1820, was also a time of deep global cooling, as was the period from 1890 to 1915. Global cooling during 1945 to 1977 was also a time of minimum sun spot numbers. Correspondence of cold periods and solar minima from 1700 to 1980 was a time of sharply reduced global temperatures .In this period correlation between sun spots and global climate is very close, while correlation of CO2 with climate changes is very poor. Soon (2005), Soon and Yaskell, (2004), Scafetta (2009), and Scafetta and West (2005, 2007, 2008) also show correlations of solar variation and climate recently. They have also proposed a mechanism for explaining the relationship between solar fluctuations and climate changes.

Soon (2005) showed how the arctic temperatures correlated with solar irradiance far better than with the greenhouse gases over the last century .For the 10 year running mean the correlation between total solar irradiance (TSI) and Arctic-wide air temperature anomalies (Polyokov, 2002) found 0.79 while the correlation between greenhouse gases and Arctic-wide air temperature anomalies is found just 0.22.

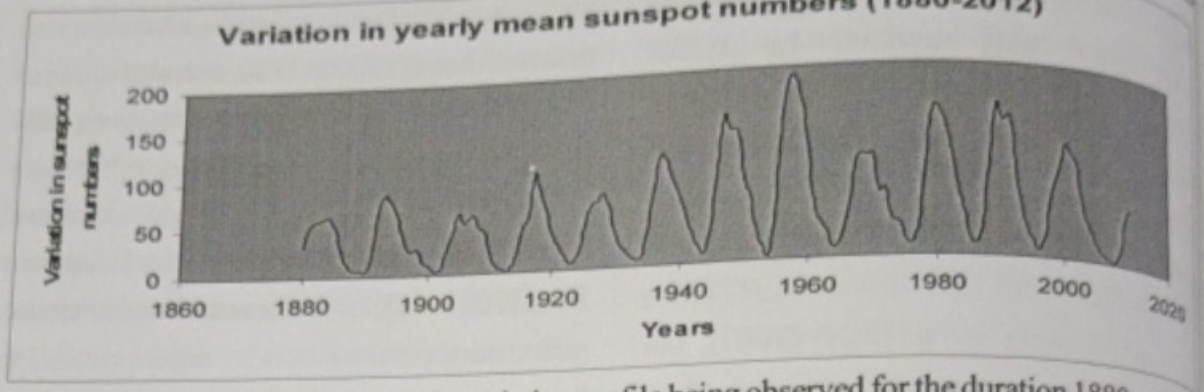

Figure (1) depicts the Sunspot Cycle variation profile being observed for the duration 1880-2012. The higher sunspot numbers represent the enhanced solar activity resulting in more solar ejecta, i.e. Solar energy.

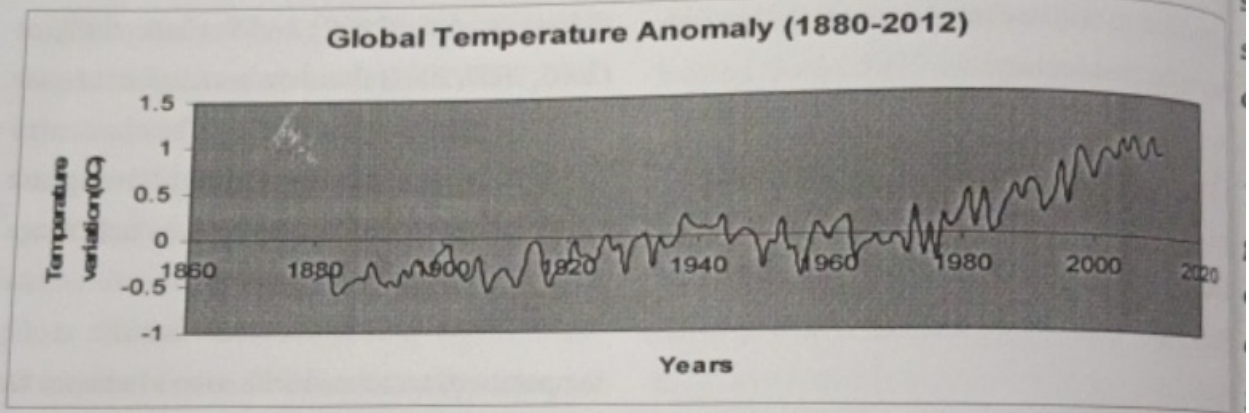

Figure (2) depicts the average Global temperature variation pattern recorded for the duration 1880 - 2012. The gradual average increase is clearly seen in the recent years.

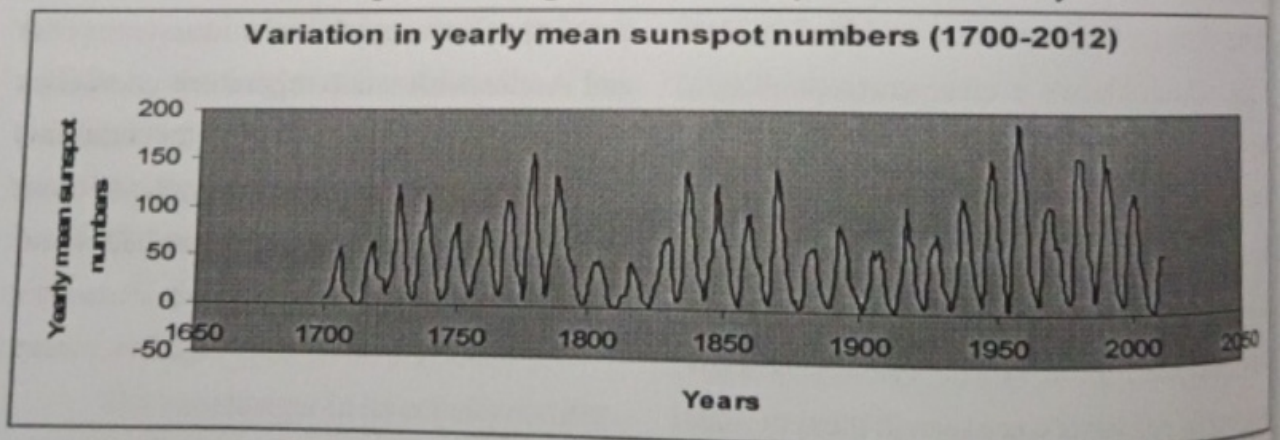

Figure (3) depicts the Sunspot Cycle variation profile being observed for the duration 1700-2012.It shows less sunspot numbers during Dalton Minimum (1790-1820).

CONCLUSIONS

The study of sunspot activity in relation to global temperature variability suggest that the climate changes are mostly due to the fluctuations in solar activity. A good correlation between solar activity and climate occurred during the Maunder Minimum (Maunder, 1894, 1922; Eddy, 1976, 1977; Hoyt and Shatten, 1997; Soon, 2005; Soon and Yaskell, 2004; Krivova et al., 2007; Lean, 2000; Grove, 1988, 2004; Fagan, 2000). In our study we have found a good correlation between sunspot numbers and global temperature anomaly during Dalton Minimum (1790-1820).

These plots show the similar pattern till 1989 afterward the sunspot numbers are less but global temperature is seen raising. It suggests that current pattern of global warming is not completely defined by solar activity but long term variation in global temperature is highly correlated with solar activity.

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