Sun-climate connection: an overview

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Abstract: The historical and geological records show that the Earth’s climate has always been changing. The Sun is the continuous source of the energy that causes the motion of the atmosphere and thereby controls weather and climate. Any change in the energy from the Sun received at the Earth’s surface will therefore affect our climate. During stable conditions there has to be a balance between the energy received from the Sun and the energy that the Earth radiates back into space, are creates the mean temperature of the Earth. The Sun’s output to change over an 11-year sunspot cycle, and variations over longer periods occur as well. A number of correlations between solar activity variations and climate changes, some more significant than others, have been reported but they have traditionally been accompanied by a considerable skepticism among scientists because a plausible physical mechanism to account for these correlations has not yet been found. The most immediate cause of climate changes would be changes in the total irradiance (TSI) of the Sun. The determination of the natural climate variability is therefore of decisive importance for a credible estimation of the human-made signal and hence for possible political decisions regarding initiatives to mitigate the effects of the increased amount of greenhouse gases. The increasing amount of greenhouse gases, in particular Co₂, which is due to human activities related to the burning of fossil fuel. In the present work, we have discussed about perspective roll of above activities on recent climate change.

Keywords: SSN, TSI, GSTemp.

I. Introduction

The Earth’s climate has always been changing. The climate variations prior to the industrial era may thus be strongly influenced by variations in solar activity. The Sun is the source of the energy that causes the motion of the atmosphere and thereby controls weather and climate. Solar activity variations have traditionally been associated with the sunspot number although it is well known that solar activity may not be described by a single number. The Solar activities follow over an 11-year cycle. Eddy (1976) provided the first thorough study of long-term (century scale) variations in solar activity and climate. This study indicated a very strong link which he hypothesized could be accounted for by small changes in the solar total irradiance. Subsequently studies of palaeoclimatic and historical solar activity inferred by its modulation of 1⁴C in tree rings and ⁷⁹Be in ice cores provided evidence that long-term minima in solar activity seems to be associated with climate on Earth that is colder than average.

The total solar irradiance (TSI) is integrated solar energy flux over the entire spectrum which arrives at the top of the atmosphere at the mean Sun-Earth distance. The TSI observations show variations ranging from a few days up to the 11-year SC and longer timescales (Lockwood and Fröhlich, 2008). The historical reconstruction of TSI absolute value is described by Kopp and Lean (2011) based on new calibration and diagnostic measurements by using TIM V.12 data on 19th January 2012, and is updated annually. TSI are known to be linked to Earth climate and temperature. The historical reconstruction of TSI and their association with 11-year sunspot cycle from 1700 onwards are shown in Figure 1. From the plot, it is find that TSI variation trend follows with SSN within a limit but centurial variation trends of TSI have not shown clear association. Linear variation of TSI for last 311 years shows continuously increasing trend. It is find that decadal TSI variation trend follows with SSN within a limit, except Maunder Minimum period. The centurial variation trends of TSI have not shown clear association. Surface temperatures and solar activity both increased during the past 400 years, with close associations apparent in pre- and post-industrial epochs (Lean et al., 1995; Reid, 1997).
However, the inference from correlation studies that Sun-climate relationships can account for a substantial fraction of global warming in the past 150 years is controversial.

**Figures 1:** Shows the long-term variation of TSI and yearly mean SSN, during 1700 onwards. [The data were taken from SOURCE website (http://lasp.colorado.edu/sorce/index.htm)]

The associations of TSI with global surface temperature (GSTemp) from 1880 onwards are shown in **Figure 2**. From the plot, centurial variation trends of TSI and GSTemp both show increasing trends.

**Figures 2:** Shows the variation of TSI and global surface temperature, during 1880 onwards.

The associations of sunspot number (SSN) with global surface temperature (GSTemp) from 1880 onwards are shown in **Figure 3**. From the plot, centurial variation trends of SSN and GSTemp have not very clear associations.
The basic components that influence the Earth’s climatic system can occur externally (from extraterrestrial systems) and internally (from ocean, atmosphere and land systems). The external change may involve a variation in the Sun’s output. Internal variations in the Earth’s climatic system may be caused by changes in the concentrations of atmospheric gases, mountain building, volcanic activity, and changes in surface or atmospheric albedo. The basic causes of increase in global temperature can occur from variation in TSI and human made activities (mainly emission of CO2). Atmospheric carbon dioxide (CO2) is an important kind of greenhouse gas which influences global temperature. Its concentration variation could indicate the distribution of human and natural activities in various regions. The increase in CO2 then amplified the global warming by enhancing the greenhouse effect. The long-term climate change represents a connection between the concentrations of CO2 in the atmosphere and means global temperature. CO2 concentrations in the atmosphere have increased from about 280 ppm in pre-industrial times to 395 ppm at present. The variation of atmospheric CO2 (in ppmv) collected at Mauna Loa, Hawaii and their association with global surface temperature (GSTemp) during 1880 onwards are scatter plotted in Figure 4. From the plot, it is clear that the rate of concentration of atmospheric CO2 and GSTemp both are increasing continuously during above mentioned periods.

**Figures 3:** Shows the variation of SSN and global surface temperature, during 1880 onwards.

**Figures 4:** Shows the variation of CO2 and global surface temperature, during 1880 onwards.

**References**