Solar activity and regional climate over short time scales at Thiruvananthapuram, South Kerala, India

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Possible correlation between solar activity and surface air temperature, however, small yet statistically significant that could exist over very small time scales at a particular station, is presented during a period in which the sunspot number exhibit a rising trend. The correlation between the variability of the daily and monthly average surface air temperature and solar irradiance at Trivandrum with sunspot number from January 2008 to March 2011 was investigated. The year 2008 was a solar minima year marking the end of 23rd solar cycle from May 1996 to December 2008 with duration of 12.6 years, while year 2009 was the beginning of the 24th solar cycle with the sunspot number showing a gradual rise during 2009-2010. The correlation between sunspot number, solar irradiance and surface air temperature were estimated during winter and pre-monsoon seasons when the effect of clouds was minimum. No statistically significant correlation was obtained between the surface air temperature or solar irradiance and sunspot number over small time scales unlike the small yet statistically significant correlation reported for studies over longer time scales.

Keywords: Solar irradiance, Sunspot number, Surface air temperature

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1 Introduction

In the development of basic science of climate change, which has become an extremely important and active field in recent times, both global and regional perspectives are equally important. The identification of factors which affect global and regional climate changes is being pursued at a very intensive scale. The anthropogenic greenhouse gas concentration in atmosphere plays the major role in climate change and the contribution of solar variation is negligible with a certainty of 95%. However, empirical studies have proved that the surface and atmospheric temperature changes are driven by solar irradiance variations and hence, solar variations could play a not so insignificant role on the climate change at micro and global scales. Some of the notable works in this regard are the positive correlation between the sunspot cycle length and the land temperature of the northern hemisphere from 1861 to 1989 by Christensen & Lassen, correlation between the sunspot number and annual surface air temperature from 1881 to 2004 in Egypt, correlation between sunspot number, global surface air temperature and geomagnetic aa-indices for the period 1850–2000 (Ref. 1), etc. The correlation between sea surface temperature (SST) and solar activity using two independent data sets of surface marine weather observations during 1990–1991 and upper bathythermograph temperature profiles during 1955–1994 (Ref. 4) are also reported. Most of the studies use data sets recorded over many years exceeding over many decades. Surface air temperature is used by most researchers as the most suitable parameter for quantifying the climate, and the average annual temperature is often used for correlation studies since investigations were on a longer time scale. It has been known for many centuries that the property of the Sun vary and because of the continuous changes in solar activity, the total solar irradiance vary over different time scales from seconds to centuries. The changes in solar activity are most evidently visible in the solar cycle with a period of 11 years and sunspot number is often used as a quantity which represents the solar activity.

In the present work, the correlation between the variability of the daily and monthly average surface air temperature and solar irradiance at Trivandrum with sunspot number has been studied from January 2008 to March 2011. The possible correlation, however, small yet statistically significant that could
exist over very small time scales at a particular station during a period in which the sunspot number exhibit a rising trend is examined. Such an investigation will be of interest from the point of view of microclimatology.

2 Data and Method

The experimental site is Astronomical Observatory, University of Kerala, Thiruvananthapuram (76°59’E longitude and 8°30’N latitude), Kerala, India situated at about 64.31 m above mean sea level and nearly 8.4 km inland from the coast. Roxy et al.\(^7\) established the relationship of surface albedo with soil moisture at Thiruvananthapuram, while Abraham & Renuka\(^8\) had studied the energy budget across the soil-air interface which is essential for forecasting climate. For the present study, half hourly data of surface air temperature and solar irradiation was measured and the daily means were estimated. Surface air temperature was measured using a P-N junction semiconductor detector with an accuracy of ±1°C while the solar irradiance was recorded using a wide spectrum photodiode with an accuracy of ±1 W m\(^{-2}\). Sunspot numbers were obtained from the NOAA website for each day of the entire duration of the present study. The sunspot number was treated as a parameter representing solar activity and the possible cause-effect relationship with solar irradiance and surface air temperature was investigated. For correlation analysis, scatter plots were plotted between: (i) sunspot number and solar irradiance and (ii) sunspot number and surface air temperature and the correlation coefficient was estimated.

3 Results and Discussion

Figure 1 shows the variation of the daily averages of surface air temperature, solar irradiance and sunspot number for the entire period of the study, January 2008 to March 2011. Scatter plots were drawn and correlation coefficient between: (i) sunspot number and solar irradiance and (ii) sunspot number and surface air temperature were estimated for the entire period of study and separately for different seasons. It was observed that maximum correlation was obtained only during the winter (December-February) and pre-monsoon (March-May) seasons. This is because the period June-November correspond to the south-west and north-east monsoon seasons in Kerala where the conditions are mostly overcast which naturally influence the daily temperature significantly. As measurements in the present study are ground based, the solar irradiation data is bound to be affected by overcast conditions and possible correlation between solar activity and surface temperature is expected to be evident only during winter and pre-monsoon seasons. A correlation coefficient of +0.021 was obtained between sunspot number and solar irradiation while it was +0.087 between sunspot number and surface air temperature (Fig. 2). These values are too low to be statistically significant. Valev\(^1\) had reported a correlation coefficient of +0.27 between global temperature and sunspot number using 15 decades yearly averages. It was pointed out that though the correlation coefficient is small, it is statistically significant\(^1\). The correlation coefficient obtained, in the present study, leads to the conclusion that over short time scales, such as days and months, the dependence of solar irradiation and air temperature on the solar activity is not significant.

In order to examine whether the lack of correlation at shorter time periods is limited to solar minima...
period, a similar analysis was performed for the period 2001-2002 which correspond to the maxima of a solar cycle. In order to minimize the influence of clouds, the analysis was done only for data corresponding to the winter (December-February) and pre-monsoon (March-May). Data is shown in Fig. 3 and the correlation coefficient was found to be 0.106. It may be noted that there is an enhancement of correlation coefficient by 21.84% and even though the correlation is small, it is statistically more significant.

4 Conclusion

Possible correlation between surface air temperature and sunspot number at short time scales were investigated using daily averaged data at Trivandrum in the light of the reported small yet statistically significant correlation that exist over larger time scales. The study was conducted over a period January 2008-March 2011, which included one solar minima year and the onset of a new solar cycle. There exists no statistically significant correlation between the two parameters at shorter time scales during the period of study. It was also observed that correlation between the sunspot number and surface air temperature shows a slight but notable increase during 2001-2002, a solar maximum period. The investigation of the relationship between air temperature and solar activity over medium and longer time scales will be performed and the possibility of using parameters such as thermal anomaly instead of daily means will also be explored in the near future.

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References

