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CORRELATION BETWEEN THE GLOBAL RADIATION AND SOLAR INDICES

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ABSTRACT

The relationship between Global radiation on a horizontal surface at Chennai and solar indices(smoothed sunspot number,10.7cm solar flux, aa index and sunspot area) are individually analyzed in this paper. Analysis has been done for the period from 2008-2010. The method used for the analysis has been Least square regression method. The relationship revealed that the Global radiation correlates negatively with the solar indices.

INTRODUCTION

Global solar radiation is an important parameter necessary for most ecological models and serves as an input for different photovoltaic conversion system, which is of greater Economic importance for renewable energy alternation. The solar radiation reaching the Earth's surface depends on the climatic conditions of the specific site location. The sun is a constant energy source and is known for its cyclic behavior. Solar radiation output changes periodically and it affects the Earth and its atmosphere different ways , such as the formation of aurora, adverse effects on the satellite communications. Various indicators for the sun-climate connection such as sunspot numbers(Chambers,1878)[1],Solar cycle length(Friis-Chrislensen and Lassen.1991)[2] , Geomagnetic aa indexes(Cliver and Borier Koff,1998)[3] and Solar irradiance changes (Floyd et.al 2001)[4] have been reviewed in past literature. Recently Samuel selvaraj et.al 2011[5] have done research on the variation of Chennai global radiation due to sunspot number.

W.E.Alnaser et.al(1991) developed a correlation study between Global radiation and sunspot number.[6] Earth receives a total amount of radiation by its cross section ($\pi \cdot RE^2$), but as it rotates this energy is distributed across the entire surface area ($4 \cdot \pi \cdot RE^2$). Hence the average incoming solar radiation (called the solar irradiance), taking into account the angle at which the rays strike and that at any one moment half the planet does not receive any solar radiation, is one-fourth the solar constant (approx 342 W/m²). At any given moment, the amount of Solar radiation received at a location on the Earth's surface depends[10] on the conditions of the atmosphere and the latitude of the location.

This Solar Irradiance hits the surface of the earth in two forms, beam (Gb) and diffuse (Gd). The beam component comes directly as irradiance from the sun[11,12], while the diffuse component reaches the earth indirectly and is scattered or reflected from the atmosphere or cloud cover.The total irradiance on a surface is G = GB + Gd

Sunspots are temporary on the photosphere of the sun that appear visibly as dark spots compared to surrounding regions. The F 10.7 index is a measure of the solar radio flux per unit frequency at wavelength of 10,7cm, near the peak of the observed solar radio emission. The aa index is a measure of the disturbance level of the Earth's magnetic field based on magnetometer observations at two nearly antipodal stations. The daily sunspot area is the measure of the area of solar surface covered by spots (in the sunspot area unit namely ppm of solar hemisphere) in an observational day. The monthly average of the daily sunspot area usually bears information of long term variations of solar activity.[7,8] As the number of spots increases the total area of the spots naturally increases and their magnetic complexity usually grows as well.

The objective of the work is to look for individual correlation between the monthly averaged daily global radiation on a horizontal surface at Chennai with solar indices like sunspot number .10.7cm solar flux , aa index and sunspot area . Method of least squares is used to find out the Mean Bias Error , Root Mean Square Error and Mean Average Percentage Error.

DATA ANALYSIS AND METHODOLOGY

The local climate was analysed using the following data. The monthly average daily global radiation on a horizontal surface for Chennai for 30 months(July2008 to December2010) were obtained from the Indian Metrological Department, Pune. The solar indices data were taken from the site ftp://Ftp.ngdc.noaa.gov/STP/SOLAR_DATA

Table. 1 gives information about the data and location .Chennai is located in the coastal region of Tamil Nadu state in India.

Location	Chennai
Latitude	13^0N
Longitude	$80^0$11'E
Altitude	16m
Year/months of data used	July2008-December2010/30months

The concept of 'correlation' is a statistical tool which studies the relationship between two variables. "Regression analysis is a mathematical measure of the average relationship between two or more variables in terms of the original units of the data."Regression analysis, in general sense, means the estimation or prediction of the unknown value of one variable from the known value of the other variable.

For this study, correlation coefficients are calculated to analyze the statistical relationship between global radiation and solar indices like sunspot number,10.7cm solar flux, aa index and sunspot area. Correlation coefficient for global radiation with solar indices have been found individually for every index. Table 2 shows the comparison of the correlation coefficient of Global radiation with the sunspot number,10.7cm solar flux, aa index and sunspot area.

Table 2 Correlation coefficient of Global radiation with solar indices

	Global radiation	Sunspot number	Solar flux	aa index	Sunspot area
Global radiation	1.0000	-0.4548	-0.4595	-0.0216	-0.4044
Sunspot number	-0.4548	1.0000	0.9947	0.4138	0.8316
Solarflux	-0.4595	0.99472	1.0000	0.3432	0.8359
aa index	-0.0216	0.4138	0.3432	1.0000	0.1920
sunspotarea	-0.4044	0.8316	0.8359	0.1920	1.0000

Sunspot number,10,7cm Solar flux,sunspot area are negative correlation with the Global radiation,but aa index show no significant correlation with the Global radiation.

After performing all the Regression techniques to study the correlation between global radiation and the solar indices, it was found that the linear model works with least error.

The linear regression equation for solar indices are Y=aX + b

Where Y-Global radiation, X-Solar indices, and a,b-regression coefficients obtained by fitting measured data.

The following statistical errors are used to test the performance of model.[9]

Mean Bias Error is defined as

MBE=(1/N)∑(Hcomputed –Hmeasured)

Where N denotes total number of observations.

This test provides an information on the long term performance. A low MBE is desired. Ideally a zero value of MBE should be obtained. A positive value gives the average amount of over-estimation in the calculated value or vice versa. One draw back of this test is that over estimation of an individual's observation will cancel under estimation in a separate observation.

Root Mean Square Error is defined as

RMSE={[∑(Hcomputed - Hmeasured)2]/N}1/2

Root mean Square Error is always positive, a zero value is ideal. This test provides information on the short term performance of the models by allowing a term by term comparison of the actual deviation between the calculated value and the measured value.

Mean percentage error is defined as

MPE=[∑(Hmeasured – Hcomputed/Hmeasured) X 100]/N

Table 3

Solar indices	MBE	RMSE	MAPE
Ssn	0.67995	1.661619	9.542989
10.7cm	0.69509	1.815245	10.22973
Aaindex	2.104048	2.828876	13.99744
Sunspot area	-0.01392	9.591663	12.04038

RESULT AND CONCLUSION

The monthly average daily global radiation by the linear model have been compared with solar indices . The present study shows that linear model between global radiation and sunspot number can result in low error level. MPE is 9.54298, RMSE is 1.661619 and MBE is 0.67995,followed by the 10.7solar flux MPE 10.22973 ,RMSE 1.815245, MBE 0.69509 ,then aa index MPE 13.99744, RMSE 2.828876, MBE 2.104048 and the sunspot area MPE 12.04038 RMSE 9.591663 MBE -0.01392. So sunspot number is more correlated with Global radiation as there is least error in comparison to other indices.

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