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RESEARCH ARTICLE

Estimation of the Global Solar Radiation in Anyigba Kogi State Using Hargreaver And Samani

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Abstract
This work estimates the global solar radiation in Anyigba with latitude 7.498 using Hargreaves and Samani model. The average monthly global radiation for Anyigba was found to be 32 MJ/m^2 /day with a MBE of 15.6333 MJ/m^2 /day and RMSE OF 5.985 MJ/m^2 /day.

Keywords: Hagreave and Samani; Global Solar Radiation; Extraterrestrial Solar Radaiation; Clear Sky Index

Introduction

Having adequate information of the global solar radiation and other meteorological factors is important both in the field of solar energy and agriculture. Empirical models such as Angstrom-Prescott and Hargreaves and Samani model can be used to estimate global solar radiation. This is because many locations in developing countries do not have weather stations that record this meteorological factors such as temperature, humidity and global solar radiation (Abdu and Ayodele, 2016).
Solar radiation data is important in architectural design, solar energy design and irrigation system and crop growth (Okogbue and Adedokun, 2002). Most empirical models uses sunshine meteorological factor for the estimation of global solar radiation (Abdu and Ayodele, 2016). Temperature factor based models like Hargreaves and samani can also be used were temperature data is available.
Some related work includes the research conducted by Bernadetta, *et al* 2017, which involves testing of the performance of some empirical models. The model tested includes Garcia's model. This research was conducted in Makurdi using weather data between 1990-1991 and 1995 to 2003 (Jegede *et al*, 2017) where the global solar radiation month variation for the location was estimated.
Ayegba *et al*, used Hargreaves and Samani model to estimate the global solar radiation for Abuja using minimum and maximum temperature data between February 1-29, 2016, obtained from weather online limited . The maximum global radiation was estimated to be 29.60.609 MJ/m^2 / day.
Jegede *et al* 2017, estimated the monthly global solar radiation on Ida campus of Ida Federal polytechnic in Kogi State using maximum and minimum temperature data between July 1998 to June 30, 2015. It was observed that Hargreaves and Samani's model has their values of maximum global solar radiation more than Angstrom model's estimated global solar radiation. Therefore there is need to extend the use of Hargreaves and samani model beyond Ida and ascertain its suitability for other locations.

Aim

Aim of this study is to evaluate the global solar radiation in Anyigba, Kogi state, using Hargreaves and Samani Model, by obtaining the solar radiation data from the Centre for Atmospheric Research, determine the variability of solar radiation in Anyigba using Hargreaves and Samani then have better understanding of how solar radiation changes in different months of the year using this model.

Scope of the study

This study will be carried out in the geographical area of Anyigba with altitude of 420metres above sea level. Five (5) years solar radiation data (2011-2016) would be used for this work. The availability and variability of solar radiation will be analyzed using Hargreaves and Samani model.

Materials and method

In order to estimates the global solar radiation using Hargreaves and Samani model, solar radiation data from 2011 to December 2016 was obtained from the Centre for Atmospheric Research Centre (CAR), in Kogi State University Anyigba with coordinate 7.498 ^{0}N, 6.829^0 E. The data collected was recorded using Campbell weather station. Campbell weather station is powered using a solar panel and designed to work automatically unmanned for a longer time. It comes with an enclosed data logger,

pressure sensor and a 12 volt battery. Campbell weather instrument has a sensor which records the meteorological factors such as the solar radiation, wind speed, wind direction and soil temperature. The weather instrument records meteorological data automatically for 24 hours every day, and resolution of five minutes. The data was recorded in Watt per meter square (W/m^2). The solar radiation data obtained was sorted from hourly data to a monthly data solar radiation, a six year data of minimum and maximum temperature was obtained for the year 2011 to 2016. The minimum and maximum data of the temperature was used to obtained the global solar radiation using Hargreaves and Samani model as shown in equation one(1). Muhammad J.Y.,(2018).

$$H/H_0 = a\,(T_{max} - T_{min})^{1/2} \quad (1)$$

Where a is set at 0.16 for interior region

Hargreave and samani after more research took the coefficient of the Model as a=0.16 for interior region and a=0.9 for costal region.

Where H_o is the extraterrestrial radiation (radiation intensity outside the earth's atmosphere) measure in joule per day.

The value of H_o can be calculated using the equation given by Abdu and Ayodele, 2016 as:

$$H_o = \overline{H_O} = \frac{24\times3600}{\pi} I_{sc}\left[1 + 0.033cos\frac{360d}{365}\right] \times \left(cos\varphi\ cos\delta\ sin\omega s + \frac{\pi}{180}\omega s\ sin\varphi\ sin\delta\right) \quad (2)$$

Where:

w_s = sunset hour angle in degree defined as:

$$w_s = cos^{-1}(-tan\varphi tan\delta) \quad (3)$$

δ = declination angle given as:

$$\delta = 23.45 \sin\left(360 \times \frac{[284+75]}{365}\right) \quad (4)$$

ø = the latitude of the location;

ḍɳ = day number of the year starting from the first of January;

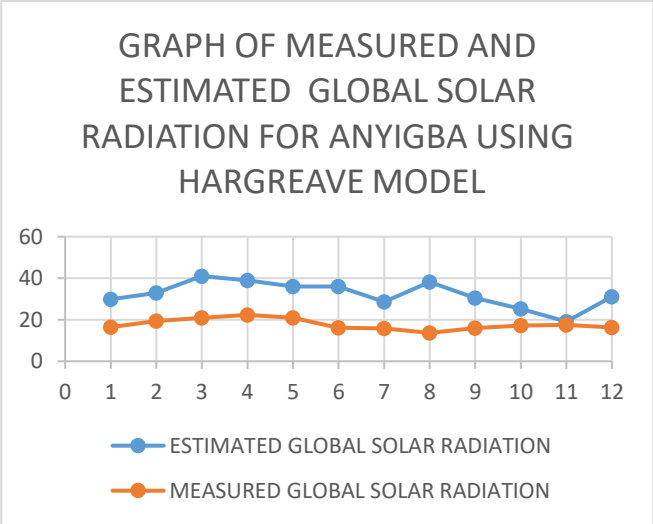
I_{sc} = Solar constants given as 1367 (Wm^{-2});

Result and discussion

Table 1: Average solar radiation from 2011 to 2016

A_{MODEL} = 0.16

MONTH	T_{MIN} (^{O}C)	T_{MAX} (^{O}C)	$\overline{Ho}$ (MJ/day)	$\bar{H}_{icalculated}$ A_{model} (MJ/day)	$\bar{H}_{measure}$ (MJ/day)
January	5.25	37.34	32.9788	29.8900	16.4020
February	8.20	42.34	35.2930	32.9953	19.4216
March	8.63	56.10	37.2209	41.03139	20.9286
April	7.63	49.43	37.7024	39.0012	22.3609
May	8.24	45.42	36.8846	35.9849	20.8980
June	9.20	48.05	36.1095	36.0114	16.1654
July	9.80	34.73	36.3333	28.6273	15.1654
August	3.51	44.75	37.1392	3816 03	13.6800
September	8.70	35.10	37.1568	30.5464	16.0092
October	7.77	27.45	35.6608	25.3118	17.2066
November	6.51	19.35	33.3857	19.1409	17.5666
December	9.60	46.00	32.1839	31.0669	16.2436



Discussion

From Table 1, it shows the month of March to be the month with the highest global solar radiation which corresponds with the measured global solar radiation. Fromm table 1, it can be seen that the month of November recorded the lowest global solar radiation while the month with the lowest global solar radiation in the measured data happens to be the Month of August. This is an anomaly as the pattern of the estimated data is supposed to correspond with the measured data, from the graph in figure 1, it can be seen that as the global solar radiation of the measured global solar radiation increases and decreased , there is a corresponding increase and decrease in the estimated global solar radiation except for the month of August and December, in the month of August the estimated increase while the measured data decrease. In December estimated data increase abruptly whereas the measured data decreases, this is as a result of errors in the minimum and maximum temperature data used and the suitability of the model for the estimation of the global solar radiation

Conclusion

In areas where there are no solar radiation data but minimum and maximum temperature data, the temperature data can be used with Hargreaves and samani model to estimate global solar radiation. The global solar radiation for Anyigba was estimated using Hargreaves and Samani model. The average monthly global solar radiation was found to be 32MJ/m^2 /day with a RMSE of 15.633314MJ/m^2 /day and MBE of 5.9805 MJ/m^2 /day . This implies that comparing the measured and estimated global solar radiation for Anyigba using the model, the estimated global solar radiation shows an overestimation of about 15.6314 MJ/m^2 /day , which is above acceptable range. Therefore the global solar radiation estimated does not show a good agreement with the measured global solar radiation. This may be as a result of inaccurate temperature data.

Recommendation

There is need for further investigation of suitability of Hargreaves and Samani model for Anyigba using data from different weather stations.

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