

Estimations of Solar Energy Potentials of Sokoto State Using Temperature Base Model of Armstrong Empirical Equations

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ABSTRACT:In this study the solar energy potential available in sokoto state Nigeria is Estimated using Temperature base model of Armstrong empirical equations for a period of three years (2013 , 2014, 2015), The aim of the study is to; investigate solar energy potential available in the state and to test the validity of temperature base model of the Armstrong empirical equations, compare the estimated data of the state solar radiations with measured data by the meteorological stations, calculations were made and the results of the estimated and measured data where compared and analysed , the result shows a variations of solar radiations with respect to weather conditions for both the measured data from the metrological stations and the estimated using temperature model of Armstrong empirical equation.

KEYWORDS:Armstrong empirical equations , temperature , solar radiations , sokoto, estimate, Metrological.

I. INTRODUCTION

Sokoto is in the dry Sahel surrounded by sandy savannah and isolated hills. With an annual average temperature of 28.3 °C (82.9 °F), its believed that it's one of the hottest cities in the world, however the maximum daytime temperatures are generally under 40 °C (104.0 °F) most of the year,[1]

Solar radiation affects the earth's weather processes which determine the natural environment. Its presence at the earth's surface is necessary for the provision of food for mankind. Thus it is important to be able to understand the physics of solar radiation, and in particular to determine the amount of energy intercepted by the earth's surface at different locations[2]

Knowledge of local solar radiation is essential to many applications including architectural designs, solar energy systems, crop growth models, hydrological models, and design of irrigation systems[3] [4] . Auwal Muhammad and T .H. Darma (2014) , state that , Global solar radiation in Nigeria is measured in few stations, and even in these few stations the use of estimate from theoretical models is important with a view to authenticate the measured data.[5]

The aim of this work is to investigate solar radiation characteristics for sokoto region using temperature base model of the Armstrong empirical equations and compare the estimated data of the state solar radiations and to the measured data by the meteorological stations, and also to shows the variations of the solar radiations with respect to weather conditions . for both the measured data from the metrological stations and the estimated data from temperature model of Armstrong empirical equations .

II. MATERIAL AND METHOD

Maximum and minimum temperature data obtained from Nigeria Meteorological Agency (NIMET) was used to Estimate the Global solar radiation of the state for a period of three years (i.e 2013 , 2014 , 2015) . sokoto was located at a (13 o.1/N , 5 o.15/E).

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Linear regression analysis was employed to estimate the global solar radiation. Where H_g/H_o is the clearness index, [6]. while T_{min}/T_{max} is the ratio of minimum to maximum monthly temperature of a location.

$$\frac{H_g}{H_o} = a + b \left(\frac{T_{min}}{T_{max}} \right) \quad (1)$$

In a similar work by Ndilemeni C. C. et al, in which they calculate the global solar radiations of sokoto using sunshine hours data of the state, they found that the regression constants a and b of the above equations as $a=0.31$ and $b=0.47$. [7]

H_o is known as the monthly mean daily extra-terrestrial radiation falling on horizontal surface while H_g is a measure of monthly mean daily global solar radiation falling on horizontal surface, while the ratio of this two important variables is known as the clearness index of the state .[8].

$$H_o = \frac{24}{\pi} \times 3600 I_{sc} \left(1 + 0.033 \cos \frac{360n}{365} \right) (\cos \phi \cos \delta \sin W_s + \sin \phi \sin \delta W_s) \quad (2)$$

Where

I_{sc} is the solar constant in MJm^{-2} -day,

W_s is the hour angle, expressed as

$$W_s = \cos^{-1}(-\tan \phi \tan \delta) \quad (3)$$

$$\delta = 23.45 \sin \left(\frac{360}{365} (284 + n) \right) \quad (4)$$

where N is the characteristic day number for each month: $N = 1$ on 1st January to 365 on 31st December. The mean day length is expressed as:

$$\bar{N} = \frac{2}{15} W_s \quad (5)$$

The values of the mean extra-terrestrial solar radiation and day length as in equation (1) were calculated for the fifteenth day of the month as given by Igbal (1983), Duffie and Beckman (1991) and Nwokoye .[2][9]

III. RESULT AND DISCUSTIONS

Result Table

month	Tmax (°C)	Tmin (°C)	Hg KJ/m ² day	Ho KJ/m ² day	Tmin/Tmax	Hg/Ho
Jan	35.5	18.8	11619.89	30550.17	0.5295775	0.380354
Feb	36.21111	20.8	12981.11	33500.66	0.5744093	0.387488
Mar	39.22222	23.63333	14443.93	36373.23	0.6025496	0.397103
Apr	41.04444	26.86667	15624.77	38039.39	0.654575	0.410752
May	39.31111	26.2	15677.61	38184.24	0.6664783	0.410578
Jun	37.56667	24.38889	15105.21	37825.15	0.6492162	0.399343
Jul	32.45556	23.31111	16231.21	37846.55	0.7182471	0.428869

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Aug	30.57778	22.93333	16551.25	37869.08	0.75	0.437065
Sep	33.55555	22.73333	15284.58	36788.05	0.6774835	0.415477
Oct	35.32222	20.85555	13015.3	34202.27	0.5904372	0.380539
Nov	35.91111	20.84445	12237.88	31154.99	0.5804456	0.392806
Dec	34.45556	20.57778	12053.4	29575.65	0.5972266	0.407545

Above is the table of values obtained from the calculations, where both estimated monthly global solar radiations and monthly mean daily extra-terrestrial radiation falling on horizontal surface were measured in $\text{KJ/m}^2 \text{ day}$, while the minimum and the maximum temperatures monthly average temperature are in degrees

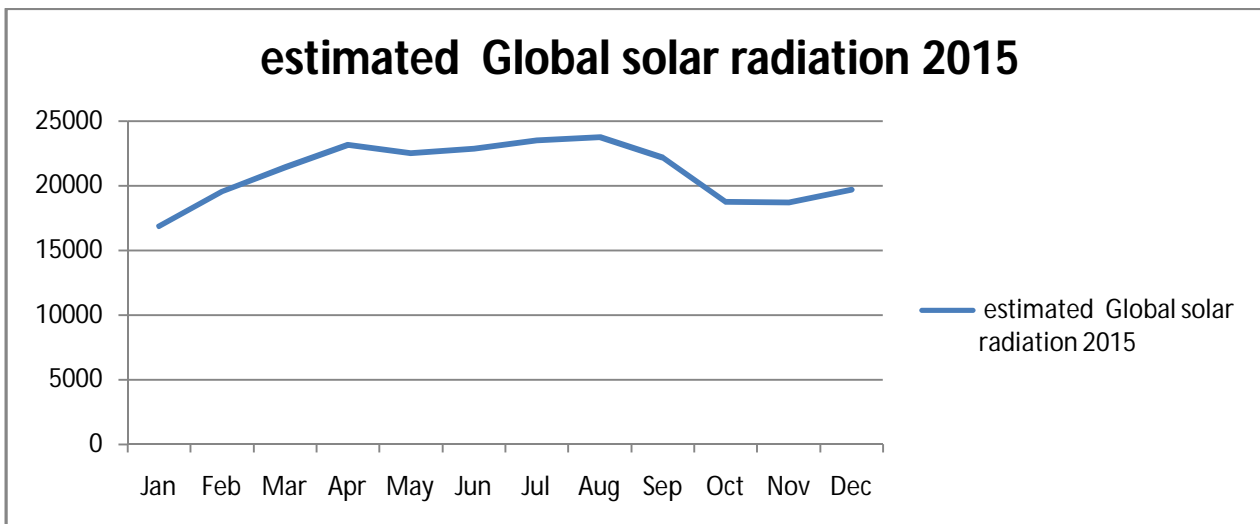


Fig. 1 Graph of estimated monthly average Global solar radiation for the 2013, the figure shows highest value of the estimated global solar radiations was recorded in September while the smallest value in January .

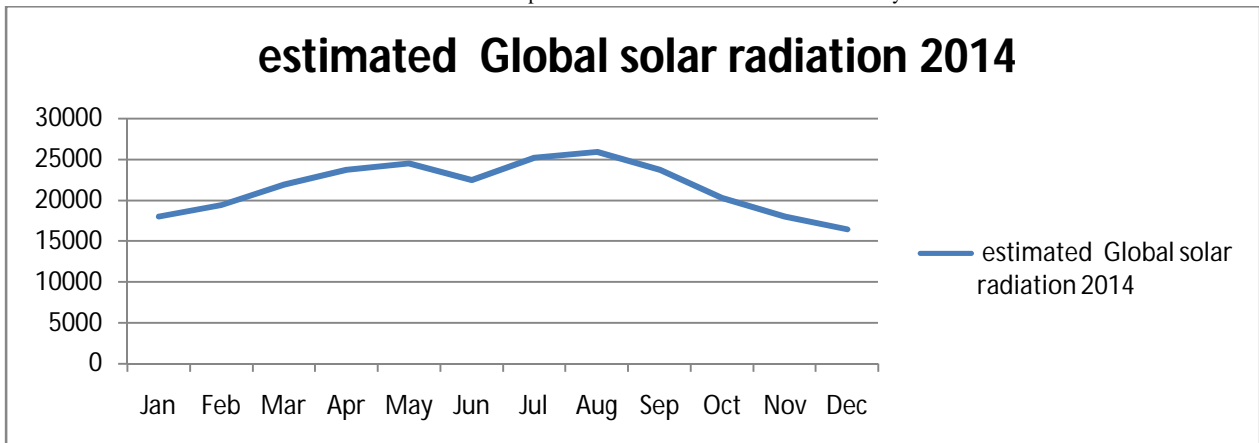


Fig.2 Graph of estimated monthly average Global solar radiation for the 2014, the figure shows highest value of the estimated global solar radiations was recorded in August while the smallest value in December.

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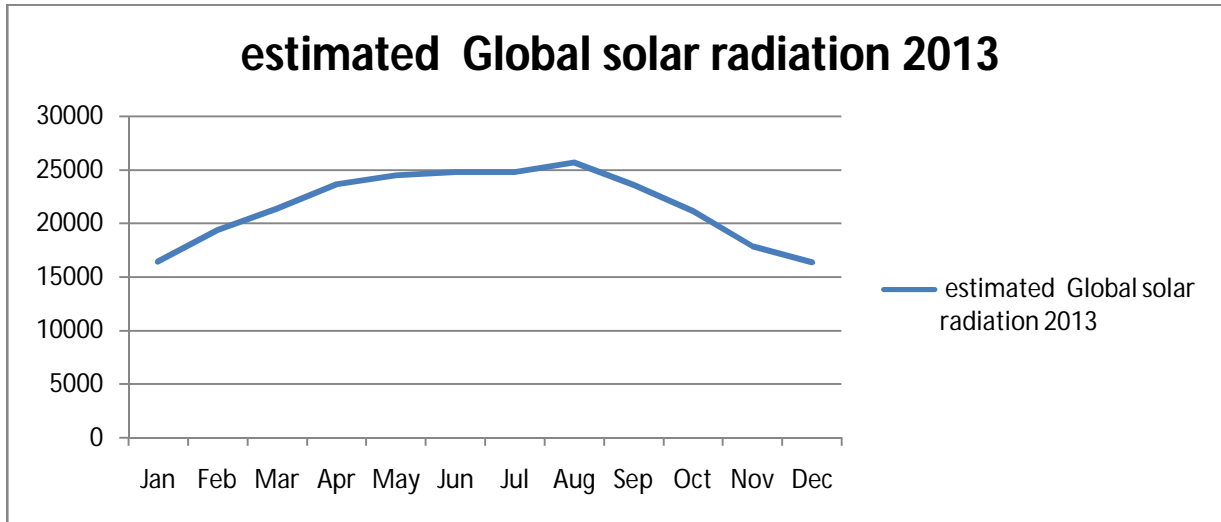


Fig.3 Graph of estimated monthly average Global solar radiation for the 2013 , the figure shows highest value of the estimated global solar radiations was recorded in august while the smallest value in December, which is much similar with that of the year 2014.

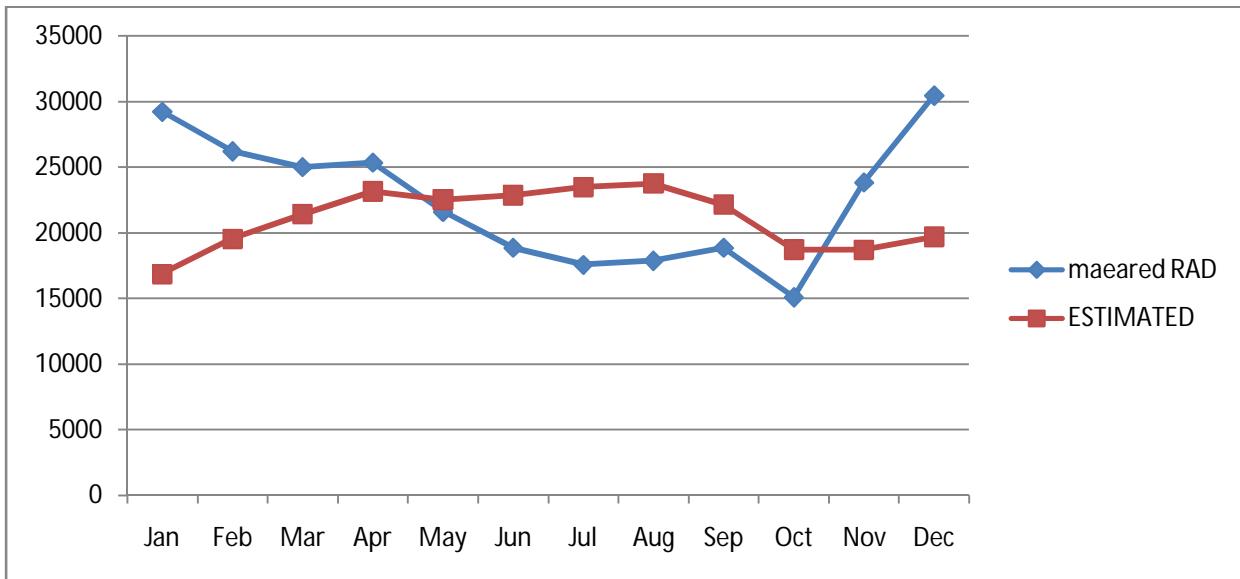


Fig.4Graph Of The Measured Average Monthly Solar Radiations And Estimated Monthly Average Global Solar Radiation For The year 2015

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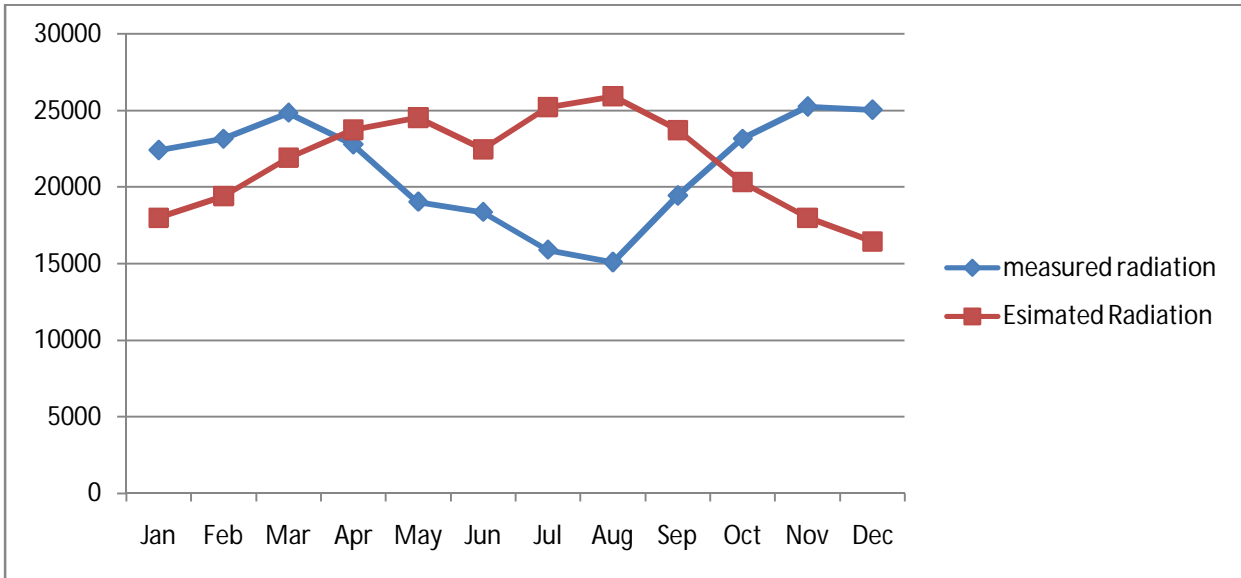


Fig.5 Graph Of The Measured Average Monthly Solar Radiations And Estimated Monthly Average Global Solar Radiation For The year 2014

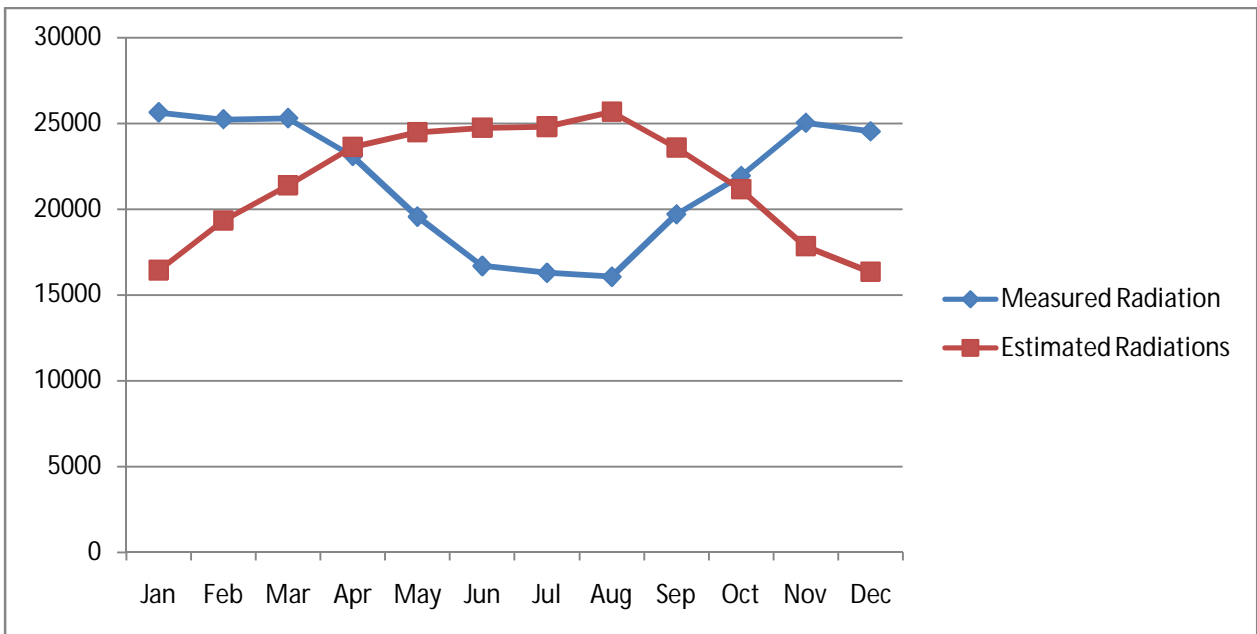


Fig.6 Graph Of The Measured Average Monthly Solar Radiations And Estimated Monthly Average Global Solar Radiation For The year 2013

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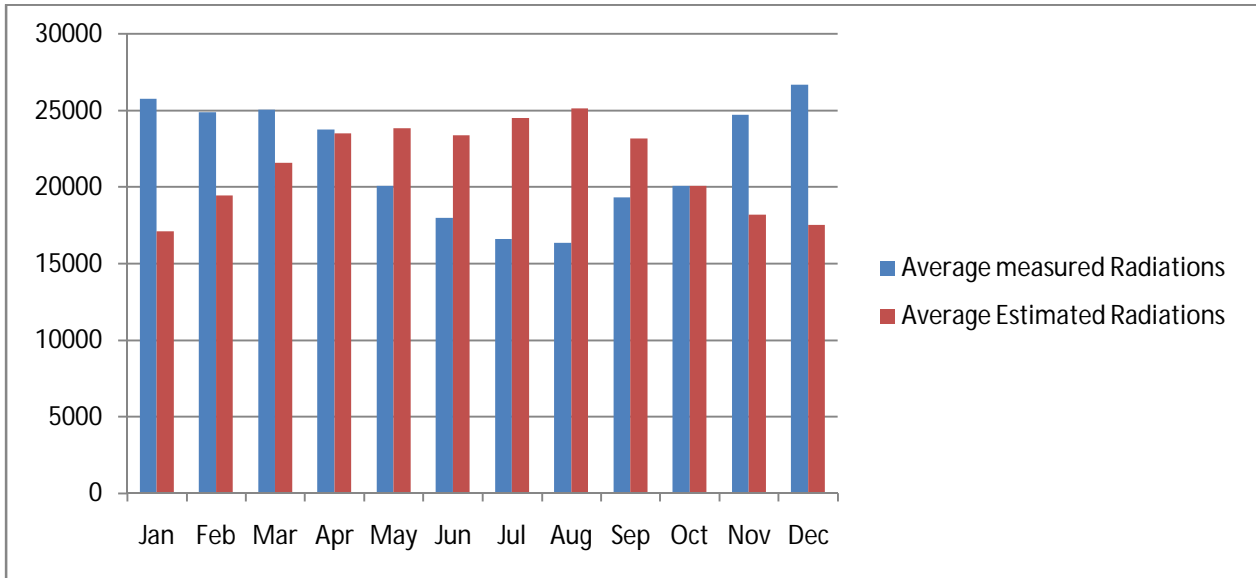


Fig.7 Graph Comparing The Average Estimated Global Solar Radiations With The Average Measured Solar Radiations Over The Period Of Study (2013 To 2015).

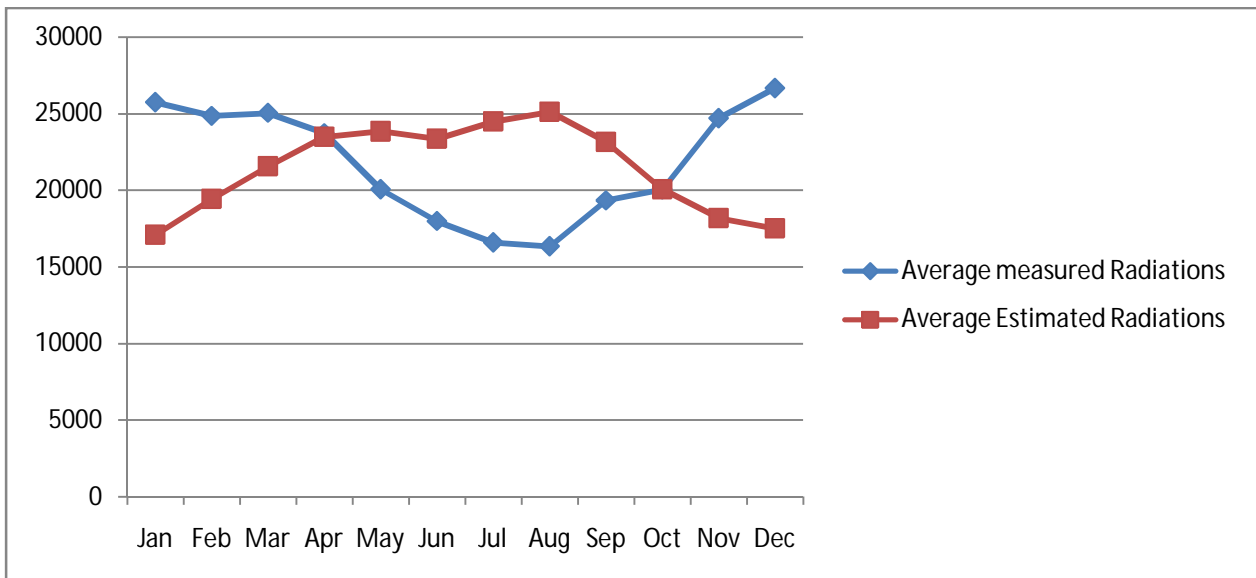


Fig.8 A graphs that compare the average estimated radiations and the average measured radiations over the period of the study

Fig.7 Shows that From January to April the average estimated radiation is far less than the measured value of the radiations. But from the May to September, the estimated radiations is greater than the measured radiations while at October they appear to have almost equal value. But from Nov. to December the measured radiations is becomes greater than the estimated radiations

These changes where do the effect of other metrological data especially rainfall, relative humidity, cloud, and hazed, which we believe they have a reasonable effects on the temperature changes and clearness of the sky, and may also have an influence on the measured data of solar radiations.

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Climatic data report of the state, report that , the state usually experience rainfall from the start of May to September. and some extent it exceed to October, and within that period the amount of radiations received was low (measured) as shown clearly from the fig.8 while the estimated radiation appeared to have a reasonable high value , this happens because the estimations is based on temperature of the state , and the state experience a high temperature during this period despite of the rainfalls, to an average high of about 38°C per month .

IV. CONCLUSION

Its clear and well proven by this study that sokoto is well blessed with abundant solar radiations which is available throughout the year. Its peak value of the estimated radiations is 25111.77KJ/m² day in the month of the August while the peak value of the measured radiations of the period of the study is 26666.66 KJ/m² day but in the month of the December , the discrepancies between the estimated and measured data is because ofr the environmental and climatic conditions of the state which effect both the measured and estimated data , but the fall of the amount radiations in the state between April and October is due to the raining seasons where the clearness of the sky is highly effected by clouds , while the fall of the amount of the estimated radiations between month of October to the April is due to the winter , which mostly characterize by low temperature and high Haze and wind.

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