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Artificial neural network and empirical models for the correlation of annual average global solar radiation with maximum temperature at Uyo, Nigeria

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ABSTRACT

Annual average daily values of global solar radiation and annual maximum temperature over a period of seventeen years (1991-2007) using artificial neural network model and Angstrom-Prescott model have been developed to estimate annual global solar radiation at Uyo which lies latitude 5^o 30'N, and Longitude 5^o 41'E. It was found that both models has estimating capacity but artificial neural network has better estimating ability and was suggested for the estimation of global solar radiation of Uyo and its environ. The dependency of the models was tested in terms of mean percentage error (MPE), mean bias error (MBE) and root mean square error (RMSE) and the artificial neural network model were found to have low error values when compared to Angstrom model.

Key-words: Global solar radiation, artificial neural network model, Angstrom model, Uyo, Temperature, Estimation

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INTRODUCTION

Nigeria is faced with immense energy challenges, characterized by low rates of access to electricity, irregularities and a general shortage in electricity supply in the country. Solar energy can provide Nigeria governments with the opportunity to address these challenges. She is endowed with sufficient solar radiation potential that can be effectively harnessed as renewable energy resource in the country.

Temperature plays an important role in determining the global solar radiation and the conditions in which living organisms can exist. Thus, birds and mammals demand a very narrow range of body temperatures for survival and must be protected against extreme heat or cold (Ibeh et al, 2011)

It is one of the determining factors of the weather. It varies with altitude from one atmospheric layer to another, and stays constant for about altitude of 10 km. The atmosphere always contains some moisture in the form of water vapor; the maximum amount depends on the temperature. The amount of vapour that will saturate the air increases with a rise in temperature.

The temperature of the atmosphere is greatly influenced by both the land and the sea areas. In dry season, for example, the great landmasses of the northern hemisphere are much colder than the oceans at the same latitude, and in rainy season the situation is reversed (Landis, 2009). At low elevations the air temperature is also determined largely by the surface temperature of the earth (Landis, 2009). The temperature of the atmosphere is greatly influenced by both the land and the sea areas (Ibeh et al, 2012).The periodic temperature changes are due mainly to the sun's radiant heating of the land areas of the earth, which in turn convert heat to the overlying air. Solar energy travels to Earth through space in discrete packets of energy.

The amount of solar radiation reaching the earth is usually know through solar measurement equipments while these devices are not available in some of remote or rural locations that specially have potential of solar installation. Even locations with these devices, the maintenance and logistics are enormous. Using prediction tools such as artificial neural network and empirical models are the best alternative methods to have a good estimation of solar radiation.

The objective of this study is to develop artificial neural network (ANN) and empirical based models by using meteorological data of annual maximum temperature of Uyo, located in south – south of Nigeria to estimate the annual global solar radiation of the same area.

MATERIALS AND METHODS

The monthly mean daily data for maximum temperature were collected from the Nigerian Meteorological Agency, Federal Ministry of Aviation, Oshodi, and Lagos, Nigeria.

The global solar radiation data were collected courtesy of Renewable Energy for Rural Industrialization and Development in Nigeria. The data obtained covered a period of seventeen years (1991 – 2007) for Uyo, Nigeria (latitude 5^o 1', N and longitude 7^o 53' E). The monthly averages data processed in preparation for the annual correlation of global solar radiation with maximum temperature are presented in Table 1.

EMPIRICAL MODEL

According to Iheonu (2001), the monthly mean daily solar radiation reaching a horizontal surface is on earth $\overline{H}_M$ is related to the maximum temperature $\overline{T}_M$ by the formula

$$H / Ho = a + b\, Tm \qquad (1)$$

H = measured solar radiation
Ho = monthly mean daily extraterrestrial radiation
a and b = regression constants
Tm= maximum temperature
For annual estimation, equation one we be modify to be

$$\frac{\overline{H}}{\overline{H}_O} = a + b\,\overline{T}_m \qquad (2)$$

$\overline{H}$ = annual measured solar radiation
$\overline{H}_o$= annual mean daily extraterrestrial radiation
$\overline{T}_M$ = annual maximum temperature

ARTIFICIAL NEURAL NETWORK

The basis of the artificial neural network model is neuron structure. These neurons act like parallel processing units. (Ibeh et al, 2012). The weighed sum of the inputs (Maliki et al, 2011).

$$v_k = \sum_{j=1}^{n} V_K W_{jK} + b_k \qquad (3)$$

is calculated at *kth* hidden node.

w_{kj} is the weight on connection from the jth to the *kth* node; *xj* is an input data from input node; n is the total number of input (N = 17); and b_k denotes a bias on the kth hidden node.

Each hidden node then uses a sigmoid transfer function to generate an output

$$z_k = [1+e^{-v_k}]^{-1} = f(v_k) \quad (4)$$

between -1 and 1.
We then set the output from each of the hidden nodes, along with the bias b_0 on the output node, to the output node and again calculated a weighted sum

$$Y_K = \sum_{k=1}^{n} V_K Z_K + b_K \quad (5)$$

Where n is the total number of hidden nodes; and vk is the weight from the kth hidden node to the sigmoid transfer function of the output node

RESULTS AND DISCUSSION

Table 1 also contains the results of Angstrom model, artificial neural network model and measured values of global solar radiation. Close observation of Table 1 shows that the high value of actual value occur in 1993 which is 19.05364 MJ/M^2/Day.

Table 1: Annual meteorological parameters for Global solar radiation And Maximum Temperature of Uyo from 1991 to 2007

year	$\bar{H}$ MJm^{-2} day^{-1}	$\bar{T}_M$ ^{o}c	$\bar{H}_O$ MJm^{-2} day^{-1}	$\bar{K}_T$	ANGS P MJm^{-2} day^{-1}	ANN P MJm^{-2} day^{-1}
1991	15.07624	31.4083	35.87	0.420302	16.36820	16.55
1992	14.50804	31.4583	35.86	0.404574	16.37224	14.56
1993	19.05364	31.5500	35.87	0.531186	16.41124	16.70
1994	14.83002	31.2083	35.87	0.413438	16.30794	14.81
1995	15.04783	31.1167	35.87	0.419510	16.39402	15.04
1996	16.43045	31.4250	35.86	0.458183	16.97469	16.43
1997	17.96459	31.4917	35.87	0.500825	16.79003	17.89
1998	16.03271	31.6833	35.87	0.446967	16.89334	16.03
1999	17.47215	31.3417	35.87	0.487096	16.48011	17.48
2000	17.40586	31.6500	35.86	0.485384	16.44970	16.55
2001	16.32628	31.8833	35.87	0.455151	16.55759	16.33
2002	16.49674	31.3500	35.87	0.459904	16.24768	16.50
2003	16.70508	31.5500	35.87	0.465712	16.49733	16.70
2004	15.88119	31.4500	35.86	0.442866	16.62183	16.55
2005	16.97024	31.3917	35.87	0.473104	16.48872	16.97
2006	16.59144	31.4750	35.87	0.462544	16.93638	16.59
2007	16.79031	31.7500	35.87	0.468088	16.45429	16.55

It is seen clearly from Fig. 1, that there is a defined crest in the curves of measured and ANN during the year 1993. This is a clear indication that the state of the atmosphere in Uyo and its surroundings was at good condition in which the sky was clear and bright. The crest nature of the curve also indicates that 1993 has high intensity which could be dangerous to health, which suggest that the years was most dangerous to human skin compared to other years. The high value of solar radiation in 1993 also suggests that it has longer dry season.

It is interesting to note from Table. 1,the close agreement between the actual values and the estimation made from ANN model. The results of MBE, RSME and MPE of ANN estimation, which are 0.0345, -0.0613 and 0.00752 respectively, which also prove the accuracy of the estimation of solar radiation in Uyo and it environ.

It is important to note that the two models have the ability to estimate the global solar radiation of Uyo and its environment, but ANN model has high performance capacity and accuracy in its estimation, thus, suggested for estimation of global solar radiation of Uyo and other areas that have similar climate conditions.

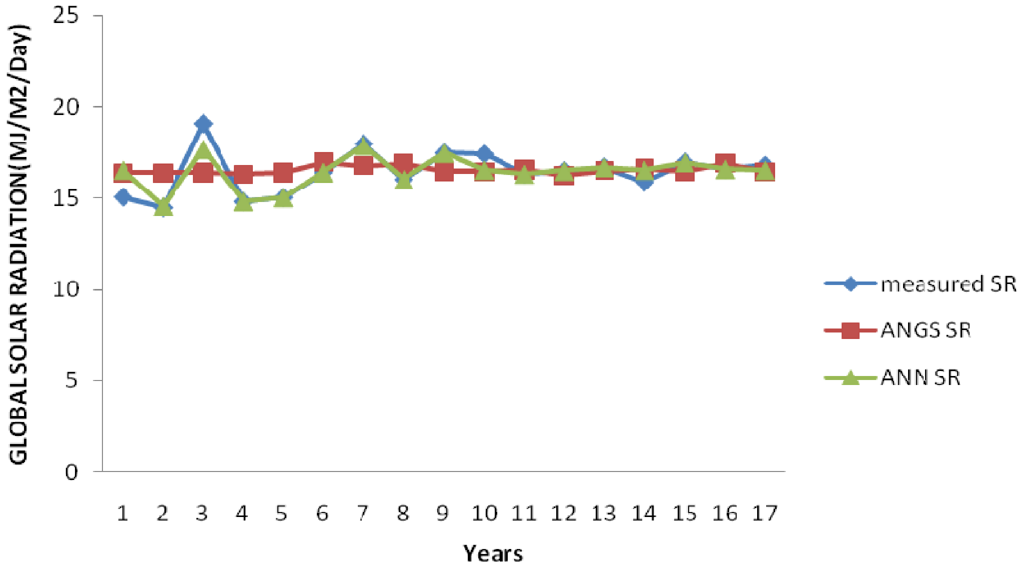

Fig. 1: Graph of measured, Angstrom(ANGS) and Artificial neural network (ANN) of solar radiation(SR) of Uyo.

CONCLUSION

The comparison of the ANN and Angstrom estimation of global solar radiation of Uyo compared with the actual values showed that ANN and actual values has negligible difference. Hence, the study confirms the ability of the ANN- based model for accurate modeling and prediction of solar radiation data. The ANN model was capable of estimating accurately and therefore, can be used to estimate solar radiation for any location without solar radiation data but provided that comprehensive meteorological data are available.

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REFERENCES

[1] G.F., Ibeh, G.A., Agbo, P.E., Agbo and P.A., Ali, *Advances in applied science research,* **2012,** 3(1):130-134.
[2] E. E., Iheonu, *Nigerian Journal of solar Energy*, **2001,** 9, 12-15
[3] M, Landis, *Microsoft Encarta*. **2009**.
[4] O. S., Maliki, O. A., Agbo, A. O., Maliki, L. M., Ibeh and C.O., Agwu Advances in Applied sciences research, **2011,** 2(5): 329-339
[5] R. Hile, *Bull. U.S. Bur. Fish*., **1936**, 48 (19), 311- 317.
[6] V.R. Martin, *Pub. Ont.Fish. Res. Lab*. **1949**, 63, 1-91.
[7] K.R. Allen, *J. Anim.Ecol*., **1938**, 7, 333- 349.
[8] M.A. Jr. Moe, Biology of the red grouper *E.morio* (Valenciennes) from the eastern Gulf of Mexico. Florida Dept. (Natural Resources Mar. Res. Lab. Professional Papers Series, **1969**)10.
[9] S.M Tan and K.S Tan, *J. Primary Ind* , **1974**, 2,123-133.
[10] R. Thompsonand and J.L. Munro, *J.Fish Biol*, **1978**, 12, 115-146.
[11] M.K. Baddar, Length - weight relationship and age determination of hamoor (*Epinephelus tauvina*). In: Annual research report for 1982 Kuwait Inst. for Scientific Research, Safat (Kuwait), **1983**. 76-77.