GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL. 8, NO. 1, JANUARY 2002:121-123
 ISSN 1118-0579

ON THE RELATIONSHIP BETWEEN NET RADIATION AND SOLAR RADIATION

K. O. OGUNJOBI, J. O. OLALEYE and J. A. ADEDOKUN

(Received 23 November 2000; Revision accepted 5 September, 2001)

ABSTRACT

Measurements of net and solar radiation are rarely carried out in meteorological stations in Nigeria. Therefore studies on radiation had been very limited. In this paper, the net and global radiation data acquired from January to May 1994 at the office of the Meteorological Department, Osogbo in Southwest Nigeria were used to study the relationship between net radiation and solar radiation. Results of the study show: that the heating coefficient varied considerably from month to month with maximum value occurring in February and minimum in January. The values are however, high and all are positive which imply an increase in the long wave radiation loss with increase in the incoming short wave radiation.

The monthly totals of net radiation expressed as percentage of total incoming radiation varied from a maximum of 79.54% in January to a minimum of 30.34% in February.

Keywords: Solar radiation, Net radiation, Heating coefficient, Albedo.

INTRODUCTION

Net radiation is a fundamental quantity for surface energy studies as it is required to estimate the atmospheric fluxes of both sensible heat and latent heat (Spittlehouse and Black, 1980). Net radiation is also required as an index for the classification of atmospheric stability in pollution studies and a lot of climatological and agricultural problems concerned with energy budget require a good understanding of net radiation (Jegede, 1997). Net radiation can be represented by the algebraic sum of the incoming and outgoing short and long wave radiation. In terms of the solar radiation (H) and net long wave (Ln) and the albedo (α), net radiation on a surface can be expressed as

$$Rn = (1-\alpha) H + Ln \quad (1)$$

Most of the locations in Nigeria receive abundant solar radiation, and solar energy utilization and studies can be profitably carried out in this region. This method of deriving the net radiation also gives the radiation balance of natural surfaces from measurement of total short wave radiation which is extremely useful (Stanhill et. al., 1966).

However, information on measured solar radiation and net radiation data are not available for most part of the country as measurements of net and solar radiation are rarely carried out in meteorological stations here in Nigeria.

For stations where no measurements exist, hourly net radiation can be estimated using empirical correlation developed from the measured data of nearby locations having similar climatological conditions.

Data and Instrumentation

The net and global radiation data used for this study were acquired from January to May 1994 at the Meteorological Service Osogbo, Southwest Nigeria. A double dome net radiometer manufactured by Weathertronic Inc. USA with a high precision 40- junction thermopile was used for the measurement. The time constant of the instrument is 20s. Due to the very humid nature of the tropical station, dew formation inside the hemispherical domes was reduced by silica gel placed inside the tube. Similarly the global radiation data were measured by the CM11 pyranometer. All instruments were connected by cables to a data logger and on each occasion the net and solar radiation were measured at approximately fifteen-minute interval from before sunrise or after sunset to solar noon.

METHOD OF ESTIMATION

Correlation of the form equation 4 connects the mean hourly global radiation on a horizontal surface and net radiation

$$Hn = \{H(1-\alpha)/(1+\beta)\} + Lo \quad (4)$$

K. O. OGUNJOBI, Department of Meteorology, Federal University of Technology, Akure, Nigeria.
J. O. OLALEYE, Department of Meteorology, Federal University of Technology, Akure, Nigeria.
J. A. ADEDOKUN, Department of Physics, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.

where Hn is the net radiation, H is the total solar radiation from the sun and sky, α is the albbedo or reflection coefficient of the surface, β and Lo are the heating and the net loss of long wave radiation respectively.

Equation 4 is linearly dependent on the net solar radiation (short wave radiation) $H(1-\alpha)$. Lo is the balance between the long wave radiation at the surface at sunrise and sunset when insolation is zero and the heating coefficient β allows for change in the loss as the surface and atmosphere get hotter. Measured fifteen minutes data of net and solar radiation (converted to hourly measurements) during the months of January to May 1994 at Oshogbo are used in the linear regression analysis to obtain the constant of equation 4.

RESULTS AND DISCUSSION

NET RADIATION

A linear regression was performed on the data from Oshogbo and equation 5 below was developed to express the dependence of net radiation on total short wave radiation.

$$Hn = 0.67H - 4.37 \quad \text{.............................(5)}$$

To test the applicability of the developed correlation for Osogbo, a set of measured data from Ile-Ife (in Southwest Nigeria) was used. The developed correlation was then tested by estimating hourly net radiation values during October and November 1998 and then compared it with the measured values.

The estimated and measured values of net radiation for Ile-Ife during October and November 1998 are presented in Figs. 1 and 2 respectively. This method was also compared with Davies (1965) method of estimating net radiation over West Africa which is suggested to be the best method (Hu and Lim, 1983). However, for the two months under consideration the estimates obtained using the present method are better, than those from Davies's formula when compared with the actual measurements.

The present results as shown in Figures 1 and 2 is superior over Davies's equation clearly demonstrates in both cases that the estimate of Hn is in better agreement with the actual between 0700Hr-1000Hr and also 1500Hr-1900Hr. The measured and estimated radiation values always agree very well and the errors involved in the estimation are very low.

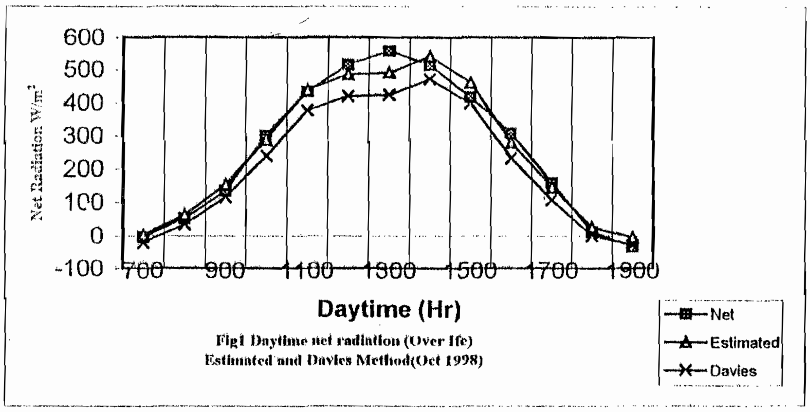

Fig1 Daytime net radiation (Over Ife) Estimated and Davies Method(Oct 1998)

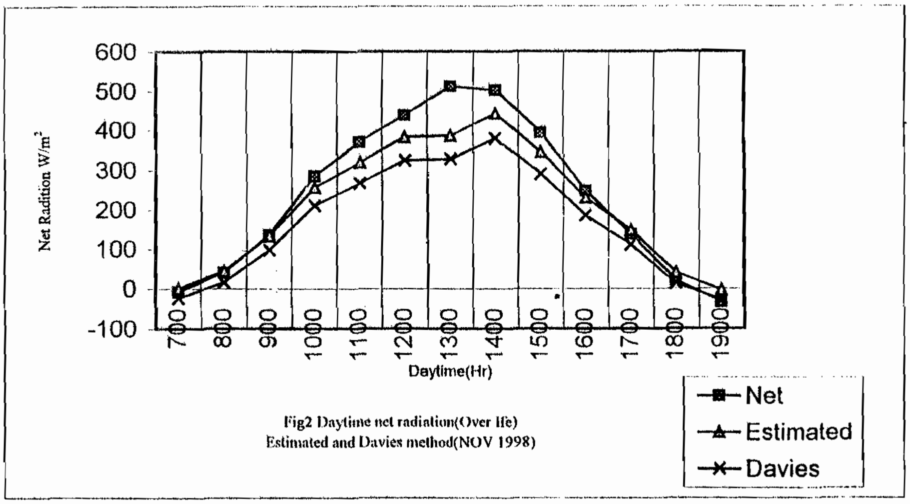

Fig2 Daytime net radiation(Over Ife) Estimated and Davies method(NOV 1998)

TABLE 1		RESULT OF MEASUREMENT					
				Ratio as percent			
	ALBEDO	RR	H/COEF	LW			
				Balance	1- α	Lo/Q	Rn/Q
JAN	0.24525	0.99728	0.32495	17.333	75.4745	3.5663	79.54
FEB	0.28734	0.99120	0.63223	-26.186	61.2660	-5.971	30.347
MARCH	0.33134	0.99511	0.49552	-14.594	66.8664	-3.29	48.1780
APRIL	0.34324	0.99445	0.52263	-12.838	65.6758	-3.397	48.071
MAY	0.30935	0.99638	0.44790	-2.769	69.0654	-0.671	58.002
A/DATA	0.31	0.99596	0.49073	-4.368	67.0180		

ALBEDO

The albedo or the reflection coefficient of the horizontal surface was calculated for each month under consideration as shown in Table 1. This was obtained as the slope of the linear regression equation. The average albedo for the set of data is 0.31 which is higher than the albedo of sand given as 0.25 – 0.30 (Bader et al., 1995). In fact, many other studies of the albedo of vegetated surface have been carried out (Stanhill et. al., 1966, Igbal, 1983), however it is difficult to compare them with the present values of this studies because the instrumentation set-up was mounted on a roof top in the Department of Meteorological Services in Osogbo. The albedo of the surface is minimum in January (α = 0.25) and maximum in April (α = 0.34).

Heating Coefficient

The heating coefficient β was calculated from the slope of the regression line of Hn plotted against Ho(1- α) as β = (1-slope)/slope. There exists a strong correlation (r = +0.995) between the two radiation parameters for estimation purpose. The values of heating coefficient obtained for each of the months under consideration are shown in Table 1. It can be seen from Table ! that for each month there is a considerable difference in the values of the heating coefficient. The dry month of February recorded maximum heating coefficient of 0.63. These values differ from the heating coefficient β for summer growing periods in Britain (Stanhill et. al., (1966) which are 0.10 for agricultural crops and between 0.10 and 0.20 for vegetation surfaces. The positive values of heating coefficient imply an increase in the long wave radiation loss with increase in the incoming short wave radiation.

CONCLUSION

With good measure of solar radiation, equation 5 gives an approximate estimate of net radiation for solar radiation studies in many areas where net radiation data are sparse or not available.

The linear relationships between net and solar radiation can be used in areas where the albedo is between 0.2 and 0.4 as shown in this study.

The ratio of the radiation-balance to total radiation are expressed as percentages in Table 1 for the station under consideration. These can be compared with values of 41% and 46% for [illegible] short and tall vegetation b Monteith and Szeicz (Stanhill et. al., 1966). The variations in values can be attributed to the different surfaces used.

REFERENCES

Bader, M. J., Foorbes, G. S., Granted, J. R., Lilley, R. B. E. and Waters, J. A., 1995. Images in weather forecasting, Cambridge University Press, pp 10-11

Chong, H. and Lim, J. T., 1983. Solar and net radiation in Peninsular Malaysia. Journal of Applied Climatology, 3: 271- 283

Davies, J. A., 1967. A note on the relationship between net radiation and solar radiation. Quart, J. R. Met. Society 93: 109-115.

Igbal, M., 1983. An introduction to solar radiation, Academic Press Onatario, 399pp.

Jegede, O. O., 1997. Daily averages of net radiation measured at Osu, Nigeria in 1995. International Journal of Climatology, 17 1357 1367.

Spittlehouse, D. L. and Black, T. A., 1980. Evaluation of Bowen ratio-energy balance method for determining forest evapotranspiration. Atmos, Ocean. 13: 98 116.

Stanhill, G, Hofstede, G. J. and Kalma, J. D. 1966. Radiation balance of natural and agricultural vegetation, Royal Meteorological Society Quarterly Journal, 92: 128 – 138.