ESTIMATION OF HOURLY GLOBAL RADIATION AT CAMPINA GRANDE (PB)

KAMADA KARUNA KUMAR[1]; MAGALY DE FÁTIMA CORREIA[1]; TANTRAVAHI VENKATA RAMANA RAO[1]; CARLOS ANTONIO COSTA DOS SANTOS[2]

[1] Prof. Dr. Unidade Acadêmica de Ciências Atmosféricas, UFCG, Campina Grande – PB, karuna@dca.ufcg.edu.br
[2] M.Sc., Pós-Graduando, Programa de Pós-Graduação em Meteorologia, UFCG, Campina Grande – PB, carlostorm@gmail.com

Apresentado no XVI Congresso Brasileiro de Agrometeorologia – 22 a 25 de setembro de 2009 – GranDarrell Minas Hotel, Eventos e Convenções – Belo Horizonte – MG.

ABSTRACT: Ratios of hourly to daily global radiation derived from two empirical correlations are compared with measured values at Campina Grande. Global radiation for the year 2007 is used and data for all days with cloud cover less than 0.8 are considered. The results show that the correlation of Collares-Pereira and Rabl (1979) can be used to estimate hourly global radiation values with much accuracy.

KEYWORDS: Hourly global radiation, cloud cover, solar energy

RESUMO: Razões entre radiação global horária e diária derivadas de dois métodos de correlações empíricas são comparadas com valores medidos em Campina Grande. Radiação global para o ano de 2007 é usado e dados de todos os dias com nebulosidade menor do que 0,8 são considerados. Os resultados mostram que a correlação de Collares-Pereira e Rabl (1979) pode ser usada para avaliar valores horários de radiação global com muita precisão.

PALAVRAS-CHAVE: Radiação global horária, nebulosidade, energia solar

INTRODUCTION: Solar energy occupies an important position among the various possible alternative energy sources. An accurate knowledge of the solar radiation distribution at a given location is of importance for the development of many solar energy devices. Hourly values of solar radiation are needed for such purposes as calculating the irradiation on tilted surfaces and assessing the performance of solar energy devices. Several studies have been carried out in the past to determine the hourly values of global radiation through its relationship with daily global radiation. Using monthly average data from a number of stations studies of the time distribution of global radiation through the day have led to generalized charts of the ratio of hourly to daily global radiation as a function of day length and the hour in question. Such studies have been carried out by Liu and Jordan (1977),Whillier (1956) and Hottel and Whillier(1958). The procedures and equations suggested provide best results for clear days with increasing uncertainties as the daily global radiation decreases due to cloudiness. Results of a study on the estimation of hourly global radiation at Campina Grande (PB) are reported in this paper.

MATERIALS AND METHODS: Hourly values of global radiation measured at the meteorological observatory of the Federal university of Campina Grande during the year 2007 are used in this study. The cloud cover data is provided by the Embrapa station situated at a distance of 2 Km from the observatory.

Liu and Jordan (1977) proposed the following equation to estimate monthly mean hourly global radiation from the monthly mean daily global radiation

$$R = \frac{\text{Monthly mean hourly radiation}}{\text{Monthly mean daily radiation}} = \frac{(\pi/24)\,(\text{Cos W} - \text{Cos W}_s)}{Sin W_s - (\frac{2\pi W_s}{360})\,\text{Cos W}_s} \qquad (1)$$

where W is the hour angle in degrees for the mid point of the hour for which the calculation is made and W_s is the sunset hour angle.

Collares-Pereira and Rabl (1979) suggested the following expression for R

$$R = (a + b\,\text{Cos W})\,\frac{(\pi/24)\,(\text{Cos W} - \text{Cos W}_s)}{Sin W_s - (\frac{2\pi W_s}{360})\,\text{Cos W}_s} \qquad (2)$$

Where a and b are given by

$a = 0.409 + 0.5016 \text{ Sin } (W_s - 60)$

$b = 0.6609 - 0.4767 \text{ Sin } (W_s - 60)$

Measured values of R between sunrise and sunset are compared with thise derived from Eqs 1 and 2.

RESULTS AND DISCUSSION: Measured and calculated values of the ratio of hourly to daily global radiation (R) for six months are shown in Fig 1. For all months of the year the equation suggested by Collares Perreira and Rabl (Eq 2) yields better results than that of Liu and Jordan (Eq 1). Between 10 and 14 hours Eq 2 yields values higher than those from Eq 1 and for the remaining hours the reverse is true.

For both the equations difference between measured and estimated values are minimum near midday and maximum near sunset. In general between 9 and 15 hours measured values are higher than calculated values and during the remaining hours less than calculated values. An interesting feature noticed is that measured values of R near sunset are always lower than values near sunrise.

Results for monthly mean values and daily values show that the difference between measured and estimated values of hourly global radiation are smaller the more symmetrical around noon the measured values are (i.e less cloudiness). In the case of Collares Perriera and Rabl equation for monthly data, for 70% of the hourly values between 8 and 16 hours the error is less than 10% and for nearly half the values less than 5%. It should be noted that in this study data for all days with cloud cover of upto 0.8 are considered. It can therefore be concluded that on days with clear skies or with little clodiness, hourly values of global radiation can be obtained with much accuracy using equation 2. The large difference between measured and estimated values of R at sunrise and sunset are of little importance since solar energy at these times is only a small fraction of the daily total.

CONCLUSIONS: Measured values of hourly global radiation at Campina Grande are compared with those derived from two empirical correlations. It is found that on days with little or no cloudiness the equation suggested by Collares Perreira and Rabl (1979) can be used with much accuracy to estimate the hourly values of global radiation.

REFERENCES:

WHILLIER .A. 1956. The determination of hourly values of total radiation from daily summations. Archives of Meteorology, Geophysics and BioK Ser B 7 197.

HOTTEL, H.C. AND WHILLIER, A. 1958. Evaluation of flat plate solar collector perfoemances. Transactions of the conference on use of solar energy. Vol 2. Univ. Arizona press. 74pp

LIU, B.Y. AND JORDAN, R.C. 1977. Availability of solar energy for flat plate solar-heat collectors. In Applications of solar enegy for heating and cooling of buildings. ASHRAE, NY.

COLLARES-PEREIRA, M. AND RABL, A. 1979. The average distribution of solar radiation-correlation between diffuse and hemispherical and between daily and hourly insolation values. Solar energy 22 155

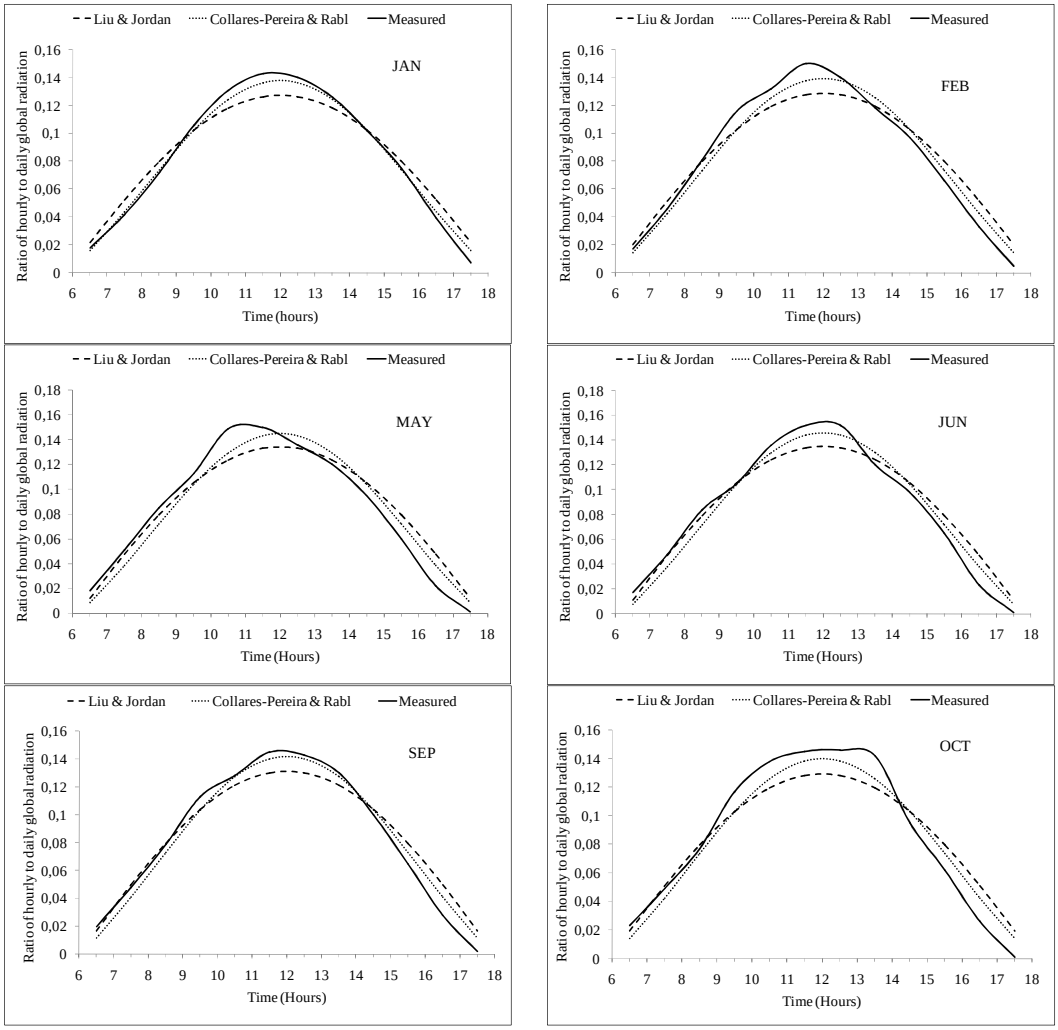

Fig. 1. Measured and estimated values of of the ratio of hourly to daily global radiation at Campina Grande.