The comparison between long-wave solar radiation data at Sri Samrong and model

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EXTENDED ABSTRACT

The comparison is carried out to test values of long-wave solar radiation at Sri Samrong Observatory because the observatory is being relocated to Pimai. So, it is helpful if we are able to find a practical model to use in place of the lacking observation. The radiation data used in this paper are the long-wave solar radiation observed at Sri Samrong Observatory during 2001-2003. We investigate the pattern of long-wave solar radiation then compare with Idso and Jason model (1969). The result can be grouped into three conditions. The first condition is dry period (January-February). The values of longwave solar radiation are greater than the model about 100 W/m^2. Meanwhile the values from the model are greater than those of observation about 100-200 W/m^2 in the period of March-April. After July the observation values are greater than model again in such amount of 150-200 W/m^2.

Keyword: long-wave solar radiation

1. Introduction

The radiation budget consists of the incident and reflected sunlight and the long-wave (infrared and far-infrared) radiation emitted to space. The source for the recent spurt in scientific and public interest in the greenhouse effect and global warming is the alteration of the radiation budget by the anthropogenic emission of trace gases into the atmosphere. Solar radiation is the major source of energy that drives the atmospheric system (Ramanathan, 1999). The solar radiation can be measured by several kinds of instruments. In many areas, the solar radiation data are limited. Partly, radiation observation programs are not widely supported or viewed as the vital part of national meteorological observation network. This results in a few numbers of radiative instruments being installed in the field. In Thailand, for example, very few numbers of meteorological stations in Thailand are readily installed with solar radiation instruments. To overcome the lacks of the field solar radiation data, various methodologies are proposed to estimate the solar radiation in absence of the ground data. Among many methods, values of radiation are estimated by a mathematical radiation models. One of such models, Idso and Jason (1969), requires simply surface temperatures as input. Idso and Jackson (1969) proposed the solar radiation model based on the studies previously done by Robinson (1947) and Monteith (1961). They established the linear relationship between the ratio of solar radiation transmitted through the atmosphere, a black body and an optical depth of precipitable water. Although, many factors, such as water vapor, carbon dioxide, ozone, aerosol and gases in the atmosphere, affect solar radiation in the atmosphere, the most important is water vapor (Exell 1978).

In this paper, the solar radiation data from a field pyrgeometer are collected to be compared with the values estimated by the mathematical radiation model, proposed by Idso and Jackson (1969). The model calculation requires only surface temperatures; thus, makes it handy to use for wide applications.

2. Data

The field radiation data are collected from the Atmospheric Observatory at Srisamrong, Observatory in Sukhothai (Northern part of Thailand) under GAME-Tropics project. The data are collected from the pyrgeometer during 2001-2003. During the observation period the first Pyrgeometer was replaced by the second. The first Pyrgeometer S/N31504F3 was used in the year 2000 and the second Pyrgeometer S/N 32834F3 was used in the year 2002. The data are then grouped into 3 categories: clear, cloudy and rainy conditions.

3. Methodology

In this paper we compare the data between the data measured from the pyrgeometer and the values calculated from the Idso and Jackson (1969) model as shown below:

$$R = \sigma T^4 \left\{ 1 - c \exp\left[-d(273 - T) \right]^2 \right\}$$

Where σ = 5.67x10-8 W/m^2 K^4, c = 0.261, and d = 0.000777 K^2

From the Idso and Jackson model, the long-wave solar radiation is proportional to the air temperature.

4. Results

4.1 Data from Pyrgeometer S/N31504F3

Data in 2003 are selected here because the long-wave solar radiation data correspond to the nearby station were already studied by the others (K. Gopala Peddy, 2003 and Masuda, K. 2004). In rainy season long-wave solar radiation is about 430 W/m^2. It is almost constant in the period. The minimum of long-wave solar radiation occurred in December which is about 375 W/m^2.

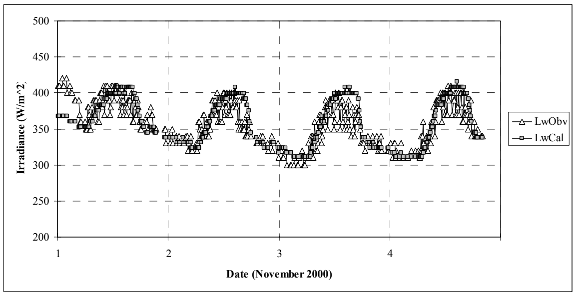

Fig 1. The comparison between the long-wave solar radiation during 1-4 November 2000 which is clear sky condition and calculation from Idso and Jackson (1969) model.

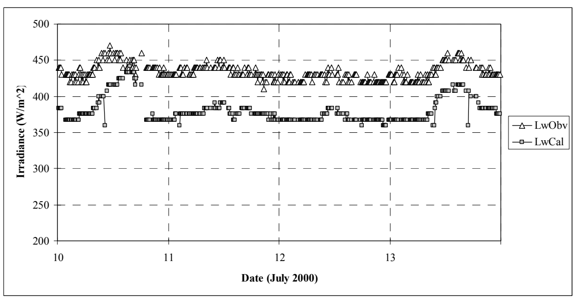

Fig 2. The comparison between the long-wave solar radiation during 10-13 July 2000 which is cloudy condition and calculation from Idso and Jackson (1969) model.

4.2 Data from Pyrgeometer S/N32834F3

On the 7th January, 2002, the clear sky day, the values of the observed long-wave solar radiation show the ridge from 7 a.m. to p.m. (Fig 3.). The maximum value is observed at about 650 watts per square meter around 2 to 3 p.m. In the same plot, values calculated from Idso and Jackson (19169) model show a similar pattern. The maximum calculated value using surface temperature is 400 watts per square meter at about the same time. Both patterns have the similar trends as shown in Fig 3. The average difference long-wave solar radiation between measurement and calculation shows bias about 200 watts per square meter.

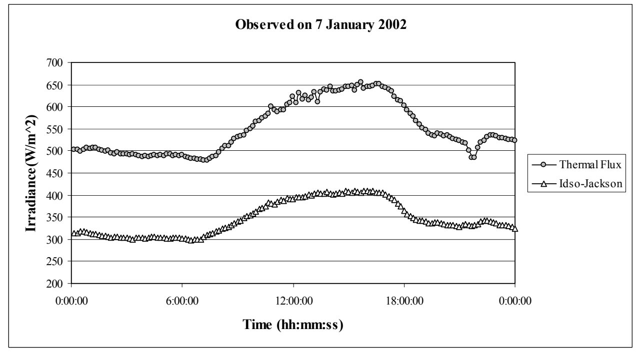

Fig 3. Downward Long-wave Radiation on 7th January 2002 which is the clear sky condition.

For cloudy condition (Fig. 4), on the 30th June, 2002, the long-wave solar radiation shows a lower ridge around 9 a.m. to 6 p.m.. The pattern of the observed long-wave solar radiation shows its maximum value around 1 p.m. The observed maximum values are about 630 watts per square meters. On the other hand, calculated values from Idso and Jackson (1969) model using surface temperature are plotted and show a similar pattern to the observed one. The calculated maximum value is 450 watts per square meter. The patterns are the same as shown in Fig 4. The difference of long-wave solar radiation between measurement and calculation is biased about 170 watts per square meter.

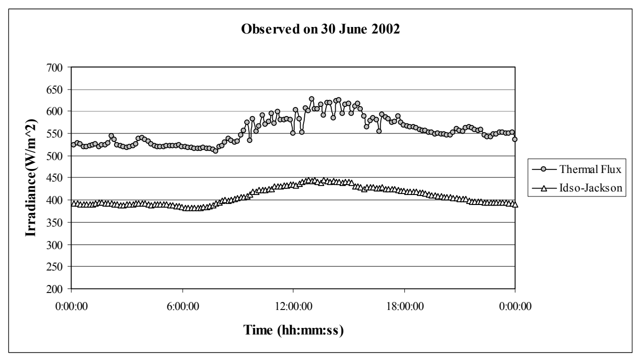

Fig 4. Downward Long-wave Radiation on 20th June 2002 which is the cloudy sky condition.

For the rainy condition, the pattern of the long-wave solar radiation on the 26th June 2002 shows the maximum value in the afternoon (Fig. 5). The maximum value from the measurement is about 600 watts per square meter. From Idso and Jackson (1969) model, the calculated values, using surface temperature, show the maximum at 430 watts per square meter. The patterns are both similar, as shown in Fig 5. The difference of long-wave solar radiation values between the measurement and the calculation is biased about 150 watts per square meter.

The slope of the long-wave radiation curve in the rainy condition is quite distinguished from the clear sky and cloudy conditions. The long-wave solar radiation emits to the atmosphere more slowly and drops down sharply in the evening.

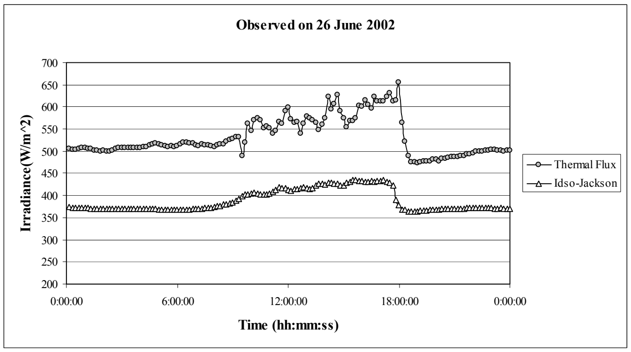

Fig 5. Downward Long-wave Radiation on 26th January 2002 which is the rainy sky condition.

The long-wave solar radiation patterns of the observed data from a pyrgeometer S/N32834F3 and those calculated from Idso and Jackson (1969) model are similar and show some bias in all cases. The observed values are higher than the calculation about 150-200 watts per square meter. So we try to some number to modify the Idso and Jackson (1969) model as the bias values might possibly come from the constant values used in the Idso and Jackson (1969) model. Therefore we modified the Idso and Jackson (1969) model by multiplying the outcome by minus one then the result is very close to the observed from pyrgeometer S/N31504F3 in the year 2000 as shown in the Fig 6.

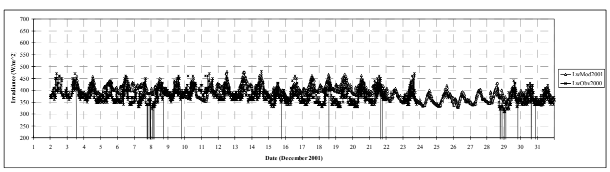

Fig 6. The long-wave solar radiation which observed in 2000 by pyrgeometer S/N32834F3 and modified Idso and Jackson (1969) model which use the data from pyrgeometer S/N31504F3 in 2001.

5. Conclusion

The long-wave solar radiation which observed by pyrgeometer S/N31504F3 in 2000 is about 373-432 W/m^2 and pyrgeometer S/NM32834F3 in 2002 is about 500-600 W/m^2. The long-wave solar radiation data have some inherited instrumental errors from pyrgeometer S/N32834F3 as indicated by the previous work by other researches.

The long-wave solar radiation can be estimated by Idso and Jackson (1969) model in clear sky condition. The calculated values are greater than the observation ones. The difference between observation and calculation is 3.41 W/m^2 in clear sky condition meanwhile the observation will give the value 35.67 W/m^2 greater than the calculation in cloudy condition.

Finally data in 2000 are shown in Table 1 as representative data in comparing with the model. The Idso and Jackson (1969) model can be used in clear sky condition better than cloudy condition. The value of Normalized Mean Biased Error (NMBE) is 0.0128 and the Normalized Root Mean Square Error (NRMSE) is 0.0577 as shown in table1.

	NMBE	NRMSE	SE
Clear Sky	0.0128	0.0577	19.95318
Cloudy	-0.121	1.97	16.85891

Table 1. The comparison of long-wave solar radiation between Idso and Jacson (1969) model and observation which are clear sky condition during 1-4 November 2000 and cloudy condition during 10-13 July 2000.

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