The Estimation of Receiving Solar Radiation at Earth's Surface in Kermanshah Province

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Extended Abstract

Introduction

Solar radiation is the most important meteorological element which affects all climatological and biological processes such as evaporation and transpiration, snowmelt and plant growth directly and indirectly. Various planning in agriculture, hydrology, architecture and energy largely depend on the correct estimation of the amount of solar radiation. One of the most accurate methods in measuring solar radiation is using pyranometer which its usage is still limited in many parts due to the lack of facilities. Consequently, the researchers are trying more to estimate the radiation, instead of directly measuring it. Most of the previous studies have used Angstrom model, having the values of sunshine hours as its input, or regression equations through considering the climatic factors and elements affecting the radiation, to estimate the solar radiation. The aim of this study is to estimate and evaluate the spatial-temporal changes of receiving solar radiation in Kermanshah Province by using the "Bird and Hulstrom" model.

Research Methodology

In this study, optimized "Bird and Hulstrom" model is used to estimate incoming solar radiation in Kermanshah Province by using the daily data from synoptic weather stations of the province between the years 1990- 2009. For this purpose, the amounts of incoming solar radiation on a daily basis were estimated considering local (altitude, latitude and longitude) and climatic (Humidity, temperature, pressure, length of day, sunshine hours, solar angle, sky albedo, absorption by aerosols, ground albedo, air mass, absorption by ozone, and Rayleigh distribution) characteristics. Bird and Hulstrom presented the equation (1) for estimating solar radiation concerning the effect of climatic parameters:

$$H = (H_B \cos\theta + H_{DF})/(1 - r_g r_s) \quad (1)$$

Where:

H Daily global irradiation at earth's surface,
H_B Direct daily global irradiation at earth's surface,
Θ Zenith angle,
H_{DF} Daily diffuse irradiation at earth's surface,
r_g Ground albedo,
r_s Sky albedo,

The H_B (direct daily global irradiation at earth's surface) value is calculated by equation (2):

$$H_B = I_B \frac{n}{N} \quad (2)$$

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Where:

I_B Direct beam irradiance for clear sky,

n Hours of measured sunshine,

N Potential astronomical sunshine hours,

In equation (1), the H_{DF} (daily diffuse irradiation at earth's surface) value is calculated by equation (3):

$$H_{DF} = I_{DF}\frac{n}{N} + K^*(1-\frac{n}{N})(I_B + I_{DF}) \quad (3)$$

Where:

I_{DF} Diffuse irradiance for clear sky,

K^* 0.32

I_B Direct beam irradiance for clear sky,

Based on the above-mentioned equations, all parameters of the model were calculated for stations, and receiving solar radiation maps were plotted for the region in all months of the year.

Discussion and Results

The results showed that all components of the Bird and Hulstrom model at the stations, including I_B (direct beam irradiance for clear sky), I_{DF} (diffuse irradiance for clear sky), H_B (direct daily global irradiation at earth's surface), and H_{DF} (daily diffuse irradiation at earth's surface) reach their maximums in June, the time of maximum solar altitude, maximum sunshine hours and minimum air mass. In contrast, the lowest amounts of radiation happen in December and January, when the solar angle and sunshine hours decrease, and consequently the effect of atmospheric factors increases. Therefore the final output of the model or daily global irradiation at earth's surface (H) also obeys this rule. Generally, the largest amounts of receiving solar radiation occur in the highlands. Spatial-temporal differences of radiation in the region are high during the warm period of the year (from 32 to 42 MJ/m2/day with a difference of 10 MJ/m2/day) due to the direct radiation at highlands, and elimination of radiation by water vapor and other atmospheric factors in the lowlands; While in the cold period of the year, this spatial difference is reduced (from 9 to 13 MJ/m2/day with a difference of 4 MJ/m2/day) because of the diffuse radiation.

Conclusion

Most previous studies have used the Angstrom model and calibration of its coefficients for estimating the receiving solar radiation in Iran. Some studies have also used other methods such as regression models and artificial neural networks through considering the factors that affect the radiation. This study has attempted to estimate the amount of receiving solar radiation in Kermanshah province with the Bird and Hulstrom model using all relevant local and climatic parameters, and to evaluate its spatial-temporal changes. Comparing the amount of solar radiation measured by pyranometer in Kermanshah station (422.8 Cal/cm2/day) with the estimated amount in this study (402.9 Cal/cm2/day) indicates the acceptable accuracy of the estimates. Also comparing our results with the results of other studies is another evidence for the reasonableness of the results. To complete the studies in this regard, more precise studies can be provided in future on the role of slope effect, and condition of land cover on the amount of receiving solar radiation.

Keywords: Estimating, Recieving Solar Radiation, Kermanshah Province, Spatial Changes, Bird and Hulstrom Model.

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