A study of determining a model for prediction of solar radiation

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Solar radiation is defined as the amount of energy radiated from the sun in the form of electromagnetic waves that reaches the Earth surface. Solar radiation plays a key role in many various natural processes and hydrological cycle. Since, Solar radiation provides the energy for many natural processes such as photosynthesis, evaporation, evapotranspiration, cloud formation, snow melt, etc. [1].
Various types of models have been developed by researchers for estimation of Solar radiation based on other meteorological data, which are more commonly available worldwide [2]. From these models it can be referred to artificial intelligence based models [3], remote sensing retrievals [4], single-layer and multi-layer radiative transfer models [5], and empirical models.
Introduction

Based on the accuracy required for a research and available meteorological data, different types of empirical models have been proposed: sunshine-based models [6], temperature-based models [7], cloud-based models [1].
Introduction

Solar energy is one of the most common renewable energy sources. Using of this energy is profited by solar radiation arriving in earth. Photovoltaic (PV) technologies using solar energy ensure a clean, renewable and sustainable energy source. PV technologies are quickly developing. Recently, PV has been used a great many large utility like photovoltaic power plants, residential systems, and irrigations. Accordingly, solar radiation model in summer season (June, July and August) is conducted by using Angstrom-Prescott linear regression. Data is gathered from meteorological measuring device.
This device was established in 20 m high from the ground level. Measured data on solar radiation and sunshine duration has been recorded by a Vantage pro 2 station. In order to verify the predicted results, statistical methods as mean bias error (MBE), root mean square (RMSE), and relative percentage error are used. The new linear equation is obtained for monthly-average daily global solar radiance.
Solar radiance measurements consist of global and/or direct radiation measurements taken periodically throughout the day. The measurements are taken using either a pyranometer (measuring global radiation) and/or a pyrheliometer (measuring direct radiation).

The azimuth angle is the compass direction from which the sunlight is coming.

\[ \beta = \cos^{-1} \left( \frac{\sin(\alpha)\sin(\phi)}{\cos(\alpha)\cos(\phi)} - \sin(\delta) \right) \]

The declination angle can be calculated by the equation

\[ \delta = 23.45\sin \left( \frac{360(D + 284)}{365} \right) \]
Model Description

Angstrom-Prescott formula is as follows:

\[ \frac{H}{H_0} = a + b \left( \frac{S}{S_0} \right) \]  

(1)

where \(H\) (monthly mean daily) and \(H_0\) (daily) are global and extraterrestrial radiation on a horizontal surface respectively. Moreover, \(S\) (monthly average daily) and \(S_0\) (monthly average maximum possible daily) are both sunshine duration
Model Description

Basic statistical error analyses which are coefficient of determination ($R^2$), mean absolute percentage error (MAPE), mean absolute bias error (MABE), root mean square error (RMSE), were tested to measure accuracy and performance of the derived models.

\[
\text{MAPE} = \frac{1}{x} \sum_{i=1}^{x} \left| \frac{H_{i,c} - H_{i,m}}{H_{i,m}} \right| \times 100
\]

\[
\text{MABE} = \frac{1}{x} \sum_{i=1}^{x} |H_{i,c} - H_{i,m}|
\]

\[
\text{RMSE} = \sqrt{\frac{1}{x} \sum_{i=1}^{x} (H_{i,c} - H_{i,m})^2}
\]

\[
R^2 = 1 - \frac{\sum_{i=1}^{x} (H_{i,m} - \overline{H_m})^2}{\sum_{i=1}^{x} (H_{i,m} - \overline{H_m})^2}
\]

Where $H_{i,c}$ and $H_{i,m}$ are the $i$th calculated and measured values, respectively and $x$ is the total number of observations.
Conclusions

In this study, the ratios of $H/H_0$ and $S/S_0$ can be used to estimate the global radiation Osmaniye province in Turkey. It was seen that the equation which include the summer periods (June-July-August) gave better results.

![Graph showing relationship between $H/H_0$ and $S/S_0$ for June-July-August. The equation $y = 0.8813x - 0.0956$ is plotted, with $R^2 = 0.8515$.](image)
Conclusions

Several sunshine based models have been employed for estimating global solar radiation for Osmaniye [8-9]. The differences between the results of the different models are negligible. The linear degree equation is calculated, according to R-squared, MAPE, MABE and RMSE. The linear seasonal partitioning equation can be used to estimate the global solar radiation in Osmaniye.

Table 1. The summary of all the statistical parameters for Linear

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>MABE</td>
<td>1,1372</td>
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<tr>
<td>RMSE</td>
<td>0,9204</td>
</tr>
<tr>
<td>MAPE</td>
<td>38,306</td>
</tr>
<tr>
<td>R²</td>
<td>0,8515</td>
</tr>
</tbody>
</table>


THANKS FOR YOUR PARTICIPATION