ESTIMATION OF SOLAR RADIATION MODEL USING MEASURED DATA IN A SPECIFIC REGION

Bülent Yaniktepe, Osman KARA, Coşkun Ozalp
Osmaniye Korkut Ata University,
Energy Systems Engineering Department, Osmaniye, Turkey
Recently, renewable energy has been dramatically used in the world, because fossil fuels such as coal, petroleum, and natural gas are finite of their sources and have their negative effects on the environment. In this concept, renewable energy plays an important alternative role as replacing fossil fuels. Energy supply and demand from renewable sources such as solar, wind in many countries, which are in developed and developing countries, are considered the current and future the years world's energy systems by most of researchers and experts for using sustainable.
Governments in these countries have evaluated in terms of different policies strategies for investments in renewable energy generation. The important one of the renewable energy sources is solar energy, which is taken into account as one of the greatest renewable energy sources because of its availability in the most parts of the world. Solar energy may use different forms power generation, heating/cooling generation, combined power and heat/cooling generation, and passive systems. It is useful to know the amount of solar energy to use in such places. The quantities of solar energy are measured.
Solar energy consists of two parts; extraterrestrial solar energy which is above the atmosphere and global solar energy which is under the atmosphere. The global solar energy incident on a horizontal surface may have direct beam and diffuse solar energy. Diffuse solar energy is usually measured by pyranometers, solarimeters. These measuring devices are usually installed at selected sites in specific region and it is not feasible to install at many sites due to high cost of these devices [1].
In spite of the importance of solar radiation measurements, this information is not readily available due to the cost and maintenance and calibration requirements of the measuring equipment. The limited coverage of radiation values dictates the need to develop models to estimate solar radiation [2]. Many solar energy models have been presented in the literature using mathematical linear [3] and nonlinear functions [4], artificial neural network [5] and fuzzy logic [6].
In this study, solar radiation models have been investigated from the meteorological measurement device (vantage PRO2). A new model, two empirical models (linear and second-order polynomial equation) are analyzed according to correlation coefficients for a month, for the global solar radiation on horizontal surface in Osmaniye has been developed. Besides, with a view to showing performance analysis of models, the statistical testing methods such as mean absolute percentage errors (MAPE), mean absolute bias error (MABE), root mean square error (RMSE) were used.
System Description

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.
Osmaniye province, is located in the eastern Mediterranean region in Turkey, coordinates 37.05 north latitude and 36.14 east longitude. Osmaniye is height of 120 m. above the average sea level and distance from the Mediterranean Sea is about 20 km. Experimental data for Osmaniye were measured with meteorological measuring device which is called Vantage Pro2 Weather Station established in the university campus of Osmaniye Korkut Ata.
System Description

Experimental set-up is located at the Department of Energy Systems Engineering. Meteorological measuring device was established in 20 m high from the ground level, shown in figure 1 and measured actual global solar radiation data on horizontal surface of Osmaniye in five-minute time interval for one complete year.
The first Sunshine duration model was proposed by Angstrom [7], which related the clear sky index with sunshine duration fraction by using linear equation. Some researchers have done a large number of modifications on these models to improve the accuracy [8]. These models are given in Table 1.

**Table 1.** The comparison of different regression models for monthly average daily radiation.

<table>
<thead>
<tr>
<th>Models</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{H}{H_0} = a + b \frac{S}{S_0} )</td>
<td>Linear [7]</td>
</tr>
<tr>
<td>( \frac{H}{H_0} = a + b \frac{S}{S_0} + c \left( \frac{S}{S_0} \right)^2 )</td>
<td>Quadratic [8]</td>
</tr>
<tr>
<td>( \frac{H}{H_0} = a + b \frac{S}{S_0} + c \left( \frac{S}{S_0} \right)^2 + d \left( \frac{S}{S_0} \right)^3 )</td>
<td>Cubic [9]</td>
</tr>
<tr>
<td>( \frac{H}{H_0} = a + b \frac{S}{S_0} + c \log \left( \frac{S}{S_0} \right) )</td>
<td>Logarithmic [10]</td>
</tr>
<tr>
<td>( \frac{H}{H_0} = a \left( \frac{S}{S_0} \right)^b )</td>
<td>Exponent [11]</td>
</tr>
</tbody>
</table>
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.

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

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

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

\[
R^2 = 1 - \frac{\sum_{i=1}^{x} (H_{i,m} - H_{i,c})^2}{\sum_{i=1}^{x} (H_{i,m} - \bar{H}_m)^2}
\]

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

Although it is not possible to estimate the daily total amount of global solar radiation on a particular day from sunshine duration using this method, it does enable an estimation of a monthly value. In this study, the experimental data of monthly average global solar radiation is calculated for Osmaniye province.
The authors described a second order polynomial regression between measured daily values of $H=H_0$ against $S=S_0$ for a month for June, in the province of Osmaniye [12], given in Table 1 as using equation reference [8].

\[
\frac{H}{H_0} = -0.149 + 0.960 \frac{S}{S_0} \quad (1)
\]

\[
\frac{H}{H_0} = -0.351 + 1.488 \frac{S}{S_0} - 0.343 \left(\frac{S}{S_0}\right)^2 \quad (2)
\]
Conclusions

The values of MABE, MAPE and RMSE for each model are shown in Table 2. As a result of linear, second order polynomial regression analysis, the best model is second order polynomial model. Quadratic has the smallest errors than the others and is found to be most accurate model.

Table 2. The summary of all the statistical parameters for Linear and Quadratic

<table>
<thead>
<tr>
<th>Models</th>
<th>RMSE</th>
<th>MAPE</th>
<th>MABE</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>0.398</td>
<td>11.668</td>
<td>0.456</td>
<td>0.868</td>
</tr>
<tr>
<td>Quadratic</td>
<td>0.397</td>
<td>6.663</td>
<td>0.455</td>
<td>0.867</td>
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</tbody>
</table>
THANKS FOR YOUR PARTICIPATION