Relation between global solar radiation and duration of sunshine in Tehran and Karadj

B. HADJEBl and NEHZAT MOTALLEBl
Institute of Geophysics, University of Tehran, Tehran, Iran

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ABSTRACT. Using mean monthly values of the relative global solar radiation, \( Q_m/Q_r \), and the relative duration of sunshine, \( n/N \), the least square regression constants \( a \) and \( b \) in equation \( Q_m/Q_r = a + b (n/N) \) and the correlation coefficient, \( r \) have been calculated for Mehrabad, Tehran \((a=0.25, b=0.48, r=0.90)\), Karadj \((a=0.38, b=0.35, r=0.79)\), and also for Mehrabad (Tehran) and Karadj collectively \((a=0.30, b=0.43, r=0.84)\), \( Q_m^* \) and \( Q_r^* \) being the daily global solar radiation received by one square centimetre of horizontal surface measured on the earth and calculated for the top of the atmosphere, respectively, and \( n \) and \( N \) the actual and the possible maximum duration of sunshine respectively. It is seen that the sum \( a + b \) remains constant.

Furthermore, the ratio \((Q_m/Q_r)M/(Q_m/Q_r)K\) is considered for clear days, where \( M \) and \( K \) stand for Mehrabad and Karadj stations. The ratio is generally less than unity, indicating that less radiation is normally received in Mehrabad (Tehran) compared to Karadj in a clear day.

1. Introduction

In order to estimate the solar radiation received on the earth, Angstrom suggested an empirical linear relationship between the global solar radiation and the duration of sunshine in 1924. Since then, similar relations have been established by several investigators (Prescott 1940, Penman 1948, Black et al. 1954, Glover and McCulloch 1958a and 1958b, Exell 1976 etc) for a number of stations with various latitudes and altitudes.

It is now possible to compute the global solar radiation by making use of the information on the altitude of the sun, the atmospheric turbidity, the types, thickness, water droplet content and the amount of clouds. However, the lack of precise information particularly on the latter quantities and the complication of the computation makes this method not always desirable.

Since the duration of sunshine is available for various regions in Iran, and due to the simplicity of the relationships of the type suggested by Angstrom and the others, in order to investigate the relationship between the global solar radiation and the duration of sunshine the equation:

\[
Q_m/Q_r = a + b (n/N)
\]  

is used in this work, where \( Q_m \) and \( Q_r \) are the daily global solar radiation received by one square centimetre of horizontal surface measured on the earth and calculated for the top of the atmosphere, respectively, and \( n \) and \( N \) are the actual and the possible maximum duration of sunshine, respectively. It is also to be mentioned that since the effects of the astronomical factors are cancelled in this equation, it becomes possible to compare the duration of sunshine and also radiation climate of different regions.

2. Records and Instruments

Daily values of \( Q_m \) and \( n \) were available from Mehrabad (Tehran) and Karadj Meteorological Observatories of Iranian Meteorological Organization (IMO) for the three years 1974 to 1976 inclusive, except for the Karadj station where the record of radiation was not completed for 1974. Mehrabad and Karadj stations are located, respectively, at Lat. 35°41' N, Long. 50° 19' E and 35°47' N, 50°00' E, and heights 1191 and 1313 m above mean sea level.

The Moll-Gorczyński pyranometer is used to measure the global solar radiation and the records of the duration of sunshine are obtained by the Campbell-Stokes recorder in both stations.

3. Analysis of records and the results

In addition to the daily values of the ratios \( Q_m/Q_r \) and \( n/N \), the mean monthly values are also computed for each month of the period and plotted in Fig. 1.
Monthly values of \( n/N \) are plotted against
the corresponding values of \( Q_m/Q_e \) in Figs. 2, 3
and 4 respectively, for the Mehrabad, Karadj
and Mehrabad and Karadj collectively. Then,
the parameters \( a \) and \( b \) are reckoned by the least
square method and the regression lines are drawn
on the corresponding figures, where the dots
represent the measured values.

The equations of the regression lines deduced
so far are as follows.

For the Mehrabad station:
\[
Q_m/Q_e = 0.25 + 0.48 \times n/N, \quad a + b = 0.73,
\quad r = 0.90
\]

For the Karadj station:
\[
Q_m/Q_e = 0.38 + 0.35 \times n/N, \quad a + b = 0.73,
\quad r = 0.79
\]

For the two stations collectively:
\[
Q_m/Q_e = 0.30 + 0.43 \times n/N, \quad a + b = 0.73,
\quad r = 0.84
\]

where \( r \) is the correlation coefficient between
\( Q_m/Q_e \) and \( n/N \).

As deduced from equations 2, 3 and 4 and given
following each equation, the sum of \( a \) and \( b \)
is actually constant with a value of 0.73. Also,
the following points may be seen in Fig. 1:

(1) A good correlation between \( Q_m/Q_e \) and
\( n/N \), particularly in the case of Mehrabad
station which is also indicated by the
correlation coefficient \( r = 0.90 \), deduced
from Fig. 2.

(2) Analogous of the corresponding curves
for the two stations which is accounted
for the small differences in latitude
and altitude of the two stations.

(3) A very pronounced and consisting
maximum from June to September
which may occasionally be extended up
to October.

(4) Minimum occurring sometime between
December and the March of the
following year.

In addition, the amount of daily relative global
solar radiation received at two stations in clear
days has been compared. The result of this
comparison shows that in 95 per cent of the cases
the ratio \( (Q_m/Q_e)_M/(Q_m/Q_e)_K \) is less than unity,
where \( M \) and \( K \) stand for Mehrabad and Karadj
stations. This means that there is often less radia-
tion received in Tehran (Mehrabad) than in
the Karadj which may be accounted mainly for
the relatively excessive air pollution in Tehran.
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Fig. 2. Relation between $Q_m/Q_r$ and $n/N$ using mean-monthly values for Mehrabad (Tehran) station, 1974-1976

Fig. 3. Same as Fig. 2, but Karadj station and except for 1974

Fig. 4. Same as Figs. 2 and 3, but Mehrabad (Tehran) and Karadj stations collectively

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