

COMPUTER PROGRAM FOR THE SOLAR IRRADIANCE EVALUATION – SIMULATED DATA VALIDATION

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Abstract: This paper proposes a comparative study of the climatological parameter values obtained as a result of the theoretical simulations with the program SimClim and the values obtained from the real meteorological data processing.

1. GENERAL CONSIDERATIONS

The real variation for the Braşov urban area presents a series of features; it is taken into consideration the fact that Braşov town is located in a basin area and the physical and geographical conditions extend the following feature: temperature inversion caused by the occurrence of radiative-orographic fogs and cloudiness. Thus, during the winter, the depression plains get cooler than the higher places and during the summer the depression lowland of Braşov gets warm more intensively than the surrounding slopes. Because of the surrounding mountains, the possible duration of the direct sunshine is diminished [3]

It must be also mentioned, the maximum value of the solar direct radiation is recorded around 13 solar time (and not around 12 solar time); therefore the real variation curve of the direct radiation is not a curve symmetrical to 12 solar time; besides the solar radiation values (for a day that keep to the clear-sky conditions) during the afternoon have higher values than those recorded during the morning (usually the solar radiation value at the sunset has a certain value and it is not 0).

Taking into consideration all above mentioned, the conceiving of some theoretical models for the different climatological parameters calculus was necessary [1, 2]. All these models were implemented in a computer program (*SimClim*) designed for Braşov urban area.

The theoretical modelling of the climatological parameters was achieved on the basis of a 3 years meteorological data base (2006 - 2008), and the results validation is proposed for days from 2009. All the conceived models are for clear sky conditions.

This paper proposes a comparative study of the climatological parameter values obtained as a result of the theoretical simulations with the program **SimClim** and the values obtained from the real meteorological data processing.

The meteorological data measurement was carried out for Braşov area, altitude: 790m, longitude: 25.35° and latitude: 45.39°. The local weather station Delta-T, is positioned on the building roof of the "Transilvania" University of Braşov (Romania). The data sets have been collected since October 2005 until now and they comprise:

- global solar radiation [W/m²],
- diffuse solar radiation [W/m²],
- air temperature [°C],
- wind speed [m/s],
- wind direction [degrees],
- relative humidity [%],
- rainfall [pluviometric mm],
- sunshine.

The horizontal global radiation, diffuse radiation, as well as all recorded data, are related to 10 minutes range, in a continuous way.

2. SIMULATED DATA VALIDATION

This comparative study is achieved for the urban area of Braşov. The simulation program **SimClim**, designed especially for the urban area of Braşov, uses original computer procedures for the correction pressure factor, Linke turbidity factor (its values are determined from functions depending on the solar time), the horizontal beam irradiance (and consequently the beam on a tilted surface) and the diffuse irradiance.

The paper proposes the comparative analysis of the theoretical and real values for the following parameters:

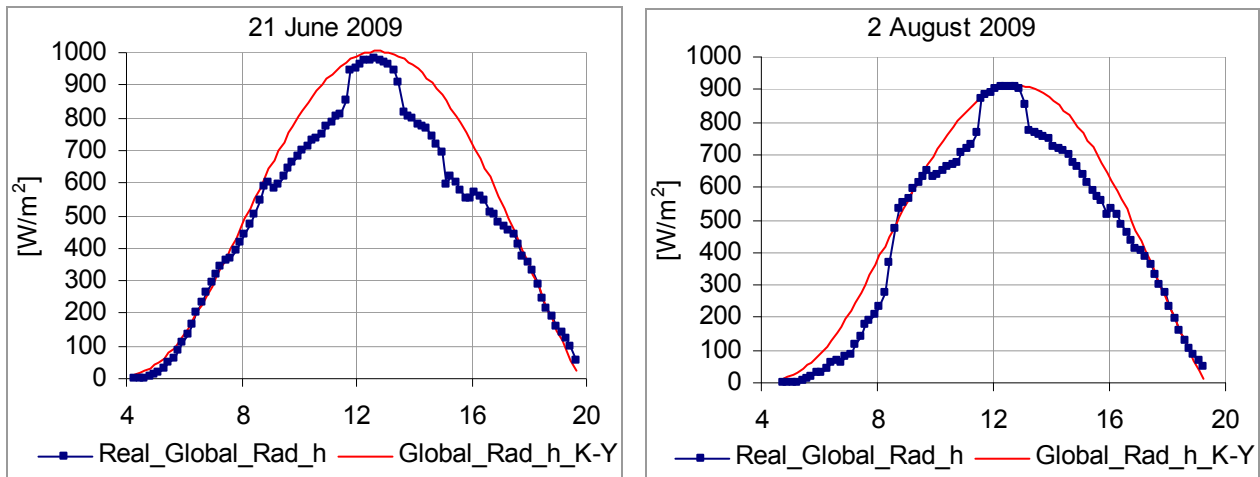
- the horizontal beam irradiance;
- the beam irradiance on a 45 degrees tilted surface;
- the diffuse irradiance on a horizontal surface.

For every diagram proposed, the resulted error, between the theoretical and real values, is calculated.

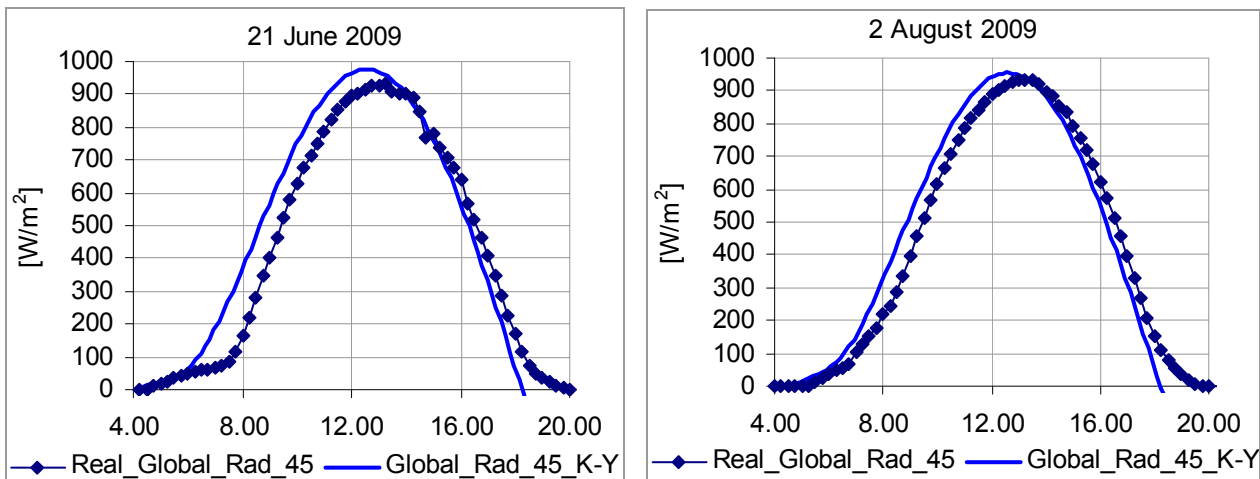
Figure 1,a presents the real recorded global radiation on a horizontal surface and the theoretical horizontal global radiation, obtained with the Kasten-Young model. Figure 1,b presents the comparative diagrams of the real and theoretical global radiation on an inclined surface with 45 degrees. It must be mentioned, between the two theoretical models (Kasten-Young and Remund Page formulas for the air mass and optical depth) there are not important registered differences.

The comparative analysis of the superimposed diagram (Figure 1) emphasizes the following conclusions:

- The most important errors between the theoretical model and the real values are registered during the afternoon, between 13 and 16 solar time. Concerning this aspect, it must be mentioned the fact, the maximum radiation value is registered around 13 solar time and the real radiation curve is not a symmetrical curve toward 12 solar time; these make very difficult the finding of a mathematical function for the theoretical model. It must be also taken into consideration the real variation of the Linke turbidity factor (Figure 2). The turbidity factor has a daily decreasing variation, but during the summer months around 13 and 15 solar time, a discontinuity (an decrease) in this variation is registered. This discontinuity in the Linke turbidity factor variation is very difficult to model.
- The theoretical functions proposed are very accurate during the sunrise and 9 solar time, 11 and 13 solar time, and from 16 solar time to sunset. These periods are characterised by very low errors between the theoretical and real values of the global radiation.
- The daily error between the theoretical model of the global irradiance on a horizontal surface and the real recorded values is around 12%. For the better theoretic modelling of the global radiation, it is recommended a more accurate modelling of the Linke turbidity factor, especially during the summer months (the Linke turbidity factor does not present discontinuities in its variation during the other months).
- The real maximum values of the global radiations on an inclined surface are recorded around 13 solar time; the theoretical curve of the global radiation on an inclined surface is a little bit out fo centre with the real curve.
- The two real and theoretical curves of the global radiation on an inclined surface are very close; the daily error is about 2-8% that means a good accuracy of the theoretical model.



a. Horizontal global irradiance



b. Global irradiance on an inclined surface

Fig. 1. Real and theoretical horizontal global radiation values for two summer days from 2009

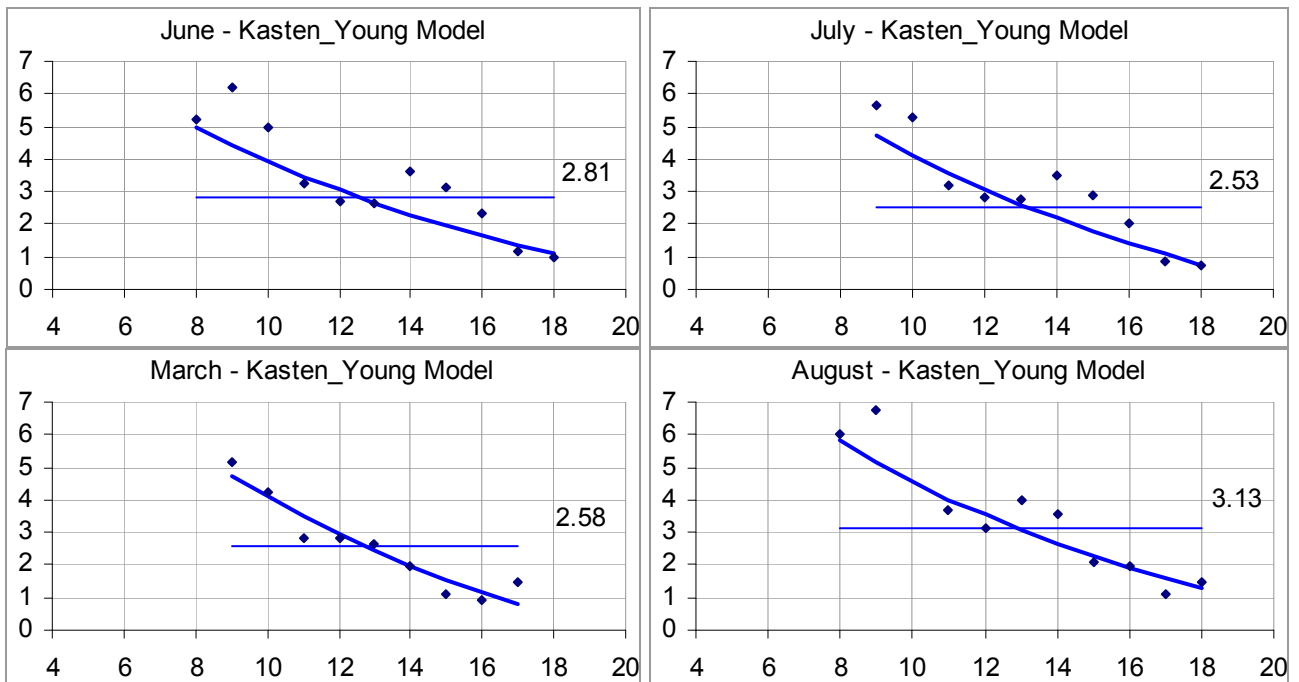


Fig. 2. Real and theoretical values of the turbidity factor

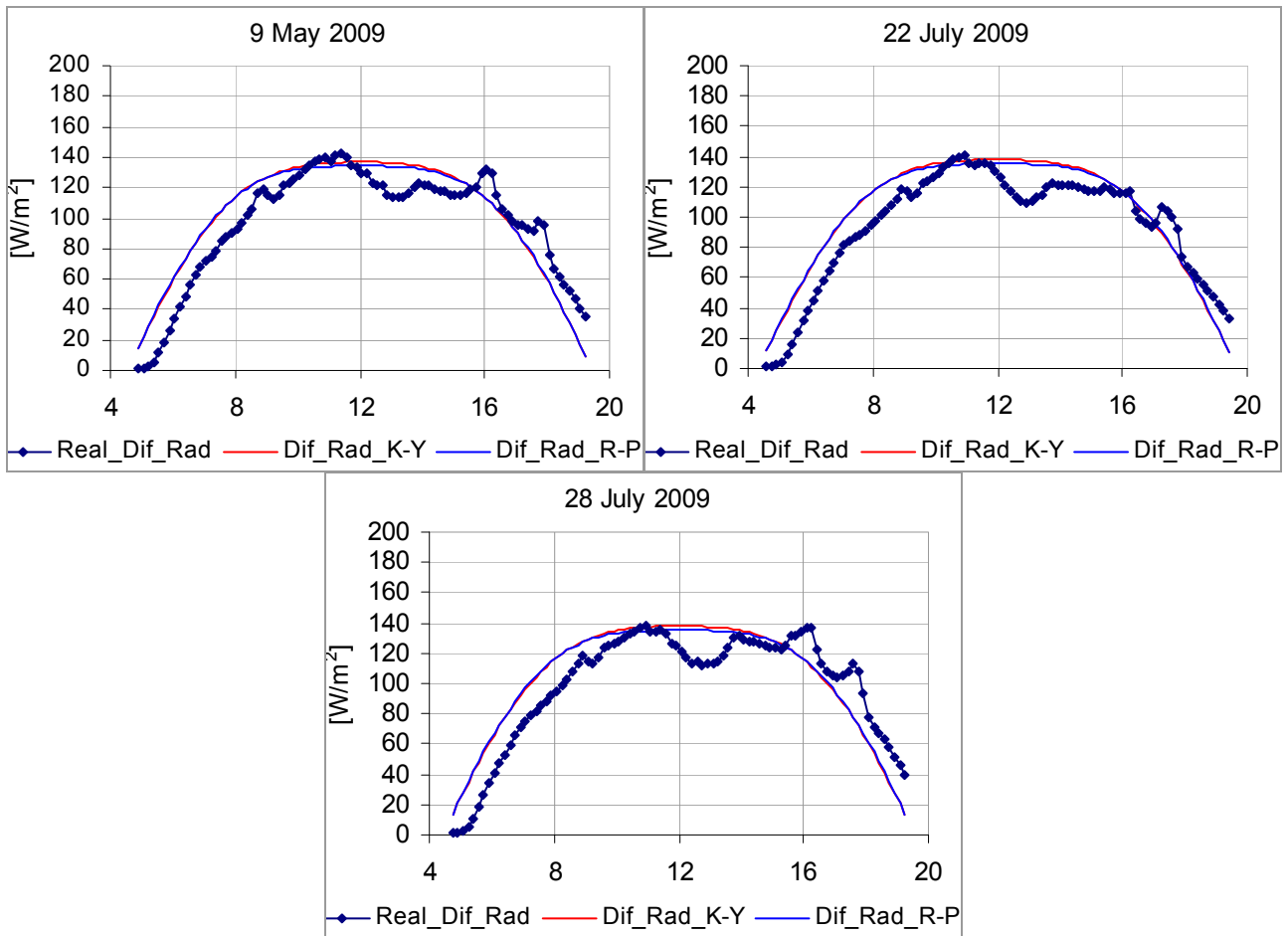


Fig. 3. Real and theoretical diffuse radiation values for three summer days from 2009

Figure 3 presents the comparative diagrams of the real and theoretical diffuse radiation. It can be noticed, the theoretical curve approximate in a great extent the real one, the daily error recorded being around 5 and 9 percentages.

4. CONCLUSIONS

The proposed program **SimClim** represents an important tool for the determination of the basic input data used to design a renewable solar energy system. Due to the fact that all the theoretical models, of the climatological parameters, are based on a real meteorological data base, the program offers very reliable results. In this way, the author intends for future papers to present the researches concerning the comparative study of the real and simulated climatological parameters.

REFERENCES

- [1] Kasten F., 1996, The Linke turbidity factor based on improved values of the integral Rayleigh optical thickness. *Solar Energy*, 56, pp. 239-244.
- [2] Kasten F., Young A.T. Revised optical air mass tables and approximation formula. *Applied Optics*, 28 (22), 1989, pp. 4735-4738.
- [3] Marcu, M., Huber, V. Air Thermal Stratification in the Depression Area Forms. "Depression Effect". *Phytogeographical Implications. Anale I.C.A.S.*, 46, p. 141-150.