ESTIMATION OF SOLAR RADIATION IN INDIA

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Problem and Purpose

Accurate crop simulation requires quality input information. One of the primary weather inputs needed to simulate evapotranspiration and plant biomass growth in crop models is the solar radiation reaching the Earth surface. Most developed country research sites record solar radiation as a part of weather data, but in developing countries the cost and expertise is often not available and less expensive approximations have to be made. In order to extend crop simulation models we need an improved procedure for estimating the daily flux of solar radiation that would be general and accurate throughout the earth when a minimum amount of critical information is available. The need for general method for estimating radiation from commonly available inputs has grown as spatial scope of research into soil-plant-atmosphere-system has expanded from local, to regional, continental and global scales.

Objectives

- To develop a generic Solar Radiation Generator for India
- Reducing the Minimum data set for crop simulation

Equations

$$\text{Solar Radiation(Simulated)} = \text{CDR} * \text{FCD} \quad [1]$$

Where

CDR= Clear day Radiation (MJ/m^2)

FCD = Fraction of Clear day

$$\text{CDR} = \text{ETR} * \text{CDT}^{\text{OAM}} \quad [2]$$

Where

CDT= Clear day transmissivity

OAM = Optical air mass determined using altitude as a function with reference to sea level pressure

$$\text{CDT} = 0.87 - 0.003 * \text{Tmin} \quad [3]$$

Tmin/max = Daily Minimum/Maximum Temperature in ^oC

Tdiff = Tmax-Tmin

$$FCD = 1.05 - \frac{0.9}{1 + \left(\frac{T_{diff}}{T_0}\right)^3} \quad [4]$$

Where

To = Inflection point temperature in ^0C. To varies in space and time. It is calculated using quality solar data and mean monthy Tdiff

Results

Calculated daily transmissivity is depicted in Fig.1 along with the modeled clear day transmissivity using Eq.[3]. Tmax-Tmin(Tdiff) is used to estimate FCD using Eq[4]. To in Eq[4] varies with time and space. The Maximum and minimum To for ICRISAT is depicted in Figure.2. Long term mean monthly Tmax-Tmin values are subtracted from monthly averaged To value to obtain data for estimation of the annual variation in To (Fig.3.) which is used to estimate To. Simulated and measured radiation is compared in Fig.4. When the cumulative error was plotted (Fig.5) , the bias at any time of the year was relatively small and the errors were mostly random.Testing the applicability of the Equation[1] with crop model like DSSAT shows no significant differences in estimating the yield and Evapotranspiration [Fig (6 and 7)].

ICRISAT Clear day transmissivity calculated using equation [3]

Figure 1 Clear day transmissivity Vs Tmin

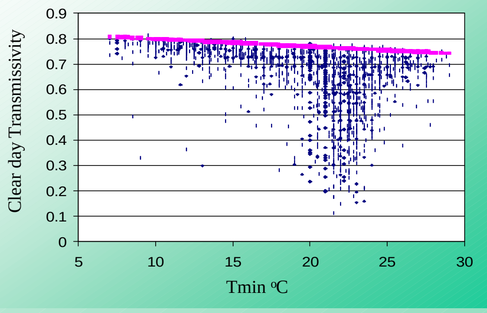


Figure 2 **FCD Vs. Tdiff**

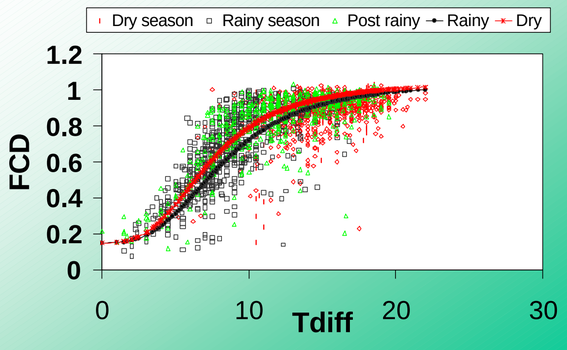


Figure 3 Spatial and temporal distribution of Tdiff- To values for India

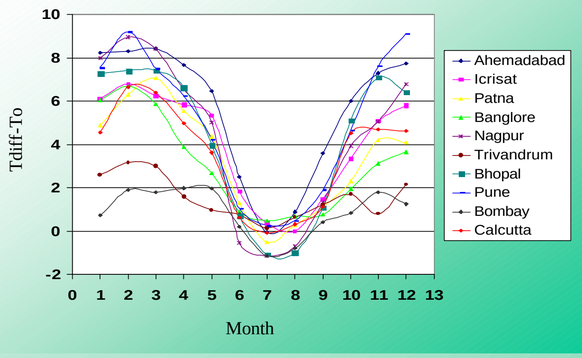


Figure 4 Comparison of measured vs simulated radiation for ICRISAT, India

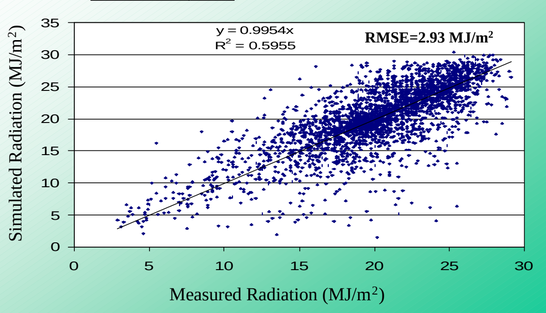


Figure 5 Cumulative daily values of measured minus estimated radiation at ICRISAT for 7 years of data

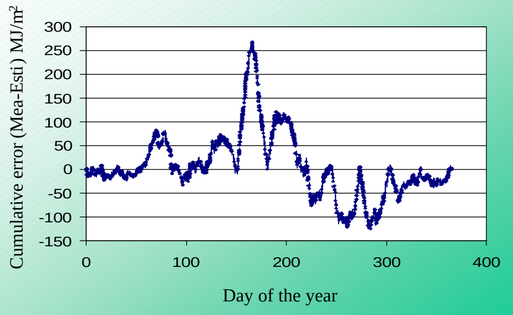


Figure 6 After running the crop model DSSAT3.5 (Soybean) for ICRISAT with simulated and measured radiation

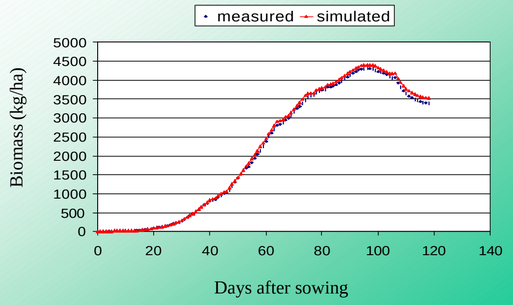
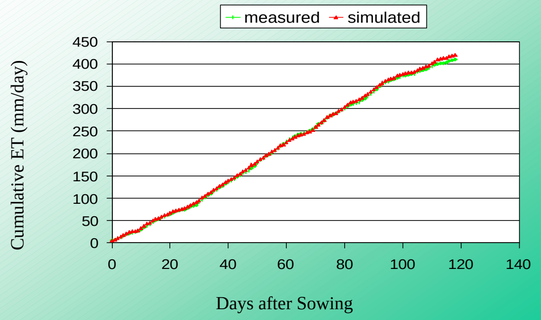


Figure 7 Comparing the cumulative evapotranspiration obtained by running in DSSAT3.5(Soybean) for ICRISAT with measured and simulated radiation



Conclusions

- The model produces satisfactory results and hence could be used for generating solar radiation in places where radiation data are not available.
- With this methodology radiation could be generated from temperature, so there is no need for measured radiation being given as an input in DSSAT models.

Acknowledgements

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Reference

Robert.J.List, Smithsonian Meteorological Tables, 1971, Published by Smithsonian Institution Press, Washington