Estimate of Daily Global Solar Radiation: New Developments in the Software RadEst3.00

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The limited availability of reliable global solar radiation (GSR) data is a negative constraint to the effective applications of simulation models. Methods to estimate GSR from more commonly and reliably measured meteorological data is useful to provide radiation data which would otherwise be unavailable. RadEst3.00 allows estimating daily values of GSR. We present here an improved version RadEst3.00 beta.

Global Solar Radiation

$$Rad = tt\ PRad$$

Rad = daily global solar radiation (MJ m^{-2} d^{-1})
tt = atmospheric transmittance (0-0.8)
PRad = radiation outside atmosphere (MJ m^{-2} d^{-1})

Models

Bristow and Campbell

$$tt = \tau\left[1-\exp\left(\frac{-b\Delta T^2}{\Delta T_m}\right)\right]$$

Campbell and Donatelli

$$tt = \tau\left\{1-\exp\left[-b\,f\left(T_{avg}\right)\Delta T^2\ f_1\left(T_n\right)\right]\right\}$$

Donatelli and Bellocchi

$$tt = \tau\left[1+f(doy)\right]\left[1-\exp\left(\frac{-b\ \ \Delta T_i^2}{\Delta T_w}\right)\right]$$

Modular DCBB

$$tt = \tau\left[1+f(doy)\right]\left[1-\exp\left(\frac{-b\ \ \Delta T_i^2 f_2(T_n)}{\Delta T_{avg}}\right)\right]$$

τ = clear sky transmissivity
i = day of the year
ΔT = $Tx_i-(Tn_i+Tn_{i+1})/2$
ΔT_w = mean ΔT weekly (mobile mean)
ΔT_m = mean ΔT monthly
ΔT_{avg} = either ΔT_w or ΔT_m
$f(T_{avg})$ = $0.017\ \exp[\exp(-0.053\ T_{avg})]$
T_{avg} = $(Tx_i+Tn_i)/2$
$f_1(Tn)$ = $\exp(Tn_i/Tnc)$
$f_2(Tn)$ = either $f_1(Tn)$ or 1
f(doy) = $c1\ \{\sin(i_r\ \pi/180\ c2)+\cos[i_r\ \pi/180\ f(c2)]\}$
i_r = either i or reverse i (361-i)
f(c2) = $1-1.90\ c3+3.83\ c3^2$
c3 = c2 minus its integer
b, c1, c2, Tnc are empirical parameters

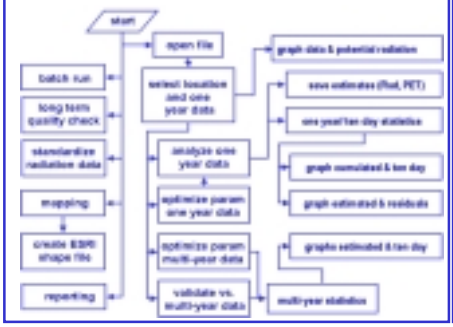
Trigonometric Factor

The term f(doy) in DB and DCBB allows:

- dealing with asymmetric seasonality
- accounting for different hemispheres
- preventing discontinuities across years

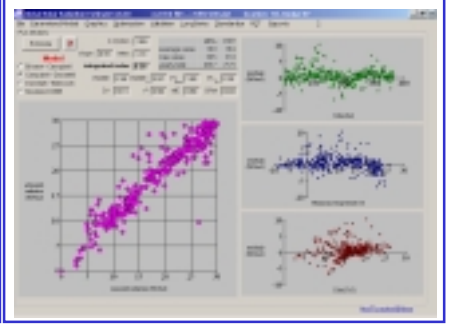
Flowchart

The program components are shown in the flowchart below. RadEst3.00 includes exclusive components, not implemented in previous releases, i.e.: DB and DCBB models, potential evapotranspiration, mapping weather stations and model parameters, and extensive reporting capabilities (view/print report, view/print database, export in a variety of formats such as Excel, RTF, HMTL, etc.). Updated components are the GSR data standardization procedure, the statistical module, and the optimization procedures.



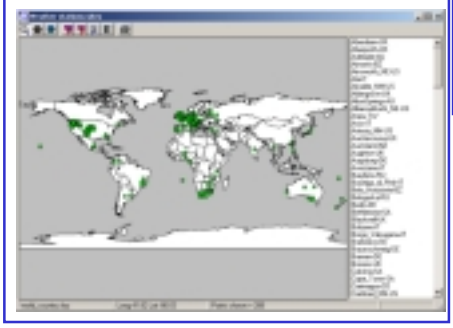
Statistical Indices

To evaluate model performance a set of statistical indices is computed. Moreorer, more statistics are aggregated into a synthetic indicator according to fuzzy rules. The **integrated index** allows a comprehensive judgment on the model performances, and is helpful to rank models and choose the best model out of alternative candidates. The performance of each model can be analyzed as ten-day means either. Model residuals are plotted vs. julian day, minimum temperature, and DeltaT.



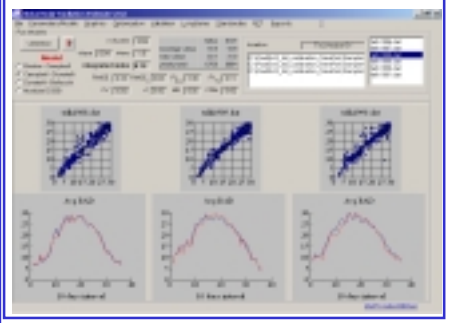
Mapping Weather Stations

Geo-referenced weather stations can be shown overlaying on a user chosen map. This is done by loading weather stations from the RadEst database and creating an ESRI shape file, which is overlaid on a country/region etc. polygons map. A zoom tool allows selecting areas in a map, and the weather stations included in the rectangle zoomed can be shown and exported both as shape file and as RadEst database.
Other tasks are allowed, e.g., get information on the active layer (either polygons or points), etc.



Multi-year Evaluation

The model estimates may be tested against more than one year of radiation data. The plots 1:1 and yearly profiles of both estimated and measured data are shown. The relevant statistics are computed.



RadEst3.00 is a freeware. The installation file is available in the Symposium CD-ROM, and it can also be downloaded from: http://www.isci.it/tools.