CALCULATING EVAPOTRANSPIRATION AND CROP BIOMASS USING ESTIMATED RADIATION INPUTS

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Introduction

Crop growth estimation is very sensitive to the calculation of potential evapotranspiration (***PET***). The Priestley-Taylor (PT) equation is a relatively simple ***PET*** estimator that is useful when daily maximum and minimum temperature, and solar radiation are available. Global solar radiation (***GSR***) is frequently not recorded by weather stations, so when radiation records are incomplete or not available, the PT model cannot be applied unless estimates of solar radiation are done. Estimates of solar radiation are affected by both an overall error and seasonal patterns, that propagate in either ***PET*** estimates or derived outputs, e.g. above ground crop biomass (***AGB***).

Methods

Radiation models. Three models to estimate ***GSR*** from temperature data were applied (BC: Bristow-Campbell; CD: Campbell-Donatelli; DB: Donatelli-Bellocchi). The measured radiation data were used to parameterize the three models at each location.

Evapotranspiration estimate. The PT model was used to estimate ***PET***. Average values of both PT constant (PTc=1.26) and aridity factor (a=0.03 kPa^{-1}) were used.

Above ground crop biomass simulation. ***AGR*** was estimated by the crop growth model CropSyst. One representative crop was selected for each location (table below), and parameterized loading the default crop values provided with CropSyst.

Data processing. The amount of residuals generated by each estimate was quantified by the relative root mean squared error (RRMSE, %). A relative measure of the presence of patterns versus time (calendar days) was also calculated, arranging the residuals in four groups (RPI_4, %).

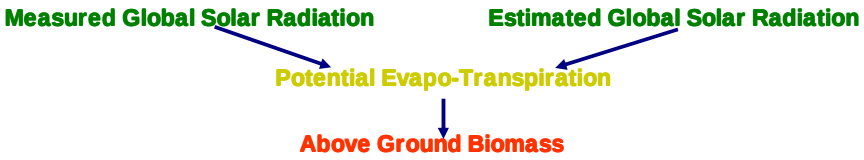
Weather data. Twenty locations with 6 years of complete weather records (rainfall, maximum and minimum temperature, solar radiation) were selected for this study.

Country	Location	Latitude	Longitude	Crop
Australia	Longreach	-23.43	144.27	sunflower
Colombia	Palmira	3.52	-76.32	maize
France	Toulouse	43.32	1.37	maize
Germany	Würzburg	49.77	9.97	wheat
India	Hyderabad	17.45	78.47	wheat
Italy	Perugia	43.08	12.5	sugarbeet
Malawi	Lilongwe	-13.98	33.63	millet
Mexico	Poza Rica	20.53	-97.45	maize
Philippines	Los Baños	14.17	121.25	wheat
Republic of China	Taichung	24.15	120.68	wheat
Spain	Cordoba	37.88	-4.77	sunflower
Syria	Tel Hadya	36.02	36.93	wheat
Tanzania	Morogoro	-6.83	37.65	millet
Thailand	Chiang Mai	19.01	99.01	wheat
The Netherlands	De Bilt	52.1	5.18	wheat
Turkey	Konya	37.87	32.5	wheat
United Kingdom	Blacknell	51.38	51.38	wheat
United States	Gainesville FL	29.63	-82.37	maize
United States	Prosser WA	46.25	-119.7	wheat
Zimbabwe	Kado	-18.32	29.88	millet

2002 – VII ESA Congress, Cordoba, Spain

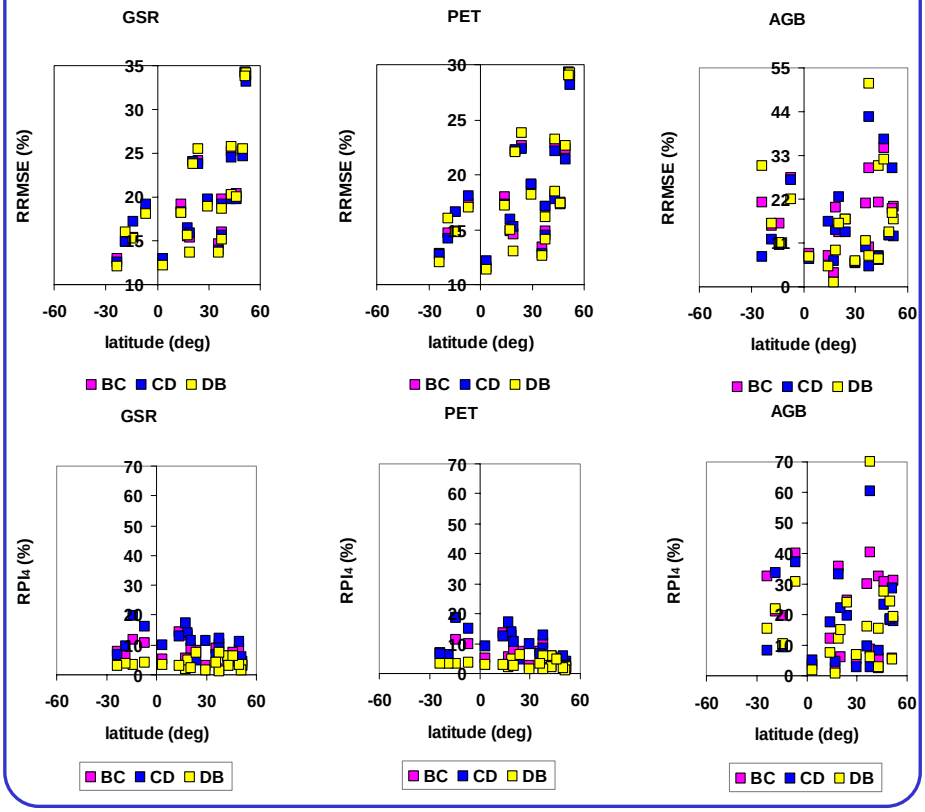
Objective

To compare ***PET*** and ***AGB*** of different crops at maturity calculated using complete daily weather records with recorded solar radiation from a variety of locations against values calculated using estimated ***GSR*** values.



Results

The results obtained with ***GSR***, ***PET*** and ***AGB*** are shown in the graphs below.



Conclusions

❑ The three radiation models did not provide appreciable differences in RRMSE for GSR and PET estimates. However, the model DB gave consistently better performance than both BC and CD in preventing ***GSR*** and ***PET*** estimates from showing patterns over time, with few exceptions in temperate locations.

❑ DB gave the lowest value of both RRMSE (1.2%) and RPI_4 (0.7%) for ***AGB***, and provided the best performance in 6 cases (both indices). The model CD allowed the best estimates of ***AGB*** in 10 cases (both indices). Therefore, better estimates of ***AGB*** tend to be associated with the use of ***GSR*** models accounting for seasonality, i.e. CD and DB, with a certain preference on the model CD.

❑ In general, there was almost no change in RRMSE and RPI_4 when estimating ***PET***, compared to ***GSR*** estimates, whereas ***AGB*** estimates have noticeable differences: reduction and amplification of RRMSE, and increase of RPI_4. Such an increase indicates that the use of estimated ***GSR*** may affect biomass estimates unevenly over the growing season.

❑ Further study is required for a better understanding of the distribution of model residuals over specific growing seasons at each location.