

3.a. Using FUZZY LOGIC to develop a system to test solar radiation models

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The problem

How good are solar radiation estimates in a site?

Data available

Differences between estimates and measurements (residuals) of daily solar radiation data in MJ m⁻² d⁻¹ at a site in 1 year.

Why use this method and not another method?

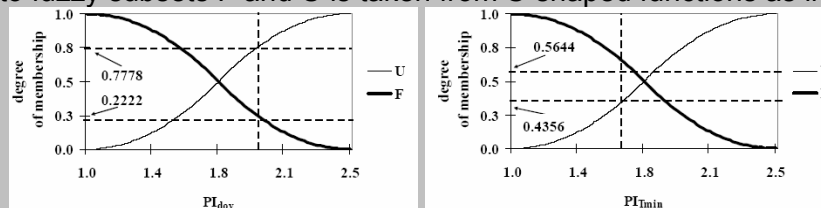
Aggregating more statistics into one synthetic measure is desirable in order to have a comprehensive assessment of the model response. Fuzzy-based rules are proficiently applied to this problem.

Simple description of how it was done

Two indices are computed to quantify the presence of patterns in the residuals, against day of year and daily minimum air temperature: $PI_{\text{doy}}=2$, $PI_{\text{Tmin}}=1.7$. PI values are classified as favourable (F) when $PI_{\text{doy}}, PI_{\text{Tmin}} \leq 1$, and unfavourable (U) when ≥ 2.5 . Partial membership to F or U is looked upon intermediate values. Four rules are generated when aggregating both indices in a weighted mode (same weight, 0.5, is attached to each PI in this case):

if PI_{doy} is F and if PI_{Tmin} is F then 0.0 (best)
if PI_{doy} is F and if PI_{Tmin} is U then 0.5 (partial)
if PI_{doy} is U and if PI_{Tmin} is F then 0.5 (partial)
if PI_{doy} is U and if PI_{Tmin} is U then 1.0 (worst)

Membership to fuzzy subsets F and U is taken from S-shaped functions as in the figure.



An aggregated index (*pattern*) is given by the following weighted mean:

$$pattern = \frac{0.0 \cdot 0.2222 + 0.5 \cdot 0.2222 + 0.5 \cdot 0.5644 + 1.0 \cdot 0.4356}{0.2222 + 0.2222 + 0.5644 + 0.4356} = 0.5739$$

Model performance is not entirely good as *pattern* is closer to 1 (worst) than to 0 (best).

Software used and alternative generic packages that could be used

The library IRENE_DLL was used, with Microsoft Excel as a client (http://www.sipeaa.it/tools/IRENE_DLL/IRENE_DLL.htm).

Reference

Bellocchi, G., Acutis, M., Fila, G. & Donatelli, M. 2002. An indicator of solar radiation model performance based on a fuzzy expert system. *Agronomy Journal* 94: 1222-1233.

Further reading

Donatelli, M., Acutis, M., Bellocchi, G. & Fila, G. 2004. New indices to quantify patterns of residuals produced by model estimates. *Agronomy Journal* 96: 631-645.

Fila, G., Bellocchi, G., Donatelli, M., & Acutis, M. 2003. IRENE_DLL: A class library for evaluating numerical estimates. *Agronomy Journal* 95: 1330-1333.