Temperature based daily incoming solar radiation modeling based on gene expression programming, neuro-fuzzy and neural network computing techniques.

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The correct observation/estimation of surface incoming solar radiation (R_S) is very important for many agricultural, meteorological and hydrological related applications. While most weather stations are provided with sensors for air temperature detection, the presence of sensors necessary for the detection of solar radiation is not so habitual and the data quality provided by them is sometimes poor. In these cases it is necessary to estimate this variable.

Temperature based modeling procedures are reported in this study for estimating daily incoming solar radiation by using Gene Expression Programming (GEP) for the first time, and other artificial intelligence models such as Artificial Neural Networks (ANNs), and Adaptive Neuro-Fuzzy Inference System (ANFIS). Traditional temperature based solar radiation equations were also included in this study and compared with artificial intelligence based approaches. Root mean square error (RMSE), mean absolute error (MAE) RMSE-based skill score (SS_{RMSE}), MAE-based skill score (SS_{MAE}) and r^2 criterion of Nash and Sutcliffe criteria were used to assess the models' performances.

An ANN (a four-input multilayer perceptron with ten neurons in the hidden layer) presented the best performance among the studied models (2.93 MJ m^{-2} d^{-1} of RMSE). A four-input ANFIS model revealed as an interesting alternative to ANNs (3.14 MJ m^{-2} d^{-1} of RMSE). Very limited number of studies has been done on estimation of solar radiation based on ANFIS, and the present one demonstrated the ability of ANFIS to model solar radiation based on temperatures and extraterrestrial radiation. By the way this study demonstrated, for the first time, the ability of GEP models to model solar radiation based on daily atmospheric variables. Despite the accuracy of GEP models was slightly lower than the ANFIS and ANN models the genetic programming models (i.e., GEP) are superior to other artificial intelligence models in giving a simple explicit equation for the phenomenon which shows the relationship between the input and output parameters. This study provided new alternatives for solar radiation estimation based on temperatures.