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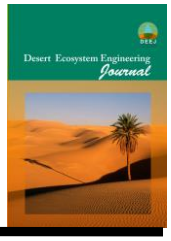

Assessing Experimental and Intelligent Models in Estimating Reference Evapotranspiration

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Extended Abstract

Introduction: As the most important element in the hydrologic cycle which depends on climate variables such as near-ground wind speed, air temperature, solar radiation, and relative humidity, reference evapotranspiration (ET0) is normally computed through a variety of methods, each of which requires different and in some cases extensive data that are unavailable in many circumstances, especially in arid and semi-arid regions like Iran, providing different results based on the type of meteorological assumptions and data considered.

ET0 values can be estimated and simulated via meteorological models using physical equations or the empirical relationship existing between meteorological variables. in this regard, the FAO model is commonly used as a reference method worldwide for estimating evapotranspiration, requiring large sets of input data, including maximum/minimum air temperature, maximum/minimum relative humidity, solar radiation, and wind speed. However, as all of such information may sometimes be impossible to access, it is necessary to select models with fewer input data and reasonable accuracy.

Therefore, this study set out to investigate the applicability of seven reference evapotranspiration estimation models with fewer input data, including Kimberley penman, FAO radiation model, Hargreaves Samani, Makkink, belany Kridle FAO 24, Turc, and Priestly Teylor. The optimal model for estimating reference evapotranspiration was then determined using Gene Expression Programming Model (GEP), whose results were compared with the experimental methods. On the other hand, multivariate regression was used to identify the model's input patterns and to examine the influence of climatic parameters on ET_0.

Materials and methods: Expressing the relationship between several predictor variables and the response variable in question, multivariate regression models are based on two basic assumptions that distinguish them from the simple regression model:

1) The number of predictor (independent) variables in the regression should be less than the number of observations.

2) There is a complete linear correlation between predictor and response variables. Accordingly, in cases where the two assumptions are violated, the regression equation cannot be estimated.

Gene expression planning is a combination of the GA and GP methods developed by Ferreira in 1999, where, similar to decomposition trees in genetic programming, linear and simple chromosomes of constant length are combined, taking the genetic algorithm and branch structures of different sizes and shapes into account. Therefore, the genotype and phenotype are separated in this method, and the system is unable to enjoy all the evolutionary benefits.

While the GEP's phenotype is similar to that of the branched structure of GP, the tree expression in GEP (i.e., its branched structure) represents all independent genomes. Thus, in GEP, refinement occurs in a linear structure and is expressed as a tree structure, merely resulting in a modified genome that is transferred to the next generation.

Considering the fact that GEP requires no heavy structures to reproduce and mutate, this study used the meteorological data collected from Aligodarz Synoptic Station for a 35-year period (1983–2017), including the maximum and minimum daily temperature, maximum and minimum relative humidity, wind speed, and sunlight

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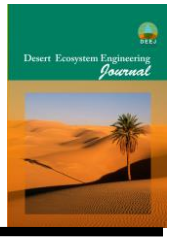

hours, 70% of which were used for training and the remaining 30% for testing the model. Moreover, two types of mathematical operators were used in the GEP method, including four-element operations and default model operators.

Results and discussion: The study's results suggested that the Kimberley Penman and FAO Radiation models were more accurate than the other experimental models. Furthermore, multivariate regression results indicated acceptable modeling accuracy, with the R^2 being 0.95. Also, the analysis of the model's coefficients revealed that the maximum temperature had the highest influence on the prediction and estimation of reference evapotranspiration, with its correlation coefficient being 0.58, followed by wind speed, sunshine hours, minimum temperature, and, maximum and minimum relative humidity, respectively.

Taking the above-mentioned results into account, this study found six models for estimating reference evapotranspiration that required fewer input data. Accordingly, in Gene Expression Programming, model 2 comprising default operators with RMSE of 0.843 and R^2 of 0.932, and the one with RMSE of 0.76 and R^2 of 0.941 performed better at training and test phases, respectively.

Moreover, the comparison of the reference evapotranspiration estimation models indicated that the Gene Expression Programming model outperformed the other ones. The GEP model was also found to have acceptable applicability for estimating reference evapotranspiration in Aligodarz city under climatic conditions, being a readily applicable model in this field.

Keywords: Radiation Model, Temperature Model, Radiation-temperature Model, Regression Model, GEP.