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On the reliability of soft computing methods in the estimation of dew point temperature: The case of arid regions of Iran

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ABSTRACT

Owing to the importance of dew point temperature (T_{dew}) as a determining factor in hydrological parameters, especially water vapor and evaporation, we aim for the estimation of T_{dew} by three different computational models including gene expression programming (GEP), multivariate adaptive regression splines (MARS), and support vector machine (SVM) models to establish their reliability. Three different data divisions were defined as extreme values and were taken as input data for examining the reliability of these models in predicting T_{dew} using the coefficient of determination (R^2), the root mean square error (RMSE) and the Akaike information criterion (AIC). In this study, thirteen synoptic stations in arid regions of Iran were selected, representing a period of 55 years from 1960 to 2014. Nine of the stations were used for training stages of the study, and the remaining for testing stages. T_{dew} were taken as the function of several parameters, such as the maximum temperature (T_{max}), the minimum temperature (T_{min}), the relative humidity (R_H), the wind speed (W), the atmospheric pressure (P) and the sunshine hours (n). We found that the MARS model agrees well with observed data in predicting the T_{dew} when compared with other used methods.

1. Introduction

The dew point (T_{dew}) is one of the meteorological components in the hydrological cycle and defied as the temperature at which the air becomes saturated with water. When the air temperature is equal to the T_{dew}, the saturated air changes to the liquid phase (Shiri et al., 2013). Exact knowledge about the T_{dew} can help us to find out the available moisture in the air (Shank et al., 2008).

In arid and semi-arid regions with low precipitation, T_{dew} could have a great impact on agricultural products in terms of evapotranspiration, plant growth, and crop production (Agam and Berliner, 2006). Moreover, bearing in mind the effect of T_{dew} on hydrological, agronomical and climatological studies, it is important to find a reliable method to estimate this parameter (Feld et al., 2013; Mohammadi et al., 2015). Other meteorological parameters such as temperature (Hubbard et al., 2003), evaporation (Agam and Berliner, 2006), relative humidity (Lawrence, 2005) and has been already simulated using mathematical models. However, to the best of our knowledge, there are rare studies on the estimation of T_{dew} in arid regions, especially for Iran.

Soft computing methods have been conducted to model various phenomena such as hydrogen production (Faizollahzadeh Ardabili et al., 2018), flood management (Fotovatikhah et al., 2018, and dam intake (Ghazvinei et al., 2017). Gene expression programming (GEP), Support vector machine (SVM), and Multivariate adaptive regression splines (MARS) as commonly used soft computing techniques are the powerful tools which could be used to correlate the relationship between parameters in complicated models, especially in meteorological studies. In brief, the GEP technique begins by randomly producing chromosomes of the certain program before their expression and evaluation of the reliability of programs. This process will be continued until a reliable and accurate equation achieved for the case study (Ferreira, 2001). MARS as another method of soft computing approaches correlates independent and dependent variables using a piecewise linear spline. In this method, basis functions formed the MARS equations, leading us to response variables (Friedman, 1991). Next, SVM is based on machine learning methods which found various applications in different fields, has been used for classification and regression by employing kernel functions. This function subdivided into four main groups including radial basis function, linear, polynomial and sigmoid (Cortes and Corinna, 1995). Up to now, there are some reports working on T_{dew} estimation through different computational methods by employing different number of input parameters (Amirmojahedi et al., 2016; Baghban et al., 2016; Hubbard et al., 2003; Jothiprakash et al., 2011; Kimball et al., 1997; Kisi et al., 2013; Mahmood and Hubbard, 2005; Mehdizadeh et al., 2017a; Shank et al., 2008; Shiri et al., 2014; Upreti and Ojha, 2017; ZareNezhad and Aminian, 2010).

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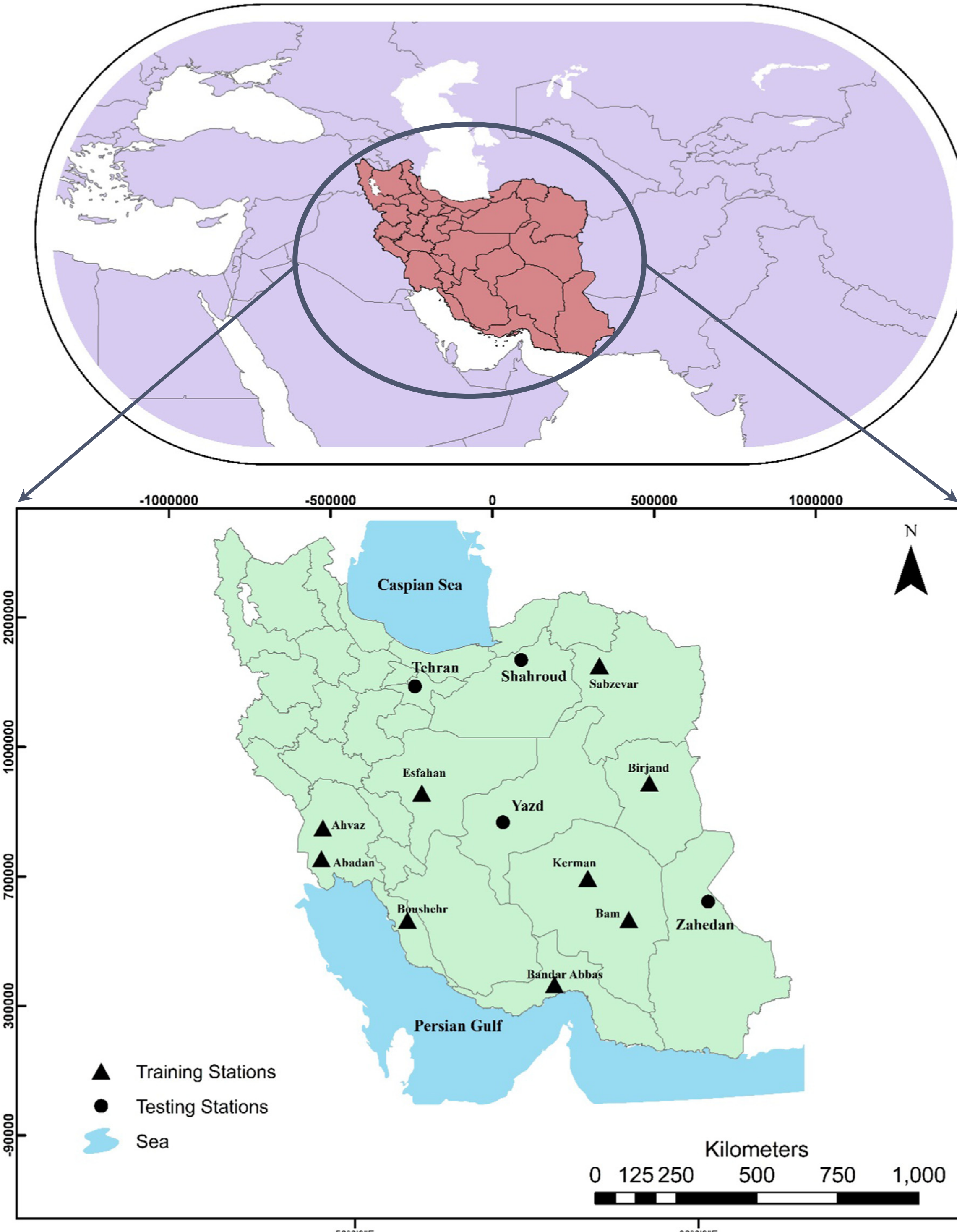

Fig. 1. Geographical locations of studied stations (training and testing stations have been marked).

For example, least square support vector machine (LSSVM) and adaptive neuro-fuzzy inference system (ANFIS) models were applied to estimate the T_{dew} using two input parameters including temperature and relative humidity and optimization point was found by genetic algorithm (GA). They found good agreement between statistical analysis and GA–LSSVM model (Baghban et al., 2016). In another study, eight parameters were assumed as a determining factor in prediction of T_{dew} including minimum, maximum, and average air temperatures (T_{min}, T_{max}, and T_m), relative humidity (R_H), atmospheric pressure (P), water vapor pressure (VP), sunshine hour (n) and horizontal global solar radiation (H) over period of seven years. In the case of Tabass and Kerman located in Iran, ANFIS model was performed and found that water vapor weight plays the most important role in deciding the T_{dew} while R_H has a minor effect (Mohammadi et al., 2016). The role of vapor pressure on T_{dew} was approved by another research in which the GEP model with seven input parameters were used for Tabriz and Urmia located in Iran. In another research, the accuracy of three models including wavelet regression, artificial neural network (ANN), GEP in the