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Selection of meteorological parameters affecting rainfall estimation using neuro-fuzzy computing methodology

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ABSTRACT

Rainfall is a complex atmospheric process that varies over time and space. Researchers have used various empirical and numerical methods to enhance estimation of rainfall intensity. We developed a novel prediction model in this study, with the emphasis on accuracy to identify the most significant meteorological parameters having effect on rainfall. For this, we used five input parameters: wet day frequency (d_{wet}), vapor pressure ($\bar{e}_a$), and maximum and minimum air temperatures (T_{max} and T_{min}) as well as cloud cover (cc). The data were obtained from the Indian Meteorological Department for the Patna city, Bihar, India. Further, a type of soft-computing method, known as the *adaptive-neuro-fuzzy inference system* (ANFIS), was applied to the available data. In this respect, the observation data from 1901 to 2000 were employed for testing, validating, and estimating monthly rainfall via the simulated model. In addition, the ANFIS process for variable selection was implemented to detect the predominant variables affecting the rainfall prediction. Finally, the performance of the model was compared to other soft-computing approaches, including the artificial neural network (ANN), support vector machine (SVM), extreme learning machine (ELM), and genetic programming (GP). The results revealed that ANN, ELM, ANFIS, SVM, and GP had R^2 of 0.9531, 0.9572, 0.9764, 0.9525, and 0.9526, respectively. Therefore, we conclude that the ANFIS is the best method among all to predict monthly rainfall. Moreover, d_{wet} was found to be the most influential parameter for rainfall prediction, and the best predictor of accuracy. This study also identified sets of two and three meteorological parameters that show the best predictions.

1. Introduction

Increasing population and industrialization have put tremendous pressures on the natural processes (e.g., Bawa and Seidler, 2015; Brown, 2015; Gupta, 2014; Heald and Spracklen, 2015; Lemaire et al., 2014). In addition, in recent years, the frequency of natural hazards (i.e., droughts, floods, hurricanes, cyclones and tsunamis) have increased (Gong and Forrest, 2014; Guan et al., 2015; Kumar et al., 2015; Sowmya et al., 2015). Therefore, temporal prediction of natural processes, such as rainfall, is helpful in appropriate planning and management of urban areas. For example, rainfall determines the ground water level, which in turn supports the water supply to urban and rural populations (Dhakal and Sullivan, 2014; Van Eekelen et al., 2015). In addition, rainfall endures various human ecology interactions such as agriculture, thermal comfort, and evaporation (Arvor et al., 2014; de Abreu-Harbich et al., 2015; Müller et al., 2014; Singh et al., 2014).

Rainfall is not easy to predict, because it depends on the space and time scales. Researchers consider rainfall as a stochastic process (Kundu et al., 2014; Ramesh et al., 2013; Schleiss et al., 2014). In this regard, various empirical and numerical models have been developed to investigate the non-linear trend of rainfall (Buzzi et al., 2014; Dai et al., 2015; Kumar et al., 2014; Nicholson, 2014; Nielsen et al., 2014). Recently, accuracy of conventional prediction models have been improved through the meteorological and satellite observations (Mehran and AghaKouchak, 2014; Zhou et al., 2014). The efficiency of soft-computing techniques was investigated for non-linear natural processes, such as rainfall (Nastos et al., 2014), drought (Deo and Şahin, 2015), oceanic wave (Sayemuzzaman et al., 2015), and sediment transport (Makarynskyy et al., 2015). In this view, use of the soft-computing methods for predicting rainfall can be beneficial.

Rainfall models that employ soft-computing techniques can be classified into two groups. The first group uses historical time series data of a station to train the model and predict rainfall (e.g., Ramana et al., 2013;

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