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Evaluation of the Effect of Changes in Climatic Variables at Different Levels on the Rate of Potential Evapotranspiration in Arid and Semi-Arid Regions

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Abstract—Potential evapotranspiration (PET) is an effective variable in the hydrological cycle which has a determinative role in the amount of water consumption, especially in agricultural sectors. Considering the effect of climatic variables and their changes on the rate of PET, in this research, the effects of changes in six climatic variables on the rate of PET were evaluated at seven levels, namely −20%, −10%, −5%, observed or actual data, +5%, +10%, and +20%. In this study, five stations were used from March 21, 1988, to January 20, 2019, on the daily and seasonal time scales. The fuzzy clustering algorithm (FCA) was applied to evaluate the effect of the changes in climatic variables on the PET. The results indicated that the sensitivity of PET to the increasing changes in the mean daily maximum and minimum temperature, the mean daily maximum and minimum relative humidity, and the mean daily wind speed variables were more than the decreasing changes. Our analysis indicates, on daily and seasonal time scales, PET was most sensitive to changes in the maximum temperature. A 20% increase in maximum temperature corresponds to a 10% increase in the rate of PET. Also, PET was least sensitive to changes in the minimum temperature. A 20% increase in minimum temperature corresponds to a 0.5% increase in the rate of PET. The results showed that the effect of change in maximum temperature and minimum temperature variables on the PET values in warmer seasons such as summer and spring was more than in colder seasons such as winter and autumn.

Keywords: Fuzzy clustering algorithm, climatic variables, potential evapotranspiration, FAO Penman–Monteith, Fars Province.

Abbreviations

NTWP	Negative twenty percent (−20%)
NTP	Negative ten percent (−10%)
NFP	Negative five percent (−5%)
OBS	Observed data or actual data
PFP	Positive five percent (+5%)
PTP	Positive ten percent (+10%)
PTWP	Positive twenty percent (+20%)
Ma-Te	Mean maximum temperature
Mi-Te	Mean minimum temperature
Ma-RH	Mean maximum relative humidity
Mi-RH	Mean minimum relative humidity
Su-Sh	Mean sunshine hours
Wi-Sp	Mean wind speed
FCA	Fuzzy clustering algorithm

1. Introduction

Potential evapotranspiration (PET) is one of the most important and effective water cycle parameters (Afzal & Ragab, 2020; Hunt et al., 2020; Sun et al., 2020; Zarei et al., 2021; Zhang et al., 2020) which play a significant role in water consumption, especially in agriculture (Abrishambaf et al., 2020; Wang et al., 2020; Xiang et al., 2020; Zarei, 2019). Globally, almost 70% of freshwater is consumed in agriculture every year, and more than 99% of this water consumption in agriculture is relevant to evapotranspiration (Alizadeh, 2013; Harris et al., 2020; Schewe et al., 2014). Considering the influential role of climatic variables and their changes in the rate of PET, many researchers from all over the world have tried to assess the relationship between climatic variables and PET (Ageena & Froja, 2020; Liu et al., 2020; Murumkar et al., 2020; Zarei & Mahmoudi, 2020; Zarei et al., 2015). The following mentions the relevant studies on the relationship between climatic variables and PET.

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