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The impact of climate change on severity, duration, and magnitude of drought using SPI and RDI in the Semnan region

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Extended abstract

Introduction

In recent years human activities have induced increases in atmospheric carbon dioxide (CO2). Increases in [CO2] caused global warming and climate change (IPCC, 2001; IPCC, 2007). Climate change is anticipated to cause negative consequences, some of which will have directly obvious impacts, such as intense precipitation, surface water resources and flooding while some will have long-term impacts such as sea level rise, diseases and droughts. Globally, droughts have a devastating impact on agriculture, the economy, and society. Drought monitoring is an essential component of drought risk management. Drought indices are indispensable tools to detect, monitor, and evaluate drought events. These indices were classified as meteorological drought indices. The Reconnaissance Drought Index (RDI) and standardized precipitation index (SPI) are the most popular drought assessment Indices.

As global warming cascades into the next generation, a change in drought intensity and duration as considered by many studies is becoming a threat to humanity. Therefore, any measures for mitigation and adaptation require careful assessment of historical events and accurate representation of future drought based on new methodological approaches. Since Semnan is located in the arid and semi-arid region, drought assessment is very important. To be prepared for the negative impacts of drought, it is essential to predict their properties. Therefore, the aim of this paper is to examin of climate change impacts on drought frequency, severity and duration using two drought indices (SPI and RDI) for Semnan region located in Iran.

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Material and method

Study Area

The synoptic station of Semnan, with an elevation of 1127 meters has longitude of 53°23 ′ East, latitude of 35°35 ′ North. The annual precipitation at this station is 140 mm, the average Tmin and Tmax is, respectively, 12.5 and 23.8 °C, respectively.

Generating climate precipitation scenarios

The outputs from 13 AOGCMs following two emission scenarios RCP8.5 and RCP4.5 were utilized to produce monthly rainfall and temperature climate scenarios. The periods 1971-2000, 2010-2039, 2040-2069 and 2070-2099 were selected as baseline and future periods, respectively. The LARS-WG model was used for spatial and temporal downscaling of temperature and precipitation time series and daily precipitation and temperature scenarios were generated at probability levels of 0.50, 0.75 and 0.90 for the three future periods.

Drought indices

Standardized precipitation index (SPI) and Reconnaissance drought index (RDI)

For the calculation of SPI and RDI, the long-term data (precipitation for SPI, precipitation and evapotranspiration for RDI) are fitted to a gamma distribution. Drought occurs when SPI and RDI reach a value of –1.0 or less.

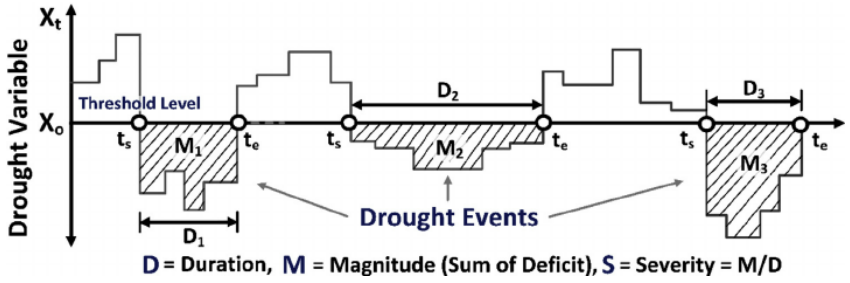
Evapotranspiration and precipitation deficit (PD)

There are several models for the estimation of reference evapotranspiration (ET_o). In this study, FAO Penman–Monteith (FAO PM) and Hargreves-Samani methods were used to estimate ETo.

Drought characteristics

Yevjevich (1967) proposed the Run theory to identify drought parameters (duration, magnitude and severity) which are described in Fig 1. The most key element for extracting these parameters is the threshold level, which may be a constant or a function of time.

Fig. 1. Drought characteristics

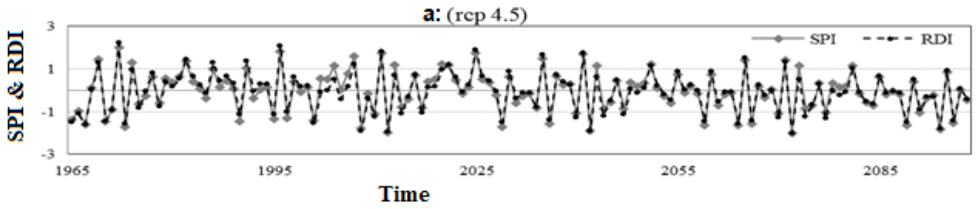


Results and Discussion

As a result, the FAO Penman-Monteith method (FAO PM) was found to be more precise than the Hargreves-Samani method for estimating ETo Therefore, in this study FAO PM used for estimation of RDI in climate change scenarios.

Temporal changes of SPI and RDI at 1-year timescale, under the risk level of 0.5 are illustrated in Fig 2.

Fig 2. Temporal changes of SPI and RDI at 1-year timescale, under the risk level of 0.5 (a): RCP4.5 (b): RCP8.5



The results revealed that as compared to the RCP4.5 scenario, in the RCP8.5 scenario, there will be more dry and wet periods. Drought duration predicted by RDI index compared to SPI index (at 1-year and 3-month time scales), under both emission scenarios in the future period (2010-2099) has decreased compared to the past period (1965-2009), but the number of droughts has increased. Additionally, increases and decreases in drought magnitude and severity were found at time scales 3-month and annually, respectively. These results provide observational evidence for the increasing risk of droughts as anthropogenic global warming progresses.