

Drought Assessment in Büyük Menderes Basin of Turkey

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Abstract

Drought is one of the most important phenomenon related to the agriculture-food and socio-economic problems all over the world. The Aegean region has a variety of water resources, including but not limited to seacoasts, lakes, streams, and groundwater aquifers. For this reason, the evaluation of historical and future drought events and their effects on water resources is important in the planning and development of the region. In this context, this study aims to evaluate the historical droughts in the inner Aegean region. Monthly precipitation time series were used in three meteorology stations, which are in the Büyük Menderes basin and have a continental climate, recorded between 1973 and 2020. First, to figure out whether the drought analysis is correct and dependable, consistency, randomness, and trend in time series were investigated using the binary mass curve, run and linear trend tests. Next, the standardized precipitation index SPI is used in conjunction with the moving average (MA) operator to evaluate the historical gap associated with meteorological (SPI-1), agricultural (SPI-3), and hydrological (SPI-6 and SPI-12). Finally, the results are evaluated based on the behavior of the SPI time series at different time intervals.

Keywords: Uşak, Standardized Precipitation Index, Precipitation, Denizli, Drought assessment, historical drought

1. Introduction

As drought has become more common around the world, the findings on the definition and perspectives of drought have become more concrete. There is no globally accepted standard definition for drought, and even among experts, a single definition of drought has not been agreed upon. To summarize these individuals, a deficiency in precipitation from an expected average over a time frame can be defined as drought. Therefore, it is necessary to understand the context in which drought and its effects are expressed. In this respect, the standardized precipitation index (SPI) is the most famous drought index used in the evaluation of droughts and uses precipitation as an input. This study aims to evaluate historical droughts in the inner parts of the Aegean region.

2. Materials and Methods

In this study, daily average daily total precipitation data obtained from the General Directorate of State Meteorology between 1973 and 2020 at Uşak, Güney, and Denizli stations of the Büyük Menderes basin were used (Figure 1). To begin with, the missing daily data were reconstructed using the spatiotemporal features of the time series holding seasonal averages and the historical features of the precipitation time series at other stations. Then the time series were converted into time series consisting of average monthly data and total monthly data. Then, consistency, randomness, and trend in the data run were examined using a double mass curve, run test, and linear trend test, respectively. Finally, reconstructed monthly time series with 1, 3, 6, and 12-month moving averages are used in the SPI drought analysis. For this, a data series is converted to a standard normal distribution and then fitted to a Gamma distribution. The results obtained are then evaluated by using predefined categories of a range from extremely dry to extremely wet conditions.



Figure 1: Locations of the stations

3. Results and Discussion

As a beginning, double mass curve, run test, and linear trend analysis were performed to investigate the reliability, consistency, and randomness of the time series. All the selected stations proved that there is no problematic condition. Table 1 shows that the time series at the selected stations are not random and have a decreasing trend; where a is the variable coefficient showing declining or increasing behavior of the data and Z is the run test score.

Table 1: Summary of Results of the Run test and Linear Trend Analysis

Stations	Tests	
	Linear	Run
	<i>a</i>	<i>Z</i>
Güney	-63.21	-8.97
Uşak	-6.09	-7.7
Denizli	-25.21	-8.98

Selected time series were used in SPI analysis after their suitability was understood. For this purpose, SPI-1, SPI-3, SPI-6, and SPI-12 values for each of the three stations (Güney, Denizli, and Uşak) were calculated using the moving average operator (MA). In this context, Figures 2-5 show the SPI values and historical cycle for selected stations. When SPI-1 is taken into account, it is noteworthy that all three stations have experienced exceptionally dry periods (meteorological) on the midline from time to time, especially since 2004. However, when considering SPI-3, moderate drought was observed especially in 1973-1990. In addition, there was a severe agricultural and hydrological drought between 2004-2010. SPI-6 values are also very similar to SPI- values. Extraordinary hydrological droughts were experienced between 1985-1990 and 2003-2008. On the contrary, there was a very wet hydrological period between 1990-2000 (especially at Güney and Uşak stations). Also, the SPI-12 values are nearly the same as SPI-6. Between 1985-1990 and 2003-2008 years, the moderately dry hydrological seasons and 1990-2000 years are hydrologically wet years.

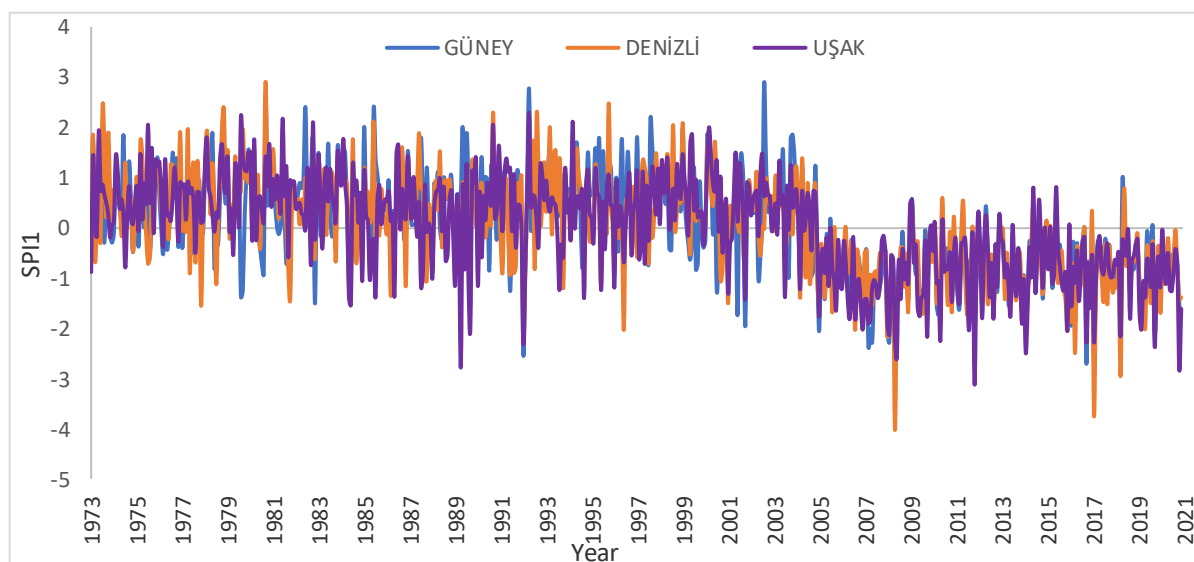


Figure 1: SPI-1 values

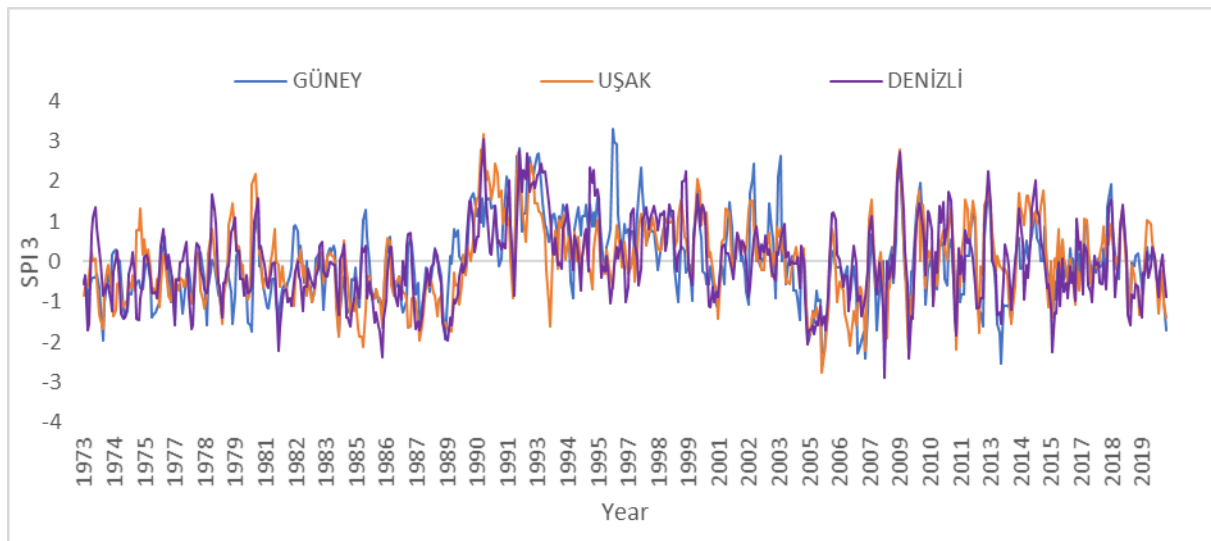


Figure 2: SPI-3 values

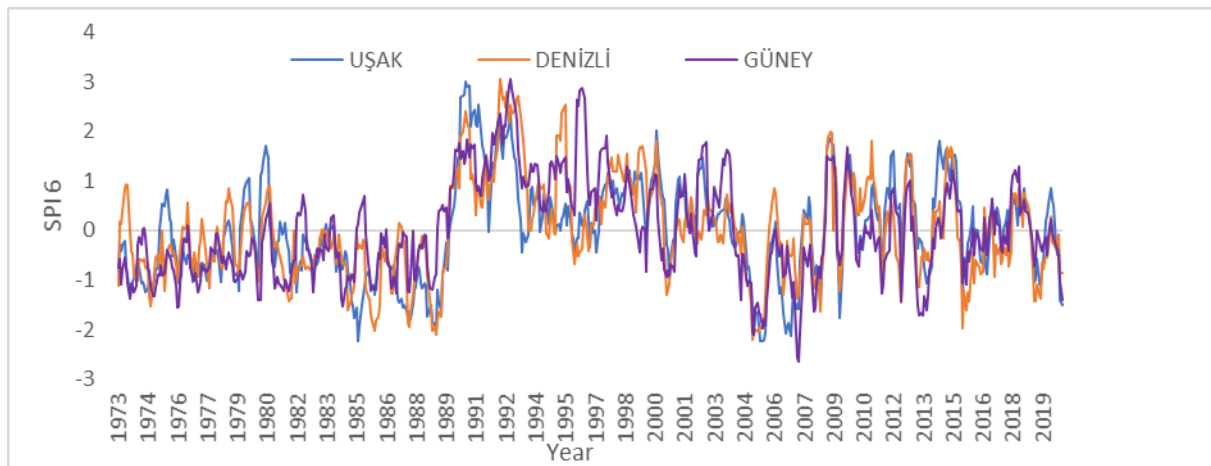


Figure 3: SPI-6 values

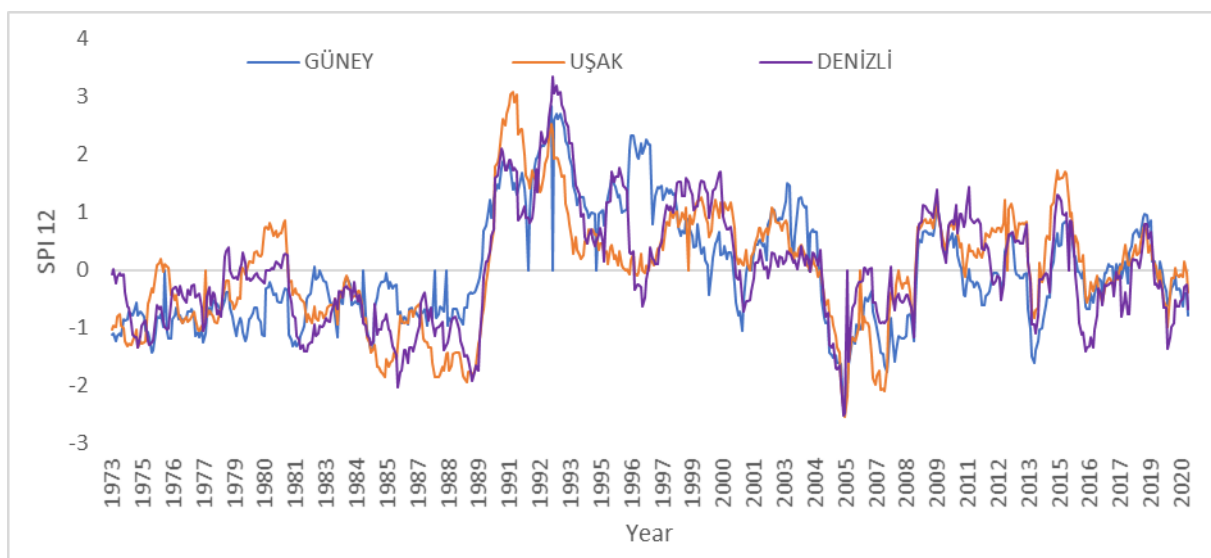


Figure 4: SPI-12 values

5. Conclusion

This study presents the SPI application with the moving average operator to evaluate the meteorological, agricultural, and hydrological droughts in the interior region of the Büyük Menderes basin in Turkey. For this application, the data reconstruction, trend analysis, consistency check, and randomness tests are used to assess the reliability of the analysis. SPI-1, SPI-3, SPI-6, and SPI-12 with Gamma-distribution are used. It has been concluded that the behavior of these three stations (Güney, Uşak, Denizli) is quite similar and many droughts have occurred in the past under the influence of the subaerial climate.

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