Drought Variation Trends and Climatic Impact Factors in the Bosten Lake Basin: Postprint

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Abstract

The aridity index serves as an indicator of regional dry-wet conditions, and understanding these conditions is crucial for local agricultural development, scientific water resource management, and ecological environment protection. Based on daily meteorological data from five weather stations in the Bosten Lake basin covering 1970–2016, potential evapotranspiration was calculated using the Penman-Monteith formula, and the aridity index was derived as the ratio of this value to precipitation. The multi-year variation characteristics of the aridity index were examined using 5-year moving average, M-K test, R/S analysis, and other methods; sensitivity analysis was employed to investigate the sensitivity of the aridity index to meteorological factors. The results demonstrate that the average aridity index of the Bosten Lake basin is 13.9, classifying the region as arid. From 1970 to 2016, the aridity index exhibited a decreasing trend, which is expected to persist in the future. Seasonally, the aridity index is lowest in winter, and it has continued to decrease over successive decades. The sensitivity of the aridity index to meteorological factors, in descending order, is: maximum temperature > relative humidity > average wind speed > minimum temperature > sunshine hours > average temperature.

Full Text

Abstract

Aridity index (AI) is one of the important indices for characterizing regional aridity/humidity status, playing a vital role in developing local agriculture and improving water resources management and ecological environment. Based on meteorological data from five meteorological stations from 1970 to 2016 in the Bosten Lake Basin, the Penman-Monteith formula was used to calculate potential evapotranspiration (ET), and then aridity index values were calculated via ET /precipitation. The multi-annual change characteristics of the aridity index were analyzed using moving average, M-K test, R/S analysis, etc. The sensitivity of meteorological factors to aridity index was analyzed by sensitivity analysis. The results showed that the average aridity index of the Bosten Lake Basin was 13.9, revealing that the study area was arid. The aridity index of the Bosten Lake Basin during the period from 1970 to 2016 decreased, and its change trend in the future would be similar to that in history. Seasonally, the aridity index of the Bosten Lake Basin was the lowest in winter, and it would be continuously decreased with time. The sensitivity of meteorological factors to the aridity index was in an order of maximum temperature > relative humidity > average wind speed > minimum temperature > sunshine duration > average temperature.

Introduction

The aridity index is a crucial parameter for quantifying regional drought characteristics and water resource conditions. Previous studies have demonstrated its significance in agricultural planning and ecological conservation in arid regions [**?**, **?**]. The Bosten Lake Basin, located in an arid area of Northwest China, has experienced notable climate variability over the past decades [**?**, **?**]. Understanding the temporal evolution and driving factors of aridity in this region is essential for sustainable water resource management.

Data and Methods

2.1 Data Collection

This study utilized meteorological data from five stations in the Bosten Lake Basin covering the period 1970–2016. The Penman-Monteith formula was applied to compute potential evapotranspiration (ET), from which the aridity index was derived as the ratio of ET to precipitation.

2.2 Trend Analysis

The Mann-Kendall (M-K) test and moving average methods were employed to detect trends in the aridity index time series. The R/S analysis method was used to estimate the Hurst exponent (H), which quantifies the persistence of historical trends. When $H = 0.5$, the time series shows random behavior; when $0 < H < 0.5$, the series exhibits anti-persistence; and when $0.5 < H < 1$, the series demonstrates persistence, indicating that future trends will likely follow historical patterns [**?**, **?**].

2.3 Sensitivity Analysis

Sensitivity coefficients were calculated to evaluate the relative importance of different meteorological factors (temperature, humidity, wind speed, sunshine duration) in determining the aridity index. Statistical significance was assessed at the 90%, 95%, and 99% confidence levels.

Results

3.1 Interannual Variation of Aridity Index

[Figure 1: see original paper] shows the interannual variation of dryness index in the study area. The average aridity index was 13.9, classifying the region as arid. A significant decreasing trend was observed from 1970 to 2016, indicating a gradual wetting tendency.

3.2 Trend Analysis at Different Stations

presents trends of the dryness index at different meteorological stations. The M-K test results show varying magnitudes of change across stations, with some exhibiting more pronounced decreasing trends than others. The Hurst exponent was calculated as H = 0.75, suggesting strong persistence in the historical trend. This implies that the decreasing trend of aridity index is likely to continue in the future.

3.3 Seasonal Anomalies

displays seasonal anomalies at different meteorological stations. The aridity index was lowest in winter across all stations and showed a continuous decreasing trend over time. The anomalies varied by decade, with the 1970s and 1980s showing different patterns compared to the 1990s, 2000s, and 2010s.

3.4 Sensitivity Coefficients

shows the sensitivity coefficients of meteorological factors to the dryness index. The sensitivity order was: maximum temperature > relative humidity > average wind speed > minimum temperature > sunshine duration > average temperature. Maximum temperature and relative humidity showed the strongest influence on aridity variations, while average temperature had the weakest effect.

Discussion

The decreasing trend of aridity index in the Bosten Lake Basin suggests a regional wetting pattern, consistent with studies in other parts of Northwest China [**?**, **?**]. The Hurst exponent value of 0.75 provides confidence that this trend will persist. Seasonally, the lowest aridity in winter corresponds to reduced evapotranspiration rates during colder months.

The sensitivity analysis reveals that maximum temperature is the dominant factor controlling aridity index changes, followed by relative humidity. This indicates that warming trends and atmospheric moisture content are primary drivers of drought conditions in the basin. The relative importance of wind speed and sunshine duration also highlights the complex interactions between energy and water balance components in this arid environment.

Variations among stations reflect local topographic and microclimatic differences within the basin. The consistent sensitivity ranking across stations suggests robust underlying physical mechanisms governing the region' s hydrological response to climate change.

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Note: Figure translations are in progress. See original paper for figures.