

Postprint: Analysis of Spatiotemporal Characteristics of Drought in Heilongjiang Province Based on SPI

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Abstract

Using daily precipitation data from 10 meteorological stations in Heilongjiang Province from 1953 to 2015, the Standardized Precipitation Index (SPI) at different scales was calculated, and run theory was combined to analyze the spatiotemporal evolution characteristics of drought in Heilongjiang Province. The results show that: precipitation remains the main influencing factor of drought in Heilongjiang Province; drought in summer and autumn in Heilongjiang Province shows an intensifying trend, with [WTBX]SPI[WTBZ] change rates of decreasing by 0.029 and 0.135 per decade, respectively, while spring drought and winter drought show a mitigating trend, with rates of increasing by 0.061 and 0.074 per decade, respectively, and the annual [WTBX]SPI[WTBZ] change rate is decreasing by 0.044 per decade; in Heilongjiang Province, from the mid-to-late 1960s to the late 1970s, droughts were relatively frequent, with long drought duration, high drought severity, and high drought intensity, and a continuous drought period from 1974 to 1980 occurred, from the 1980s to the mid-1990s was relatively normal, and from the late 1990s onwards, drought frequency and its duration, severity, and intensity show an increasing trend; drought event duration shows an increase-decrease trend from northwest to southeast, and drought event duration is the longest in central Heilongjiang Province.

Full Text

Spatial-temporal Characteristics of Drought in Heilongjiang Province Based on Standardized Precipitation Index

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Abstract: As one of China's major grain-producing provinces, Heilongjiang Province is susceptible to drought risk, with drought events occurring much more frequently in recent years. Currently, only a few studies have focused on drought in this region, and most of them have paid more attention to the frequency and degree of drought than to the changes in the spatial-temporal characteristics of drought events. This study analyzed the changes of drought and the spatial-temporal characteristics of drought events in Heilongjiang Province based on daily precipitation data from 1953 to 2015 using different scales of Standardized Precipitation Index (SPI) combined with run-length theory. The results showed that precipitation, compared with temperature, has been the main factor related to drought. The research indicated that the SPI is an effective index for assessing drought conditions in Heilongjiang Province. The trend of summer drought and autumn drought increased, while the trend of winter drought and spring drought decreased. The summer SPI and autumn SPI decreased with average rates of 0.029 and 0.135 per ten years respectively, while the spring SPI and winter SPI increased with average rates of 0.061 and 0.074 per ten years separately. Annual SPI decreased with an average rate of 0.044 per ten years. From the middle of the 1960s to the late 1970s, drought in Heilongjiang Province happened frequently, with long drought event duration, large drought degree, and high drought intensity. A consecutive drought period occurred from 1974 to 1980, during which droughts happened at a higher frequency and for a longer duration. The situation was comparatively normal from the 1980s to the middle of the 1990s. The duration, severity, and intensity of drought events showed an increasing trend from the late 1990s. From the Northwest to the Southeast, the duration of drought events decreased after the first increase. This study could contribute to monitoring and assessment of drought, and could be used in guidelines of water resource management and agricultural production.

Keywords: drought; Heilongjiang Province; SPI; spatial-temporal characteristic

1. Data and Methods

1.1 SPI Classification Scales

The Standardized Precipitation Index (SPI) is a widely used index for drought assessment. Table 1 presents the classification scales for SPI values.

[TABLE:N]

1.2 Study Area and Data

Heilongjiang Province is located in northeastern China, with a temperate continental monsoon climate. The province experiences cold, dry winters and warm,

rainy summers. Annual average temperatures range from -5 to 5°C , with annual precipitation between 400–650 mm. Precipitation shows significant seasonal and interannual variability, with most rainfall concentrated in summer and autumn.

Daily precipitation data from 1953 to 2015 were obtained from meteorological stations across Heilongjiang Province. The data quality was controlled and processed following standard meteorological procedures. Figure 1 shows the location of Heilongjiang Province and the distribution of meteorological stations.

[FIGURE:N]

1.3 Methodology

The SPI was calculated at multiple time scales (1-month, 3-month, and 12-month) to characterize different types of drought. The calculation followed the standard procedure of fitting a gamma distribution to precipitation data and then transforming the cumulative probability to a standard normal distribution.

Drought events were identified using run-length theory. A drought event was defined as a continuous period when SPI values remained below zero. The drought duration was calculated as the length of this continuous period. Drought severity was defined as the cumulative SPI values during the drought period, while drought intensity was calculated as the ratio of drought severity to drought duration.

2. Results

2.1 Temporal Variation of SPI

The temporal variation of SPI showed distinct seasonal patterns. From 1953 to 2015, summer SPI and autumn SPI exhibited decreasing trends, indicating intensifying drought conditions during these seasons. In contrast, spring SPI and winter SPI showed increasing trends, suggesting wetter conditions.

[FIGURE:N]

The annual SPI series revealed significant interannual variability with a slight decreasing trend overall. The most severe drought periods occurred from the mid-1960s to the late 1970s, particularly during 1974–1980 when consecutive drought events dominated.

[FIGURE:N]

Analysis of drought event characteristics showed that the duration, severity, and intensity of droughts varied considerably across different decades. The 1-month, 3-month, and 12-month SPI drought events exhibited different temporal patterns.

[FIGURE:N]

During the period 1974-1980, drought events were particularly severe. The duration of drought events reached maximum values, with the severity and intensity also showing peak values during this period. The 1-month SPI drought events occurred most frequently, while the 12-month SPI drought events represented long-term drought conditions.

[FIGURE:N]

The intensity of drought events, calculated as the ratio of severity to duration, showed an increasing trend from the late 1990s onward. This indicates that recent drought events have become more intense despite varying durations.

[FIGURE:N]

Spatial analysis revealed that from northwest to southeast, drought duration initially increased then decreased. The northwestern regions experienced longer drought durations compared to southeastern areas. The spatial pattern of drought severity and intensity followed similar trends.

3. Conclusions

- (1) The SPI index effectively characterizes drought conditions in Heilongjiang Province, with precipitation being the primary factor influencing drought occurrence and development.
- (2) Seasonal drought trends showed contrasting patterns: summer and autumn drought trends increased, while winter and spring drought trends decreased. Specifically, summer SPI and autumn SPI decreased at rates of 0.029 and 0.135 per ten years, respectively, whereas spring SPI and winter SPI increased at rates of 0.061 and 0.074 per ten years. Annual SPI decreased at a rate of 0.044 per ten years.
- (3) From the 1960s to the 1970s, Heilongjiang Province experienced frequent drought events with long duration, large severity, and high intensity. The period from 1974 to 1980 was particularly notable for consecutive drought events. From the 1980s to the mid-1990s, drought conditions were relatively normal. However, from the late 1990s, the duration, severity, and intensity of drought events showed an increasing trend.
- (4) Spatially, drought characteristics varied from northwest to southeast, with drought duration, severity, and intensity showing distinct regional patterns. The northwestern regions were more prone to severe and prolonged drought events compared to southeastern areas.

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