Analysis on the Change Trend and Influencing Factors of Meteorological Drought in Huaihe River Basin

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Abstract: Since the 21st century, the global warming trend has attracted the attention of the general public. Global temperature changes have caused many extremely severe weather events. This paper uses the meteorological data of 20 stations in the Huai River Basin from 1960 to 2017, combined with the historical records of meteorological disasters, and uses the SPI index to analyze the temporal and spatial distribution of meteorological drought. The conclusions are as follows: (1) SPI has a 14a main cycle and 4a, 5a, 6a, 11-12a and 22-24a secondary cycles. (2) The evolution characteristics of SPI show that the annual scale, spring, autumn, and winter increase at different speeds, and decrease in summer.

1. Introduction
Drought is the most common and common natural disaster in the world. It has the characteristics of high frequency, long duration and wide range of influence. Under the combined influence of climate change and human activities, the global drought problem has become more and more serious[1,2]. Compared with natural disasters such as floods, droughts have a large area, harm a wide range of industries, involve many people, last for a long time, and cause huge economic losses[3]. Meteorological drought refers to the phenomenon of water shortage caused by continuous lower than average precipitation or imbalance between evaporation and precipitation for a certain period of time [4,5]. The Standardized Precipitation Index (SPI) developed by McKee et al. uses distribution probability to describe changes in precipitation, which is one of the indicators that characterize the probability of precipitation in a certain period of time[6]. Wavelet analysis is mainly used in the study of time series in geosciences. It can reveal a variety of change cycles in the time series and reflect the change trend of the system in different time scales[7,8]. This article takes the Huaihe River Basin as the research object. According to previous research, the meteorological data of this area was classified and analyzed. Combine the SPI meteorological drought index with ArcGIS and other software to analyze the influencing factors of meteorological drought, and use wavelet analysis to determine the meteorological drought time cycle. This research will provide references for the deployment and rational utilization of water resources in the Huaihe River Basin.
2. Research area

The Huaihe River Basin is located in the eastern part of my country, with a geographical location of 30°55′~36° N, 111°55′~121°25′ E. The Huai River basin is 270,000 km². The Huai River originates from the Tongbai Mountain in Henan Province, flows through Henan and Anhui in turn, and flows into the East China Sea in Jiangsu. The Huai River Basin is located between the Yangtze River Basin and the Yellow River Basin. The basin is adjacent to the Yellow River Basin by the South Bank of the Yellow River and the Yimeng Mountains in the north, and the Yangtze River Basin is separated by the Dabie Mountains, Jianghuai hills, Tongyang Canal and Rutai Canal South Bank in the south [9]. The study area has a large drop, the highest altitude is 2153m, while the lower plain area has an altitude of less than 10m. Therefore, the geological structure of this area is complex and the climate environment is changeable. The detailed geomorphology of the study area is shown in Figure 1.

![Figure 1](image1.png)  
Figure 1. Changes in the number of undergraduate colleges offering geography science majors in China in 2007-2016

3. Periodic analysis of meteorological drought

In order to study the periodic variation characteristics of meteorological drought in the Huaihe River Basin, wavelet analysis is performed on the annual scale SPI, and the wavelet frequency (Figure 2) and variance (Figure 3) are obtained. From Figure 2, it can be seen that the annual scale SPI has an obvious process of alternating dry and wet. The contour line in 2017 is not completely closed. It is predicted that the climate will be dry in the next time period. At the same time, it can be seen that on the 20a scale, there has been a trend of dry-wet-dry-wet-dry-wet-dry-wet-dry, which has global characteristics. On the scale of 11-13a, there were 7 oscillations of alternating dry and wet.
Combining Figure 3, we can see that SPI has obvious periodicity on the annual scale, where 4a, 5a, 6a, 9-10a, 11-12a, 14a, 20a and 22-24a have peaks on the time scale. Among them, the peak value of 14a is the highest, indicating the strongest vibration, which is the main cycle of SPI in the Huaihe River Basin, and the other cycles are the secondary cycles of SPI.

4. Analysis on the characteristics of meteorological drought

This chapter selects the seasonal and annual SPI values to study the temporal variation of meteorological drought. The trend distribution of SPI values on the annual scale is shown in Figure 3.3 (a), which alternated between dry and wet before 1970. Among them, the value of SPI in 1966 was low, -0.94, indicating a mild drought. Between 1971 and 2000, the climate alternated between dry and wet. After 2001, the SPI index showed an overall downward trend. After 2010, the results indicated by SPI have a clear tendency to become wet. On the whole year scale, SPI is increasing at a rate of 0.0006/a. But the increasing trend is not obvious.
From 1960 to 2017, the SPI in the spring (Figure 3.3(b)) showed an upward trend, at a rate of 0.0012/a. Specifically, between 1960 and 1990, the value of SPI in spring changed from high to low. Before 1980, there was very little drought in spring. After 1990, the dry and wet alternate distribution, the highest SPI reached 1.29, the lowest value was -1.41, the two are quite different. After 2010, there is an upward trend in SPI in the spring.

In summer (Figure 3.3(c)), the SPI value has a downward trend. Before 1965, the SPI value was mostly less than 0, the lowest value reached -1.14, and the drought reached the moderate drought level. There was a peak in 2005, reaching the maximum value of 1.13 in summer SPI during the 58 years. From 1971 to 2000, most of the SPI values were greater than 0, mainly humid, and there was no drought in summer. From 2001 to 2010, SPI showed a fluctuating state. After 2010, there has been a slow rise.

In autumn (Figure 3.3(d)), the overall SPI showed a downward trend, with a speed of -0.003/a. During the period 1960-1970, SPI showed regular fluctuations. From 1971 to 1980, the SPI fluctuated slightly. From 1981 to 2010, dry and wet alternated. In 2010, SPI reached its minimum value of -1.89. Subsequently, the SPI showed a fluctuating state. After 2010, there is an upward trend.

In winter (Figure 3.3(e)), SPI fluctuated greatly from 1960 to 2017, the lowest value was -1.53, reaching the severe drought level, and the highest value was 1.78. The fluctuation from 1971 to 1980 was significantly lower than the previous 10 years. From 1981 to 1990, the SPI value first decreased, then increased and then decreased. In 1991, the SPI reached its maximum value of 1.73, and then fell to -0.54 in 1995. There is a large difference between the two values. The changes are dramatic. Between 2001 and 2017, the SPI value fluctuated up and down. The overall SPI is on the rise, with a speed of 0.0031.
5. Conclusion

This paper uses meteorological data from 30 stations in the Huai River Basin from 1960 to 2017, combined with historical records of meteorological disasters, and uses the SPI meteorological drought index and wavelet analysis methods to analyze the periodic law of meteorological drought and the evolution characteristics at different scales. The conclusions are as follows:

(1) The SPI in the Huaihe River Basin has a 14a main cycle and 4a, 5a, 9-10a, 11-12a, 20a and 22-24a sub-cycles. On the 20a scale, there is a trend of dry-wet-dry-wet-dry-wet-dry-wet-dry, which has global characteristics. On the scale of 11-13a, there were 7 oscillations of alternating dry and wet.

(2) The evolution characteristics of SPI show that SPI rises at a rate of 0.006/a in the annual scale. Among them, dry and wet alternately occurred from 1971 to 2000, and after 2010, there was an obvious tendency to become wet. In the spring, between 1960 and 1990, the value of SPI decreased, and there was an upward trend after 2010. In summer, before 1965, the SPI value was mostly less than 0, and the maximum value was 1.13 in 2005. After 2010, it showed a slow increase. In autumn, SPI showed a downward trend as a whole, reaching its minimum value -1.89 in 2010. In winter, from 1981 to 1990,
the SPI value showed a process of first falling, then rising and then falling.

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