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## Analysis of Drought Evolvement Characteristics Based on Standardized Precipitation Index in the Huaihe River Basin

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### Abstract

Using the precipitation data of 35 meteorological stations in Huaihe River Basin, SPI is applied to analyze annual drought index of nearly 50 years (1961-2010). The results show that the frequency of drought in Huaihe River Basin reduced and the intensity of drought increased at the beginning of 21st Century, but drought areas decreased; main drought type is mild-medium drought, severe drought rarely occurred; in the current situation of climate change, the negative impact of drought on agricultural production will be lowered in Huaihe River Basin.

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*Keywords:* Standardized Precipitation Index; rainfall; Evolvement Characteristics; Drought Evaluation Indicators

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### 1. Introduction

Drought is a natural disaster which causes the greatest loss in the world and has the largest impacts among all the natural disasters [1]. Nowadays, some domestic and foreign experts put forward a variety of drought indexes to analyze quantitatively the drought [2~3]. The standardized precipitation index (SPI), which was proposed by McKee in 1993, can monitor the drought in different time scale. It change sensitively in response to drought, has strong space-time adaptability, the necessary information is easy to get and could calculate in a simple way [4]. This paper uses the SPI as meteorological drought index, and analyzes the temporal and spatial evolution characteristics of the frequency and the intensity of drought in Huaihe River Basin. The precipitation data is from China Meteorological data network that offers monthly rainfall data of 35 meteorological stations in Huaihe River Basin from 1961 to 2010. The results can provide a scientific basis for drought early warning and monitoring.

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**2. Materials and methods**

*2.1. SPI calculation method*

SPI is suitable for drought monitoring and assessment of climate scenarios in a period of months or longer time[4~5]. SPI can be formulated as follows:

$$SPI = S \frac{t - (c_2 t + c_1)t + c_0}{((d_3 t + d_2)t + d_1)t + 1.0}, \quad t = \sqrt{\ln \frac{1}{H(x)^2}} \tag{1}$$

$$G(x) = \frac{1}{\beta^\gamma \Gamma(\gamma)} \int_0^x x^{\gamma-1} e^{-x/\beta} dx, x > 0, \quad \Gamma(\gamma) = \int_0^\infty x^{\gamma-1} e^{-x} dx \tag{2}$$

Where: x- rainfall values; β, γ-the scale parameter and shape parameter of the Γ function; S- positive and negative coefficients; c0, c1, c2 and d1, d2, d3-Calculating parameters. Its value is as follows: c0=2.515517, c1=0.802853, c2=0.010328, d1=1.432788, d2=0.189269, d3=0.001308. G(x)-the probability of precipitation distribution. When G(x) > 0.5, H(x) =1- G(x), S=1. When G(x) ≤ 0.5, H(x) = G(x), S=-1.

The standard of drought grades divided according to the SPI[5] (Table 1).

Table 1. Classified scales for SPI

Grade	SPI	Type
1	-0.5<SPI	No drought
2	-1.0<SPI≤-0.5	Mild drought
3	-1.5<SPI≤-1.0	Medium drought
4	-2.0<SPI≤-1.5	Severe drought
5	SPI≤-2.0	Special drought

*2.2. Drought evaluation indicators*

Drought frequency (F<sub>i</sub>) is the evaluation of a station's frequency of drought in some years. The formula is as follows.

$$F_i = n / N \times 100\% \tag{3}$$

Where: n-the total number of drought of a site; N-the number of precipitation data of the site; i-a site.

Drought Stations Proportion (P<sub>j</sub>) is a way to indicate the range of drought occurrence using the ratio of a regional drought station number in total station number. The formula is as follows.

$$P_j = m / M \times 100\% \tag{4}$$

Where: m-the number of station of drought; M-the total number of station; j-some year.

Drought Intensity (S<sub>ij</sub>) is used to represent the severity of the drought. The drought intensity of a site within a certain period is usually reflected by the SPI value. Bigger the SPI absolute value is, more serious the drought is. Its formula is as follows.

$$S_{ij} = \left( \frac{1}{m} \sum_{i=1}^m |SPI_i| \right)_j \tag{5}$$

Where: m-the number of station of drought; |SPI<sub>i</sub>|-SPI absolute value.

### 3. Results and Analysis

#### 3.1. Drought frequency in the Huaihe River Basin

Using the formula (1) ~ (5) to calculate and count drought frequency for many years. According to the calculation results (Fig.1.(a)), we can analyze drought occurrence frequency of the meteorological stations based on SPI in Huaihe River Basin. The drought frequency in the Huaihe River Basin ranges from 14% to 30%.

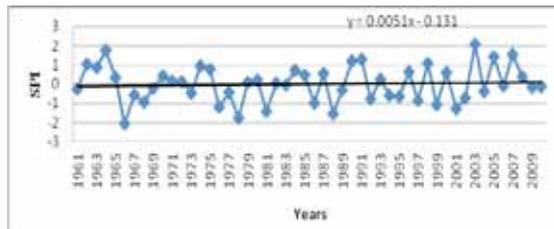


Fig.1. (a) the SPI changes of the Huaihe River Basin (1961~2010);

#### 3.2. Drought stations proportion year changes in the Huaihe River Basin

According to Fig.2.(a), drought stations proportion ranged from 0 to 85.7% and moderate drought stations proportion ranged from 0 to 75.7% during 1961-2010 in the Huaihe River Basin. According to Fig.2.(b), severe drought stations proportion ranged from 0 to 29.8% and special drought stations proportion ranged from 0 to 20.5% during the past 50 years in the Huaihe River Basin.

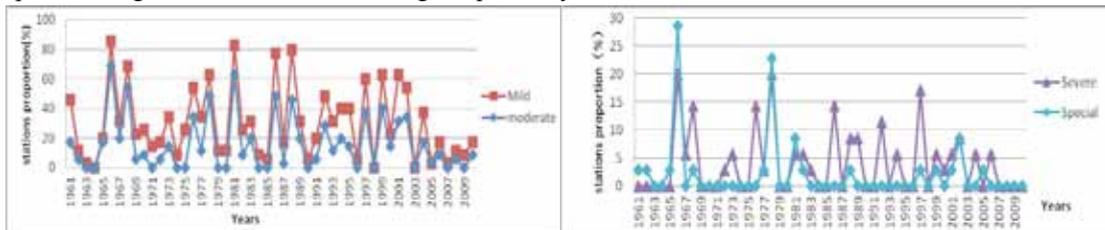


Fig.2. (a) Characteristics of Mild drought and Moderate drought changes during 1961-2010 in the Huaihe River Basin ;(b) Characteristics of the severe drought and special drought changes during 1961-2010 in the Huaihe River Basin

#### 3.3. Drought intensity in the Huaihe River Basin

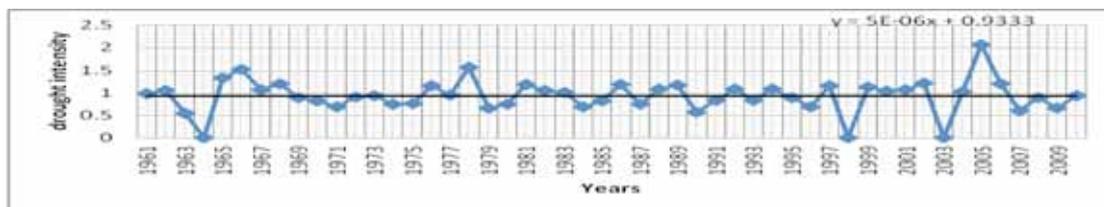


Fig.3. characteristics of the drought intensity changes in the Huaihe River Basin (1961~2010)

Fig.3 shows that the drought intensity characteristics of the Huaihe River Basin from 1961 to 2010.

mild drought and moderate drought were the major ones in the Huaihe River Basin. The Huaihe River Basin drought intensity is increased, but the increasing trend is very small.

Fig.4. shows the intensity of drought and the ratio of drought occurring stations in different years. As we can see, the intensity of drought show an increasing trend in Huaihe River Basin, but the ratio of drought occurring stations gradually lowered which means drought area decreased. The ratio of medium drought occurring stations is lower than the ratio of drought occurring stations, but both of them have the similar development trend.

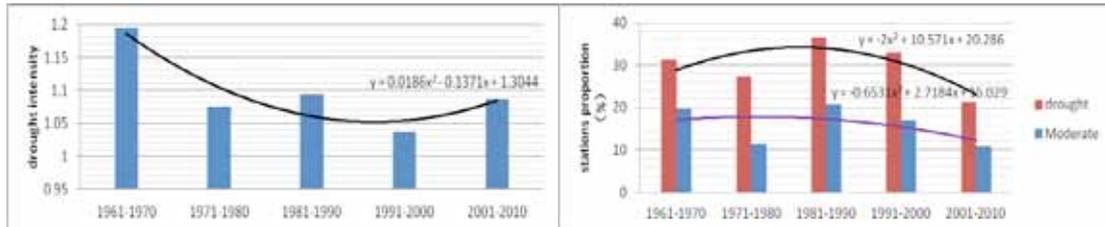


Fig.4. (a) Comparison of Annual drought intensity in the Huaihe River Basin; (b) Comparison of Annual drought stations proportion in the Huaihe River Basin

#### 4. Conclusion

After processing the monthly precipitation data of 35 stations from 1961 to 2010 in Huaihe River Basin, and analyzing annual drought index with the SPI, the main conclusions are made as follows:

(1) In the early 21st century, drought frequency of the Huaihe river basin decreased. Annual drought Stations Proportion and the drought intensity show a clear periodic distribution characteristic reduced with time.

(2) Mild drought and moderate drought were the major drought in the Huaihe river basin, and severe drought and special drought were relatively less.

(3) According to the actual statistics of annual drought, serious drought occurred in the Huaihe river basin in 1966, 1968, 1978, 1982, 1994 and 2001, which was similar to the results from this study.

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