Analysis of precipitation time characteristics in key water demand period of main crops in Western Guanzhong

Tong Qu¹, Cong Xia² and Lingmei Huang¹*

¹College of Water Conservancy and Hydro-Electric Power, Xi’an University of Technology, Xi’an, Shanxi, 710048, China
²College of Water Conservancy and Hydro-Electric Power, Xi’an University of Technology, Xi’an, Shanxi, 710048, China
*Corresponding author’s e-mail: huanglm@xaut.edu.cn

Abstract. Based on the daily precipitation data of seven meteorological stations in the western part of Guanzhong area from 1970 to 2016, the time characteristics of precipitation series are analysed by using the methods of sliding t-test, wavelet analysis and R/S. The results showed that the annual precipitation, summer maize and winter wheat precipitation in the key water demand period generally showed no significant downward trend, and there is no significant mutation point. It will maintain the change characteristics consistent with the recent historical period in the future, which provides certain reference for the regional water resources planning and reasonable allocation, agricultural planting structure adjustment, and irrigation system improvement.

1. Introduction
Grain safety is an important foundation of national security. Although the total amount of grain has grown up rapidly in recent years, it is hard to satisfy the increasing needs for the grain. Wheat and maize which depend on the natural precipitation as well as artificial irrigate are two major grain in the western Guanzhong area. Thus, it is vital to forecast the rainfall to ensure the output of the grain. Grains have a certain period in which they need much water to ensure their growth. The period for wheat is April and May and that for maize is August and September.

M-K method was used by Dong Qingqing to analyze the rainfall change feature in the recent 60 years, and the results that the rainfall turns to reduce in these years. Trend analysis approach, T-test as well as GIS technology were used by LI Hongmei to analyze the rainfall change feature in 44 weather station and same result were gotten too.

The research above focuses only on the yearly change of rainfall in the western Guanzhong area. Since wheat and maize are two major grain in this area, it is meaningful to discover the trend for the rainfall in these certain periods.

2. General information about research area and origination of data
As illustrated below in the figure, western part of Guanzhong area is about 2.2176km². it is warm temperate continental monsoon climate with an annual rainfall of 578.9mm.

Data used in this paper comes from Chinese national meteorological information center (CIMMIS). Research period is from 1970 to 2016. Daily rainfall information is chosen from Longxian, Baoji, Taibai, Fengxiang, Changwu, Yongshou and Wugong meteorological stations. The specific locations
are shown below in figure 1.

![Figure 1. Distribution map of meteorological stations used in the study](image)

According to the rainfall information from these seven meteorological stations, rainfall series are gotten by Thiessen polygon method.

3. Research method

3.1. Wavelet Analysis
Wavelet analysis combines the window function, and decomposes the time series into the contribution of time and frequency based on the Fourier transform. It is used to study the non-stationary signal under the multi-time scale change. In recent years, wavelet decomposition is frequently used to extract the low frequency components of precipitation, runoff and other time series or signals, so as to judge the change trend of the series.

3.2. Sliding T test
Sliding T test is based in traditional T test method and test series point by point with T test. The basic thinking is that supposing the two series distributing function around the sliding point is $F_1(x)$ and $F_2(x)$, and then get $n_1$ and $n_2$ two samples to calculate.

3.3. Mann—Kendall (M-K) test method
Mann—Kendall (M-K) test method is a nonparametric test method. It is widely used in analysis the changes in the rainfall time series. The M-K method does not necessarily fit some distribution. Besides, it does not be interfered with low frequency.

3.4. R/S analyzing method
R/S analyzing is a statistical method which is raised by Hurst after huge amount of experiments. It is commonly used in the hydrology series continuing analysis. The principle is that H value which is gotten by simple linear regression represents the differential changing feature.

4. Rainfall time feature result

4.1. Trend analysis
Trend analysis is mainly used to analyze whether the rainfall time series is increasing or decreasing. Rainfall time series is calculated by wavelet analysis and the low frequency part represents trend component.

Considering annual rainfall time series as well as water requiring periods of summer maize and
winter wheat, the wavelet composing result where wavelet type is db5 and decomposing scale is 5 is shown as figure 2. The result shows that the rainfall in critical water demand period of maize is showing a decreasing trend while that of wheat turns an increasing trend after decreased for some years.

![Wavelet Composition Result](image1)

(a) Annual precipitation
(b) Winter wheat
(c) Summer maize

Figure 2. precipitation trend curve in 1970-2016

4.2. Mutant analysis
Combined with the sliding t test and Mann—Kendall mutation test, the annual precipitation sequence from 1970 to 2016 and the precipitation sequence of wheat and maize in the critical water demand period were tested with a 95% confidence level. As shown in Figure 3, none of the three statistics of the sliding t test exceeded the significance level, indicating that there was no time region of mutation.
Figure 3. statistical curve of precipitation sliding t-test

Through the analysis of M-K test, it can be seen from Figure 4 that the T statistics of the year corresponding to the intersection of UF and UB curves of these three time-series do not exceed the significance level of 0.05, thus the intersection is not a mutation year.

Therefore, based on the comprehensive analysis above, there is no mutation in the annual precipitation in the 47-year-period of 1970 to 2016.
4.3. Duration analysis

As shown in the table 1, all the $H$ value is larger than $0.6$ which indicate that the three time-series studied has a significant Hurst phenomenon.

| Sequence                | Change trend in recent historical period | $H$     | Future continuity         |
|-------------------------|------------------------------------------|---------|---------------------------|
| Annual precipitation    | Reduce                                   | 0.6845  | Continuity of decline     |
| Critical period of Wheat| Rise                                     | 0.6443  | Continuity of increase    |
| Critical period of Maize| Reduce                                   | 0.6649  | Continuity of decline     |

5. Conclusion

In this paper, Wavelet Analysis, sliding T test, R/S analyzing method as well as Mann—Kendall (M-K) test method are used to analyze the rainfall time-series in 7 meteorological stations to get the changing feature. The rainfall overall in certain periods has a decreasing trend but the rainfall in water requiring period of wheat has an increasing trend after many years’ decrease. All the series has no mutant. The annual rainfall is basically stable over years. However, the water distribution change inside years especially in the maize and wheat key period have some influence on the crops in this area.

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