Analysis on precipitation variation characteristics of Xiangyang River Basin during 1979-2014

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Abstract. This paper selects Xiangyang Han River area as the research object, based on nearly 36 years of rainfall data during 1979-2014 through the MK trend test, precipitation concentration degree, frequency statistics, statistical method analysis, Xiangyang part of Hanjiang River Basin rainfall characteristics. Results show that in Xiangyang years precipitation was not significant downward trend, precipitation concentration degree is high, mostly concentrated in May to September rainy season, flood and non-flood season precipitation concentration degree is high and the precipitation in flood season for many years was not significantly decreased. On the whole, the precipitation in Xiangyang is relatively abundant, but the distribution is uneven and the water supply resource management and control can bring great pressure, so it can be combined with relevant measures to strengthen the water resources.

1. Introduction
With the rapid development of industrialization, the concentration of greenhouse gases such as carbon dioxide in the atmosphere has increased, resulting in global temperature rising in the past 100 years, and climate change characterized by climate warming has gradually strengthened [1]. Hydrological factors such as precipitation, evaporation, runoff, and soil moisture will change with the change of climate, causing the redistribution of water resources in time and space and the change of total water resources [2]. Among them, the impact of precipitation changes is the most direct and significant, which will lead to an increase in regional water resources, leading to frequent floods and other disasters [3]. In recent years, many scholars have carried out research on the characteristics of precipitation in China in recent decades. Li Hongmei et al [4] studied the precipitation trends and interannual variations in the mid-summer of eastern China over the past 40 years. The research shows that the precipitation, precipitation frequency, extreme precipitation frequency and storm precipitation intensity in the Yangtze River Basin increased in summer, but decreased in North China. This paper selects the Xiangyang area in the middle reaches of the Han River as the research object. Xiangyang City is run by Hanshui, the water system is developed, the total water resources are 6.313 billion m³/a, and the per capita water resources for many years are 1182 m³/a, which is 51.4% of China's per capita water resources. The spatial and temporal distribution of water resources in Xiangyang City is uneven[6]. At present, scholars have done research on precipitation changes in the Xiangjiang River Basin. Chen Hua et al. [7] have analyzed the temporal and spatial variation trend of precipitation and temperature in the Xiangjiang River basin in...
the past 50 years. The research shows that there is no obvious change trend of precipitation in most areas of the Xiangjiang River basin in the past 50 years at the significant level $\alpha=0.1$; the average precipitation in the upper reaches of the Danjiangkou Reservoir in the 1980s was 9.7% more than the average annual precipitation. The average precipitation in the 1990s was 11.6% less than the average annual precipitation. In 1991, there was a sudden change from the rainy period in the 1980s to the less rainy period in the 1990s. The upstream temperature showed an upward trend, synchronized with the temperature in the northern hemisphere, and the precipitation changes are affected by the temperature, and there is an inverse relationship between the two.

This paper analyzes the precipitation data from 1979-2014 in the Xiangyang section of Xiangjiang River. Through the statistical methods such as MK trend test, precipitation concentration and frequency statistics, the annual precipitation in the study area, the annual precipitation, and the precipitation in different periods account for the annual precipitation. The study of specific gravity aims to identify the impact of changes in precipitation characteristics on the water resources utilization in the Xiangyang section of the Xiangyang River, in order to provide a scientific and reliable reference and basis for the development, utilization and management of water resources in the Xiangyang area and similar areas.

2. Materials and Methods

2.1. Survey of research area
Located in the northern subtropical continental monsoon climate zone, Xiangyang has a north-south transitional climate. The average annual rainfall is 889mm, which is generally decreasing from southwest to northeast, and the mountainous area is larger than the hill. The rainfall was unevenly distributed during the year, mainly concentrated in May to September, accounting for more than 70% of the whole year. The Xiangyang River has a vertical and horizontal water system, and there are 985 large and small rivers. There are 66 river basins with an area of 100km2 or more. There are 131 river basins with an area of more than 50km2. Most of them belong to the Xiangyang River Basin. The water surface area of the river accounts for 5.4% of the city's total area.

At present, there are 943 reservoirs in Xiangyang, including 14 large reservoirs and 60 medium-sized reservoirs; the total storage capacity is 4.87 billion m3, and the storage capacity is 2.64 billion m3. The control rate of local runoff is 43.0%, which is much higher than the national 17.2%. However, the characteristics and topography of the precipitation in the Xiangyang area are unique. The allocation and storage of water resources in the basin is difficult, and the storage and utilization of water resources is difficult. Coupled with the adjustment of regional development strategies, industrial development, and the growth of demand for living and ecological water, the water supply capacity is difficult to meet. The need for social and economic development.

2.2. Source of date
In this paper, the surface precipitation data (1979-2014) calculated by the Tyson polygon method [8] from the data of 17 precipitation sites in the Xiangyang River Basin are selected, using concentration analysis, Mann-Kendall trend test and frequency statistics [9], and other statistical methods to analyze the precipitation characteristics of the Xiangyang section of the Xiangyang River.

2.3. Research method

2.3.1. Mann-Kendall test. In this paper, the Mann-Kendall method is used to test the trend and the mutation point of the precipitation sequence [10]. The method is a non-parametric method based on order. Because it does not need samples to follow a certain distribution, it is stable and has little interference with outliers. It is suitable for non-normal distribution data such as hydrology and meteorology. It is convenient to calculate [11] and thus subject to Widely recognized by the International Hydrographic Organization [12].
2.3.2. Precipitation concentration degree. Precipitation concentration refers to the cumulative amount of precipitation in each month in a vector manner, and its synthetic amount accounts for the percentage of annual precipitation. The value of precipitation for one year is regarded as the length of the vector, and the corresponding year is taken as the direction of the vector.

3. Analysis and discussion of results.

3.1. Analysis of interannual variation of precipitation

Through the statistical analysis of the surface rainfall data from 1979-2014 in the Xiangyang section of the Xiangyang River, the annual average rainfall is 889mm, the annual maximum precipitation is 1235mm, the annual minimum rainfall is 597mm, and the extreme value of precipitation is 1.068. The annual variation of precipitation characteristics Larger, see Table 1 for details.

The MK trend test was carried out on the precipitation and precipitation days of the Xiangyang section of the Xiangyang River from 1979 to 2014. The UFkestic of the precipitation trend test is -0.29, which does not exceed the critical value of the significant $\alpha =0.05-2$, indicating that the annual precipitation in the Xiangyang section of the Xiangyang River has a decreasing trend, but it is not significant. The annual precipitation change process and the 5-year moving average curve are shown in Figure 1. The UFk statistic of precipitation days is -1.50, which does not exceed the critical value of significance==0.05, indicating that the annual precipitation days in the Xiangyang section of the Xiangyang River showed a downward trend, but it was not significant. The above results show that during the period from 1979 to 2014, there was no significant change in annual precipitation in the Xiangyang section of the Xiangyang River, and the number of annual precipitation days decreased slightly. MK test sequence mutations were performed on the precipitation in the study area from 1979 to 2014, and the trend changes of the sequence were further analyzed by analyzing the statistical sequences UFk and UBk, as shown in Fig. 2. The results show that the study area between 1979 and 2014, 1996, 1998, 1999 and 2011 are all intersections, which is the moment when the mutation begins.

| Annual average precipitation / mm | Annual average precipitation days / d | Cv | Maximum annual value Precipitation / mm | Year of occurrence | Minimum annual value Precipitation / mm | Year of occurrence | Abundance ratio |
|----------------------------------|--------------------------------------|----|----------------------------------------|-------------------|----------------------------------------|-------------------|---------------|
| 889                             | 124                                  | 0.18 | 1235                                   | 1996              | 597                                    | 1981              | 1.068         |

Table 1. Precipitation characteristic value

Figure 1. Change process of surface precipitation and 5-year sliding curve from 1979 to 2014
3.2. Analysis of precipitation changes during the year

The distribution of precipitation in the Xiangyang section of the Hanjiang River is extremely uneven during the year. The average precipitation during the non-flood period (October-April) is 270 mm, accounting for 29.7% of the annual precipitation. The average precipitation during the flood season (May-September) is 649.6 mm, accounting for 70.3% of the annual precipitation. The precipitation is distributed in a single peak year (see Figure 3). The average monthly precipitation increases from January to July, reaching a maximum of 142 mm in July, gradually decreasing from July to December, and reaching a minimum in December. The value is 15 mm, and the main precipitation is concentrated in May-September (the flood season).

In order to more clearly analyze the trend of precipitation during the year in the Xiangyang section of the Hanjiang River, the precipitation concentration of the 1979-1997 precipitation data in the study area was calculated. The annual average precipitation concentration (PCD) was 0.43, and the precipitation concentration period (PCP) was 5.95, the concentration and concentration period of each year are shown in Figure 4 and Figure 5. The value of PCD is between 0.0 and 1.0, and the closer the PCD value is to 1.0, the more concentrated the precipitation is in a certain period of time; on the contrary, the closer the PCP value is to 0, the more precipitation is averaged in each time period. The results show that the precipitation in the Xiangyang section of the Hanjiang River has a concentrated trend for many years. It can be seen from Fig. 4 and Fig. 5 that the precipitation concentration in the study area is the most obvious in 1981 and 1993, the PCD value is close to 0, and the precipitation concentration is high. In 1980, the maximum PCD value was 0.59, and the concentration of precipitation was low. During the study period, the PCP value was the lowest in 1980, the precipitation was relatively average, and the
concentration was weak.

![Figure 4. Multi-month monthly average precipitation concentration (PCD) curve](image)

![Figure 5. Multi-month monthly average precipitation concentration period (PCP) curve](image)

4. Conclusion

In this paper, the precipitation characteristics such as interannual and intra-annual variation, concentration change and precipitation change during the flood season in the Xiangyang section of the Hanjiang River are analyzed, which provides a scientific basis for the allocation of water resources and the prevention and control of flood disasters in the Xiangyang area. The main findings are as follows:

1. The precipitation characteristics of the Xiangyang section of the Hanjiang River vary greatly from year to year from 1979 to 2014. The annual average rainfall is 889 mm, the annual maximum precipitation is 1235 mm, the annual minimum rainfall is 597 mm, and the absolute ratio is 1.068. The UFk statistic of the precipitation trend test is -0.29, which does not exceed the critical value of the significant $\alpha = 0.05 - 2$, indicating that the annual precipitation in the Xiangyang section of the Hanjiang River has not decreased significantly during the study period.

2. During the research period in Xiangyang, the average monthly precipitation increased gradually from January to July, reaching a maximum of 142 mm in July, gradually decreasing from July to December, and reaching a minimum of 15 mm in December, of which the main precipitation was concentrated. From May to September, the average annual precipitation concentration (PCD) is 0.43, and the precipitation concentration period (PCP) is 5.95. The precipitation is concentrated in many years, and the changes are most obvious in 1981 and 1993.

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