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The Law Analysis of the Weihe River Basin (Shaanxi Section) Precipitation

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Abstract: Based on 1956-2010 of precipitation of Weihe river basin in shanxi section, this paper statistical analysis the precipitation characteristics, the cycle, the abrupt, the trend and sustainable. The results show that the average of many years is 606.63 mm, the maximum is 931.86 in 2003, the minimum is 368.56 in 1995; the precipitation is more in 20 century 50, 60 and 80s, less in 70, 90s and the 2000s and the average of precipitation is close to average of many years in 70s and 2000s; The rainfall process has the remarkable periodic, the first main cycle for 18 years, the second cycle for 7 years, the third for three years; The average rainfall not happened obviously mutations; and the precipitation is not significant decrease trend; Hurst index greater than 0.5, which suggests that past trends of precipitation will be continue in the future, namely in the future precipitation is not significant digressive tendency. The conclusions have the important reference value to weigh river water resources development.

Keywords: Cycle, rainfall, R/S, trend

INTRODUCTION

The 4th global climate estimation report of IPCC (The Intergovernmental Panel on Climate Change) shows that according to the data of global earth surface temperature (since 1850), in the last 12 years (1995-2006), there are 11 years in the warmest 12 years; the temperature linear tendency of the last 100 years (1906-2005) is 0.74°C (0.56~0.92°C); the linear warming tendency (every 10 years)in the last 50 years (1906-2005) is 0.13°C (0.1~0.16°C), it is nearly twice of that of the last 100 years (1906-2005) and there is no doubt for the warming of the climate system. The global substantial climate warming will cause the abnormal change of the precipitation so as to deeply influence the water resources, conditions of the ecological system, the development of social economy, etc (IPCC, 2007). The Wei River is the biggest branch of the Yellow River; it belongs to the typical continental monsoon climate. The temporal and spatial distribution of precipitation is not uniform and there are frequent disasters of flood and draught. In recent years, the runoff and sediment in the watershed of the Wei River obviously decrease and the hydrology condition greatly changes, which causes certain influences on the agriculture of the local irrigation area, the development of the city industry along the river, the establishment of the ecological environment of the watershed, etc., thus, systematically studying the change rule of precipitation of the watershed of the Wei River plays a significant role for finding out the mutual connection between the climate change and runoff of the watershed of the Wei River, reasonably allocating the water resources, making the measure for conserving soil and water, developing the agriculture, etc.

The thesis utilizes the data of annual precipitation from 1956 to 2010 of eight weather stations in the watershed of the Wei River (section of Shanxi) and Mann-Kendall check, wavelet analysis and the R/S method to discuss the variation characteristics of precipitation in more than 50 years of the watershed of the Wei River (section of Shanxi) so as to provide theoretical and data bases for the research of the runoff variation in the area, the analysis of the evolution rule of water and sediment, the reasonable allocation of the water resources and the scientific research of the other relevant fields.

DATA AND METHODOLOGY

Summary of the study area: The Wei River is the biggest branch of the Yellow River. It is originated from the north side of Niaoshu Mountain, Weiyuan County, Gansu Province. It flows through Tianshui, Baoji, Xianyang, Xi'an, Weinan, etc., from west to east. It flows into the Yellow River in Tongguan, Shanxi province. Its whole length is 818 km and the total area of the watershed is 135000 km^2. The length of the river section in Shanxi province is 502.4 km and the area of the watershed is 67100 km^2. The study relates to the whole scope of the watershed of the Wei River in Shanxi province. The geographic coordinates are E106º20′~110º37′, N33º40′~37º18′. The watershed belongs to the typical continental monsoon climate. The

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temperature in spring is unstable. The precipitation is little. Most part of the Northern Shanxi is sandy and windy. It is hot and rainy in summer. The precipitation centralizes from July to September, there are many thunderstorms and summer drought is common. It is cool and humid in autumn and rainy. It is cold and dried in winter. Because of the influences of the landform, etc., the precipitation distribution in the watershed decreases from southwest to northwest.

Data source: The meteorological data includes the data of annual precipitation of 8 stations in the watershed of the Wei River (section of Shanxi) and is mainly downloaded from the China Meteorological Data Sharing Service System. For the decade of establishment and data quality of the stations are different, the station data with the long sequence is used. The linear regression method is used and the short time sequence is interpolated and prolonged so as to unify the length of the precipitation time sequences of all stations at the time period from 1956 to 2010.

Wavelet analysis: The wavelet analysis is a new method of signal time-frequency partial analysis, which is developed from the beginning of 1980s. It owns outstanding localization functions on both time domain and frequency domain. It can carry out localization analysis on the time sequence and analyzes the inner fine structure, so it is an important tool for studying the long-term variation of the hydrometeorology elements (Zeng *et al*., 2010; Sun and Cai, 2010; Gao *et al*., 2011). The thesis utilizes the Morlet wavelet analysis method for studying the rule of time variation of mean precipitation year after year in the whole area during more than 50 years of the watershed of the Wei River (section of Shanxi).

Mann-kendall check: In the analysis of the tendency of the time sequence, the Mann-Kendall check is the widely-used non-parameter check method which is recommended by the world meteorologic organization. It is originally proposed by Mann and Kendall (Mann, 1945; Kendall, 1975). Many scholars continuously apply the Mann-Kendall method to analyze the tendency variation of the time sequence of elements such as precipitation, runoff, temperature, water quality, etc. The Mann-Kendall check does not require the sample to obey a certain distribution nor is disturbed by few abnormal values. It is suitable for the data of the abnormal distribution of hydrology, meteorology, etc. The calculation is simple. The detailed algorithm is shown in the literature (Wei, 1999).

R/S check: Rescaled range analysis is the R/S analysis technique. It is a new statistic method originally proposed by the English scientist Hurst (1951) when he studied the multi-year hydrometry data of the Nile. The thesis calculates the Hurst index to judge the continuity of the tendency of precipitation and refer to the literature for the analysis method (Zhang *et al*., 2009).

RESULT ANALYSIS

Annual and decadal variation characteristics: According to the precipitation data of the station year after year and the boundary map of the watershed in the Wei River (section of Shanxi), in ArcGIS, the Tyson polygon method is used for calculating the mean precipitation of the area year after year. The maximum value of 931.86 mm is in 2003 and the minimum value of 368.56 mm is in 1995. The trend rate of the mean precipitation of the whole area is -1.28 mm/a, which shows the mean precipitation of the whole area is approximately in the tendency of decrease.

Table 1 shows the mean precipitation departure of the whole area of each decade. The departures of the precipitation in 1950s, 1960s and 1980s are positive, which means the precipitation is high. The departure value of the other three decades is lower than zero, which means the precipitation is less, wherein the departures in 1970s and 2000s are -1.77 and -4.03, which means the mean precipitation of the whole area in the two periods is very close to the multi-year mean value.

Cycle variation: The wavelet coefficient reflects the strength degree of the signal. The full line means the contour line of positive values and represents the period with more precipitation. The dotted line means the contour line of negative values and represents the period with less precipitation. The point of which the wavelet coefficient is zero corresponds to the turning point. Shown by The large-scale variation includes the small-scale variation structure which is more complex. On the temporal time scale of 18 to 25 years, the periodic oscillation of the mean precipitation of the whole area is obvious. It experienced the circulating alternate process of High-Low-High-Low. The central cycle is about 18a. The precipitation in the years before 1966, from 1979 to 1989 or 2001 to 2010 is high and the precipitation from 1967 to 1978 or 1990 to 2000 is low. The points of alternate sudden change occurred in 1966, 1978 and 1989. There are six high-low alternates on the time scale from 5 to 10 years. The central cycle is about 7a. On the time scale lower than 5a, the high-low variation cycle of the mean precipitation of the whole area is more complex and the points of sudden change increase. The scale corresponding to the peak value is the primary time scale of the sequence which is used for reflecting the primary cycle of the time sequence.

Characteristics of sudden change: The mann-kendall method is used for carrying out the check of sudden

Table 1: Decade departure of mean precipitation and temperature of the whole area

	Decade departure of mean precipitation and temperature of the whole area				
Decade	Precipitation departure/mm	Decade	Precipitation departure/mm	Decade	Precipitation departure/mm
56~59	46.43909	70s	-1.72645	90s	-62.56200
60s	31.17191	80s	24.40417	00s	-4.03409

Table 2: Mann-Kendall statistics and Hurst index of precipitation and temperature in the whole district

Elements	U	Tendency	H	Continuity
Precipitation	-1.401	Unobvious decrease	0.6483	Available

check on the mean precipitation of the whole area and in addition, moving t-test technique is used for verifying the result of M-K check so as to judge the authenticity of the point of sudden change and reinforce the reliability of the analysis on sudden change. There are multiple crossing points of the curves UF and UB of precipitation sequences between the critical lines from 1972 to 1984. Carry out the moving t test from 1972 to 1984 of the precipitation sequence and take n1 = 17 to 19. No statistics can pass the significance test of 0.05. It means there is no obvious sudden change in the mean precipitation of the whole area.

Variation tendency and continuity: The Mann-kendall and R/S method are utilized for studying the tendency and continuity of variation of precipitation of the whole area and the results of calculation are shown in Table 2. The significance level is 0.05, $U\ \alpha/2 = 1.96$. Combined with the absolute value of the U statistic value of precipitation, it can be seen that the tendency of precipitation is unobvious progressive decrease, all of the Hurst indexes of precipitation are higher than 0.5, it means the past tendency of precipitation will continue in future, i.e., the precipitation in future is in the tendency of unobvious progressive decrease.

CONCLUSION

- It can be known by studying the annual variation curve and linear tendency line of the mean precipitation of the area: the multi-year mean value of precipitation is 606.63 mm. The maximum value of 931.86 is in 2003 and the minimum value of 368.56 mm is in 1995. The trend rate of precipitation is -1.28 mm/a, it means the mean precipitation of the whole area is approximately in the tendency of decrease.
- It can be seen from the mean precipitation departure of the whole area. In 20th century, the precipitation was high in 1950s, 1960s and 1980s and the precipitation was low in the decades, wherein the mean precipitation of the whole area in 1970s and 2000s is very close to the multi-year mean value.
- Wavelet analysis is used for analyzing the precipitation system and there is obvious periodicity in the precipitation process of the whole area, the first primary period is 18 years, the second primary period is 7 years and the third primary period is 3 years.
- There is no obvious sudden change in the mean precipitation of the whole area and the tendency is unobvious progressive decrease.
- The Hurst index is higher than 0.5, which means the past tendency of the precipitation system of the whole area will continue in future, i.e., the precipitation in future is in the tendency of unobvious progressive decrease.

Generally speaking, there is obvious annual cycle in the precipitation system of the watershed of the Wei River (section of Shanxi). For the temperature is increasing in recent years, the evapotranspiration will increase and the precipitation is in the tendency of unobvious progressive decrease. It predicts the runoff in future will decrease, which will greatly influence the development and production of the watershed. We should prepare well for it and try best to adjust the structure of water use in the watershed, save water, ensure the water used for living, production and ecology in the watershed and scientifically and effectively utilize the water resource so as to realize the social and economic sustainable development of the watershed.

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