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Evolution of Growing Season Precipitation Series in the West Region of Heilongjiang Province Based on Wavelet Analysis

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Abstract: Global climate change is more and more serious for drought and affect for agricultural production in Semi-arid Area of the West region of Heilongjiang Province. So, steady progression of agricultural production impose challenge in this area. In order to solve above-mentioned problems, the authors took Gannan county as example, analyzed the multi-time scales variation characteristics and jump characteristics of actual growing seasons precipitation time series in Gannan county through using the wavelet theory, and the main periods of growing season precipitation change and variation trend of drought-flood in this area were revealed. The study can provide scientific gist for fully utilizing natural precipitation and exploiting maize water potential productivity in Gannan county so much as the entire Area of the West region of Heilongjiang Province.

Key word: West region of Heilongjiang Province; growing season precipitation; wavelet transform; multi-time scales analysis

It is belongs to warm temperate continental monsoon climate, characterized by significant winds, four seasons, rain hot during the same period in west region of Heilongjiang province, is China's important commodity grain production base. Agricultural production mode is rain-fed agriculture, therefore, it is important significance precipitation for agricultural production. Crop growth season is from May to September in west region of Heilongjiang province, so it is more conscious version to precipitation of crop growth season for effectively conducting agricultural production and guiding scientific agricultural development planning. Feature of growth season precipitation is researched, based on observed data of Gannan site, so this paper researched time variation trends of precipitation in growth season, and in order to provide the reference for local agricultural production.

1. Materials and Methods

This paper used crop growth season precipitation time series of Gannan site from 1956 to 2009. Gannan county is located in the western region of Heilongjiang province, it belongs to the temperate zone continental monsoon climate, spring temperature picks up fast, strong wind more frequently, so the spring drought serious, it is a typical rain-fed agricultural region. Under the background of global climate change, so it is vital significance to analysis Gannan county crop growth season precipitation rule, and to understand precipitation rule of western half arid area in Heilongjiang province.

Wavelet analysis method used this article is based on the Fourier transform into window function, thus the time series is decomposed for contribution of time and frequency. It is very effective to obtain a complex sequence of time adjustment rules, to diagnosis internal level structure of climate change, to distinguish evolution feature of time series in the evolution of different scales. Through the wavelet analysis, we can get cycle structure and abnormal change rule of the research object series in different time scales, so we can provide scientific grounds for short-term climate prediction. For wavelet analysis principle and application, see the references^[1~10].

2. Result and Analysis

2.1 Temporal evolution characteristics of precipitation in the west region of Heilongjiang Province

Anomaly variation curve of annual total precipitation and growing seasons precipitation are drawn on the basis of 54 years' annual precipitations in Gannan County, to see Figures 1 and 2.

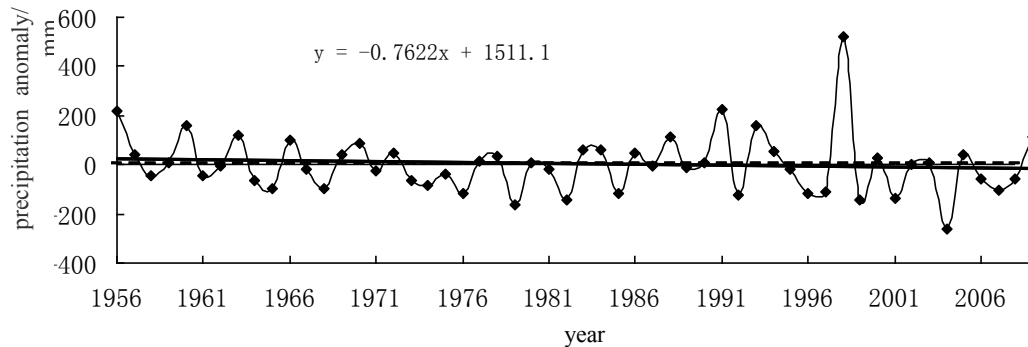


Fig.1. Anomaly variation curve of annual total precipitation from 1956 to 2009

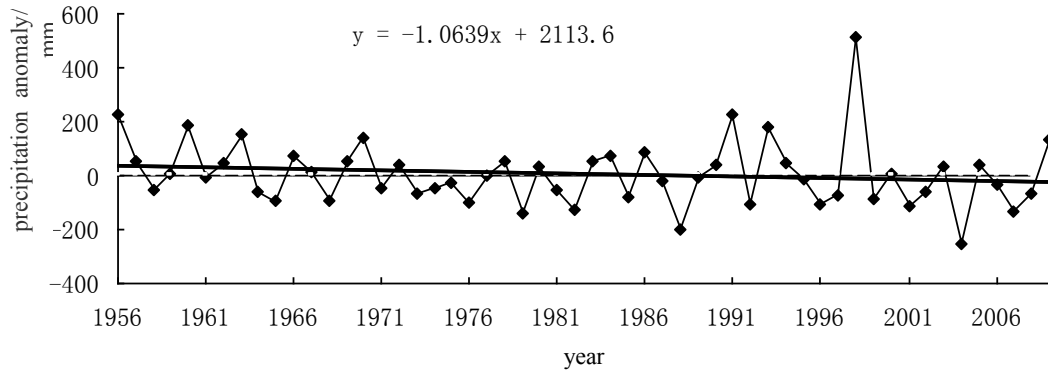


Fig.2. Anomaly variation curve of growing seasons precipitation from 1956 to 2009

The absolute value of the slope of anomaly trend line of growing seasons precipitation is larger than the slope's of anomaly trend line of annual total precipitation in Figures 1 and 2, which point out that a the falling range of growing seasons is larger than annual total precipitation's. Mean of growing seasons precipitation was 399.6mm, growing seasons precipitation varied between 148.5mm and 916mm, and coefficient of variation of growing seasons precipitation was 31.1% from 1956 to 2009. The coefficient of variation of growing seasons precipitation was greater than annual total precipitation's, so growing seasons precipitation had an more volatile variation than annual total precipitation.

From the time (Figure 2) , 54 years' growing seasons precipitation in Gannan County has a total decreasing trend, particular precipitation of growing seasons precipitation from 1999 to 2009 is obviously more decreasing than other years's. For those districts which has highly concentrated precipitation in growing seasons, precipitation is not enough for moisture of crop growth as precipitation less than 400~450mm, and it is bad for crop growth and development in where there is no irrigation condition. From the fluctuations of curve, although precipitation trended to decrease before 1982, but not too much , between 420mm and 580mm. And precipitation always had a large fluctuation from 1985 to 1999, between 430mm and 640mm. Growing seasons precipitation decreased obviously from 1999 to 2004, which was the minimum in 44 years, and it is fluctuant between 380mm and 480mm.

2.2 Analyze the multi-time scales variation characteristics of growing seasons precipitation time series in the west region of Heilongjiang Province

In order to know detailed structure characteristics and change tendency of growing seasons precipitation time series in different time scales, this article analyzed the multi-time scales variation of actual growing seasons precipitation time series in Gannan county on the basis of the wavelet analysis theory. Calculate the wavelet transform coefficients $Wf(a, b)$ of growing seasons precipitation anomaly series $f(k\Delta t)$ ($k=1, 2, \dots, 53; \Delta t=1$) in Gannan county.

2.2.1 Time-frequency analysis of growing seasons precipitation anomaly series

Draw wavelet transform coefficients $Wf(a, b)$ modulus square isoline (see Figure 3) and real part time-frequency distribution isoline (see Figure 4) of growing seasons precipitation anomaly series in Gannan county on the basis of the wavelet transformation theory, so as to analyze time frequency transformation of growing seasons precipitation anomaly series.

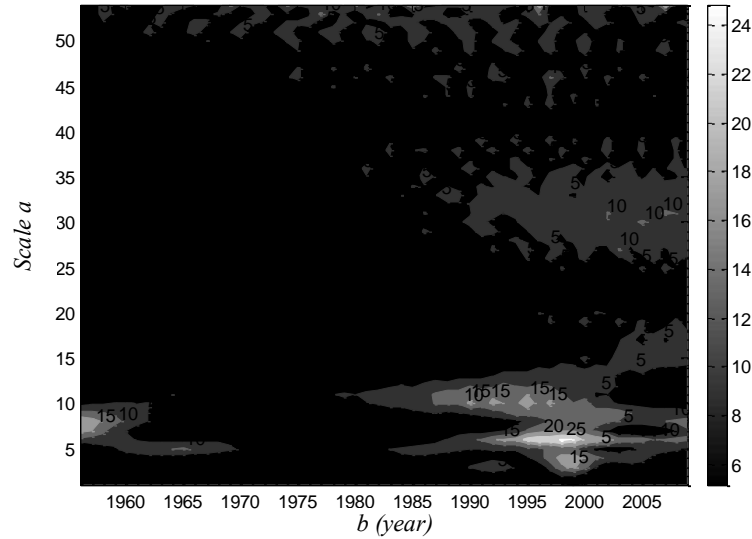


Fig.3. Wavelet transform coefficients modulus square $(\times 10^3)$ isoline of growing seasons precipitation anomaly series from 1956 to 2009

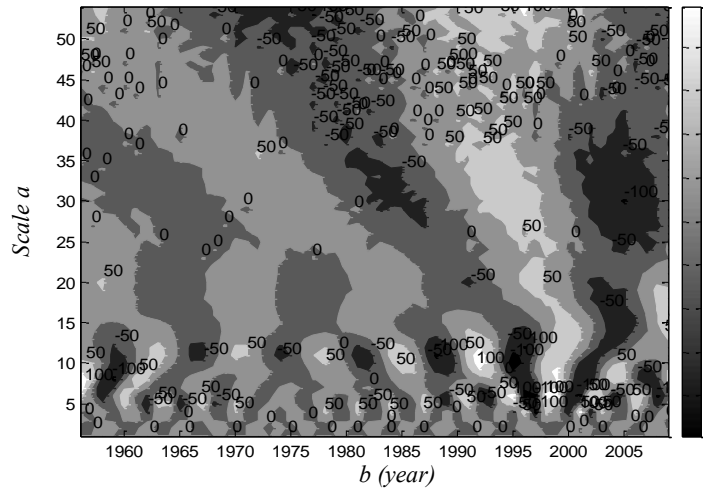


Fig. 4. Wavelet transform coefficients real part time-frequency distribution isoline of growing seasons precipitation anomaly series from 1956 to 2009

According to Figure 3, time frequency characteristic of wavelet transform coefficients modulus square is analyzed, and the strength of signal energy distribution

of different time scale can be seen from Figure 3. Change of signal energy was the strongest between three and eight years time scales, mainly it was between 1991 and 2003, oscillation center was in 1998. Change of signal energy was the stronger between 8 and 14 years time scale, mainly it was between 1980 and 2009, oscillation center is in 1959. Change of signal energy between 25 and 35 years time scale, mainly was between 1989 and 2009, oscillation center was about 2008. Change of signal energy of the others time scale was not strong.

According to Figure 4, time frequency characteristic of wavelet transform coefficients real part is analyzed. It can be seen from Figure 4 that change of Morlet wavelet transform coefficients real part of growing seasons temperature anomaly series of different time scale, distribution and phase structure of signal catastrophe point. In Figure 4, change of 3~8, 8~14 and 25~35 years time scale is most prominent, center of the time scale is about 6, 11, 31 years. In addition, between 15 and 25 years time scale also have a change, center of the time scale is about 19 years.

2.2.2 Analyze main period of growing seasons precipitation time series

The main period of growing seasons precipitation time series in Gannan county was analyzed and studied by using wavelet variogram. Use wavelet transform coefficients of different time scale, calculate on the basis of computing method of wavelet variance, and draw wavelet variogram of growing seasons precipitation anomaly series in Gannan county, see Figure 5.

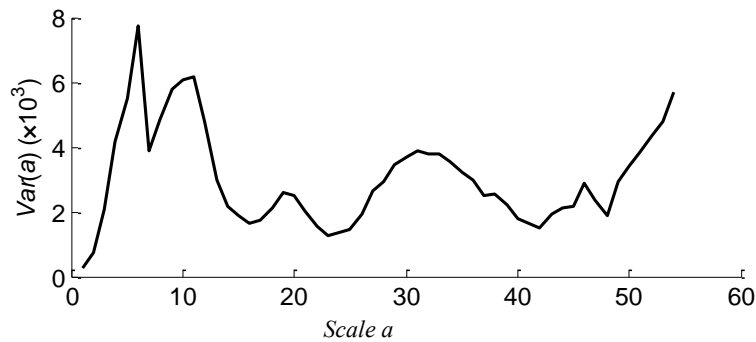


Fig.5. Wavelet variance of growing seasons precipitation anomaly series

As you can see in Figure 5, the main crest value of wavelet variance appeared respectively in those point where the value of scale equal to 6, 11, 19 and 31, and the first crest value appeared in the point where the value of scale equal to 6, which illustrated that periodic oscillation was the strongest about 6 years and the period was the first main period, moreover, the second and the third main period was 11 and 31 years respectively.

3 Conclusion

Study of variation trend and the multi-time scales variation characteristics of growing seasons precipitation time series in the west region of Heilongjiang Province is thought as to be a foundation for researching how to fully utilize grain crop water potential productivity. It can provide important theoretic meaning for reasonably exploiting grain production in the west region of Heilongjiang Province. Growing seasons precipitation time series in Gannan county is analyzed by using regression analysis and wavelet transformation analysis, and the results show that:

(1) 54 years' growing seasons precipitation has a total decreasing trend from 1956 to 2009, obviously to the disadvantage of the stable development of agricultural production.

(2) Growing seasons precipitation time series in Gannan county is recognition that maybe have four main periods which is about 6, 11, 19 and 31 years by using wavelet analysis, and the future total variation trend of growing seasons precipitation in Gannan county is uncovered. According to the amount of precipitation, various technology measures is positively taken to make the most use of natural precipitation resources, and then achieve the goal of the sustainable use of local climate resources.

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