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Analysis on Precipitation Variation Patterns of Chenzhou City

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***Abstract*—**By using linear regression methodology to analyze the data of daily precipitation from 1961-2012, this paper studied the variation tendency of precipitation in Chenzhou. The outcome showed: (1) The annual precipitation was decreasing for 52 years and the difference of precipitation variation tendency among four seasons was remarkable. The precipitation of spring and autumn showed more remarkable decrease than of summer; but the precipitation of winter significantly increased. (2) The annual precipitation frequency tended to lower, which was consistent with the tendency of yearly variation. The seasonal precipitation frequency was greatly different, namely, precipitation frequency in spring and autumn decreased, co-occurring with the phenomenon of mutation; but the winter precipitation frequency increased notably. (3) The precipitation intensity displayed a tendency of increase, including spring, autumn and winter; among them, winter had the most obvious tendency to increase, and autumn had the most yearly variation. Summer was the only season with a tendency of decreasing in precipitation intensity. (4) Annual extreme precipitation tended to reduce, spring, summer and autumn are all included; whereas, winter extreme precipitation tended to increase at the rate of 0.1d/10a. (5) The daily maximum precipitation intensity increased slightly and it varied greatly.

***Keywords*—**Chenzhou, precipitation variation, precipitation frequency, precipitation intensity.

I. Introduction

GLOBAL warming has been an obvious change over the past century. Atmosphere elements like precipitation and evaporation etc. became the focus of academic research, in which the most concerning was the study on amount of precipitation. The average precipitation of China has decreased notably from the 60s to 90s, but there was a slight increasing in the later 90s, and the precipitation of summer and winter has reached the level of the 50s and 60s, which was in accordance with the tendency of global change [1]. Under the environment of global warming, the precipitation of large area of China increased under a simulated model, while the situation in the low latitudes is on the contrary [2]. Besides, the study displayed that generally the precipitation of spring was slightly going up with an obvious change; the extreme precipitation frequency and rainstorm intensity was increasing in summer, and the frequency and intensity of heavy precipitation showed slightly going down; the mutation of average precipitation in autumn was the most notable in the whole year; roughly, the total precipitation amount, daily precipitation intensity and heavy precipitation days all went up in a different scale, however, the precipitation days actually tended to go down [3]-[6]. Recently, research on precipitation variation in Hunan province manifested the general trend of spatial distribution that more precipitation was distributed in mountain area of the west, south and east, but the middle hilly area and the north, Dongting lake plain area, had less precipitation. From 1960 to 2005, Hunan's precipitation of the coming year tended to go up; whereas the sliding average curve of seven years showed that the precipitation will go down in the future. Though the annual precipitation tended to go up, the seasonal variation was obvious, in which spring and autumn tended to go down, on contrast, summer and winter tended to go up [7]. Chenzhou, located in the southern middle part of Hunan, was chosen as a subject to study in this paper. By analyzing the daily precipitation of the city from 1961 to 2012, it revealed the precipitation variation tendency, the precipitation frequency, the precipitation intensity, extreme precipitation and the daily maximum precipitation of Chenzhou, which provided scientific evidence for biology and engineering design of this area, and urban planning as well.

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II. Data Processing

Seasons are defined as follows: 3 to 5 is spring, 6 to 8 is summer, 9 to 11 is autumn and 12 to 2 is winter.

Precipitation frequency refers to the percentage of raining days in a whole year. Precipitation intensity takes the average data of daily precipitation in all raining days. According to [8], the average data of 30 years of the 95th percentile of the precipitation sequence of yearly wet days (daily precipitation ≥ 0.1 mm) from 1981 to 2010 are defined as the threshold of extreme precipitation. When the precipitation of certain day at a monitoring station is beyond the threshold value, it is called extreme precipitation event. The detailed deduction can refer to Bonsal's method [9]: If a meteorological index has n values, then the n values are arranged in ascending order $x_1, x_2, \ldots, x_m, \ldots, x_n$, the probability that a value is equal to or less than x_m is P=(m-0.31) /(n+0.38). m is the sequence number of x_m, and n is the numbers of certain meteorological element. The 95th percentile value refers to the according value when P is 95%. The maximum daily precipitation is the top daily precipitation value of a year.

III. Outcome Analysis

A. Precipitation Time Variation and Tendency

1) Annual Precipitation

Fig. 1 shows the precipitation variation. It can be seen from the diagram that the annual precipitation slightly increased in the past 52 years. The sliding average data in five years display that from late 1960 to early 1970, the precipitation tended to go up; however, from early 1970 to late 1980, it tended to be opposite; and from late 1980 to the 20th century, the precipitation increased; but when entered into 21st century, it turned to go down again.

2) Seasonal Precipitation

The yearly variation of seasonal precipitation (Fig. 2) reveals that there was no obvious variation of precipitation in spring, summer increased slightly, whereas autumn and winter both went down. Besides, autumn did not reach the credibility of level 0.1, then winter got to level 0.02. The five-year sliding average data display that before 1980, precipitation in spring went up; but after 1980, it was converse; and autumn actually did not change; winter precipitation differed before and after the middle of 1990, which went up before1990 and then down.

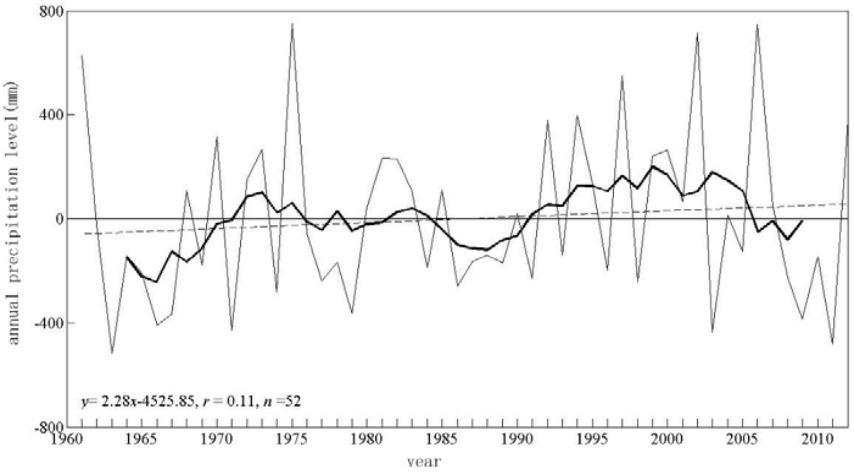

Fig. 1 Anomaly Variation of Precipitation

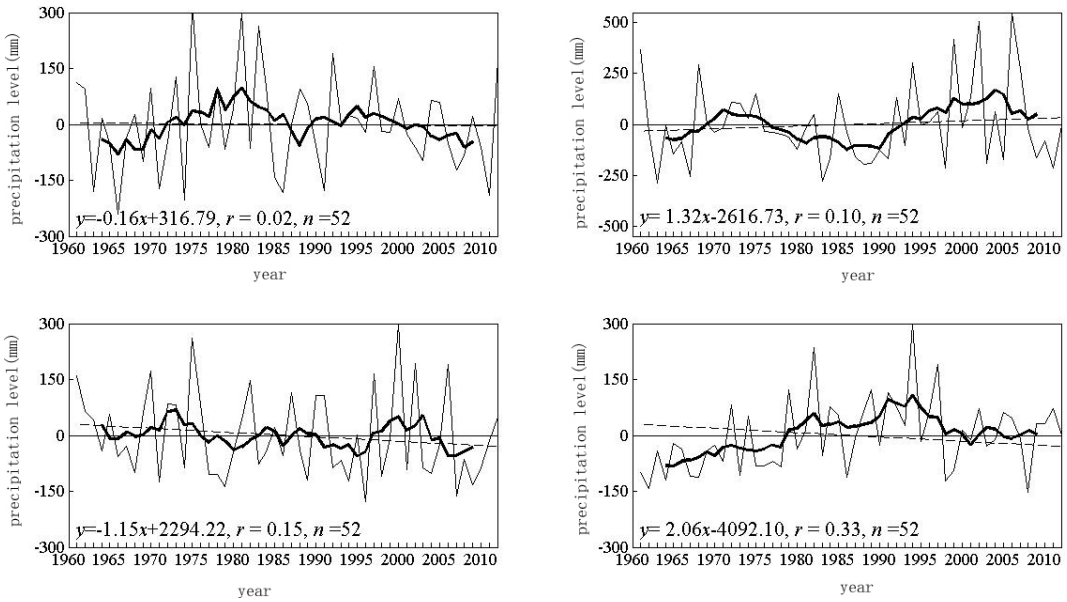

Fig. 2 Anomaly Variation of Seasonal Precipitation

B. Time Variation and Tendency of Precipitation Frequency

1) Annual Precipitation Frequency

Fig. 3 is the annual variation of precipitation frequency from 1961 to 2012. The figure shows that the annual precipitation frequency goes down slightly. The seven-year sliding average data tell that before early 1980, it tended to go up and then go down greatly after 1980; after that, it kept steady until this century although at the early 10 years, it went through a great

falling, it tended to go up again later.

2) Seasonal Precipitation Frequency

Fig. 4 is the seasonal precipitation frequency. Precipitation frequency of spring, autumn and winter all tend to decrease (the significant level of precipitation frequency in autumn reaches to 0.001, and winter reaches to 0.01). Precipitation frequency of summer shows no obvious variation.

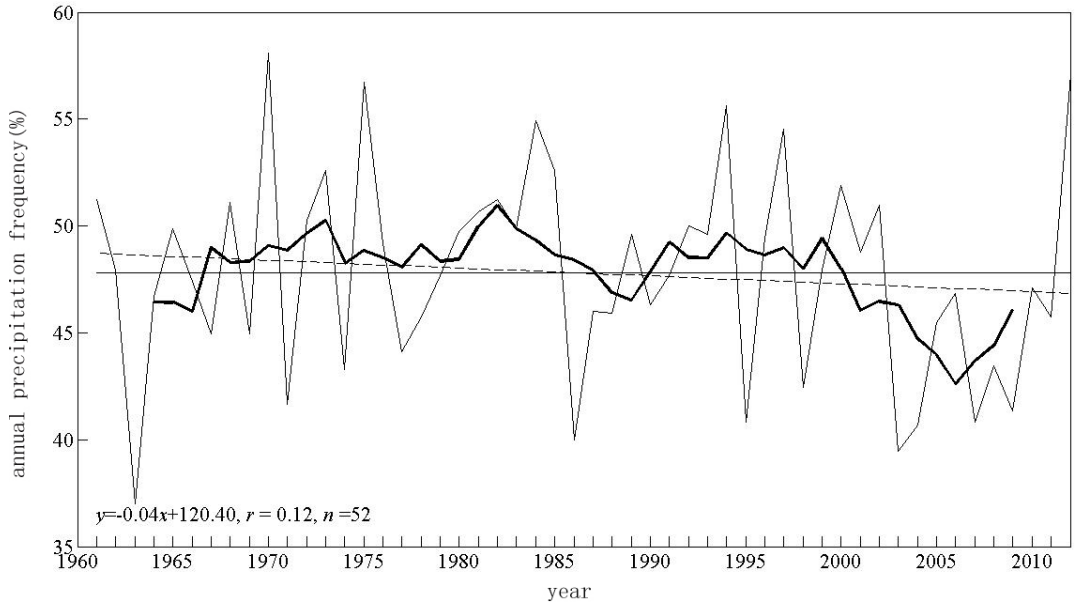

Fig.3 Yearly Precipitation Frequency Variation

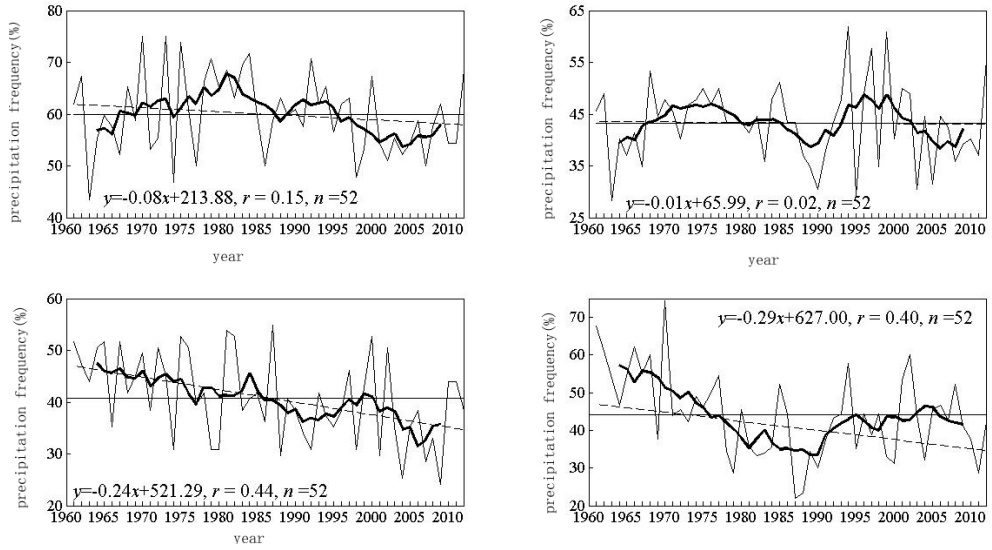

Fig. 4 Seasonal Precipitation Frequency Variation of Chenzhou

C. Time Variation and Tendency of Precipitation Intensity

1) Annual Precipitation Intensity

In order to study the features of precipitation intensity, the average value of all days that rain in a year is used to make Fig. 5 and it shows that the annual precipitation intensity tended to go up slightly from 1961 to 2012. From 1960 to 2005, it kept going up wavelike.

2) Seasonal Precipitation Intensity

From 1961 to 2012, seasonal precipitation intensity variation is shown in Fig. 6. It is obvious to see that four seasons' precipitation intensity all tend to go up (winter has gone up to a significant level of 0.1).

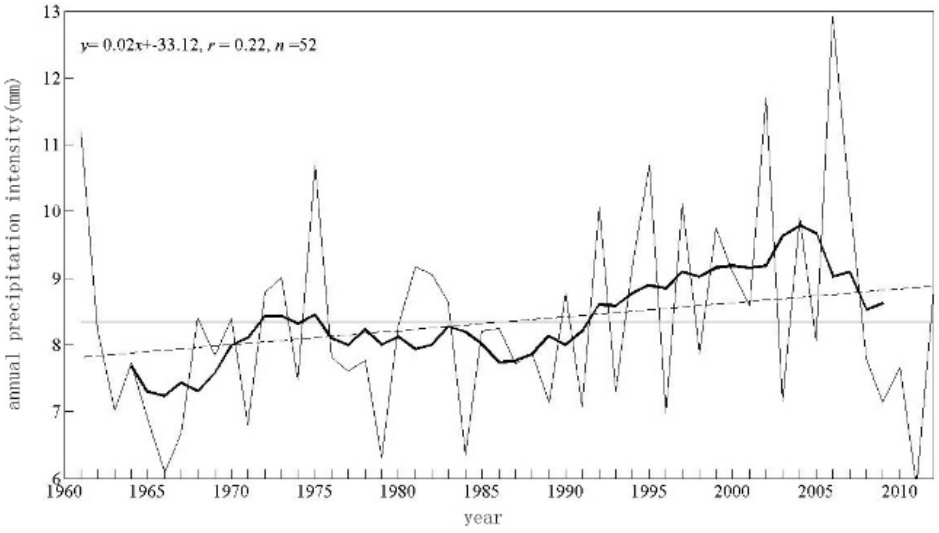

Fig. 5 Annual Precipitation Intensity Variation

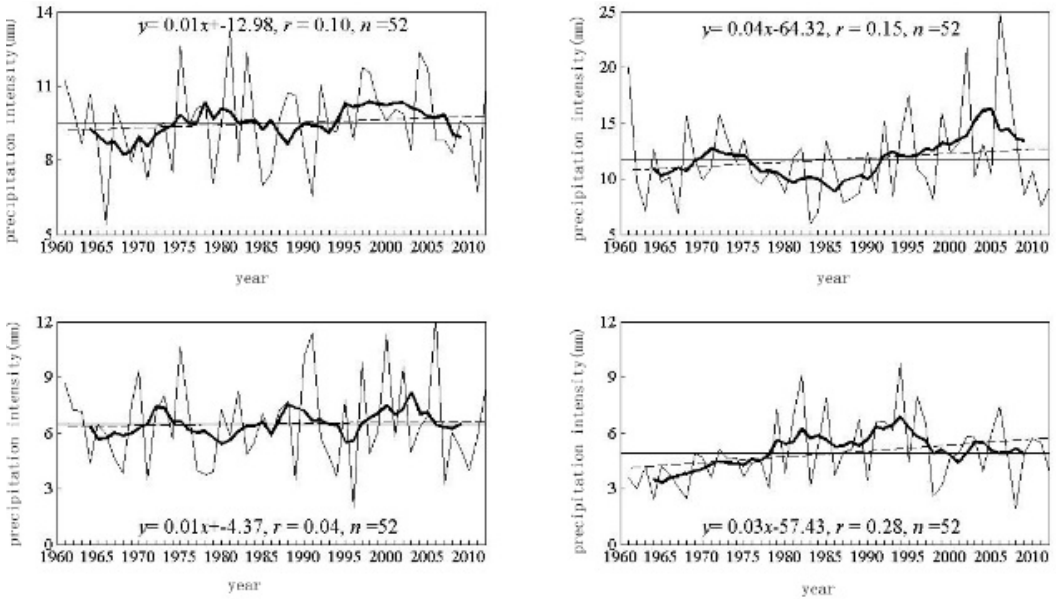

Fig. 6 Seasonal Precipitation Intensity Variation

D.Extreme Precipitation Event Variation and Tendency

1) Annual Extreme Precipitation Event

Fig. 7 reflects time variation tendency since 52 years. As Fig. 7 shows, extreme precipitation event went down at the rate of -0.3 day/10a (it reached to the significant level of 0.1). In the recent 52 years, the average times of annual extreme precipitation events were about 8 times, and the number went down notably since later 2000.

2) Seasonal Extreme Precipitation Event

Fig. 8 displays the temporal variation tendency of seasonal extreme precipitation events from 1961 to 2012. It is notable that the frequency of extreme precipitation events in spring, summer and autumn reduced at the rate of 0.1 at least; however, the situation in the winter was the opposite, which went up at a notable rate of 0.1. In all seasons, winter had the fewest extreme precipitation events because there were 34 years without extreme precipitation events in the last 52 years, which took the percentage of 65%; besides, the average times of extreme precipitation events in winter was no less than one. Though the average times of extreme precipitation events in autumn was more than in winter, it was only one time per year with a linear tendency of -0.08day/10a, which was the most stable season in all year.

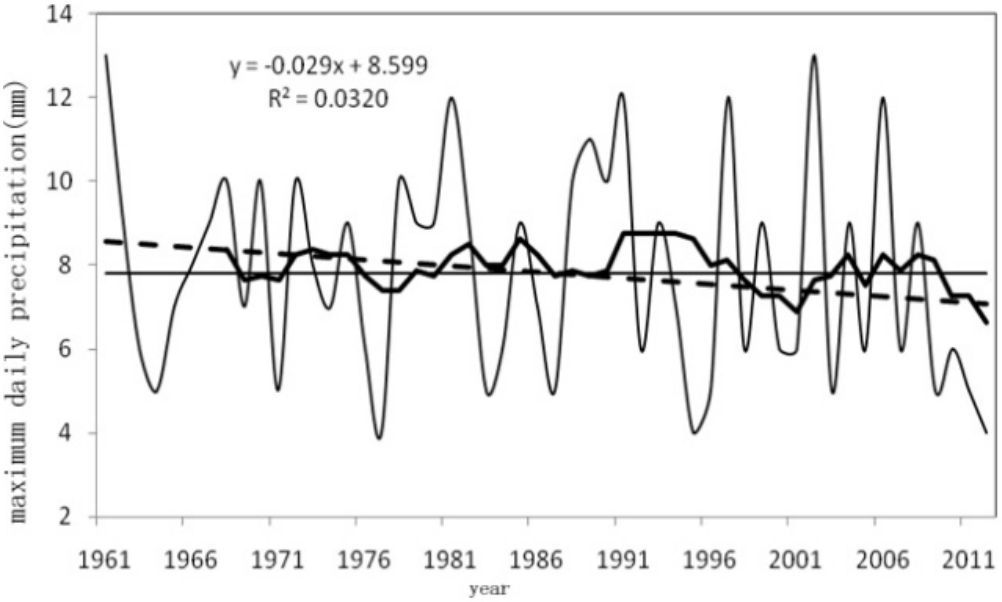

Fig. 7 Yearly Extreme Precipitation Event Variation

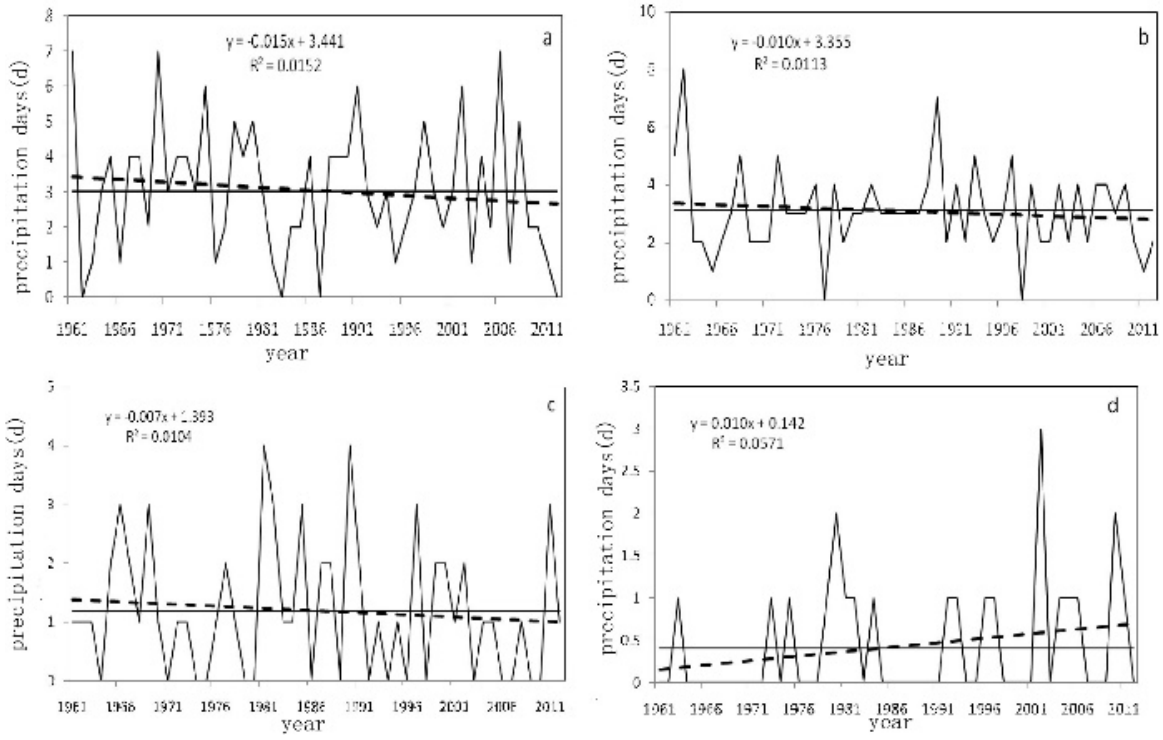

Fig. 8 Seasonal Extreme Precipitation Event Variation

E. Maximum Daily Precipitation Variation and Tendency

Fig. 9 reveals the maximum daily precipitation variation tendency from 1961 to 2012. The maximum daily precipitation was 217.4 mm, which happened in 1984; whereas the minimum value of daily precipitation was in 1965, and the precipitation was only 48.4 mm. The tendency rate of maximum daily precipitation was 0.6 mm/10 a (0.1 is the notable level). Overall, the maximum daily precipitation showed to increase slightly in the past 52 years.

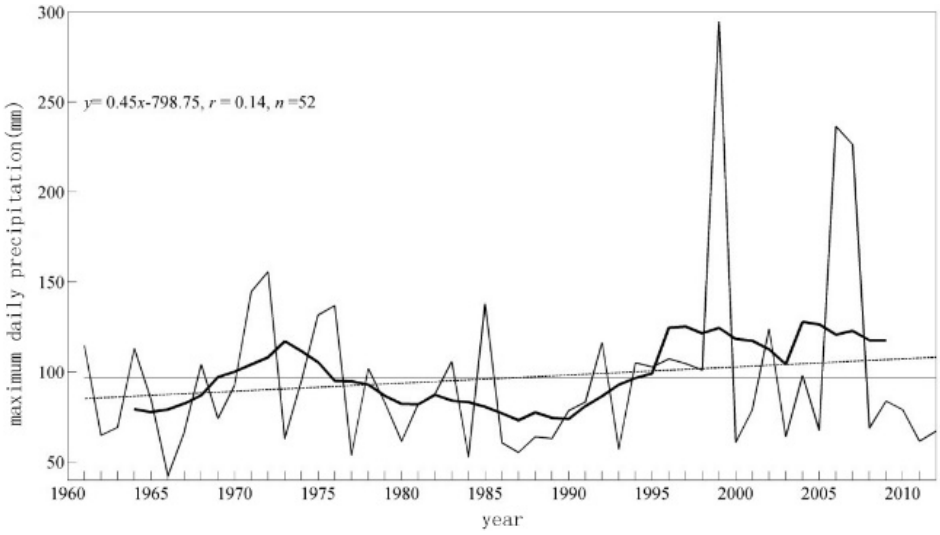

Fig. 9 Maximum Daily Precipitation Variation from 1961 to 2012

IV. Conclusion and Discussion

To make use of the precipitation data of Chenzhou from 1961 to 2012 and adopt the methodology of linear regression, this study analyzed the precipitation patterns and the outcomes can be concluded as follows:

(1) Precipitation in 52 years tended to go down, but the sliding variation did not change too much since late 1960s to 1970s; only in the late 1980s, the precipitation went up wavelike. The difference of precipitation variation among four seasons was obviously seen. The precipitation of spring and autumn showed a remarkable decrease; the precipitation of summer displayed a minor reducing tendency; and the precipitation of winter had a tendency of noteworthy increase, which finally changed at the end of 1980s.

(2) Precipitation frequency of 52 years tended to lower, which was consistent with the annual precipitation variation. Especially, it was quite obvious that it went down at the end of 1990s. The seasonal precipitation frequency was greatly different, which was also related to the variation of seasonal precipitation, with a tendency of going down as well. To be exact, the precipitation frequency in spring and autumn was differed, co-occurring with the phenomenon of mutation; the precipitation frequency in the winter increases notably and it mutated at the end of 1990s.

(3) The precipitation intensity displayed a tendency of increase (it reached to the notable level of 0.1) in three seasons except in summer and it of winter expressed the most significant. But autumn had the most yearly variation. Summer was the only season with a tendency of decreasing in precipitation intensity.

(4) In the past 52 years, the frequency of extreme precipitation events caused by rain tended to reduce in three seasons which included spring, summer and autumn, whereas only winter was on the contrary, tending to go up. The average days of extreme precipitation event in summer was slightly higher than spring, and autumn is slightly higher than winter.

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