Variation of Temperature and Precipitation in Urban Agglomeration and Prevention Suggestion of Waterlogging in Middle and Lower Reaches of Yangtze River

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Abstract. The variation trend of temperature and precipitation during flood season in the middle and lower reaches of the Yangtze River basin in recent 50 years and change characteristics of rainfall in five typical flood prone cities are analysed. Aiming at waterlogging problems in the urban agglomeration of middle and lower reaches of the Yangtze River, the comprehensive prevention and control suggestions are put forward. The results showed that: the temperature trend in the basin decreased and then increased, and the precipitation showed a downward-rising-downward trend, no mutation occurred; The incidence of heavy rainfall events in the five typical cities with daily rainfall more than 50mm showed an upward trend, and increased significantly after 2002. The intensity of precipitation increased gradually. Climate change makes urban agglomeration waterlogging disasters become increasingly prominent in the middle and lower reaches of the Yangtze River.

1. Introduction

The middle and lower reaches of the Yangtze River are economically developed and the urbanization has matured. In recent years, affected by climate change and human activities, waterlogging disasters occur frequently in the area of middle and lower reaches of Yangtze River. Large and medium-sized cities such as Wuhan, Nanjing, Hangzhou and Shanghai are suffered waterlogging disasters (in different degrees). It has an impact on the natural ecological system and social economic system of the river basin urban agglomeration [1].

From the overall climate change characteristics of the Yangtze river basin, the rainfall in the recent 60 years shows a trend of significant increase [2]. At the same time, with the combination of the regional climate warming and Urban Heat-island Effect, the frequency and intensity of heavy rainfall increased [3]. In addition, the runoff in the Yangtze River Basin is greatly affected by rainfall [4,5]. Confronted with short-term heavy rainfall in the watershed, the main water quantity increases and water level increases. The water level of water system and flood discharge facilities in the city is
relatively low. The occurrence and aggravation of urban waterlogging disasters are caused by back water pushing. In the future, the extreme precipitation events in the middle and lower reaches of the Yangtze River will be more frequent and serious [6]. It is urgent to carry out in-depth research on urban waterlogging disaster.

At present, the study of urban waterlogging mostly focused on a single city, but in fact the city waterlogging is a complex integrated system problem, the city is affected by the climate, hydrological characteristics of river basin. On the basis of the daily temperature and precipitation data derived from 74 observation stations over the middle and lower reaches of Yangtze River during the flood season (from April to October) from 1960 to 2010. Based on the change of climatic characteristics of the river basin, this paper analyses the temperature, precipitation variation trend and abrupt change in the middle and lower reaches of the Yangtze River during the flood season in nearly 50 years. Research precipitation and temperature change characteristics of five typical waterlogged cities, such as Wuhan, Nanjing, Hangzhou, Nanchang, Hefei. We analyzed the influence of the climate change characteristics on the typical urban waterlogging disasters in the middle and lower reaches of the Yangtze River, and proposes the comprehensive prevention and control suggestions for waterlogging of the urban agglomeration in the middle and lower reaches of the Yangtze River.

2. Temperature variation trend and abrupt change

According to the analysis of daily mean temperature in the middle and lower reaches of the Yangtze River region during flood season from 1960 to 1960. As shown in figure 1, the temperature fluctuates in an overall upward trend in the middle and lower reaches of the Yangtze River. Before 1993, the temperature fluctuated greatly, and the change trend was not obvious, but the trend of warming was obvious after 1993.

Since the overall fluctuation of figure 1 is large, the trend of temperature variation can’t be given accurately. In order to verify the trend of temperature change, we calculated daily temperature in the middle and lower reaches of the Yangtze River during flood season by using accumulative anomaly method [7], the formula is as follows:

$$\tilde{x}_t = \sum_{i=1}^{n} (x_i - \bar{x}) \quad t = 1,2,\ldots,n$$  \hspace{1cm} (1)

In the formula, $x_i$ is the temperature over the years, and $\bar{x}$ is the average temperature for many years.

It can be found from figure 2 that the temperature experienced a significant fluctuation in the middle and lower reaches of Yangtze River basin between 1960 and 2010. From the average of 51 years, the temperature showed a downward trend from the 1960s to the early 1990s. After the mid-1990s, the temperature began to rise rapidly and the trend of growth continued unabated.

It is generally believed that when the absolute value of accumulated anomaly reaches the maximum, the corresponding time may be a mutation year. From figure 2, the maximum value appears in around 1993. In order to detect whether the mutation occurs, we calculate the signal to noise ratio in 1993 as the turning point, and the formula is as follows:

$$\frac{S}{N} = \left| \frac{\bar{X}_1 - \bar{X}_2}{s_1 + s_2} \right|$$  \hspace{1cm} (2)

In the formula, $\bar{X}_1$, $\bar{X}_2$ are the average, $s_1$, $s_2$ are the standard deviation of temperature in the two stages before and after the turning year, and $S/N$ is the signal to noise ratio.

The value of $S/N=0.906$ less than 1, we believe that the mutation of temperature in the lower reaches of the Yangtze River basin does not exist in 51 years flood season.
3. Analysis of precipitation variation trend

3.1. Variation trend of precipitation in river basin

Based on the analysis of the rainfall during flood season in the middle and lower reaches of the Yangtze River from 1960 to 2010, we can see from the figure 3 that the overall rising trend of precipitation is not obvious, and the rainfall fluctuates greatly.

In order to find out the variation trend of rainfall, equation (1) is used to calculate the accumulated anomaly value of precipitation in the middle and lower reaches of the Yangtze River during flood season, and the cumulative anomaly curve is given by figure 4. During the past 1960-2010 years, the trend characteristics of accumulated anomaly is fluctuation decline, fluctuation rise, and decline. The fluctuation range is larger than that of the temperature. In 1960-1968, the accumulated anomaly of precipitation fluctuated decline, the rainfall was relatively less; From 1968 to 2002, the accumulated anomaly of precipitation fluctuated upward, that means precipitation increased; After 2002, the accumulated anomaly of precipitation decreased rapidly, rainfall showed a decreasing trend. Using the equation (2) to calculate the signal to noise ratio at 1968 and 2002, the results are 0.269 and 0.344 respectively, which are less than 1. It shows that there is no abrupt change in precipitation during flood season in the middle and lower reaches of the Yangtze River in recent 50 years.

3.2. Analysis of heavy rainfall characteristics in typical cities

Urban waterlogging is directly affected by heavy rainfall, the frequency and intensity of heavy rainfall is an important reference index to study urban waterlogging. Meteorology stipulates: 24 hours precipitation amounts to 50 ~ 99mm for rainstorm, 100 ~ 199mm is large rainstorm, 200mm above is extraordinary rainstorm [8]. We classified the precipitation during flood season in the middle and lower reaches of the Yangtze River in 1960-2010, and selected five cities prone to waterlogging such as
Wuhan, Nanjing, Hefei, Hangzhou, and Nanchang. Gather and analyse the frequency of rainstorm and above grade of five typical waterlogged cities.

As shown in figure 5, in recent 50 years, the frequency of rainstorm and above grade is generally on the rise during flood season in middle and lower reaches of Yangtze River. Before 2002, the frequency of heavy rainfall fluctuated from 10 to 35, but after 2002, the frequency of heavy rainfall increased rapidly and reached its peak. Combined with the less rainfall in the middle and lower reaches of the flood season from 2002 to 2009 (figure 3, figure 4), it is indicated that after 2002, heavy rainfall became more and more concentrated in the major cities of the river basin. The ratio of occurrence frequency of rainstorm and above grade to total amount of rainfall in flood season can reflect the change of urban rainfall intensity. As shown in figure 6, with the change of time, the ratio increases overall, which indicates that the intensity of rainfall in typical waterlogging prone cities is increasing.

4. Summary and suggestion

4.1. Summary
This paper analyses the variation trend of temperature and rainfall during the last 50 years in the middle and lower reaches of the Yangtze River Basin. By studying the characteristics of frequency and intensity of strong rainfall in typical cities, the conclusions are drawn as follows:

- From the change trend of temperature and precipitation in the middle and lower reaches of the Yangtze River Basin, the temperature in the flood season first decreased and then increased, and the rainfall showed a downward-rising-downward trend, and no mutation occurred.
- From the rainfall characteristics of five typical waterlogged cities, the occurrence of heavy rainfall which is more than 50mm shows an uptrend and it shows a significant increase after 2002. In precipitation events, the proportion of heavy rainfall increases with time, indicating that precipitation intensity is also increasing.
- It is speculated that the frequency and intensity of short-time heavy rainfall events in the middle and lower reaches of the Yangtze River will increase with no regularity. And the urban waterlogging problems will become more and more prominent.

4.2. Suggestions on integrated control of disasters
Due to the high level of urbanization, population and social financial are concentrated in the middle and lower reaches of the Yangtze River, Urban waterlogging caused by frequent short-term heavy rainfall brings a great impact on urban development and social stability. To solve this problem, this paper puts forward the following suggestions:

- Establish urban hydrological monitoring system with three dimensional and high stability.

According to the characteristics of the traditional city hydrological monitoring, combining traditional meteorological and hydrological monitoring instrument with new monitoring means such as
radar, satellite, ultrasonic. Monitor urban rainfall, waterlogged water, drainage flow and water level of rivers and lakes in real-time. A method for monitoring ground-air-satellite stereo is established. A variety of communication, power supply, lightning protection technology are used in the construction of automatic monitoring and acquisition system, to make sure the stability of the monitoring system and the reliability of data transmission under extreme weather conditions.

- Strengthen the basic science and technology research of urban waterlogging disaster prediction and evaluation.

Based on the research of weather prediction, flood forecast and surface runoff production and confluence simulation, the model and method of urban waterlogging disaster prediction are formed for the middle and lower reaches of the Yangtze River, and the level of disaster warning and prediction is continuously improved. Access urban waterlogging risk and impact finely, quantitatively and dynamically. It provides the basis and method for risk assessment, compartment and post disaster loss assessment.

- Improve the comprehensive prevention and control system of urban waterlogging disaster, form contingency plans and decision-making disposal methods.

Establish a truly independent, professional and systematic urban waterlogging disaster management organization, improve the urban hydrological monitoring station network layout and legal system in the middle and lower reaches of the Yangtze river. We should strengthen the propaganda and education of disaster prevention and reduction, and fully mobilize the masses of citizens and non-governmental organizations to participate in the process of disasters reporting, preventing and saving propaganda. In addition, according to the characteristics of each city, a feasible, scientific and reasonable emergency management plan is formed to improve the level of disaster emergency decision-making.

- Based on modern information technology, we can establish a comprehensive prevention and control platform for urban waterlogging disaster in the middle and lower reaches of the Yangtze River.

We can build a comprehensive information platform for urban waterlogging prevention, which includes automatic data collection, disaster prediction simulation, warning information push, disaster risk zoning, disaster assessment, emergency management and other subsystems. Make full use of technology such as cloud computing, 3S, networking, data mining, etc. To realize the real-time collection and sharing of the basic information of waterlogging disaster in the middle and lower reaches of the Yangtze River, the automatic mining of large amounts of heterogeneous big data, the rapid calculation and accurate simulation of real-time disaster, and the scientific decision making based on the model method base.

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