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Research on the Flood Classification for the Lower Reaches of Jinshajiang River

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Abstract. The characteristics of floods in a river and their classification are of great significance for the flood control, risk reduction and water resources utilization as well. This paper investigates the classification of floods in the lower basin of the Jinsha River based on flood area composition analysis and Fuzzy C-means Clustering Algorithm. The results show that the floods in the lower basin of the Jinsha River are divided into upstream type, interval type and tributary type according to their regional compositions; the three types of floods are divided into two categories according to their intensity and morphological indicators using fuzzy C-means. The flood classification of the lower reaches of Jinshajiang River in this study laid a foundation for the formulation of the joint operation rules of the cascade reservoirs in the lower reaches of Jinshajiang River, and the flood control standard of Yibin City could be raised to prevent 100-year flood approximate through the joint operation of the cascade reservoirs, additionally, it is of great importance to recognize the flood inflow as well as their control for the Three Gorges Reservoir.

1. Introduction

At present, there is no standard definition for flood classification. When the concept of classification is applied to floods, flood classification can be defined as a comprehensive and systematic classification and classification of floods according to the common points and differences of floods and certain classification principles [1-3]. As the main inflow water source in the upper reaches of the Yangtze River, Jinshajiang River has abundant and stable runoff, large flood volume and long duration. Due to the large basin area, numerous tributaries (Yalongjiang River, Minjiang River, Tuojiang River, Jialingjiang River) and many hydrological stations flowing through (from Panzhihua Station to Cuntan Station from top to bottom), the flood law and regional composition of Jinshajiang River are relatively complex and the dispatching is difficult. When classifying the flood process in the lower reaches of Jinshajiang River, its flood area composition is the main basis for classification. In this paper, according to the composition of flood areas in the lower reaches of Jinshajiang River, floods are divided into three types: upstream type, interval type and tributary type. Then statistics and classification are carried out on the secondary flood characteristics of the above three types of floods.

In this paper, a total of 32 catastrophic floods in Jinshajiang River Basin from 2003 to 2018 are selected as the objects for flood classification, so as to provide scientific guidance for flood forecasting and flood management in the lower reaches of Jinshajiang River and raise the flood control standard of Yibin City to once in a century.

2. Composition analysis of flood areas in the lower reaches of jinshajiang river

2. 1. Survey of research area

Jinshajiang River Basin is located in the upper reaches of the entire Yangtze River Basin. The natural geographical conditions of the basin are rich and varied. The topography of the basin is high in the north and low in the south, and the shape of the basin is long and narrow. The Jinshajiang River basin spans 90°~105° east longitude and 24°~36° north latitude. It is 3481km long from the headwaters of Qinghai Province to the main stream of Yibin City. The basin area is 502, 000 km^2, accounting for 26% of the Yangtze River basin area and 47% of the catchment area above the Three Gorges Dam site. A diagram of the lower basin of the Jinsha River is shown in Figure 1. The main stations and tributaries of the lower Jinsha River are shown in Figure 2.

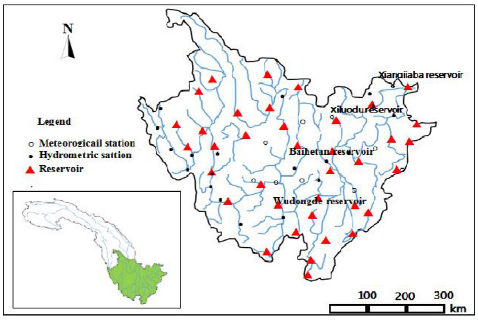

Fig. 1 Diagram of the lower jinsha river basin

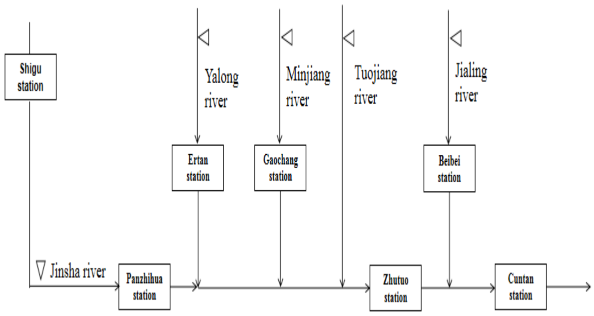

Fig. 2 Schematic diagram of flood area composition in the lower jinshajiang river basin

2. 2. Composition results of flood areas in lower jinshajiang river

Upstream flood refers to the flood volume measured by Panzhihua Station in the lower reaches of Jinshajiang River and the flood volume of Yalongjiang River flowing into the mainstream. Interval flood refers to the rainstorm flood in the lower reaches of Jinshajiang River. Tributary flood refers to three large tributaries whose flood sources are mainly downstream, namely Minjiang River, Tuojiang River and Jialingjiang River from top to bottom.

First, the peak flow, maximum 1d flood volume, maximum 3d flood volume, maximum 5d flood volume, maximum 7d flood volume, maximum 15d flood volume and maximum 30d flood volume of each flood were counted [4-6]. The composition of flood areas is analyzed according to the following methods: selecting the above indexes of each flood at Zhutuo station and cuntan station, taking into account the flood propagation time, respectively counting the flood volume of each station during the corresponding occurrence period, and obtaining the average composition of multiple floods at Zhutuo station and cuntan station. Panzhihua, Ertan and Gaochang in the upstream of Zhutuo Station are selected to calculate the proportion of flood volume of the above three stations in Zhutuo Station respectively. Panzhihua Station and Ertan Station can be considered as upstream inflow, and Gaochang is Minjiang River inflow. The residual volume after subtracting the above three stations from the flood volume of Zhutuo Station can be considered as Tuojiang River inflow and rainstorm flood in the lower reaches of Jinshajiang River. The Tuojiang Control Station Lijiawan Station catchment area only Zhu Tuo Station catchment area of 3. 4%. Therefore, the remaining part of the flood area composition of the Zhutuo Station in the following table is interval rainfall flood. Zhu Tuo Station and Beibei Station on the upstream of Cuntan are selected to calculate the proportion of flood volume of the above two stations respectively in Cuntan Station, of which Zhu Tuo Station is the main stream water and Beibei

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Station is the tributary Jialingjiang River water.

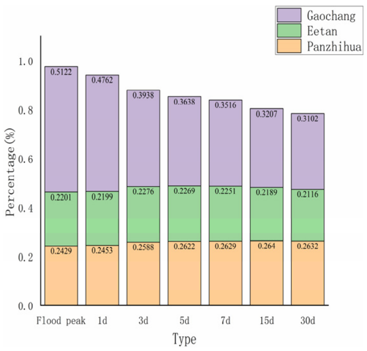

Fig. 3 Composition proportion of flood area in zhutuo station

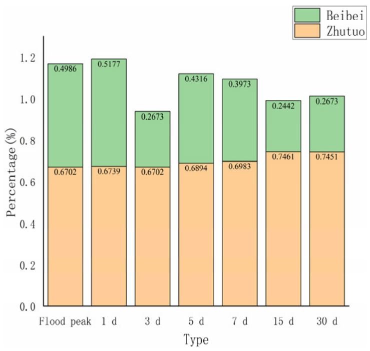

Fig. 4 Composition proportion of flood areas in cuntan station

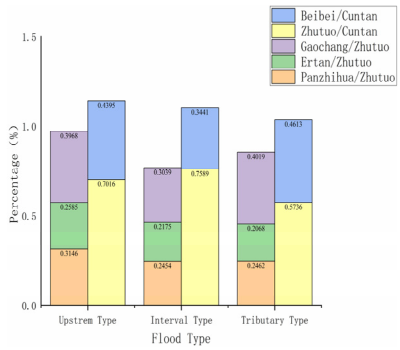

Fig. 5 Average proportion of three flood areas

Table 1 Composition proportion of flood area in zhutuo station

	Flood Peak	1d	3d	5d	7d	15d	30d
Panzhihua+ Ertan+Gaochang	0.9938	0.9435	0.8803	0.8529	0.8396	0.8165	0.7979
Interval Rainfall	0.0062	0.0565	0.1197	0.1471	0.1604	0.1835	0.2021

Table. 2 Composition proportion of flood areas in cuntan station

	Flood Peak	1d	3d	5d	7d	15d	30d
Zhutuo+Beibei	1.1862	1.1916	0.9372	1.1210	1.0955	0.9936	1.0123

Because Cuntan Station is close to Zhutuo Station and Beibei Station, its flood area composition can basically be regarded as the water from the upstream main stream (Zhutuo Station) and Jialingjiang River (Beibei Station). The sum of the percentages of Zhu Tuo and Cuntan is greater than 1, which is due to the fact that the flood propagation time cannot be accurately calculated, resulting in the time period not completely corresponding. In terms of time, the maximum 7d flood volume can accurately reflect the regional composition of the flood, so the flood can be divided into upstream type, interval type and tributary type based on the maximum 7d flood volume. According to the statistics of 32 floods, the classification results are as follows:

Table 3 Average proportion of three flood areas

Category	Session	(Panzhihua+Ertan+Gaochang)/Zhutuo	(Zhutuo+Beibei)/Cuntan
Upstrem Type	8	0.9699	1.1411
Interval Type	16	0.7669	1.1030
Tributary Type	8	0.8549	1.0349

From the above table, it can be seen that the upstream flood accounts for 25% of all the flood events. judging from the regional composition, there is basically no interval inflow in the flood volume measured by zhutuo station, and the main stream of Jinshajiang river (Panzhihua station) and Yalongjiang river (ertan station) in the upstream are the main sources. Interval floods have the largest number of times and the largest proportion. Panzhihua+Ertan+Gaochang only account for 76. 69% of the flood volume of Zhutuo Station, and the rest can be considered as interval inflow. Tributary floods also accounted for 25% of all events, obviously, the Minjiang River (high station) and Jialingjiang River (Beibei station) accounted for a large proportion of the water.

3. Flood classification in lower reaches of jinshajiang river

In this paper, a total of 32 floods selected from 2003 to 2018 have been preliminarily divided into three types by analyzing the composition of flood areas: upstream type, tributary type and interval type. Then select appropriate intensity index and morphological index to classify the three types of floods again[16-17]. Considering comprehensively, indexes such as peak discharge, peak number, peak time deviation and flood duration are selected. Fuzzy C-means Clustering Algorithm is used to classify the upstream type, tributary type and interval type floods respectively. The classification results are shown in Table 4.

Table 4 Average of main indicators of various floods

Category		Session	Average Peak Discharge (m^3/s)	Average Number of Flood Peaks	Average Duration of Flood (h)	Mean Time Skewness of Main Peak
Upstream Type	No. 1	4	48650	2	20.5	0.2773
	No. 2	4	37650	1	4	0.5417
Interval Type	No. 1	12	47383	2	12	0.3234
	No. 2	4	32750	2	7.5	0.6500
Tributary Type	No. 1	4	55300	4	17.5	0.1727
	No. 2	4	54600	3	20	0.6786

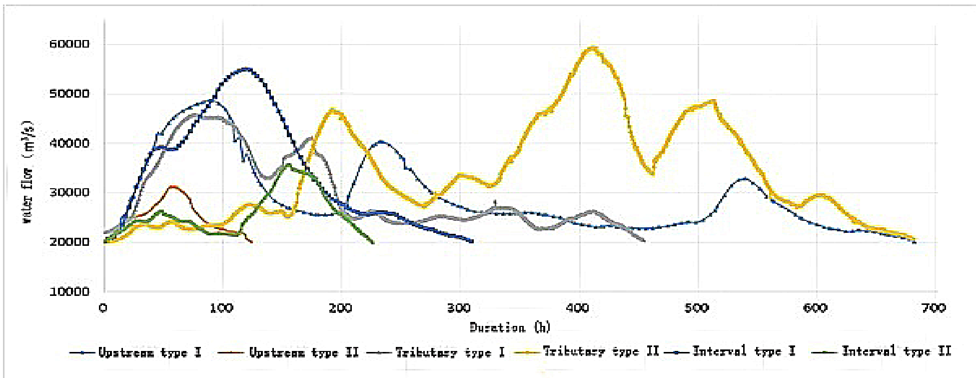

Fig. 6 Typical flood process lines for each type

As can be seen from table 4 and fig. 6, upstream type, tributary type and interval type floods are all divided into two types. The average peak discharge of the first type of upstream flood is larger, the average flood duration is longer, and the main peak appears earlier. The average duration of the second type of upstream flood is short, with the main peak slightly behind. There are obvious differences between the first type of interval flood and the second type of interval flood in the number of times, average peak discharge, average flood duration, average peak time deviation and other indicators. The average peak discharge of tributary flood is larger than that of the other two, the average flood duration is very long, and the number of flood peaks is more, which conforms to the rule that the peak occurrence time of tributary flood is inconsistent.

4. Analysis of flood classification results in lower reaches of jinshajiang river

In this paper, we classify the downstream flooding of the Jinsha River based on flood area composition analysis and fuzzy C-means to It is divided into three major categories and six minor categories. The following conclusions were drawn:

(1) Floods in the lower reaches of Jinshajiang River can be divided into three categories according to their regional composition: upstream type, interval type and tributary type, of which interval type floods have the largest number of occurrences, accounting for 50% of all occurrences, while the other two types each account for 25%.

(2) The main source of upstream flood is the Jinshajiang River and Yalongjiang River. The first type of upstream flood lasted a long time, but the time deviation of the main peak was small, and the main peak appeared earlier. The second type of upstream flood has a short duration, all of which are unimodal floods with small peak, but the peak appears late.

(3) The main source of interval flood is rainstorm flood from Panzhihua Station to Pingshan Station in the lower reaches of Jinshajiang River. Among them, the first type has larger peak discharge, longer flood duration and earlier main peak.

(4) The main sources of tributary floods are tributaries of Jinshajiang River: Minjiang River and Jialingjiang River. The main characteristics of the first and second categories are basically the same, with the characteristics of large flood peak discharge, large number of flood peaks, long duration, etc. The only difference is that the main peak of the second type of tributary flood appears later, which is more unfavorable for flood control and dispatching.

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