Analysis on annual rainfall's cycle and trend of Caoejiang sluice

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Abstract. Caoe River sluice project is located at the Caoe River Estuary on the South Bank of Jianshan River Bay of Qiantang River. The project has comprehensive utilization of moisture-proof (flood), waterlogging control, water resources development and utilization, as well as improving water environment and shipping. The completion of the Cao'e River Sluice Project has improved the flood control capacity of the main stream of the Cao'e River (below the Shangpu sluice), the drainage capacity of the plain of the Cao'e River Basin, and the navigation guarantee rate of the Hangzhou Ningbo canal and the Cao'e River section of the Hangzhou Ningbo canal. The regulation of Cao'e River sluice has an important impact on the above functions. The regulation of Cao'e River Sluice depends on the accurate analysis of rainfall. Therefore, this paper analyzes the rainfall in the area where the Cao'e River sluice is located, and finds that it has a long period of 34 years and a small period of 20 years, and will be in a dry period in the next few years.

1. Brief introduction of Cao'e River Sluice

Caoe River sluice project[1] is located at the Caoe River Estuary on the South Bank of Jianshan River Bay of Qiantang River. The project has moisture-proof (flood), waterlogging control, water resources development and utilization, taking into account the improvement of water environment and shipping. It is a key project in the comprehensive planning of Caoe River Basin and the regulation planning of Jianshan River section of Qiantang River Estuary. It is also the water distribution hub of East Zhejiang water diversion project[2]. The main civil works of Cao'e River Sluice was started on December 30, 2005, officially lowered to store water on December 18, 2008, and passed the completion acceptance on May 27, 2011. Caoejiang sluice is a large (1) water conservancy project with a catchment area of 6080km2. The pivotal project is composed of tide retaining sluice, dam blocking, fishway and diversion dike. The project grade is grade I. The tide retaining sluice has a total width of 697m, a total net width of 560m, a total of 28 holes, and a single hole net width of 20m. The normal pool level of upstream river channel is 3.9m, the low water level of diversion is 3.3m, the normal storage capacity after scouring and silting balance is 146 million m3, and the regulation storage capacity of water level from 3.3m to 3.9m is 23.4 million m3.

The completion of the Caoe River Sluice Project has completely eliminated the storm surge disaster in the estuary of the Caoe River and improved the flood control capacity of the main stream of the Caoe River (below the Shangpu sluice). The completion of the Caoe River Sluice Project fundamentally prevented the serious deterioration of the drainage conditions of the plain due to the serious siltation of the Caoe River Estuary, and improved the drainage capacity of the plain. The construction of Cao'e River sluice has greatly improved the navigation guarantee rate of Hangzhou Ningbo canal and Cao'e River section of Hangzhou Ningbo canal, and the economic benefits are remarkable. It can be seen that the Cao'e River sluice has played an important role in flood control and water resources utilization in the Cao'e River Basin. The operation of Cao'e River sluice is affected by the upstream flood. Accurate flood forecast is the basis of Cao'e River regulation. This paper analyzes the rainfall data in the area where the Cao'e River sluice is located, and forecasts the rainfall, in order to provide reference for the regulation of Cao'e River.

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Table 1 Brief introduction of Cao'e River Sluice Project

Serial number and name	unit	quantity	remarks
1. Tide retaining sluice			
form			Breast wall type
Foundation lithology			Sandy silt
Basic treatment method			C80 prestressed concrete pipe pile
Number of sluice holes	hole count	28	
Clear width of single hole	m	20	
Gate floor elevation	m	-0.5	
Gate top elevation	m	12.9	
Unit width flow	m3/s/m	19.7	
Energy dissipation mode			Underflow type
Stilling basin depth	m	1.6	
Stilling basin length	m	35.5	
2. Dam blocking			
form			Earth rock mixed dam
Foundation lithology			Sandy silt
Basic treatment method			Vibroflotation encryption
Dam crest elevation	m	11.5	The top elevation of wave wall is 12.0m
Dam height	m	21.5	
Dam length	m	574	
Dam crest width	m	11	
Dam slope		01:03.0	
3. Fishway			
form			U-groove spacer plate
number	number	2	
length	m	507.17	
		450.67	
width	m	2	Clear width in groove
4. Upstream (downstream) guide dike			
form			earth dam
Foundation lithology			Sandy silt
Dam crest elevation	m	9.7(11.5)	
Dam length	m	350(160)	Upstream (downstream)
Dam slope		01:03.0	
5. Toe protection of flood control embankment on the river gate			
Engineering form			Riprap, sheet pile and other protection
Processing length	km	30.014	

2.River Basin overview

Cao'e River sluice project is built at the mouth of Cao'e River. Cao'e River is one of the main tributaries of Qiantang River. The mainstream Chengtan river originates from chengtangping, Shanghu Town, Pan'an County, flows through Xinchang, Shengzhou and Shangyu counties (cities) from south to north, and flows into the estuary of Qiantang River 15km downstream of xinsanjiang gate. Caoe River basin covers an area of 6080km2. The upstream of Cao'e River is a mountain stream, and the tidal reach is below dongshabu. The river width gradually widens from 200m to 300m, and the river width reaches 1.2km to 1.6km below the new Sanjiang gate in Shaoxing.

The terrain of Cao'e River Basin tilts from south to north. Above Cao'e is surrounded by mountains on three sides (Siming mountains in the East, Tiantai mountains in the South and Kuaiji mountains in the West), a river valley basin in the middle and Hangzhou Bay in the north. The hilly area accounts for about 2 / 3, and the hilly plain and coastal plain account for 1 / 3.

3. Meteorology

Cao'e River Basin and Shaoxing plain belong to subtropical monsoon climate area, with significant alternation of winter and summer monsoon, moderate annual temperature, four distinct seasons, abundant rainfall, sufficient sunshine, and annual precipitation of 1200 ~ 1800mm. The surface fluctuation and variation in the region are large, and the vertical climate difference is obvious, which has typical basin climate characteristics. The temporal and spatial distribution of precipitation is uneven, which not only changes greatly between years, but also has significant differences within a year. In late spring and early summer, due to the gradual strengthening of the Pacific subtropical high, it intersected with the cold air from the north to the south, and the static front lingered, forming a continuous rainy weather, which is called the plum flood season. Summer and autumn are controlled by the Pacific subtropical high. Tropical storms or typhoons are frequent, and heavy rainstorms often occur. Typhoon rainstorm is the main factor in the formation of large floods in the basin, which is commonly known as the Taiwan flood season. It is called non flood season from late October to next April. Except for a few rainy and snowy weather, it is mainly sunny, cold and dry weather.

Shaoxing meteorological station (30km away from the gate site) is set near the Cao'e River Gate, and the accuracy of various observation data is reliable. The multi-year average temperature of the station is 16.5 ℃, the extreme maximum temperature is 39.5 ℃, the extreme minimum temperature is - 10.1 ℃, the average water vapor pressure is 17.2hpa, the average relative humidity is 81%, the average water surface evaporation is 1136mm, and the average wind speed is 2.1m/s.

4. Rainfall data selection

There are many rainfall stations in Cao'e River area, with uniform distribution and good rainfall data conditions. According to the distribution of rainfall stations, Tyson multi deformation method is used to calculate the rainfall in the area where the Cao'e River sluice is located.

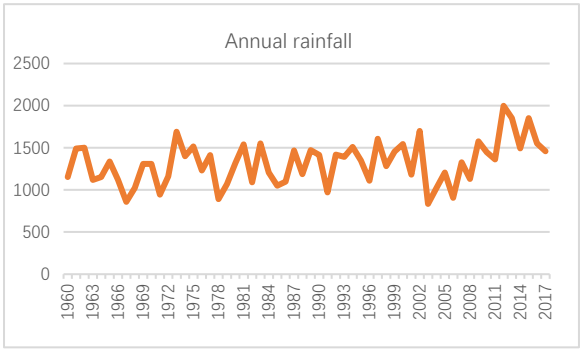

Figure 1. Rainfall trend analysis chart

5. Rainfall analysis

This time, we mainly analyze the cycle and trend of annual rainfall in the area where the Cao'e River sluice is located. The multi-resolution analysis function of wavelet analysis is used to analyze the implied change cycle of rainfall data and the trend under each cycle, so as to provide a reference basis for the dispatching of Cao'e River sluice. Referring to relevant literature, DB4 wavelet function is selected as wavelet decomposition function[3-4]. After the experiment, 1-layer wavelet decomposition is adopted. The exploded view is as follows.

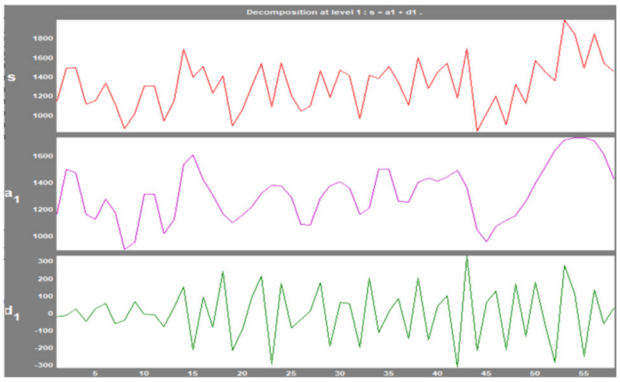

Figure 2. Wavelet decomposition diagram

6. Rainfall cycle analysis

Using the multi-resolution analysis method of wavelet analysis and the Mexican Hat wavelet function, the rainfall data are decomposed by continuous wavelet, and the modulus square and variance of the coefficients after continuous decomposition are obtained[5]. From their diagrams, it can be seen that the rainfall has a large period of 34 years and a small period of 20 years.

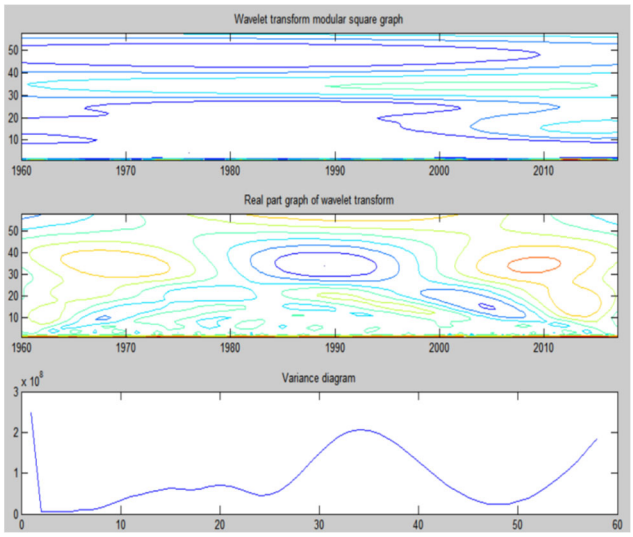

Figure 3. Wavelet continuous transform diagram.

From the trend of A1, we can see that the rainfall will tend to decrease in the next few years. The small cycle diagram of 20 years is shown in the figure below:

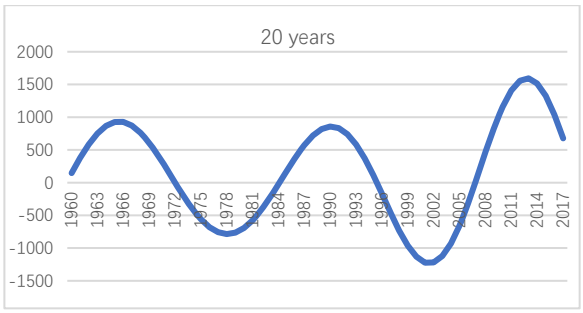

Figure 4. Small cycle change in 20 years

As can be seen from the figure, the rainfall in the next few years will be in a period of low.

The large cycle change of 34 years is shown in the figure below:

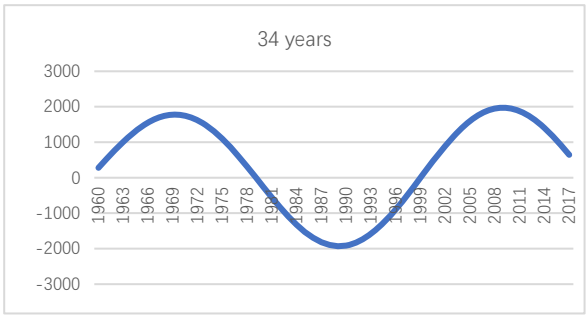

Figure 5. Big cycle change in 34 years

As can be seen from the figure, the rainfall in the next few years will be in a period of low.

6. Conclusion

This paper analyzes the annual rainfall in the area where the Cao'e River sluice is located. It is found that when one layer of wavelet decomposition is carried out, the trend

map of rainfall can be obtained. It can be seen from the first layer of wavelet decomposition that the area where the Cao'e River sluice is located will be in a dry period in the next few years. In addition, the continuous wavelet transform is also used to analyze the rainfall data. It is found that the rainfall data has a large period of 34 years and a small period of 20 years. Under the trend of large period of 34 years and small period of 20 years, the rainfall is in a dry period. It is suggested that during the operation of Cao'e River Sluice in the next few years, attention should be paid to the influence of dry rainfall.

References

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