ELSEVIER
Available online at www.sciencedirect.com
SciVerse ScienceDirect
Procedia Engineering 28 (2012) 688 – 695
Procedia Engineering
www.elsevier.com/locate/procedia

2012 International Conference on Modern Hydraulic Engineering

Preliminary Analysis of Precipitation Runoff Features in the Jinsha River Basin

SONG Meng-Bo, LI Tai-Xing, CHEN Ji-qin, a*

Changjiang Engineering Vocational College, Wuhan,430212, China

Abstract

The present paper analyzed the precipitation features of the Jinsha River by studying the data collected from 1964 to 1990 in the 14 precipitation stations of the upper and lower reaches. The result showed that the precipitation distribution in the area was rather uneven, with the main intra-annual distribution happening from June to September in small variation. Then, the annual runoff data collected in the four control stations of the main tributary were used for feature analysis. The result showed that the intra-annual runoff distribution in the area is not uneven, with obvious wet and dry periods and light inter-annual variation.

Keywords: Jinshajiang Basin; rainfall runoff; annual distribution; specificity analysis

1. Introduction

The Jinsha River Basin is located in the Qinghai-Tibet Plateau and North Yunnan Plateau. In ancient times the River was called the Sheng River and Li River while Tibetans called it the Bulei River or Buliechu River [1]. The part above the Yalong River Estuary was further named the Yan River while the part below the Lu River. Jinsha River has obtained its current name since the Yuan Dynasty. It is said that the River is named so either because the river sand is yellow in color or because it abounds in alluvial gold. The Jinsha River is a section of the main stream in the upper reaches of the Yangtze River. With a total length of about 2290 kilometers and accounting for 2/3 of the main stream, the River starts from the Batang River Estuary in Qinghai Province and ends in the Minjiang River Estuary in Sichuan Province, flowing through Qinghai, Tibet, Sichuan and Yunnan Provinces. The upper reaches of the River start

* Corresponding author. SONG Meng-Bo,Tel.: +086-27-87933301
E-mail address:cgysmb@sina.com

 doi:10.1016/j.proeng.2012.01.792

from the Batang River Estuary in Qinghai Province and ends in Lijiang County of Yunnan Province. It has a length of about 965km, a fall of 1720m and an average sloping of 1.78%. The middle reaches start from Xinshi Town to the Minjiang River Estuary of Yibin City, with a length of 106km and an average sloping of 0.4%.

The geographic location of the Jinsha River Basin is between 90°～105° east longitude and 24°～36° northern latitude. The northern part extends to the Bayan Har Mountain and the upper reaches of the Yellow River, the eastern part borders on the Big Snow Mountain and Dadu River, the southern part borders on the Wumeng Mountain, and the western part stretches to Ningjin Mountain and the Lancang River. With a total drainage area of 500,000km^2, the Jinsha River Basin has a rather complex terrain, where many high mountains and deep gullies stand along with each other, and the elevation difference of peak valleys can reach 1000～3000m. Therefore, the climate in the river basin is not only greatly variable in space-time, but also extremely obvious in vertical difference. The situation of atmospheric circulation in the area is heavily affected by airflows of the westerly zone in the winter half year (i.e., from October to next May in the northern section of the Hengduan Mountains and from November to next April in other areas), divided into the south and north rapid airflows by the Qinghai-Tibet Plateau. The south airflows move through the Yunnan-Guizhou Plateau and bring about the clear and dry continental climate. However, the northeastern part of the river basin, due to the influence of the stationary front and southwest airflows, is quite damp and rainy. In the summer half year, (i.e., from June to September or May to October), the westerly belt retreats northwards and is affected by the maritime southwest monsoon and southeast monsoon, thus giving rise to abundant precipitation, which gradually decreases from the southeast to the northwest of the river basin.

2. Analysis of Precipitation Features

2.1. Spatial Distribution of Precipitation

The general precipitation distribution in the Jinsha River Basin gradually increases from the northwest to the southeast. The Chumaer River Bank close to the source of Jinsha River has an annual precipitation of 239mm whilst the exiting Yibin Station 1154.9mm. Due to the variations in landform, topography and weather systems, the precipitation is characterized by large differences across regions, obvious topographical influences and uneven annual distribution. From the Average Annual Precipitation Figure (omitted), it can be observed that the middle and upper reaches of the Jinsha River account for an area of 300,000km^2, where the annual precipitation mean value is below 800mm, and the dry areas below 200mm occupy an area of about 70,000km^2, an area with least precipitation in the Yangtze River Basin. According to the precipitation, the zonality is classified as follows: in the upper reaches of the Jinsha River, an area of about 70,000km^2 with a precipitation below 400mm belongs to the semiarid zone, a small number of areas below 400 to 800mm in precipitation belongs to the sub-humid zone, and the rest areas with a precipitation of 800 to 1600mm the humid zone.

The Gangtuo Main Stream and Yalong River north of Ganzi is located on the Qinghai-Tibet Plateau, with a high terrain and small precipitation. The average annual precipitation is 240～550mm, which makes the area an area with least precipitation in the Water Basin and even in the Yangtze River Basin. The area from south Gangtuo to Benzilan and from south Ganzi to Wali has an average annual precipitation of 350～750mm. The area under Benzilan and Wali takes on 5 high-vale zones and 4 low-value zones in precipitation. The first high-value zone starts from the area below Dechang of the Anning River, Renli, Dahe and Yuejin of the Yalong River, and Jinmian of the Jinsha River up to the left bank area of the Yalong River Estuary. The second high-value zone located in the upper reaches of the Zhaojue River and Bier River along the upper reaches of the Anning River, with the center located close to

Tuanjie. The third high-value zone is located below Leibo and Yongshan of the Jinsha River. The fourth high-value zone is situated above Luquan of the Pudu River and along the east neighboring area. The fifth high-value zone refers to the Yili River Basin. The four low-value zones are the area around the Sangyuan River Basin, that around Yuanmou and Duoke of the Longchuan River, the area from Qiaojia to Dongchuan, and the one around Zhaotong and Jingkoutang near the Wulian Mountain.

2.2. Time Distribution of Precipitation

In order to ease the analysis, the paper divides the research area into 2 regions; i.e., the upper reaches (above the Yalong River Estuary) and the lower reaches of the Jinsha River.

2.2.1. Intra-annual Precipitation Distribution

Table 1 is a summary of the average monthly precipitation distribution of the divided regions in the Jinsha River from 1964 to 1990. The annual precipitation of the upper reaches in the Jinsha River is relatively large, with an average annual precipitation of 976.6mm whilst that of the lower reaches is relatively small, with an average annual precipitation of 940.1mm. As can be observed in Figure 1, the average monthly precipitation of the upper and lower reaches in the Jinsha River is in a normal distribution around the year, with the annual precipitation mainly concentrated on May to September. The precipitation of the flood season and June, July, August and September accounts for 78.2% and 70.5% of the annual precipitation respectively. In addition, the monthly precipitation all reaches over 128mm, with July obtaining the biggest amount, before and after which the precipitation decrease gradually. The average monthly precipitation of January, February and December is relatively small, with a month value below 15mm.

Table 1. The average monthly precipitation distribution of the divided regions in the Jinsha River from 1964 to 1990

Month	The upper		The lower	
	average monthly prep(mm)	Percentage (%)	average monthly prep (mm)	Percentage (%)
1	4.9	0.50	11.8	1.25
2	5.5	0.56	11.7	1.24
3	10.1	1.03	17.9	1.91
4	24.3	2.49	36.5	3.88
5	75.5	7.73	89.7	9.54
6	182.7	18.71	168.9	17.97
7	216.3	22.15	185.4	19.72
8	193	19.76	180.5	19.2
9	171.5	17.56	128.3	13.65
10	69	7.07	67.1	7.14
11	17.6	1.80	29.2	3.11
12	6.2	0.64	13.1	1.39
Sum	976．6	100	940.1	100

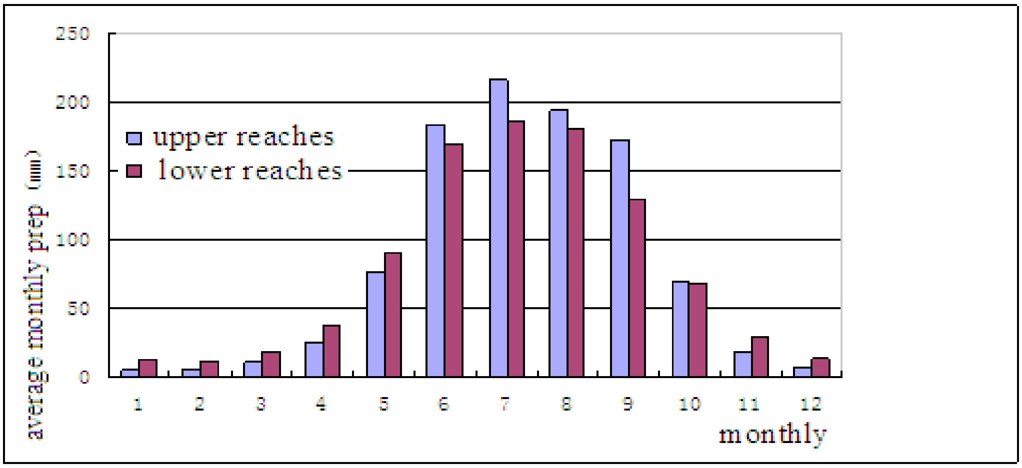

Figure 1. The average annual precipitation distribution in the Jinsha River from 1964 to 1990

2.2.2. Inter-annual Precipitation Variation

2.2.2.1. Inter-annual Variation of Annual Precipitation

Figure 2 presents the average annual precipitation variation in the Jinsha River Basin. During the 27 years, the annual precipitation basically varies from 800 to 1100mm. Only in a few years (e.g., 1968) is this range surpassed with little annual variation and stable annual precipitation.

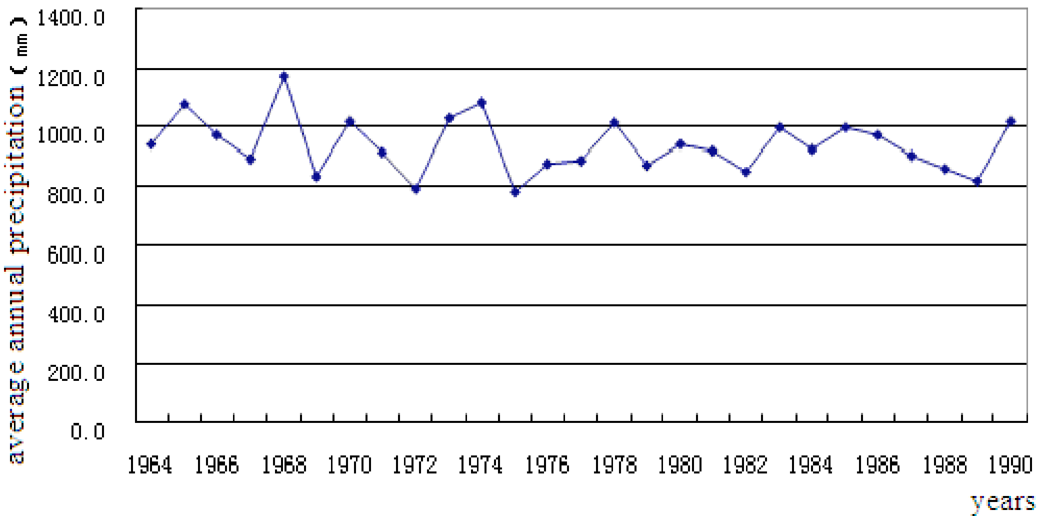

Figure 2. The change of average annual precipitation between divided regions in the Jinsha River from 1964 to 1990

2.2.2.2. Inter-annual Variation of Monthly Precipitation

The analysis of the inter-annual variation of average monthly precipitation in September, October and November displays that the precipitation of September varies from 100 to 180mm, and the monthly precipitation narrowed down and the variation was smaller from 1970 to 1980. The precipitation of

October varies from 35 to 120mm, and the above similar situation occurred again from 1968 to 1978. The precipitation of November varies from 7 to 52mm. As a whole, the monthly precipitation fluctuation is comparatively large (Figure 3).

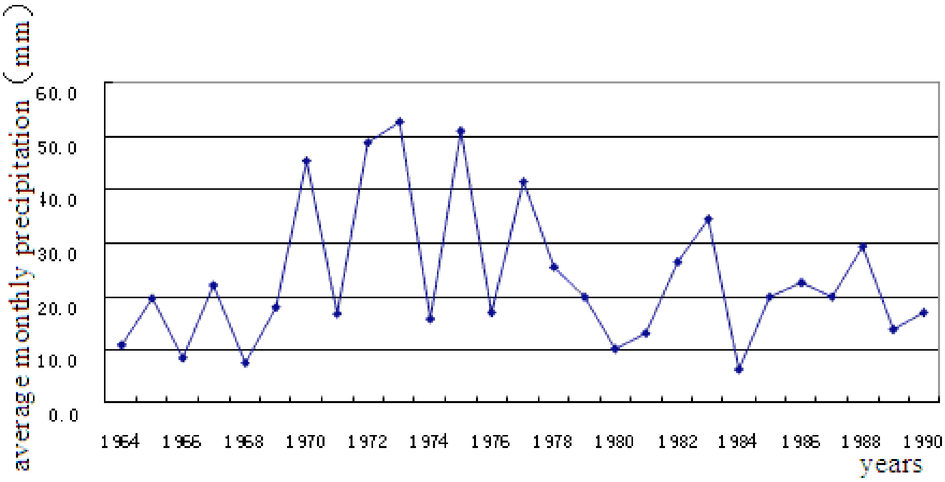

Figure 3 The change of average November precipitation between divided regions in the Jinsha River from 1964 to 1990

3. Analysis of Runoff Features

3.1. Composition of Runoff Areas

3.1.1. Distribution of Runoff Regions

Since the Jinsha River Basin is wide in area with many tributaries, the river runoff is quite rich and stable, with the average annual runoff reaching 149.8 billion m^3 (the Yibin Station). The mountain land runoff on both sides of the lower reaches is as deep as 500～900 mm, especially in the area of Daliang Mountain, where the annual runoff reaches 1200～1400mm in depth. The middle and upper reaches belong to an area of high mountains and deep valleys, where the vertical distribution of precipitation and runoff is distinct. The annual runoff in the mountains on both banks is 400～700mm in depth, among which the Big Snow Mountain and Xiaoxiang Range have a runoff reaching 800～1800mm in depth. However, in the river valleys, the depth of annual runoff is only 200～400mm, among which the sections from Baiyu to Tacheng and from Jinjiang Street to Long Street have the smallest runoff depth, only about 150～200mm.

3.1.2. Composition of Runoff Regions

The upper reaches of the Jinsha River Basin is located on the Qinghai-Tibet Plateau, where the precipitation is scarce and the water yield per unit area is relatively small. Due to the increasing influence of river directions on precipitation, the increase rate of annual runoff is larger than that of catchment areas[2,3].

Table 2 presents the composition of annual runoff area above Pinshan of the Jinsha River, where the upper reaches have a relatively small annual precipitation, and the annual runoff proportion in the Pinshan Station is lower than the area ratio. However, since the subsurface runoff and snowmelt runoff of the high plateau provide a sufficient amount, the annual runoff still accounts for about 30% of the Pinshan Station. The catchment area from Shigu to Panzhihua takes up 9.8% of the area of the Pinshan Station, and the runoff 10.8%, which is a bit larger than the occupied area ratio. The Yalong River Basin is a rainy area, where, although the catchment area accounts for only 25.8% of the Pinshan Station, the runoff proportion takes up 34.6% of the Pinshan Station. The area from Xiaodeshi to Pinshan accounts for 17.7% of the Pinshan Station, and the runoff 25.7%, which is larger than the area ratio.

As is displayed in the table, the water yields per unit area of all main stream control stations above the Pinshan Main Stream Station of the Jinsha River are all smaller than that of the Xiaodeshi Tributary Station of the Yalong River.

Table 2. The composition of annual runoff area above Pinshan of the Jinsha River

River	Station	Area		Annual runoff	
		Area(10^4km^2)	Percentage (%)	Runoff(10^8m^3)	Percentage (%)
Jinsha river	Shigu	21.42	46.7	424	28.9
Jinsha river	Shipan	4.5	9.8	159	10.8
Yalong river	Xiaodeshi	11.83	25.8	509	34.6
Jinsha river	Panxiaoping	8.11	17.7	376	25.7
Jinsha river	Pinshan	45.86	100	1468	100

3.2. Intra- and Inter-annual Runoff Variation

3.2.1. Intra-annual Runoff Distribution

Table 3. the intra-annual runoff distribution for control stations of main streams in the Jinsha River (unit: 10^8m^3) (percentage: %)

Station	Project	Jan	Feb	Mar	Apr	May	Jun	Jy	Auq	Sep	Oct	Nov	Dec	Year
Xiaodeshi	Runoff	13.9	11.2	11.8	13.7	21.7	50.9	95.7	91.6	90.7	59.5	28.9	18.9	509
	%	2.73	2.21	2.31	2.69	4.27	10.0	18.8	18.0	17.8	11.7	5.70	3.71	100
Shigu	Runoff	11.8	9.9	11.1	14.4	23.7	41.8	75.9	82.3	71.5	44.1	22.6	15.0	424
	%	2.79	2.33	2.62	3.40	5.59	9.86	17.89	19.41	16.85	10.39	5.34	3.53	100
Panzhihua	Runoff	16.9	13.6	14.7	17.9	28.7	51.2	101	118	104	63.0	32.3	21.7	583
	%	2.90	2.34	2.52	3.08	4.92	8.79	17.4	20.2	17.8	10.8	5.53	3.72	100
Pinshan	Runoff	44.5	34.8	36.0	39.9	62.3	131	257	278	258	177	89.9	58.6	1468
	%	3.03	2.37	2.45	2.71	4.24	8.95	17.5	19.0	17.6	12.1	6.12	3.99	100

The runoff source of the river basins above the Pingshan Station mainly comes from precipitation. Although the river source area of the Yangtze River has runoff supply by snow melts and glaciers, their contribution only accounts for a small proportion. Similar to the precipitation distribution, the intra-annual runoff distribution in various areas of the Jinsha River Basin is not even[4]. Table 3 and 4 present the intra-annual runoff distribution for control stations of main and tributary streams of the Jinsha River. It can be observed from the tables that the intra-annual runoff is mainly concentrated in the flood seasons. The three months with largest runoff in the Xiaodeshi, Panzhihua and Pingshan Stations all correspond to July, August and September, in which the runoff accounts for 55% of the annual one. The four, five and six months with largest runoff occur from July to October, June to October, and June to November (except for the Shigu Station, where the months are from May to October), respectively. The runoff of the six months accounts for over 80% of the annual runoff in all stations.

Table 4. The intra-annual runoff distribution character for control stations of main streams in the Jinsha River (Percentage: %)

Station	The max 3-month	(%)	The max 4-month	(%)	The max 5-month	(%)	The max 6-month	(%)
Xiaodeshi	7-9	54.7	7-10	66.4	6-10	76.4	6-11	82.1
Shigu	7-9	54.1	7-10	64.5	6-10	74.4	5-10	80.0
Panzhih	7-9	55.4	7-10	66.2	6-10	75	6-11	80.5
Pinshan	7-9	54.2	7-10	66.1	6-10	75.2	6-11	81.3

3.2.2. Inter-annual Runoff Variation

The inter-annual runoff variation of the Jinsha River is not large, where that of the upper reaches is a bit larger than that of the middle and lower reaches. The extreme value ratio of the maximal annual runoff against the minimal one in the Zhimenda Station of the upper reaches is 3.3. The Shigu Station of the middle reaches has a maximal annual runoff of 54.6 billion m^3 (in 1998) and a minimal one of 29.4 billion m^3 (in 1994), with the extreme value ratio being 1.9. The Panzhihua Station has a maximal annual runoff of 76.4 billion m^3 (in 1998) and a minimal one of 38.5 billion m^3 (in 1994), with the extreme value ratio being 2.0. The Pinshan Station of the lower reaches has a maximal annual runoff of 202.6 billion (in 1998) and a minimal one of 108.8 billion m^3 (in 2006), with the extreme value ratio being 1.9.

The Cv value of the annual runoff in all main stream stations of the Jinsha River tends to be stabilized as the catchment area increases. The Cv value of the Zhimenda Station in the upper reaches is 0.30, which gradually decreases below the Zhimenda Station and to 0.18 in the Shigu Station of the middle reaches. The Cv values of each station below the Shigu Station are largely about 0.18[5].

According to the runoff of main control stations for main streams and tributaries in the Jinsha River, the average runoff from 1960s t0 1990s and that in the years of the current century were respectively calculated (see Table 5). With the average annual runoff as a benchmark, an assessment was made as to the relatively large or small annual runoff amount of all stations over the time. The relatively large runoff alternated with the small one in each station over the time. Generally speaking, the runoff in the stations during the 1950s and 1960s was larger while that in the 1970s and 1980s smaller. In the 1990s, the runoff of the Panzhihua Station was relatively small whilst that of the other stations relatively large. After 2000, the runoff in all stations was all comparatively large.

Table 5. The runoff different of main control stations for main streams and tributaries in the Jinsha River (unit: $10^8 m^3$)

Station	The 1950s	The 1960s	The 1970s	The 1980s	The 1990s	The 2000s	Average
Xiaodeshi		528	466	502	536		509
Shigu	423	437	389	420	428	445	424
Panzhihua	578	610	533	565	580	630	583
Pinshan	1482	1519	1352	1417	1523	1514	1468

4. Conclusion

Via the collection and analysis of the precipitation and runoff data for main streams and tributaries of the Jinsha River Basin, the following conclusions were reached:

(1) The average annual precipitation of the Jinsha River Basin is about 960mm, which is rather unevenly, intra-annually distributed and takes on a normal distribution around the year. The inter-annual variation is not large. The distribution across areas is rather uneven, with the minimal value being about 200mm whilst the maximal one reaching over 1400mm.

(2) The annual runoff data of the Jinsha River Basin show that the intra-annual distribution is not even, with obvious wet and dry periods. The inter-annual variation is not big and runoff depth distribution in areas is not even. Generally speaking, the runoff depth in the south bank is larger than the north bank that in the lower reaches larger than the upper reaches and that in the mountains larger than the valleys.

(3) The runoff distribution trend is basically similar to the precipitation trend. In the flood season from June to September, the precipitation accounts for 70% of the annual amount. And the precipitation from June to October takes up 70% of the annual amount. The Cv values of annual runoff in all main stream stations of the Jinsha River tend stable as the catchment area increases, and the values are largely stabilized at around 0.18.

(4) Due to the incomplete data of early periods in some stations of the Jinsha River, some simple methods had to be employed for interpolation treatment, hence affecting the precision of the result to some extent.

References

[1] The Changjiang record: river system, Encyclopedia of China Publishing House, 2003, 1

[2] Tang qi-cheng, Cheng Tian-wen,Li. Preliminary study on the degree and time ofconcentration of monthly runoff ofchinese streams[J].Acta Geographica Sinica, 1982, 37 (4)

[3] Wang Ji-xing, Zhang Jian-yun, Li Yan. Variation trends of runoffs seasonal distribution of the six larger basins in China over the past 50 years. Advances in Water Science, 2008, 19 (5)

[4] Wang Yan-Jun, Jiang Tong, Shi Ya-feng. Changing Trends of Climate and Runoff over the Upper Reaches of the Yangtze River in 1961-2000[J].2005, 27 (5)

[5] Wang Miao-lin, The runoff trend in the upper of Changjiang River. Changjiang net