Preliminary Research on the Response of Regimen to Climate Changes in Tibet Plateau

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Abstract:

This article talks about the long- term series of temperature, precipitation, lakes, and river runoff according to observation materials. The results show: the temperature increases and the increasing range in winter (October-March) is more than in Summer (June- September) ; the water level of inland lakes descends; the precipitation and river runoff change according to regions and they usually decrease in both northwest of Tibet and inside Tibet.

Keywords: Tibet Plateau, temperature, water level of lakes, runoff

1. The Besic Characteristic of Hydrology

Tibet Plateau, with an area of about 1,200,000km^{2}and an average elevation of over 4,500m, is the main part of Qingzang Plateau, many important rivers such as the Yangtze River, Nujiang River, Salween River, Lancang River-Mekong River, Yarlung Zangbo River -Brahmaputra River, Indian River and Irrawaddy River all originate from or pass Tibet(Fig.1).

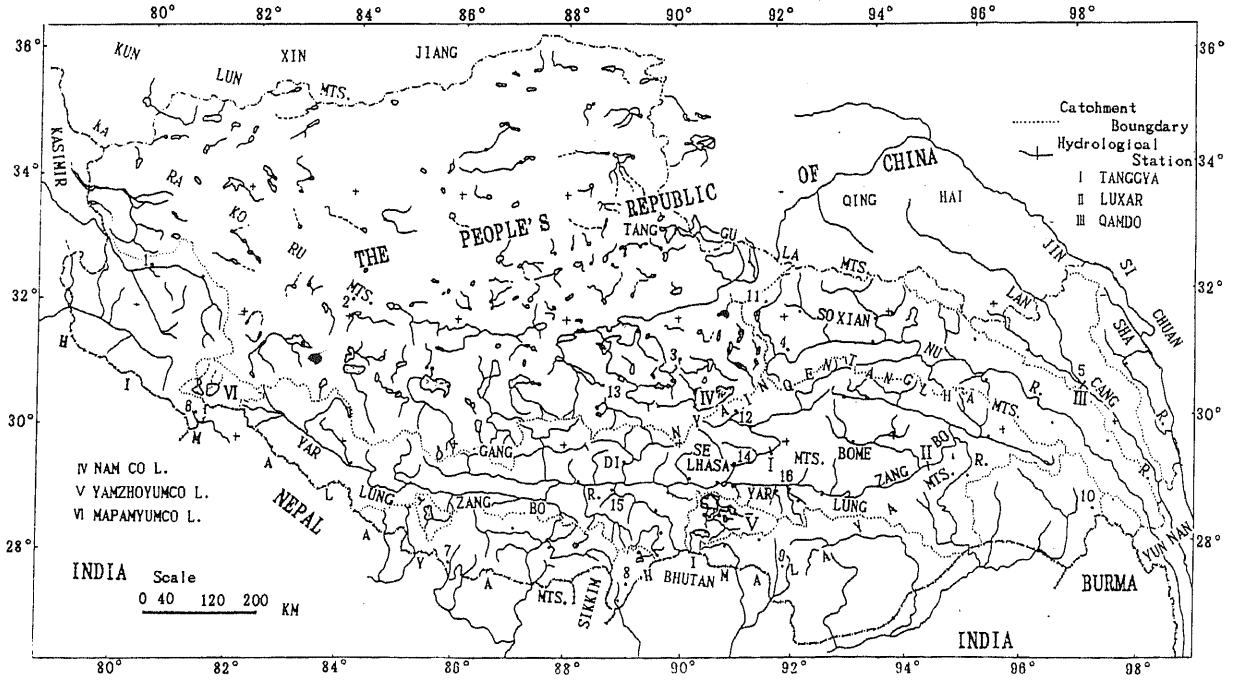

Fig. 1 The Water System in Tibet Plateau

There are more than 20 rivers with drainage area of more than 10, 000km^2 within the boundaries, including the longest one-Yarlung Zangbo River, which is 2,229km's long. It's estimated that the river runoff in Tibet Plateau is 448.2 billion m^3, The waterpower resource reserves in terms of cheory are morn than 0.2 billion kilowatt, and a hundred million kilowatt with able to open up the resources, which is one of the most plentiful province in the water reseurces and waterpower reseurces in the whole country.

The lakes on Tibet Plateau scatter all over like stars in the sky or men on a chessboard, whose area is about 1/3 of the total lake areas in China, among which there are seven lakes,each has an area of more than 500km ^{2}, and three lakes each has an area of more than 1,000km^2. Namco lake, with an area of 1,960km^2, has the highest elevation in the world. 98 percent of the lakes are inland lakes, while the outflow lakes are dotted over the outflow rivers in south Tibet and southeast Tibet and the areas are very small. Most of the inland lakes are saltwater lake. in a few freshwater lakes of the plateau, Mapam Yumco lake, with an elevation of 4,588m,is the second big freshwater lake in China.

Glacier in Tibet is 46. 7 % of the total glacier area in China. Nyainqentangcha Mountains is the concentrated distribution region of the marine glacier in China. 1,500 million m^3 glacier melts per year. The famous Qiaqing Glacier, has a length of 35 km and an area of 151.1 km^2. The continental glacier is mainly concentrated in Karakoru Mountains and the north of the Himalayas.The Rongpu Glacier, situated in the north of Mount Qomolangma, is the longest glacier of the region, which has a length of 22.2 km and an area of 86.9 km^2. The water resource of Tibetan glacier is 60% of the total in China and is the main supply to lakes and rivers. The temperature change has direct affect on the melt and growth of glaciers.

2. The Temperature and the Hydrologic Situation of Lakes, Glacier and Rivers

2.1 Temperature Change

Recently, many researches on the temperature of Tibet have been carried on. Dr. Yao, Tandong points out:"Tibet Plateau has an obvious tendency of getting warmer in recent decades.The temperature increases not only obviously higher than other areas, but also than it was. Guliya icecap is the most serious."(Yao)

We agree with Mr. Yao's opinion and further more we have done more research on space-time Change.

Temperature is not only a very important factor of climate, but also a main index that reflects the material balance of glacier.

According to observing temperature data at about 30 stations, 10 - year running average temperature was calculated at the typical stations selected(Table 1).

Table 1. Table for Timely Average Temperature Divergence of Typical Stations

District	Station		T Divergence(℃)	
	No.	Name	ΔT_1	ΔT_2
From west to east along the line of 32° north latitude	1	Shiquanhe	-0.2	0.3
	2	Gerze		-0.1
	3	Pangkog	0.4	0.4
	4	Nagqu	0.7	0.3
	5	Qamdo	0.1	0.1
From north-west to south-east along Himalayas	1	Shiquanhe	-0.2	0.3
	6	Burang		-0.1
	7	Nylam	0.1	-0.1
	8	Pagri	0.5	-0.1
	9	Conag	0.2	0.0
	10	Zayu	0.3	0.0
From north to south along the line of 91°、89° east longitude	11	Amdo	0.4	0.1
	12	Damxung	0.6	0.2
	13	Xainza	0.4	0.2
	14	Lhasa	0.5	0.3
	15	Xigaze	0.3	0.2
	16	Zetang	0.1	0.5
	8	Pagri	0.5	-0.1

Table 1 shows that not only from west to east, or from north to south in the Plateau,but also along the foot of the Himalayas,the temperature has a increasing tendency. The range of temperature increase differs with the place. The increasing range per year is between 0.5℃ and 1.0℃ in the hinterlands of plateau, while in the south edge areas of Tibet Plateau along the Himalayas,the increasing range of temperature is lower than that in hinterlands. The temperature was almost not change from 1970 to 1980, some areas decreased.

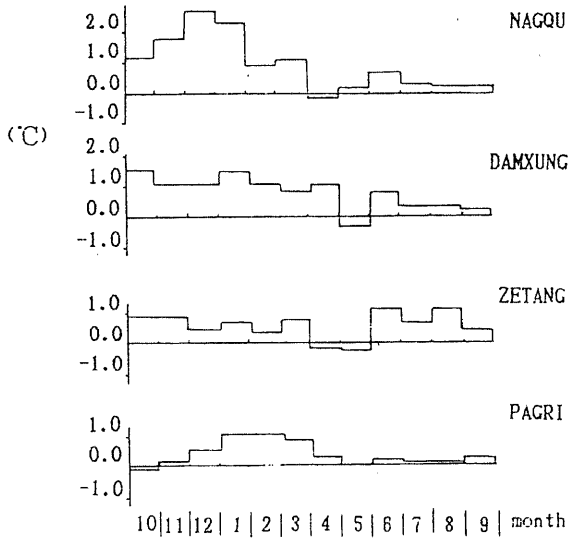

Fig. 2 Monthly Average Temperature Change in the Typical Stations

The increasing range of temperature is different in every month of a year (Figure 2) . The temperature increases mainly from Oct. to the winter (March) of the next year.For example: the average temperature per year in Naqqu increases 1.0℃ while in winter the temperature increases 1.7℃, it increases 0.8℃ and 1.2℃ in Damxung, The increasing range of tempe rature from June to September in summer is less than in winter. In the increasing process of tem perature in summer the highest temperature occurs in June which makes the melting speed of glaciers

to accelerates. Wang.LinglLan points out that "The temperature change in summer has much effect on the increasing or decreasing of zero balance line of glaciers." The Yarlung River, a tributary of the Yarloug Zangbo River,which the source the YilarXangbo Glacier was collapsed in 1995. It was caused by the temperature rapid increases from the middle ten days May to the middle ten days June. It is also found that the average increasing range of temperature per year and per season is different with the distribution of regions. The range is showing an increases tendency from south to north in Tibef.The average increasing range of temperature per year is 0.4℃ in south Pagri, it increases 0. 6 ℃ in winter and less than 1.0℃ in DamXung, but it increases gradually to north, in Nagqu, the temperature increasas to 1.7℃. (Table 1. Figure 2.)

2.2 The Change of Precipitation

All kinds of water supplies in Tibet come from rain fall.The water vapor mainly comes from the warm airflow of the Bay of Bangal of Indian Ocean, which goes to the north and enters hinterlands of plateau by the obstruction of the Himalayas and loses very quickly. Gradient Regions of precipitation form from southeast to northwest and from south to north in plateau. The change of precipitation per year is very small and the distribution is very uneven.Most areas can be divided into dry and wet seasons. The precipitation from June to September each year is 70- 80 % of the precipitation of the whole year, especially in the middle of the Plateau the precipitation is over 90%.

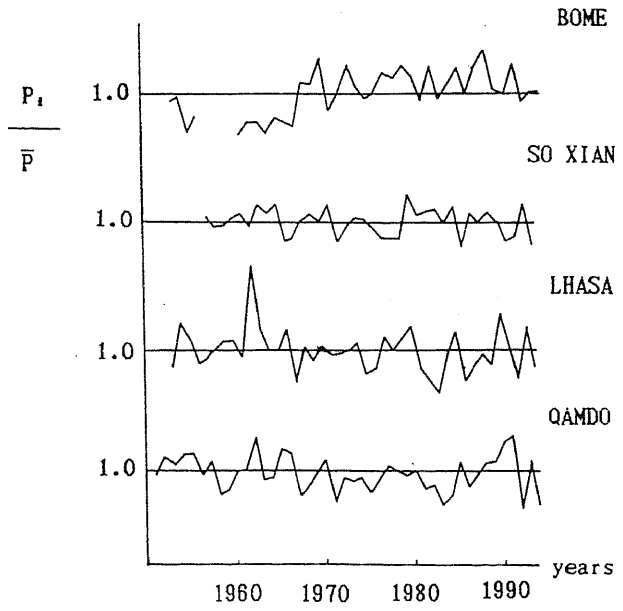

Fig. 3 The Process Line of Yearly Precipitation in the Typical Stations.

In figure 3, the vertical coordinate is designated by $P_i/\bar{P}$,P_i is the yearly precipitation, $\bar{P}$ is the average yearly precipitation of several years. To the southeast of Tibet east to Bome there is a small change in precipitation per year and the variation coefficient of yearly precipitation Cv is below 0.20. The precipitation in the 1960' was below the yearly average, while the precipitation from 70's to 80's increased to above average yearly amount. It seems that there was a little increasing tendency of precipitation: the variation coefficient Cv to the northeastern Tibet along, Sog Xian, is between 0. 20 and 0. 25. The precipitation has been fluctuating around the average of many years since 1950's. The

limterlands of the plateau, Lhasa and Qamdo, the variation coefficient Cv is around 0.30. The yearly precipitation were larger than the average in most years before 1970, while after 1970 the precipitation of almost all the years at those stations was below the average. The precipitaion has been reduced by 3-5% in the recent 40 years. In the northwest of Tibet, precipitation in Shiquanhe is below 200mm and in hinterlands the precipitation is even less than 50mm. The variation coefficient is larger than 0.35. However, this factor was above average in 1970's and below average after 1980's. The precipitation has been reduced by 5% in recent 30 years.

2.3 Hydrologic Situation of Rivers

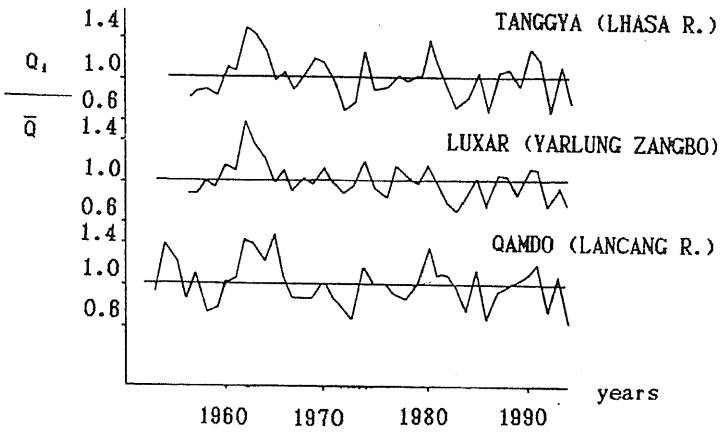

Fig. 4 Flow Amount Process Line of Typical Station in Drainage Area

This article only gives three control stations as an example, including the NuXiar Station in the middle reaches of Yarlung Zangbo River, the chomdo Station in the upper reaches of Lancang River and the Tanggya Station in the lower reaches of Lhasa River. In Fig4. the vertical coordinate flow amount process line is selected as $Qi/\bar{Q}$, Qi is the yearly runoff and $\bar{Q}$ is the yearly average runoff of many years. In order to show the change process of runoff has a decreasing tendency in receut 40 years, it reduced by 3-5% .

There are a lot of reasons which can cause the reduction of river flow amount, among which the climate changes and the human activities are the directest reasons. The drainage areas of the river stations from Fig 4. alomst be situated in the hinterlands of plateau, and the proportion of glacier areas make up quite small in the whole drainage areas. This is one region which the rising of temperature and the reduction of preciption.

The temperation increases and the melting speed of glaciers accelerates caused increasing the river runoff amount far less than the river runoff amount which the temperature increases, the evaporate increases and the condition of give and flow together in the surface is not good caused reducing. First, the reduction of precipition is the main reason, which cause the reduction of river ruaoff . Secoud, the increasing of irrigate water in farmland and pastureland also is a factor not to be ignored.

The Nyang Chu River is one of five tributaries of the YarlungZangbo River. On account of the increasing of irrigate water is the JiangZi, which catchment area is 6,200 km^2 Since 1980's, it happened to cut off the flow intermittently between April to May. The yearly runoff reduced by 20% . Some river sources and small tributaries even more like this.

2.4 The Change of Water Levels of Lakes

The outflow lakes of Tibet Plateau are mainly river's flow-in-and - out lakes, the water levels of lakes change with the water level of Rivers. The change of water levels of some moraine lakes is mainly influenced by the melt of ice and snow: When temperature increases, the melting speed of glaciers accelerates and more melting water flows into these lakes so that the water levels of lakes go up.
Inland lakes are sensitive to the climate change. This article puts much emphasis on the preliminary analysis of water level change of Yamzho Yumco, which is the biggest inland lake in the south of Tibet Plateau.

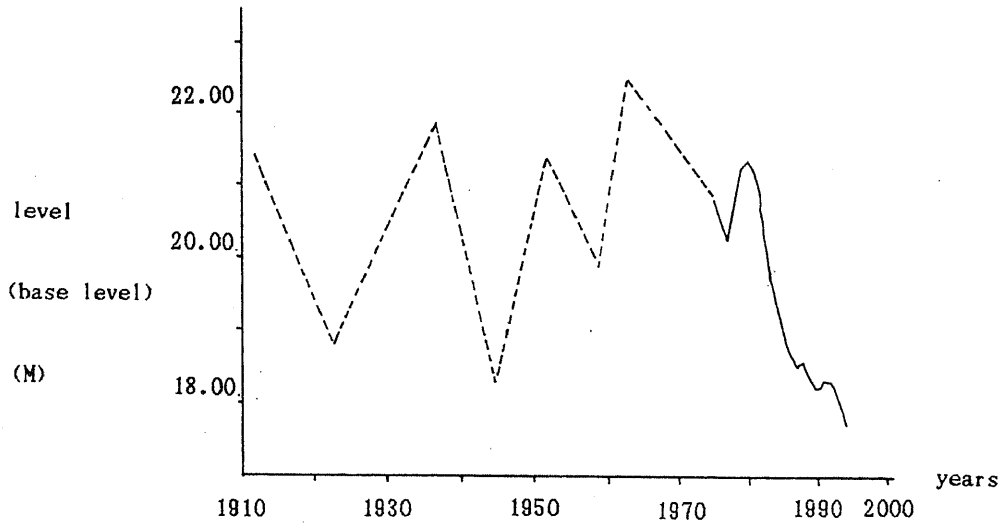

Fig.5 Water Level Process Line of Yamzho Yumco L.

Yamzho Yumco has a drainage area of 6,100km^2, a lake area of 631km^2 and a lake face elevation of 4,438m above the sea level. The precipitation of the drainage area is about 350mm and the average evaporation is 1,250mm. The yearly average temperature is 3.6℃. According to hydrologic record since 1974 and historical hydrologic survey, in recent 100 years the water level change alternates between rising period and falling period, but the whole tendency is descending, especially after 1970's because temperature increases and precipitation reduced, there was not enough water to flow into this lake; while with the influence of human activities from 1980's to 1990's (mainly caused by using lake water to irrigate the farm and pasture land), this problem became more serious. For example, CarLungXung Qu and GarMaLin Qu, which flow into Yamzho Yumco. CarLungXung Qu is the melting of snow and ice (the proportion of glacier

areas make up 20% in the whole drainage areas) ; the yearly runoff charge is stable and the coefficient of modulus of the yearly runoff is 1.56; has no obvious change from the middle of 1970's to the middle of 1990's. The temperature increases, the melting speed of glaciers accelerates and the supply of river runoff increases to make up the decreasing of precipition. Garmalin Qu is no the melting of snow and ice and the influence of human astivities, which the coefficient of modulus of the yearly runoff is 7.72. The cause of draw water from the upper and middle reaches of the drainage to irrigate the pasture land has obvious increase in 1990's, the irrigation seasons (between April to June) per year happened to cut off the flow since 1991. When the Yamzho Yumco has the year of plenty of water in 1995, but Garmalin Qu still has cut off the flow for more than two monthes and the yearly runoff was below the 50% of normal amount.

Most of the inland lakes in plateau are in the period of declination; some which have plenty of water supply (such as the melting of snow and ice) such as Pomo Yumco and saltwater lakes, geren co、Lanlang co all Mapam、Yum co、Bangong co has no obvious change in water level.

3. Remarks and Conclusions

3. 1 The average temperature of Tibet Plateau increases and the increasing range of temperature in winter (Oct.-March) is more than that in Summer (June-September); the increasing amplitude increases from South to North.

3.2 In recent 40 years, the precipitation change increased in different regions in Tibet Plateau has been unbalanced. The precipitation in southeast of Tibet has an increasing tendency and has no obvious change in northeast of Tibet, while it has a decreasing tendency in northwest and center of Tibet Plateau and reduces by 3-5% of the yearly average amount.

3.3 The levels of many inland lakes are descending and the water area is shrinking.The water level of Yamzho Yumco has a descending tendency because of the reduction of precipitation and the influence of human activities.

3.4 The getting warm of climate has changed the environment of the whole world. Almost all the glacier flood and glacier mud- rock flow often occur in Tibet Plateau , which indicates the environmental effects caused by the increasing temperature . Restricted by the observation data and especially lack of long - term field observations, the understanding of this theme is quite preliminary, and needs to be carried on in the future.

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