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THE APPLICABILITY OF RESEARCH ON FLOOD-DROUGHT TENDENCY —AN ANALYSIS ON DISASTROUS FLOOD OF TAIHU LAKE BASIN IN JUNE-JULY, 1991

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ABSTRACT: In Taihu Lake basin during June-July in 1991, there happened a catastrophic flood, the precipitation reached that of 1954 and the water level was the highest in the history in Taihu Lake. This heavy flood, happening in the relatively humid period and being well accord with flood-drought change tendency, was early precautioned. The occurrence of the flood illustrated that using records of historical climate to predict flood-drought tendency is practically significant for hazard-reduction project.

KEY WORDS: Taihu Lake, flood, flood-drought tendency, the Changjiang River

The precipitation in Taihu Lake area was more than the average since early spring in 1991, for example, the precipitation from the 1st of January to the 15th of July in Wujin County reached 1,465mm, 37% more than that of long the term annual average. From mid June to early July, rainstorms occurred frequently, making the average precipitation in the area more than 600mm, that in the west Taihu Lake and the Changjiang(Yangtze) River neighboring area more than 800mm, even 1,000mm, eventually resulting in highest water level in history. The great disastrous flood was early alarmed for its good accordance with the tendency of flood-drought change.

I. HISTORICAL PREDICATION OF DISASTROUS FLOOD IN 1991

There was no lack of precedents of this kind rainstorms in history: In the 40th year of Jiajing, Ming Dynasty (1561 A.D.), it was recorded that "heavy rains dominated for early winter to next summer..." (Ming Dynasty. Water Survey of Wujiang). In the 9th year of Jiaqing, Qing Dynasty (1804 A.D.), with the record that "there were little fine days in spr-

ing and heavy rainstorms continued for 30 days in early summer..." (Guangxu. Chronicle of Changshao. Vol. 47); In the 3rd year of Guangxu, Qing Dynasty(1823 A.D.) with the record that "heavy rainstorms continued from April to June..." (Guangxu. Chronicle of Changxing. Vol. 9); and so on.

In this century, the great floods in 1931, 1954, 1983 in Taihu Lake area were more striking, among which the floods in 1931, 1954 covered the whole Changjiang River area. In July of 1931, heavy rain continued for more than 20 days, in a large area including east part of Guizhou Province, Dongting Lake area, the middle and lower reaches of the Hanjiang River, as well as the middle and lower reaches of the Changjiang River, the rainfall amount reaching 300mm, more than double of that of long-term average. The raining days in the middle and lower reaches of the Changjiang River was more than 25 days with a precipitation more than 400mm. The major raining areas in Taihu Lake basin were in the west part of the lake and South Jiangsu area, among which precipitation in Danyang, Jiangyin and Wujiang counties were the heaviest, 350mm in early July, 250mm in late July making the area the major hazard area.

The plum rain in the middle and lower reaches of the Changjiang River in 1954 came a month earlier, and went a month later than usual, and the raining season in the whole reach was as long as more than 3 months, concentrating in May-July. The average precipitation was 1,229mm in the middle reaches, 1,306mm in the lower reaches, and 901.7mm in Taihu Lake area, of which the major raining areas were in Tianmu mountain area and Hangzhou Bay area.

The flood in 1983 was in the middle and lower reaches of the Changjiang River, and the most severe from late June to mid July. The average precipitation in Taihu Lake basin was 373mm, 155% of long-term average, in which the precipitation in Tianmu mountain was more than 500mm, 182% of long-term average, that in South Jiangsu and the Changjiang River neighboring area was less than 300mm, 117% of long-term average.

The great flood in June-July in 1991 was mainly in the lower reaches of the Changjiang River and Huaihe River. The overprecipitation in the spring of 1991 was followed by frequent rainstorms from mid June to early July. The main disastrous rainstorms took place in the days of June 12 to 15, 1991 and June 31 to July 2, 1991. Raining area covered a vast land, mainly located in vast part of Taihu Lake basin, the Changjiang River neighboring area and Shanghai- Nanjing railway belt. Precipitation intensity was as high as over 300mm in three days (June 30 to July 2, 1991). In some places, Qingyang Town in Jiangyin County for instance, precipitation amounted to 239mm in a single day. According to historical records, excessive precipitation and storm were precedented. In the whole

Taihu basin, rainfall in 1945 can be cited as a comparable example in total amount as well as intensity except that precipitation amount and intensity of 1991 in some local areas exceeded that of 1954.

According to historical records in the last 800 years. There were 35 years with great floods of flood area covering 15–20 counties. There were 6 years with water level exceeding that of 1954, they are 1286, 1561, 1587, 1608, 1624 and 1849, and 8 years with water level reaching or probably exceeding that of 1954, they are 1290, 1408, 1481, 1651, 1670, 1680, 1708 and 1899. The water level stone in Wujiang County recorded: "The water level in the 23th year of Zhi Yuan, Yuan Dynasty (1286 A.D.) reached the seventh cut of the stone", which was approximately 4.73m[1], the highest water level in recorded history. The water level in July 14, 1991 reached 4.79m, not only exceeded that of 1954, but also the highest water level in history. In addition to the heavy rainfall and water discharge problems in the lower reaches, an important reason for that was lake reclamation. Since 1954 wetland surrounding Taihu Lake have been reclaimed to farm land which confined flood to limited lake area and river out of reclaimed land. When rainstorms happened in June and July, 1991, water could not be drained easily through these rivers, which results in rapid rise of water level to 4.79m, being 0.14m higher than that in 1954, 0.06m higher than that in 1286, which was a maximum record in history. Wetland reclamations as well as economic development reduced hazard area but increased economic losses. Comparing with disastrous floods in history, the great flood in 1991 exceeded not in precipitation but in water level, not hazard area but economic losses.

II. APPLICATION OF HISTORICAL FLOOD–DROUGHT TENDENCY

There are plentiful historical flood–drought and water level records in Taihu Lake basin since the South Song Dynasty when this area became the political, economic and cultural center. The systematic restoration of historical flood–drought records in the last 1500 years showed that those records in the recent 800 years since the South Song Dynasty had best continuity with only 21 years omissions of flood–drought and heaviest records. Sixty percent of these records came from official chronicle, hydrological survey and local chronicle on provincial level which have good credibility. On such a basis, a series of historical flood–drought with a time span of over 800 years was reconstructed using information processing method [2], and flood–drought tendency as well as the connection between flood–drought change and some solar and global factors.

Analysis of the series revealed that the historical flood and drought change is a kind of mixed vibration with dominant cycle of 100 years, other cycles being respectively 200, 11, 400 and 36 years. After later period of the 1920s relative drought period of the 8th major

cycle started. After the 1980s a relative humid period which was predicted to last for over 10 years started. The 30-year smoothing average curve showed that this was a good similarity between flood-drought change after 1660 and that after 1230. This comparison suggests that it be a relative humid period in the recent future [3]

The other analysis of time series extension and extreme value of flood-drought also showed that the ten-year period after 1983 would be a relatively humid one comparing with the 1960s and 1970s. It suggests that there occur a great flood like that of 1954, 1-2 floods like that of 1980, a drought, and little possibility of great drought before 1994 [4]

On the other hand, the study on the connection between flood-drought change and solar activities, reveals that in the peak and decline years of solar activities, the probability of great flood occurrence is 1.7-2.1 times of that of great drought in Taihu Lake basin and the lower reaches of the Changjiang River and theHuaihe River. The correlation analysis of historical flood drought grade and solar spot numbers also shows that a relative humid period may appear 1-3-years after the peak years of solar activity. There was then a prediction of the peak year of solar activity being in 1991 (actually 1990), suggesting a high precaution of flood occurrence in Taihu Lake basin [5-7]

The conclusions above were thought highly of by the local government and were considered as scientific basis for emergent flood engineering in Taihu Lake basin. In the 130th page of "The Report of Central Engineering Project of Taihu Lake Basin Management", by Changjiang River Conservancy Commission, Ministry of Water Conservancy in 1985, it was mentioned that "according to the studies of Nanjing Institute of Geography, there might occur a great flood like that of 1954, in 1992 or so". It should be noted that the flood-drought change tendency only provided climatic change background for flood hazard in macro-level, while subtropical high pressure activities, air circulation and large scale volcanic activities could become the triggering factors of flood hazard.

III. STUDYING DISASTER TENDENCY, PREDICTING FUTURE EVENTS, SERVING HAZARD-REDUCTION PROJECT

The study of historical flood and drought regularity reveals that the historical flood-drought has obvious continuity and little probability of flood-drought interchange. In a period of continuous flood or drought, there may occur continuous great drought but no continuous great flood. From 1983 to present, there happened one great flood, one flood, two droughts. Extreme value analysis and the characteristic of flood-drought continuity suggest that the period in the next 3-4 years will be relatively humid with possibility of flood occurrence and little possibility of great flood and drought. The occurrence of EL

Nino phenomenon in recent future is predicted, so precaution should be given to the flood in Taihu Lake basin.

According to recent studies, in the last 100 years the plum rain playsmore important role in the rainfall change in Taihu Basin than typhoon rain, which is in harmony with the conclusion that summer flood accounts for 70% of all floods. But since the late 1970s the precipitation change in rain season was better accordance with typhoon precipitation change than with plum rain change, especially in recent years, the precipitation in plum rain period reduced drastically while typhoon rainfall amount increased. If typhoon rain take the place of plum rain to become the major part of precipitation in rain season when climate may turn warm and heat belt move northward, the characteristics of typhoon rain, such as high intensity of precipitation and strong wind, may increase the possibility of autumn flood in Taihu Lake basin.

Although the tendency obtained from historical records and empirical facts could not understand in the level of physical mechanism, it is actually the general summary of historical change, and the prediction on the basis of that tendency would not be too far from reality. It is not very clear which mechanisms play the major role in complicated climatic change, so an ideal model of climate change is hard to be built. In this case, the study of flood–drought regularity and tendency has practical significance for hazard reduction.

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