Preliminary Analysis of Climatic Variation during the Last 39 Years in China

Chen Longxun (陈隆勋), *Shao Yongning* (邵永宁), *Dong Min* (董 敏)
Academy of Meteorological Science, State Meteorological Administration, Beijing
Ren Zhenhai (任阵海) and *Tian Guangsheng* (田广生)
Academy of Environment Science, National Environment and Protection Agency, Beijing
Received November 26, 1990; revised March 9, 1991

ABSTRACT

The preliminary analysis of climatic variation in China during the last 39 years has been made in this paper. The results show that although the global climate is getting warmer, some parts of China are cooling. The warming only occurs in Northeast, North and the west part of Northwest China while the areas between about 35°N and Nanling Mountain, east of the Tibetan Plateau in China are getting cooler. The cooling centers are located in Sichuan, the south part of Shaanxi and the north part of Yunnan respectively. According to the theory of greenhouse effect, there are much precipitation at low and high latitudes and less precipitation in middle latitude. However, the precipitation in the most parts of China has been decreased, especially in North and Northwest China.

I. INTRODUCTION

In recent years, a lot of meteorologists have investigated the problem about the global warming of climate and its influence on the environment and ecological equilibrium. Generally, it is suggested that the increases of CO_2, N_2O, CH_4 and CFC_s in atmosphere should be a significant contributor to the long-term warming trend that has been observed in global mean surface air temperature. From the curve of the global temperature given by Hansen (1988), it is found that the mean surface air temperature of the globe has increased by 0.8°C in the last 100 years. What about the climatic variation in China? Zhang Xiangong et al. (1982) analyzed the temperature change in China and divided it into three grades. Zhao Hanguang et al. (1989) investigated the features of temperature change in winter. Chen Longxun, Gao Suhua and Zhao Zongci et al. (1990) discussed the climatic variation in China and its influence on the cropping system. These researches show that during the present century, China had a maximum of temperature in 1940s, then became cooler and was getting warmer in 1980s. The temperature in 1980s is lower than that in 1940s. In this paper, we have analyzed the climatic variation during the last 39 years (1951–1989) in China with the data of temperature and precipitation for 160 Chinese stations.

II. SURFACE AIR TEMPERATURE CHANGE IN CHINA

The values of 10-year mean, 39-year mean and the temperature differences between 1980s and 1950s in most administrative areas of China have been calculated. It should be noted that Northeast (Heilongjiang, Jilin and Liaoning), North (Nei Mongol, Hebei, Shanxi and Shandong), Northwest (Ningxia, Qinghai and Xinjiang) China and Guangdong are obviously getting warmer and have maximums of temperature in 1980s. Except Guangdong, the 10-year mean temperature in these regions has been rising gradually. From 1950s to 1980s,

Northeast, North and Northwest China have the mean warming rates of 0.69°C, 0.71°C and 0.35°C respectively, larger than that of the globe (0.8°C / 100–year, 0.24°C / 30–year). Thus, the warming occurred in the Chinese area north of 35°N, not including Shaanxi and Gansu, during the last 39 years.

However, the other areas in China are getting cooler and there are three types of cooling. (1) In Sichuan and Guizhou, the temperature has been decreasing from 1950s to 1980s, and the cooling rates are 0.48°C and 0.15°C respectively. (2) The temperature had a highest value in 1950s and then decreased. It increased in 1980s, but the value in 1980s is lower than that in 1950s. This feature can be seen in Shaanxi, Gansu, Guangxi, Hainan, Yunnan and Xizang. (3) In Jiangsu, Henan, Anhui, Zhejiang, Jiangxi, Hubei, Hunan and Fujian, the maximum of temperature occurred in 1960s. Then, the temperature has decreased by 0.14, 0.03, 0.09, 0.10, 0.16, 0.20, and 0.23°C respectively and the averaged cooling rate is 0.15°C.

Fig.1 shows the distributions of the yearly mean temperature differences between 1980s and 1950s (Fig1a), 1980s and 39–year mean (Fig.1b) in China. It is found that the warming areas are located in Northeast and North China, Nei Mongol, Xinjiang, the western and central parts of Xizang, the south part of Yunnan and the reaches of Ganjiang River, which have warming centers of Huma (+1.14°C), Shenyang (+1.11°C), Zhangjiakou (+1.55°C), Jinan (+1.31°C), Lanzhou and Xining (+0.68°C), Tacheng (+1.75°C)and Jinghong (+0.87°C). Although Shenyang, Zhangjiakou, Jinan, Lanzhou and Xining are influenced greatly by the urban heat island effect, Tonghua, Chaoyang, Chengde and Duolun which are medium–sized cities have also increased by 0.68°C, 10.68°C, 0.5°C and 0.78°C respectively. In addition, there exist a lot of cooling regions in the other area of China. The cooling centers are Neijiang (–0.74°C), Guiyang (–0.48°C), Dali (–0.63°C), Xiamen (–0.75°C), Quzhou (–0.36°C) and Dunhuang (–0.36°C) which are mainly located in Southwest China and the south part of Shaanxi. The feature in Fig.1b is just similar to that in Fig.1a, but with a few differences. The cooling region in the south part of Shaanxi in Fig.1b is smaller than that in Fig.1a. The reaches of Ganjiang River is negative in Fig.1b and positive in Fig.1a.

To investigate the interannual change of temperature, we divided the whole country into seven divisions and achieved the curves of yearly mean and 10–year running mean temperature anomalies which are shown in Fig.2 (Division 1: Heilongjiang, Jilin and the east part of Nei Mongol; Division 2: Xinjiang; Division 3: Shaanxi, Gansu, Ningxia and Qinghai; Division 4: Hebei, Shandong, Shanxi, Henan and the west part of Nei Mongol; Division 5: Jiangsu, Zhejiang, Jiangxi, Anhui and Hubei; Division 6: Sichuan, Yunnan, Guizhou and Xizang; Division 7: Guangdong, Guangxi, Hainan and Fujian). We refer to Divisions No.

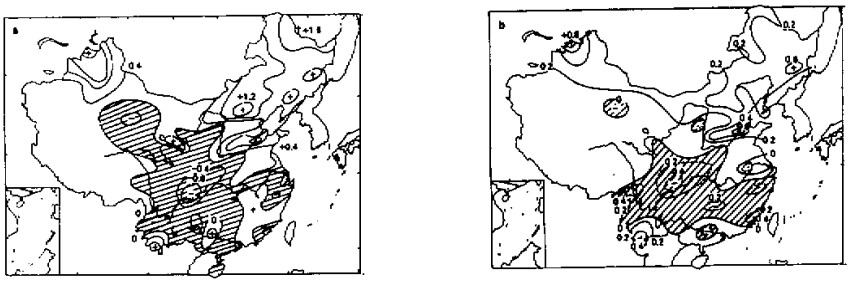

Fig.1 The distributions of yearly mean temperature (°C) differences between (a) 1980s and 1950s (with a interval of 0.4°C), (b) 1980s and 39–year mean (with a interval of 0.2°C) in China. The cooling regions are shaded.

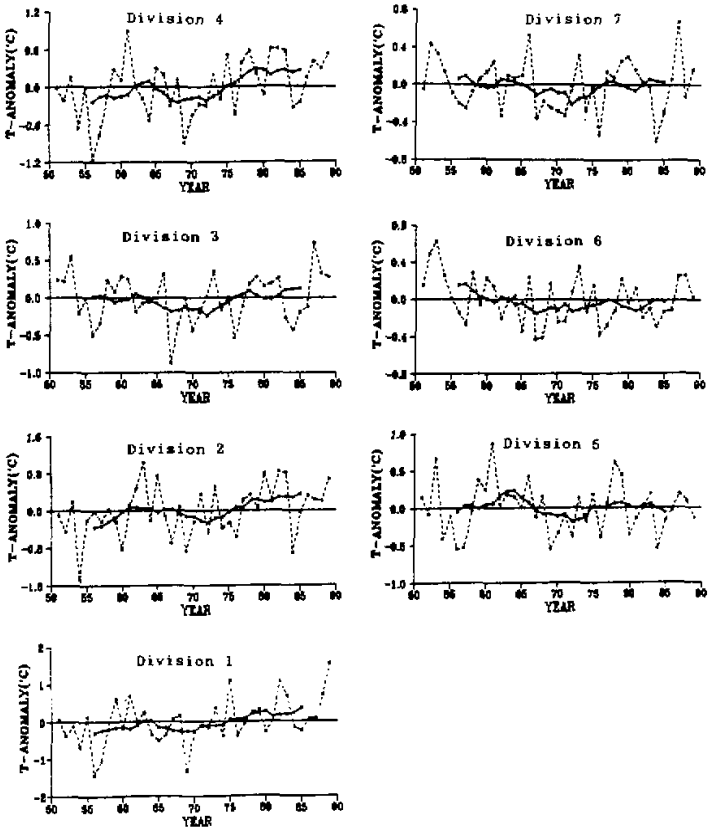

Fig.2. The curves of yearly mean (solid) and 10-year running mean (dashed) temperature(°C) anomalies in China.

1–7 as Northeast, the west and the east parts of Northwest, North, the middle and lower reaches of the Yangtze River, Southwest and South China respectively. In Fig.2, we can find that Divisions 1–2 and Division 4 are obviously getting warmer in spite of having a cooling period of 1965–1970. During the past 39-year, the temperature in Divisions 1–2 reached the highest values in 1989. For Division 4, 1961 was the warmest year and 1989 took the second place. In fact, many cities in Division 4, such as Beijing, Tianjin, Zhangjiakou and Jinan, had maximums of temperature in 1989. It is also found that the cooling has occurred in Division 6. Fig.3 gives 10-year running mean curves of yearly temperature anomalies in some provinces of China. There are slight fluctuations in Fig.3a, but the general trend is warming. The temperature rose in 1950s, reached their peaks in the middle 1960s (for Xinjiang, the peak appeared in the early 1960s) and then decreased until 1970 or so. After that, it increased again and reached the maximums (except Guangdong). It is evident in Fig.3b that the cooling has appeared in Sichuan, Guizhou, Shaanxi, Hubei, Zhejiang, Jiangsu, Fujian and Xizang. The temperature in Sichuan, Guizhou and Shaanxi decreased after 1951, rose slightly in middle 1970s and then lowered again. Hubei, Zhejiang, Jiangsu and Fujian had the maximums of temperature in 1964 and became cooler in the early 1970s. After a short warming, these re-

gions were cooling again. In Xizang, the cooling period is found during 1950s–1960s and 1976–middle 1980s, and the warming period occurred in the early 1970s and the late 1980s. But, the temperature in 1980s did not reach the high level as in 1950s.

Table 1 gives 10–year mean values of yearly (Table 1a) and seasonal (Table 1b, summer; Table 1c, winter) temperature in seven Divisions of China. The months used in making the seasonal mean are December to February (winter) and June to August (summer). For summer (Table 1b), Divisions 1–5 are getting warmer, namely, the temperature in 1980s is higher than that in 1950s. Division 5 had a maximum of temperature in 1970s, and warming over 1.33°C and 1.26°C has separately occurred in Divisions 1–2 during the past 30 years. On the contrary, Divisions 6–7 are getting cooler. Although there was a period of warmth in 1970s, the temperature in 1980s was lower than that in 1950s. In Division 6, the coolest period is found in 1960s. For winter (Table 1c), the warming and the cooling occurred in Divisions 1–2, 6–7 and Divisions 3–5 respectively. In Division 4, the temperature had a maximum in 1960s and a minimum in 1970s. The coolest period took place in 1960s in Division 6. And Division 7 had the lowest value in 1960s and the highest value in 1980s. Fig.4 shows the distributions of winter (Fig.4a) and summer (Fig.4b) mean temperature (°C) differences between1980s and 1950s in China. In Fig.4a, the warming / cooling generally has occurred in the northern / southern part of China. The boundary line is basically located in the south sides of Anhui, Hubei, Shaanxi, Gansu and Qinghai. But, Xizang and the south part of Yunnan

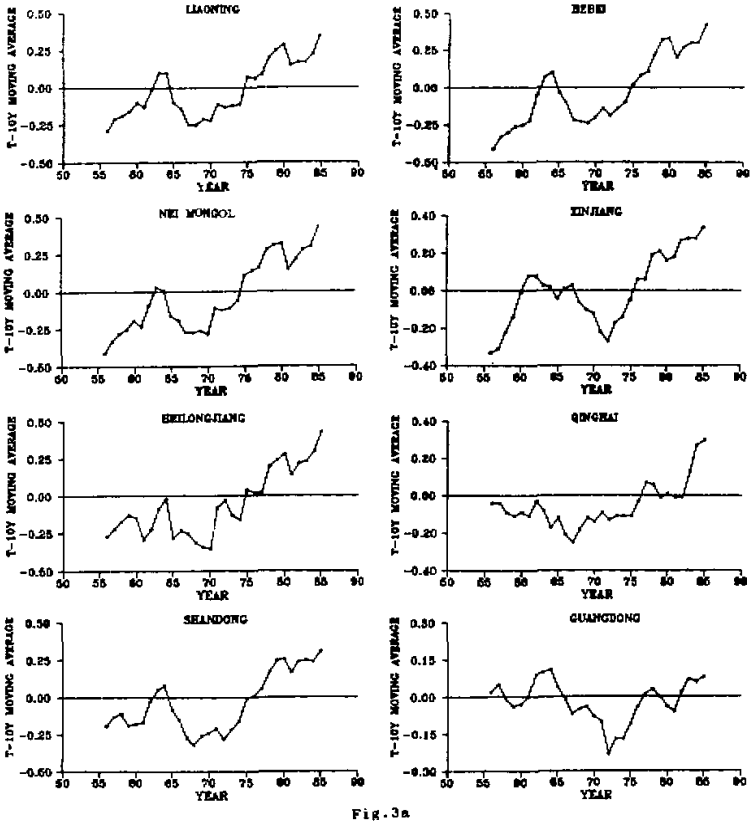

Fig.3a

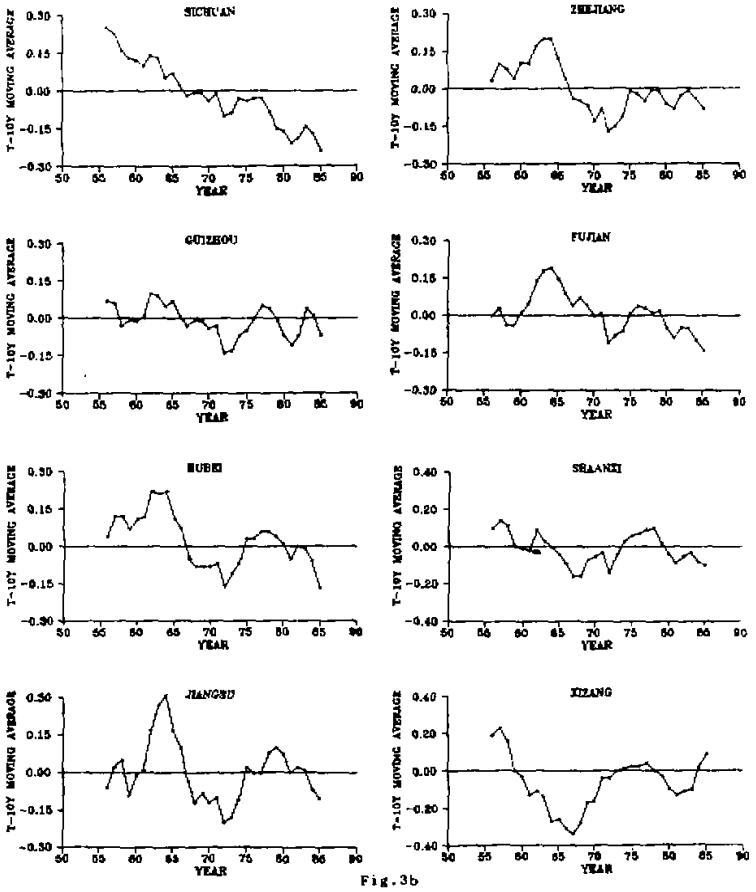

Fig.3b

Fig.3. 10-year running mean curves of yearly temperature (°C) anamolies in some provinces of China.

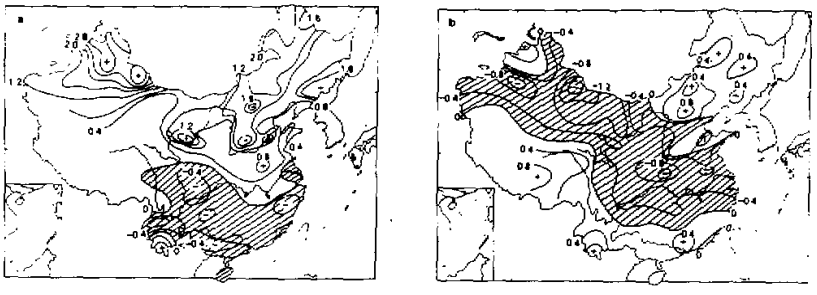

Fig.4. The distributions of (a) winter and (b) summer mean temperature (°C) differences between 1980s and 1950s in China. The cooling regions are shaded and the interval of contuors is 0.4°C.

are also warming areas. The warming centers are located in Huma, Changzhi, Shenyang, Tonghua, Lanzhou, Hami, Tacheng and Jinghong. The temperature increased by 3°C in the

warming center of Xinjiang. There are the cooling centers of Quzhou (−1.03°C), Yibin (−0.78°C), Baise (−0.74°C) and Xiamen (−1.03°C). From Fig.4b, it can be found that Northeast China, the east part of Nei Mongol, the west part of Xinjiang, South China and Xizang are getting warmer while the decrease of temperature has occurred in the other areas. The cooling centers are mainly situated in the south part of Shaanxi, Sichuan, Hami and Dunhuang. Therefore, the temperature in Sichuan, Hunan, Zhejiang, the most parts of Jiangsu and the area near Xiamen has been lowered for both winter and summer.

From the distributions of spring and autumn temperature differences between 1980s and 1950s in China (not shown), it is found that the boundary between the cooling and the warming areas lies in the south sides of Zhejiang, Jiangxi and Hunan, and turns northward along the 120°E to the south side of Nei Mongol and then westward to Tianshan Mountains ofXinjiang for spring. The areas in the south and north sides of the boundary line are cooling and warming respectively. There are the warming centers at Nenjiang (+1.84°C), Jinan (+1.81°C) and Tacheng (+1.99°C) and the cooling centers at Neijiang (−1.61°C) and Xiamen (−0.79°C). For autumn, Jiangsu, Anhui, the north part of Hubei, Sichuan, the south part of Shaanxi, the west part of Nei Mongol, the Hexi Corridor and the east and south parts of Xinjiang are getting warmer while the other areas are becoming cooler.

Table 1. 10−Year Means of Yearly and Seasonal Temperature (°C) in China. Division 1: Northeast; Division 2: West Part of Northwest; Division 3: East part of Northwest; Division 4: North; Division 5: Middle and lower reaches of the Yangtze River; Division 6: Southwest: Division 7: South. a: Yearly b: Summer c:Winter

a	51−60	61−70	71−80	81−89	39YM	80S−50S
Division 1	4.28	4.42	4.65	5.01	4.58	0.73
Division 2	5.63	5.72	5.90	6.17	5.85	0.54
Division 3	9.76	9.55	9.68	9.70	9.67	−0.06
Division 4	11.86	12.03	12.16	12.40	12.11	0.54
Division 5	16.21	16.32	16.24	16.18	16.24	−0.03
Division 6	13.42	13.15	13.22	13.24	13.26	−0.18
Division 7	21.47	21.40	21.42	21.44	21.43	−0.03
b	51−60	61−70	71−80	81−89	39YM	80S−50S
Division 1	20.68	20.72	20.67	20.38	20.73	0.20
Division 2	18.02	18.05	19.11	19.13	19.08	0.11
Division 3	22.37	22.10	21.95	21.74	22.05	−0.63
Division 4	24.65	24.92	24.51	24.56	24.66	−0.09
Division 5	27.11	27.18	26.36	26.69	26.95	−0.42
Division 6	20.43	20.22	20.30	20.52	20.36	0.09
Division 7	27.83	27.68	27.71	28.01	27.80	0.18
c	51−60	61−70	71−80	81−89	39YM	80S−50S
Division 1	−14.12	−14.27	−13.45	−12.79	−13.68	1.33
Division 2	−9.53	−9.70	−9.16	−8.27	−9.19	1.26
Division 3	−4.17	−4.45	−3.91	−3.60	−4.04	0.57
Division 4	−2.17	−2.07	−1.49	−1.20	−1.74	0.97
Division 5	4.84	4.74	5.08	4.88	4.89	0.04
Division 6	5.27	4.92	5.11	5.06	5.09	−0.11
Division 7	13.93	13.65	13.95	13.66	13.80	−0.27

As mentioned above, the yearly temperature change in China during the past 39 years is that the warming has occurred in Northeast, the east part of Northwest and North China whereas the cooling has appeared in the other areas. As for the change of seasonal mean temperature, Hanzhong Basin, Sichuan, Hunan and the north part of Jiangsu are getting cooler

and Northeast and the northwest of Xinjiang are becoming warmer in four seasons. The east part of Northeast, middle reaches of the Yangtze River (from Yichang to Nanjing) and South China are warming in winter and cooling in summer. This is not completely in accordance with the warming trend of the globe.

III. PRECIPITATION CHANGE IN CHINA

Generally speaking, in the 20th century, China is experiencing the transition period from the wet in the 18th and 19th centuries to the dry. The heavy precipitation period occurred in 1910s and 1950s. The precipitation has decreased since 1960s, although there was a little increase in 1970s. Table 2 lists the 10–year mean of yearly precipitation amount in the last 80 years in Beijing, Shanhai and Guangzhou, respectively. The precipitation in Beijing has been decreasing since 1950s and reached the lowest value in 1980s. In Shanghai, the wettest period occurred in 1940s and 1950s, then, the precipitation reduced and had a minimum in 1960s. Although the precipitation has increased after 1960s, the value in 1980s was still lower than that in 1940s. In Guangzhou, the maximum of the precipitation is found in 1920s and the precipitation amount in 1950s took the second place. After that, drying has occurred. The 10–year means of yearly precipitation amount (mm) during the past 39 years in the most areas of China are also calculated. Since 1950s, the precipitation in the most parts of China has been decreasing, especially in Hebei, Shandong, Liaoning, Jiangsu, Hunan and Hainan. And Hubei, Guangdong, Shaanxi, Qinghai and Gansu are getting wetter. Fig.5 shows the distributions of yearly precipitation differences between 1980s and 1950s (Fig.5a), 1980s and 39–year mean (Fig.5b) in China. In Fig.5a, the north part of Hubei, the east part of Sichuan, the west part of Shaanxi, Gansu, Qinghai, the south part of Xinjiang, Fujian and the coastal areas of Guangdong are getting wetter while the other areas are becoming drier. The distribution in Fig.5b is similar to that in Fig.5a. But in Fig.5b, the drying areas in Northeast China and the north part of Xinjiang are smaller than those in Fig.5a. In addition, Anhui, the south part of Jiangsu and Zhejiang are wetting areas, just opposite to that in Fig.5a. So, we can conclude from Fig.1 and Fig.5 that there are mainly two types of climatic variations of warming and drying, cooling and wetting during the past 30 years in China. The numerical simulated experiments (Chen Longxun, Gao Suhua and Zhao Zongci et al., 1990) show that due to the increase of CO_2 in the atmosphere, climate isgetting warmer and wetter at the high and low latitudes, and is becoming warmer and drier in middle latitudes. It is evident that the result of the numerical simulated experiments is in accordance with the observations only in the middle latitude areas of China.

Fig.6 shows the curves of yearly anomalies of precipitation (solid) and their 10–year running means (dashed) in seven Divisions of China. Except Division 3, the most parts of China are getting drier. In Division 1, the minimum of the precipitation occurred in 1970s and the precipitation amount in 1980s was lower by 36mm than that in 1950s. Since 1950s, Division 4 has been drying and had a minimum in 1980s. In Division 5, the precipitation reached the lowest value in 1960s and then increased slightly. The precipitation amount in 1980s was lower as compared with that in 1950s. The drying trend has taken place in Division 6 since 1960s. The decrease of precipitation can be seen in Division 7 too.

Table 2. 10–Year Means of Yearly Precipitation Amount (mm) in Beijing, Shanghai and Guangzhou

	1910–1919	1920–1929	1930–1939	1940–1949	1950–1959	1960–1969	1970–1979.	1980–1989	80YM
Beijing	642	604	583	567	820	618	605	549	624
Shanghai	1225	1093	1195	1248	1239	1048	1084	1197	1166
Guangzhou	1596	1853	1461	1737	1773	1617	1610	1604	1656

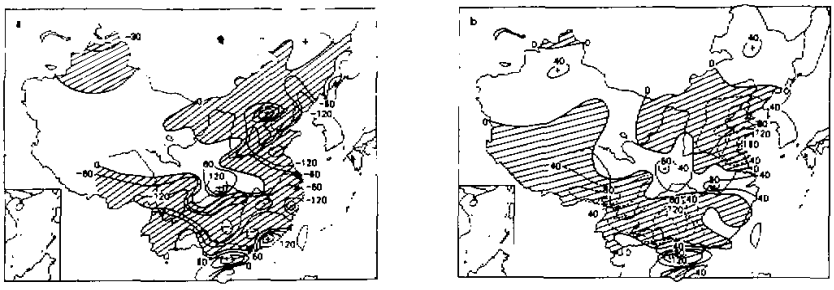

Fig.5. The distributions of yearly precipitation (mm) differences between (a) 1980s and 1950s (the interval of contours is 60mm and that in north part of Xinjiang is 30mm), (b) 1980s and 39-year mean (the interval of contours is 40mm) in China. The drying regions are shaded.

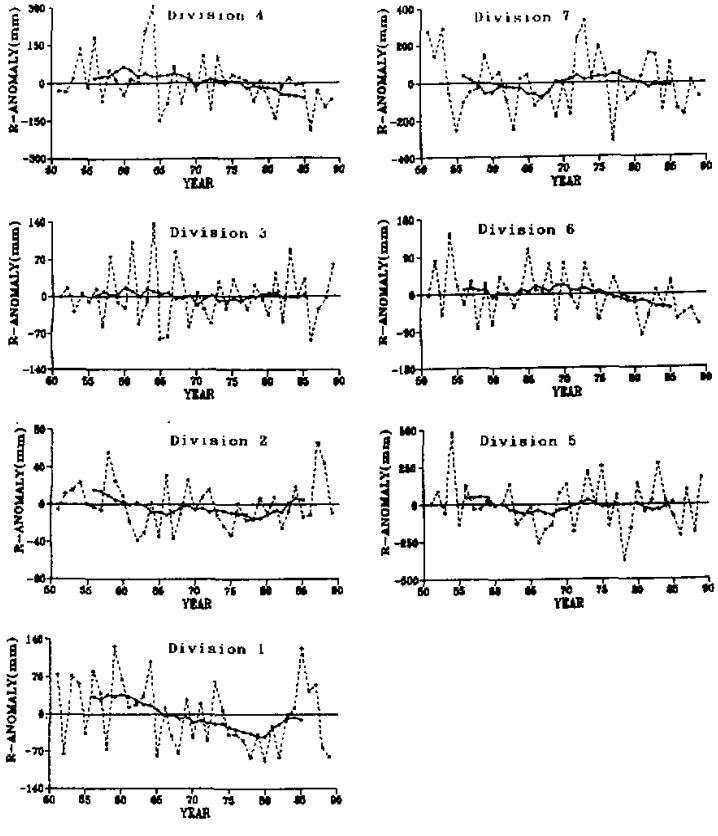

Fig.6. The curves of yearly anomalies of precipitation (solid) and their 10-year running mean (dashed) in China.

Fig.7 gives the 10-year running mean curves of yearly precipitation anomalies in some provinces of China. In Fig.7a, it is found that Hainan, Xizang and Sichuan have been drying since 1951. Hubei and Guangdong had minimums of precipitation in middle 1970s and late 1960s, respectively, then became wetter and reached the highest values of precipitation in 1980s. In Zhejiang and Xinjiang, the features of change are the same as those in Hubei and Guangdong, but with less precipitation in 1980s. The maximum of precipitation can be found in 1970s in Guizhou. In Fig.7b, Liaoning, Shaanxi, Shangdong, Hebei, Jiangsu and Henanare typical of drying areas. The lowest values of precipitation in Nei Mongol and Heilongjiang occurred in the early and middle 1970s respectively. After that, the precipitation increased. But, the precipitation amount in 1980s was lower in comparison with that in 1950s.

IV. CONCLUSION

(1) There exist obvious regional variations of temperature and precipitation during the last 39 years in China. Northeast, the west part of Northwest and North China are getting warmer and drier. The east part of Northwest China is getting cooler and wetter. The cooling and the drying have occurred in the middle and lower reaches of Yangtze River, Southwest and South China (except the coastal area of Southeast).

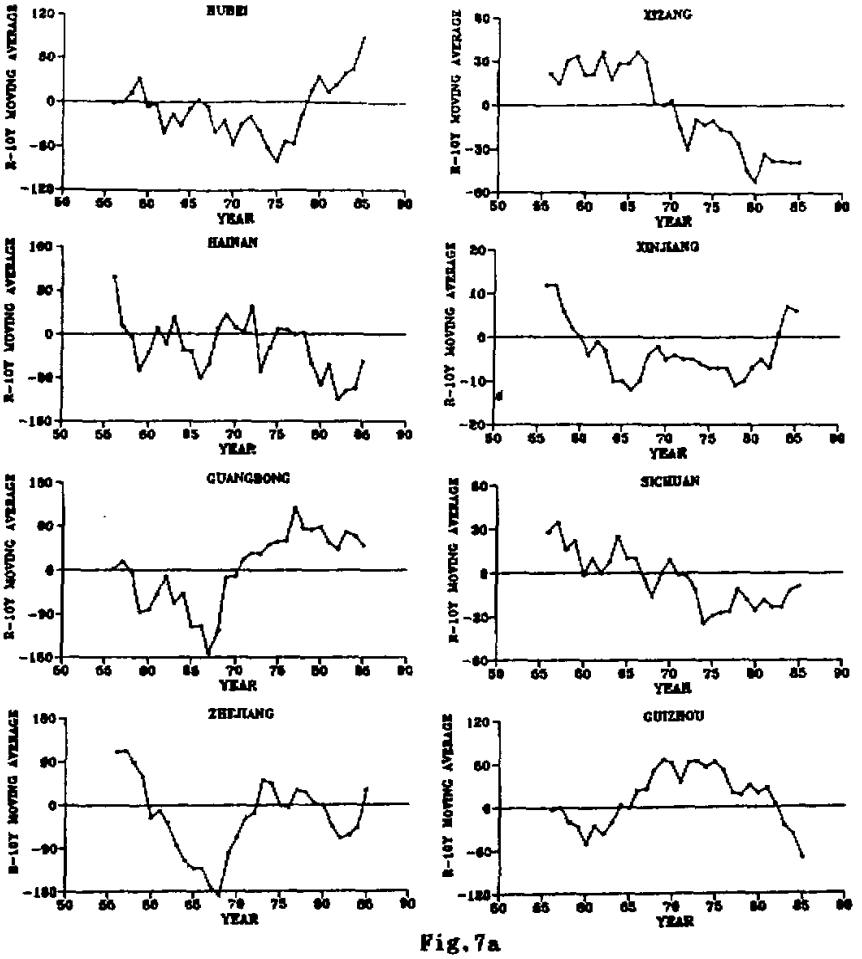

Fig.7a

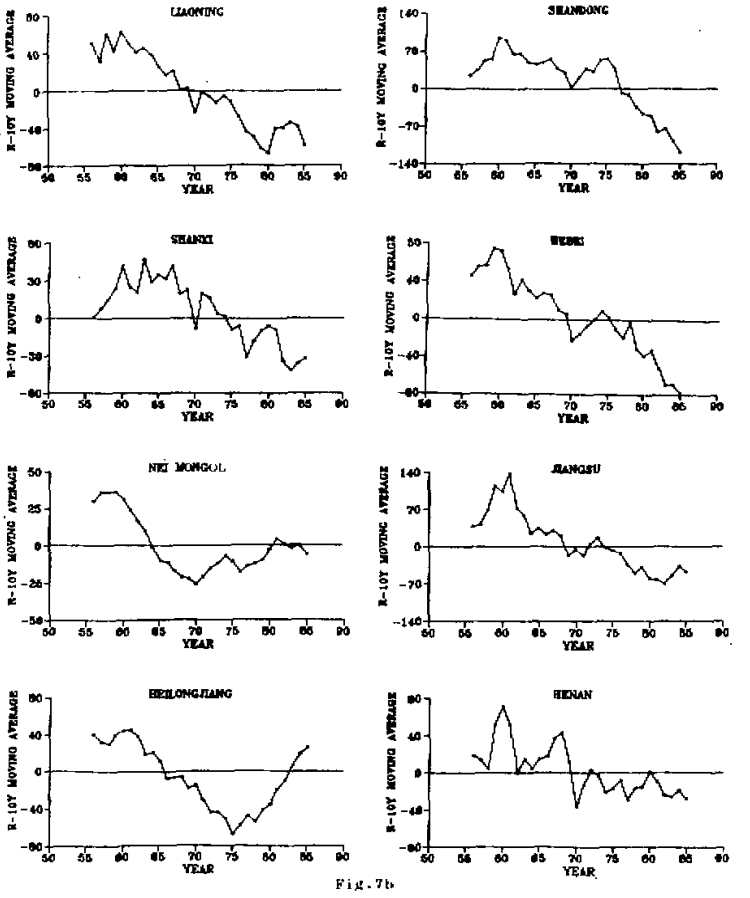

Fig.7b

Fig.7. 10-year running mean curves of yearly precipitation(mm) anomalies in some provinces of China.

(2) The warming in winter has played an important role in Northeast, Northwest and North China. Except Xizang, Southwest China is getting cooler in both winter and summer. The middle and lower reaches of the Yangtze River are getting warmer in winter and cooler in summer, just opposite to South China.

(3) It is worth noticing that the temperature in Southwest China, especially in Sichuan and the most parts of Yunnan, has been decreasing continuously since 1951. The difference between the minimum in 1980s and the maximum in the 20th century is about 1.3°C.

This work is supported by National Environment and Protect Agency under Program 891205.

REFERENCES

Chen Longxun, Gao Suhua, Zhao Zongci, Ren Zhenhai and Tian Guangsheng (1990), Change of Climate and its influence on the cropping system in China, *Acta Meteorologica Sinica*, 4: 464–474.

Hansen J. and S. Lebedeff (1988), Global surface air temperature: Update through 1987, *Geophysical Research Letters*, 15: 323–326.

Zhang Xiangong and Li Xiaoquang (1982), Some features of temperature change in China in the 20th century, *Acta Meteorologica Sinica*, 40: 198–208 (in Chinese).

Zhao Hangguang and Zhang Shuseng (1989), Analysis on anomalous warming in winter and the feature of circulation in China, *Meteorological Monthly*, 5: 16–20 (in Chinese).