STUDY ON CHANGES OF RAINSTORM DAYS IN DIFFERENT REGIONS OF CHINA IN THE RECENT 50 YEARS

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ABSTRACT: Using daily precipitation data of 601 stations from 1961 to 2010 in China, the changes of rainstorm days in different regions of China were analyzed and compared based on Mexican Hat wavelet and mathematical statistics. The main results show that the annual rainstorm days increased during the recent 50 years in most regions of China, and the amounts of increase were significantly greater than that of decrease. The annual rainstorm days increased mainly in the Lower Yangtze-Huaihe areas, the south of the Lower Yangtze River, Guangdong Province, Guangxi Zhuang Nationality Autonomous Region, Hainan Island, etc. In these areas, the risk of meteorological and geological disasters such as flood inundation, mud-rock flow, landslide, etc. were increased. After 2010, the annual rainstorm days and the risk of rainstorm disaster will possibly increase in most regions of China. Some research results in this paper provide important information of climate background for analyzing and evaluating disasters of flood inundation, mud-rock flow, landslides, etc.

Key Words: Analysis and Comparison, Change Characteristics, Different Regions of China, Rainstorm Days

1. INTRODUCTION

China is located on the west coast of the Pacific. China has more rainstorms because of its monsoon climate. China is a large country with a complex terrain and a significant difference of elevation. China has various climatic zones distributed from the equatorial climate to the alpine frigid zone and from tropical rainforest to arid desert, so the times, strength, annual variation and interannual variation of rainstorms in China show significant spatial and temporal differences.

For the purpose of rainstorms disaster prevention and mitigation, the distributions of rainstorms have been studied in the fields of meteorology, geology, water conservation, etc. Many studies on spatial and temporal distributions of rainstorm in a county(Zheng *et al*., 2008; Huang *et al*., 2013; Zheng *et al*., 2012; Huang *et al*., 2012), a province(Zhou *et al*., 2013; Li *et al*., 2012; Huang, 2006), a region(Wu *et al*., 2011; Cai *et al*., 2007; Zou *et al*., 2010)or the whole of China(Bao *et al*., 2006; Bao, 2007) have been done over the years. For example, Zheng et al. (2008) analyzed climate characteristics of rainstorm in Dongying in Shandong Province from 1971 to 2004. Zhou et al. (2013) analyzed the spatial and temporal distribution of heavy rainstorm in Hunan Province from 1952 to 2010 and built the classification model of heavy rainstorm based on atmospheric circulation situation. Wu et al. (2011) studied climate characteristics of rainstorm days, rainstorm strength, etc. during the pre-flooding season, the post-flood season and whole year in south China. Bao et al. (2006) studied the inter-decadal variations of rainstorm over China from 1961 to 2000. These authors and other researchers have made great contributions to in-depth knowledge of rainstorm regularity in whole China, studying causes and mechanisms of rainstorms and building synoptic models and numerical models of rainstorms. But there are few reports about the detailed analysis and comparison on climate characteristics of rainstorm days in different regions of China from 1961 to 2010.

Therefore, in this paper, we divided China into 13 regions, and analyzed and compared the climate characteristics of rainstorm days in these regions using daily precipitation data of 601 stations from 1961 to 2010 in China. We can provide spatial-temporal background data of weather and climate for analyzing and estimating meteorological and geological disasters such as flood inundation, mud-rock flow, landslide, etc.

2. DATA AND METHODS

The daily precipitation data of 601 stations from 1961 to 2010 in China used in this study were obtained from National Meteorological Information Center, China Meteorological Administration.

Wavelet analysis is recognized as a new milepost of the perfect combination of pure and applied mathematics after Fourier analysis, and one of its characteristics is to show the change of variables with time under different time frequency. Wavelet analysis has been widely used in many fields (Liu *et al*., 1995; Wei *et al*., 2005). There are some successful examples in analyzing changes of rainstorm days with time (Wu *et al*., 2011; Huang *et al*., 2004).

In this paper, we analyzed variations of rainstorm days in different regions of China using Mexican Hat wavelet transform and linear regression method.

In this paper, we selected daily precipitation ≥ 50.0 mm as an index of a rainstorm day for 601 stations in China.

3. CHANGES OF RAINSTORM DAYS IN CHINA

In this paper, we calculated 50-year rainstorm days for each station using daily precipitation data of 601 stations from 1961 to 2010 in China shown in Figure 1.

In Figure 1, 50-year rainstorm days decrease from southeast to northwest in China. The 50-year rainstorm days were less than 1 day in the west of Inner Mongolia and Gansu province, most places of Xinjiang Uygur Nationality Autonomous Region and Tibetan Plateau, and 1-50 days in the southeast of Tibet, most places of the northeast, Inner Mongolia and Loess Plateau, and 50-200 days in the south of the northeast, the North China Plain, the Lower Yangtze areas, most places of Sichuan province, Yunnan province and Guizhou province, and >300 days in the Middle Yangtze areas, Taiwan, most places of south China and Hainan Island. The station with maximum was Dongxing in Guangxi where the 50-year rainstorm days were 737 days.

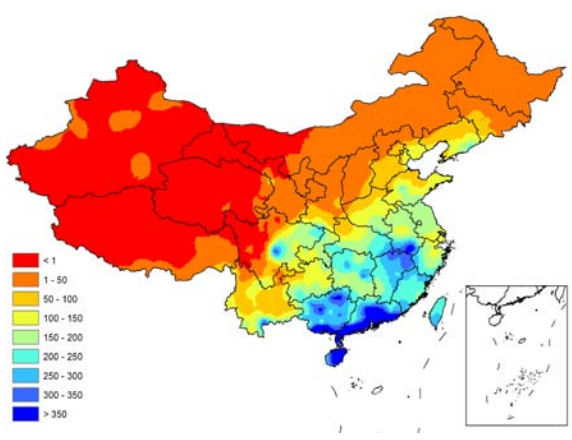

Figure 1: Distribution of 50-year Rainstorm Days in China (Day)

In China, the total rainstorm days for 601 stations during 1961-2010 were 64424 days. From January to December, the monthly rainstorm days were 227, 331, 1173, 3818, 7656, 12911, 15234, 12702, 6221, 2899, 994 and 258 days respectively, and the corresponding ratios were 0.35%, 0.51%, 1.82%, 5.93%, 11.88%, 20.04%, 23.65%, 19.72%, 9.66%, 4.50%, 1.54% and 0.40%. The annual curve of the rainstorm days was unimodal with the peak value in July. The total value from June to August was 63.4% of the total rainstorm days. Rainstorms mainly occurred in summer in China.

The annual 601-station average rainstorm days in China increased during 1961-2010 (shown in Figure 2). The rate of increase was 0.035 days per 10 years. The 50-year average rainstorm days of average station was 2.15 days (see Table 1). The time sequence functions were built based on annual anomalies of 601-station average rainstorm days in China from 1961-2010, and analyzed using wavelet (shown in Figure 3, interval: 0.04). In Figure 3, the solid line meant positive anomalies, the dashed meant negative anomalies, and the zero contour lines meant positive and negative turning. The wavelet transforms of rainstorm-day anomalies at 20-years time scale were shown in Figure 4. In Figure 4, the wavelet coefficients were equal to zero in about 1964, 1969, 1975, 1992, 2000 and 2007. According to the characteristics of wavelet singularity, the abrupt changes of the rainstorm-day anomalies occurred in these years (Liu *et al*., 1995; Wei *et al*., 2005). Correspondingly, 1961-1964, 1969-1975, 1992-2000 and 2007-2010 were multi rainstorm periods. 1964-1969, 1975-1992 and 2000-2007 were less rainstorm periods. After 2010, the annual rainstorm days in China will possibly increase.

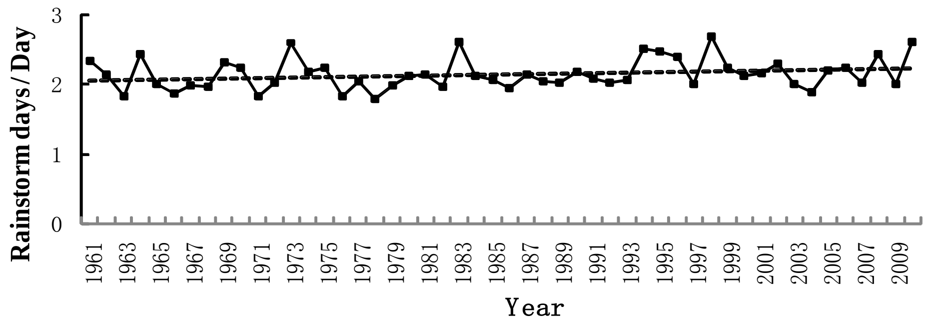

Figure 2: Interannual Variation of Average Rainstorm Days in China (dashed: trend line)

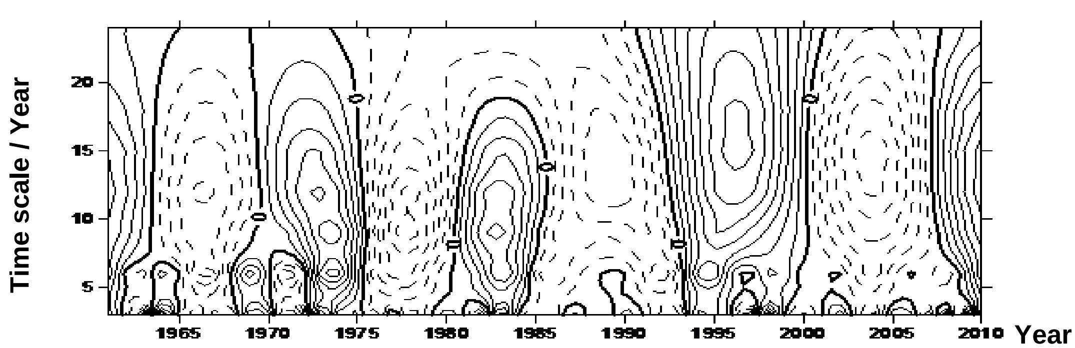

Figure 3: Wavelet Variation of Average Rainstorm-Day Anomalies in China

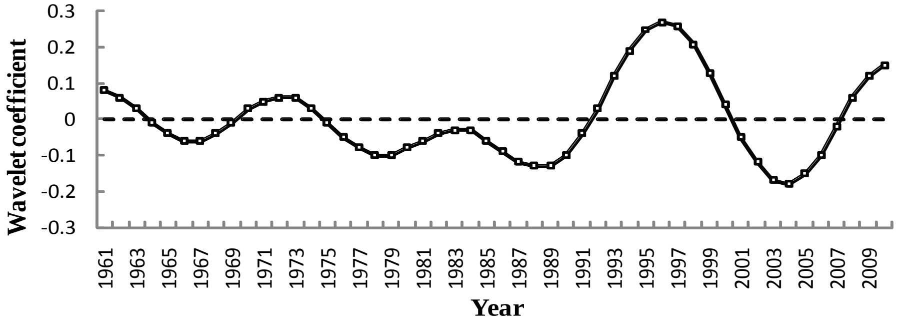

Figure 4: Wavelet Variation of Rainstorm-Day Anomalies with 20 Years in China

Table 1: Comparison of Rainstorm-Day Changes between Different Regions

Name of region	Number of stations	50-year average rainstorm days of average station (day)	Annual rainstorm-day variability of average station (days per 10 years)	Change trend of rainstorm days	Correlation coefficient	Change trend of rainstorm days after 2010
China	601	2.15	0.035	increase	0.2246	more
Hainan Island	7	7.70	0.364	increase	0.2554	more
0Xisha Islands	1	7.30	-0.162	decrease	-0.0773	more
South China	47	6.93	0.107	increase	0.1269	more
Jiangnan	67	4.39	0.204	increase	0.3050*	more
Jiang-Huai	44	3.59	0.125	increase	0.1883	more
Yunnan-Guizhou	48	2.36	0.028	increase	0.1334	less
North China	57	2.03	-0.045	decrease	-0.1232	more
Sichuan-Chengdu	44	1.99	-0.024	decrease	-0.1111	less
Northeast	72	1.16	0.004	increase	0.0165	more
Loess Plateau	67	0.52	-0.018	decrease	-0.1638	more
Inner Mongolia	46	0.29	-0.023	decrease	-0.2108	less
Tibetan Plateau	49	0.02	-0.002	decrease	-0.0890	more
Xinjiang	52	0.01	0.002	increase	0.2028	less

Note: The correlation coefficient with * passed 0.05 confidence test

4. CHANGES OF RAINSTORM DAYS IN DIFFERENT REGIONS

In order to compare the rainstorm-day changes in different places of China, we divided China into 13 regions: Hainan Island, Xisha Islands in the south China Sea, south China (Guangdong Province and Guangxi), Jiangnan (Shanghai City, Zhejiang Province, Fujian Province, Jiangxi Province and Hunan

Province), Jiang-Huai (Jiangsu Province, Anhui Province and Hubei Province), Yunnan-Guizhou, north China (Beijing City, Tianjin City, Hebei Province, Henan Province and Shandong Province), Sichuan-Chengdu, northeast (Heilongjiang Province, Jilin Province and Liaoning Province), Loess Plateau (Shanxi Province, Shaanxi Province, Ningxia Hui Nationality autonomous region and Gansu Province), Inner Mongolia, Tibetan Plateau and Xinjiang (see Table 1 and Figure 5).

Some the statistical results were shown in Table 1. In Table 1, 50-year average rainstorm days of average station in the 13 regions, respectively, were 7.70, 7.30, 6.93, 4.39, 3.59, 2.36, 2.03, 1.99, 1.16, 0.52, 0.29, 0.02 and 0.01 days. The maximum value was 7.70 days in Hainan Island and the minimum value was 0.01 days in Xinjiang, and 7.70 are 0.01 to about 770 times. The annual regional average rainstorm days increased during 1961-2010 in Hainan, south China, Jiangnan, Jiang-Huai, Yunnan-Guizhou, northeast and Xinjiang, and decreased in Xisha, north China, Sichuan-Chengdu, Loess Plateau, Inner Mongolia and Tibetan Plateau. The correlation coefficient in Jiangnan only passed 0.05 confidence test.

Figure 5: Zoning Plan in China

In order to further compare the rainstorm-day changes in different regions of China, we respectively analyzed rainstorm-day annual changes, inter-annual changes and its confidence test, and wavelet features of annual rainstorm-day anomalies in the 13 regions. In order to reduce the length of this paper, the figures about rainstorm-day inter-annual changes and wavelet features of its anomalies in south China, Jiangnan and Jiang-Huai were shown, because there were more rainstorm days and stations in these regions. The figures in other 10 regions were omitted.

In south China, the total rainstorm days for 47 stations during 1961-2010 were 16284 days. The annual curve was unimodal with the peak value in June, which was 21.6% of the total rainstorm days. The total value from May to August was 70.4%. The rainstorms occurred in every month from January to December in south China, but mainly in May-August.

The annual 47-station average rainstorm days in south China increased during 1961-2010 (shown in Figure 6). The rate of increase was 0.107 days per 10 years. The time sequence functions were built based on annual anomalies of 47-station average rainstorm days in south China from 1961-2010, and analyzed using wavelet (shown in Figure 7, interval: 0.2). In Figure 7, the zero contour lines meant positive anomalies (solid lines) and negative anomalies (dashed lines) turning. The wavelet transforms of rainstorm-day anomalies at 20-years time scale were shown in Figure 8. In Figure 8, the wavelet coefficients were equal to zero (abrupt changes) in about 1967, 1984, 1992, 2001 and 2009. Correspondingly, 1961-1967, 1984-1992 and 2001-2009 were less rainstorm periods. 1967-1984, 1992-2001 and 2009-2010 were multi rainstorm periods. After 2010, the annual rainstorm days in south China will possibly increase.

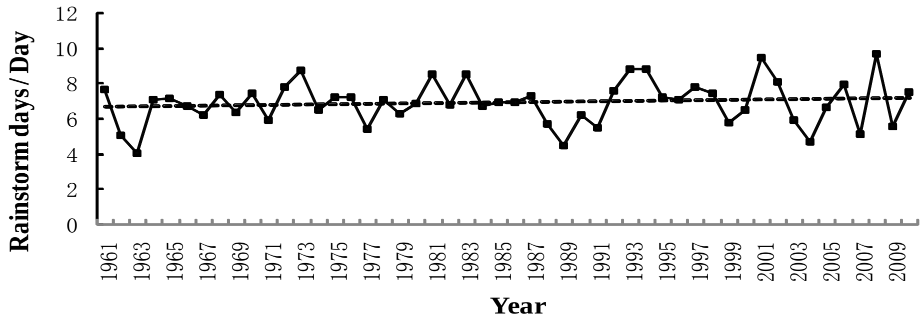

Figure 6: Interannual Variation of Average Rainstorm Days in South China(dashed: trend line)

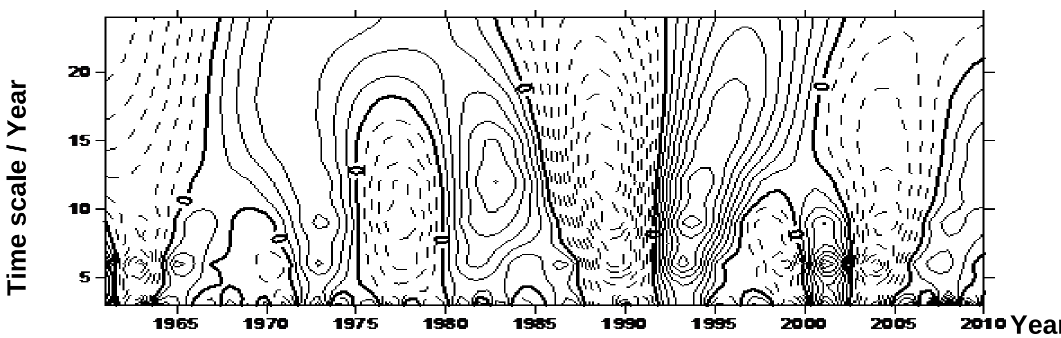

Figure 7: Wavelet Variation of Average Rainstorm-Day Anomalies in South China

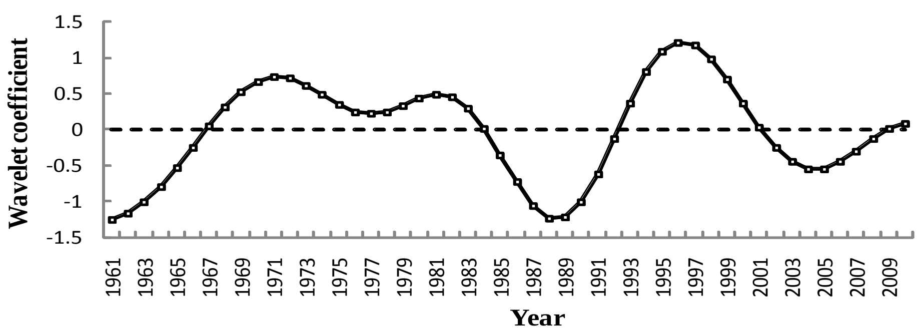

Figure 8: Wavelet Variation of Rainstorm-Day Anomalies with 20 Years in South China

In Jiangnan, the total rainstorm days for 67 stations during 1961-2010 were 14721 days. The annual curve was unimodal with the peak value in June, which was 26.8% of the total rainstorm days. The total value from May to August was 70.6%. The rainstorms occurred in every month from January to December in Jiangnan, but mainly in May-August.

The annual 67-station average rainstorm days in Jiangnan increased during 1961-2010 (shown in Figure 9). The rate of increase was 0.204 days per 10 years. The time sequence functions were built based on annual anomalies of 67-station average rainstorm days in Jiangnan from 1961-2010, and analyzed using wavelet (shown in Figure 10, interval: 0.2). In Figure 10, the zero contour lines meant positive anomalies (solid lines) and negative anomalies (dashed lines) turning. The wavelet transforms of rainstorm-day anomalies at 20-years time scale were shown in Figure 11. In Figure 11, the wavelet coefficients were equal to zero (abrupt changes) in about 1964, 1969, 1976, 1991, 2002 and 2009. Correspondingly, 1961-

1964, 1969-1976, 1991-2002 and 2009-2010 were multi rainstorm periods. 1964-1969, 1976-1991 and 2002-2009 were less rainstorm periods. After 2010, the annual rainstorm days in Jiangnan will possibly increase.

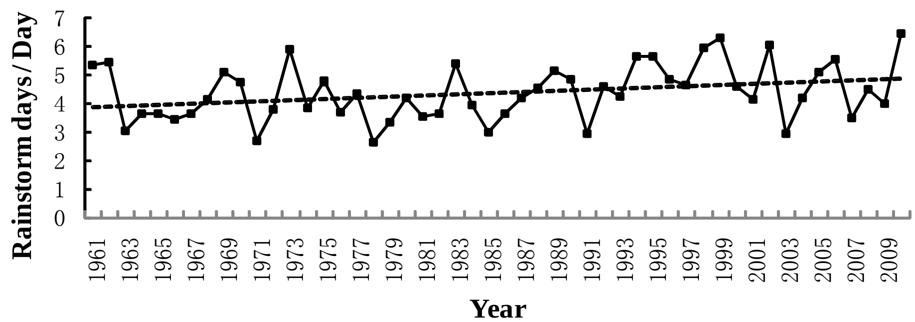

Figure 9: Interannual Variation of Average Rainstorm Days in Jiangnan (dashed: trend line)

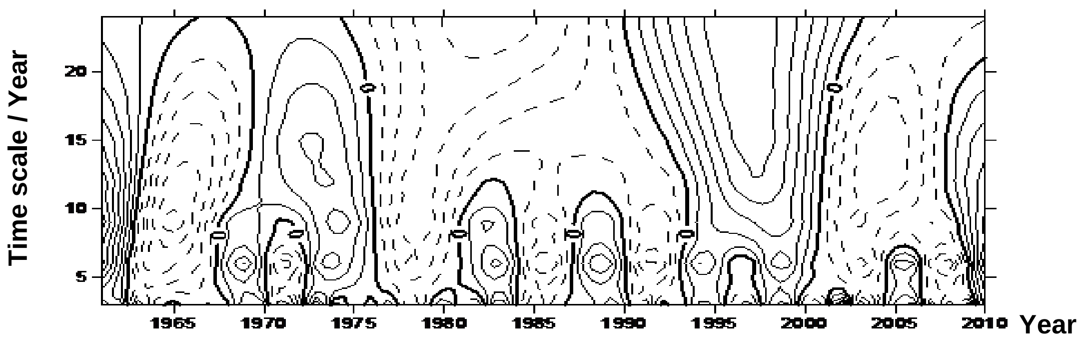

Figure 10: Wavelet Variation of Average Rainstorm-Day Anomalies in Jiangnan

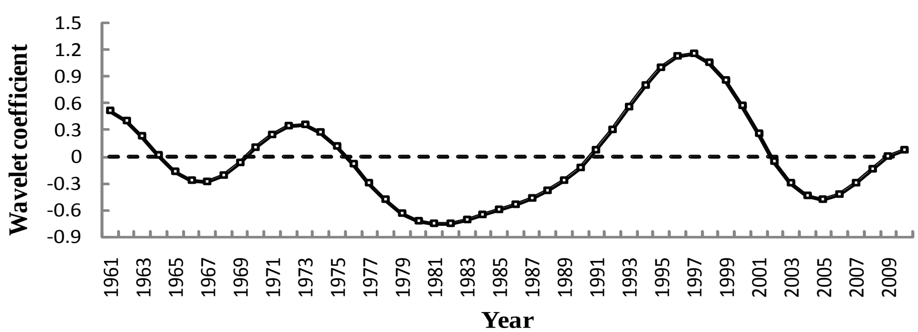

Figure 11: Wavelet Variation of Rainstorm-Day Anomalies with 20 Years in Jiangnan

In Jiang-Huai, the total rainstorm days for 44 stations during 1961-2010 were 7890 days. The annual curve was unimodal with the peak value in July, which was 29.2% of the total rainstorm days. The total value from June to August was 69.1%. The rainstorms occurred in every month from January to December in Jiang-Huai, but mainly in June -August.

The annual 44-station average rainstorm days in Jiang-Huai increased during 1961-2010 (shown in Figure 12). The rate of increase was 0.125 days per 10 years. The time sequence functions were built based on annual anomalies of 44-station average rainstorm days in Jiang-Huai from 1961-2010, and analyzed using wavelet (shown in Figure 13, interval: 0.2). In Figure 13, the zero contour lines meant positive anomalies (solid lines) and negative anomalies (dashed lines) turning. The wavelet transforms of rainstorm-day anomalies at 20-years time scale were shown in Figure 14. In Figure 14, the wavelet coefficients were equal to zero (abrupt changes) in about 1968, 1973, 1981, 1998 and 2007. Correspondingly, 1961-1968, 1973-1981, and 1998-2007 were less rainstorm periods. 1968-1973, 1981-1998 and 2007-2010 were multi rainstorm periods. After 2010, the annual rainstorm days in Jiang-Huai will possibly increase.

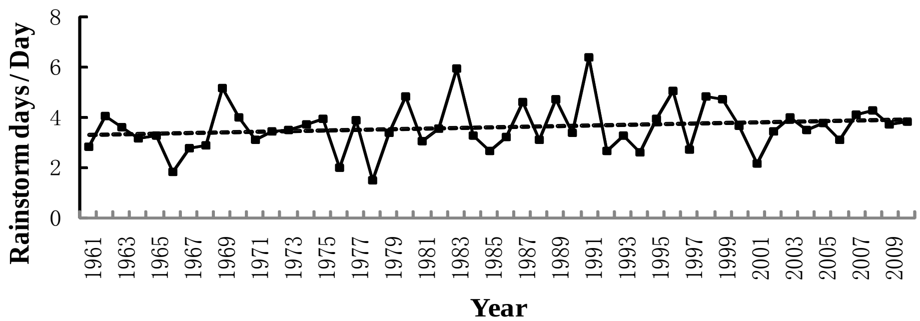

Figure 12: Interannual Variation of Average Rainstorm Days in Jiang-Huai (dashed: trend line)

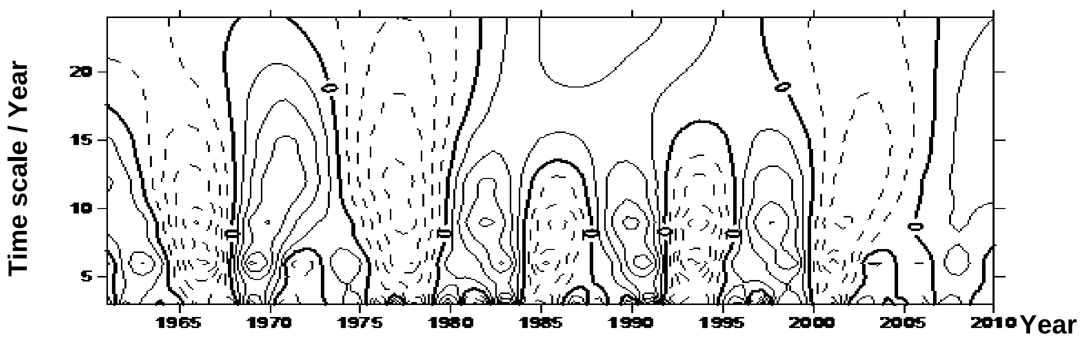

Figure 13: Wavelet Variation of Average Rainstorm-Day Anomalies in Jiang-Huai

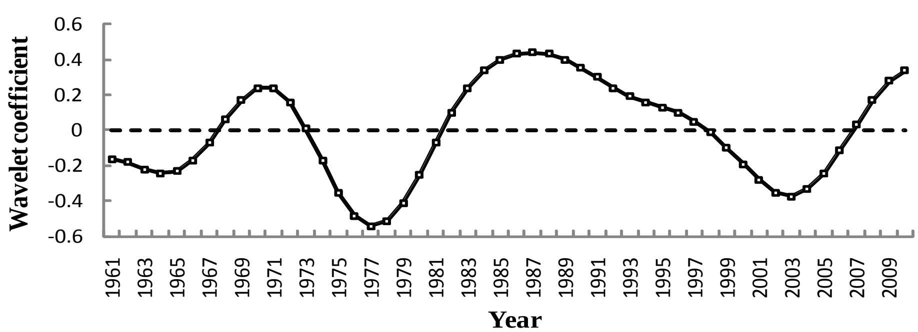

Figure 14: Wavelet Variation of Rainstorm-Day Anomalies with 20 Years in J Jiang-Huai

In Yunnan-Guizhou, the total rainstorm days for 48 stations during 1961–2010 were 5671 days. The annual curve was unimodal with the peak value in July, which was 24.5% of the total rainstorm days. The total value from June to August was 66.5%. The rainstorms occurred in every month from January to December in Yunnan-Guizhou, but mainly in June -August.The annual 48-station average rainstorm days in Yunnan-Guizhou increased during 1961-2010. The rate of increase was 0.028 days per 10 years. The time sequence functions were built based on annual anomalies of 48-station average rainstorm days in Yunnan-Guizhou from 1961-2010, and analyzed using wavelet. At 20-years time scale, the wavelet coefficients were equal to zero (abrupt changes) in about 1965, 1972, 1978, 1986, 1995 and 2005. Correspondingly, 1961-1965, 1972-1978, 1986-1995 and 2005-2010 were less rainstorm periods. 1965-1972, 1978-1986 and 1995-2005 were multi rainstorm periods. After 2010, the annual rainstorm days in Yunnan-Guizhou will possibly decrease. The figures were omitted.

In north China, the total rainstorm days for 57 stations during 1961–2010 were 5781 days. The annual curve was unimodal with the peak value in July, which was 38.4% of the total rainstorm days. The total value from July to August was 69.0%, and the monthly values in December and in February were 0. Rainstorms mainly occurred in July-August.The annual 57-station average rainstorm days in north China increased during 1961-2010. The rate of increase was -0.045 days per 10 years. The time sequence functions were built based on annual anomalies of 57-station average rainstorm days in north China from 1961-2010, and analyzed using wavelet. At 20-years time scale, the wavelet coefficients were equal to zero (abrupt changes) in about 1965, 1972, 1979, 1992, 1997 and 2005. Correspondingly, 1961-1965, 1972-1979, 1992-1997 and 2005-2010 were multi rainstorm periods. 1965-1972, 1979-1992 and 1997-2005 were less rainstorm periods. After 2010, the annual rainstorm days in north China will possibly increase. The figures were omitted.

In Hainan Island, the total rainstorm days for 7 stations during 1961-2010 were 2692 days. The annual curve of the rainstorm days was unimodal with the peak value in October, which was 21.3% of the total rainstorm days. The total value from September to October was 41.6%. The rainstorms occurred in every month from January to December, but mainly in September–October. The annual 7-station average rainstorm days in Hainan Island increased during 1961-2010. The rate of increase was 0.364 days per 10 years. The time sequence functions were built based on annual anomalies of 7-station average rainstorm days in Hainan Island from 1961-2010, and analyzed using wavelet. At 20-years time scale, the wavelet coefficients were equal to zero (abrupt changes) in about 1963, 1971, 1981, 1993, 1998 and 2006. Correspondingly, 1961-1963, 1971-1981, 1993-1998 and 2006-2010 were multi rainstorm periods. 1963-1971, 1981-1993 and 1998-2006 were less rainstorm periods. After 2010, the annual rainstorm days in Hainan Island will possibly increase. The figures were omitted.

In Xisha Islands, the total rainstorm days for 1 station during 1961–2010 were 365 days. The annual curve of the rainstorm days was double-peaked with the first peak value in August which was 19.7% of the total rainstorm days, and the second peak value in October which was 19.2%. The total value from August to October was 56.7%. The rainstorms occurred in every month from January to December, but mainly in August–October. The annual rainstorm days in Xisha Islands decreased during 1961-2010. The rate of decrease was -0.162 days per 10 years. The time sequence functions were built based on annual rainstorm-day anomalies in Xisha Islands from 1961-2010, and analyzed using wavelet. At 20-years time scale, the wavelet coefficients were equal to zero (abrupt changes) in about 1966, 1979, 1990, 2000 and 2008. Correspondingly, 1961-1966, 1979-1990 and 2000-2008 were less rainstorm periods. 1966-1979, 1990-2000 and 2008-2010 were multi rainstorm periods. After 2010, the annual rainstorm days in Xisha Islands will possibly increase. The figures were omitted.

In Sichuan-Chengdu, the total rainstorm days for 44 stations during 1961-2010 were 4359 days. The annual curve of the rainstorm days was unimodal with the peak value in July, which was 31.7% of the total rainstorm days. The total value from July to August was 58.2% and that from December to February was 0. Rainstorms mainly occurred in July to August. The annual 44-station average rainstorm days in Sichuan-Chengdu decreased during 1961-2010. The rate of decrease was -0.024 days per 10 years. The time sequence functions were built based on annual anomalies of 44-station average rainstorm days in Sichuan-Chengdu from 1961-2010, and analyzed using wavelet. At 20-years time scale, the wavelet coefficients were equal to zero (abrupt changes) in about 1962, 1969, 1979 and 1992. Correspondingly, 1961-1962, 1969-1979 and 1992-2010 were less rainstorm periods. 1962-1969 and 1979-1992 were multi rainstorm periods. After 2010, the annual rainstorm days in Sichuan-Chengdu will possibly decrease. The figures were omitted.

In the northeast, the total rainstorm days for 72 stations during 1961–2010 were 4186 days. The annual curve of the rainstorm days was unimodal with the peak value in July, which was 43.4% of the total rainstorm days. The total value from July to August was 81.0% and that from December to February was 0. Rainstorms mainly occurred in July–August. The annual 72-station average rainstorm days in the northeast increased during 1961-2010. The rate of increase was 0.004 days per 10 years. The time sequence functions were built based on annual anomalies of 72-station average rainstorm days in the northeast from 1961-2010, and analyzed using wavelet. At 20-years time scale, the wavelet coefficients were equal to zero (abrupt changes) in about 1967, 1983, 1998 and 2006. Correspondingly, 1961-1967, 1983-1998 and 2006-2010 were multi rainstorm periods. 1967-1983 and 1998-2006 were less rainstorm periods. After 2010, the annual rainstorm days in the northeast will possibly increase. The figures were omitted.

In the Loess Plateau, the total rainstorm days for 67 stations during 1961–2010 were 1734 days. The annual curve of the rainstorm days was unimodal with the peak value in July, which was 39.2% of the total rainstorm days. The total value from July to August was 72.5%, and that from December to March was 0. Rainstorms mainly occurred in July to August. The annual 67-station average rainstorm days in the Loess Plateau decreased during 1961-2010. The rate of decrease was -0.018 days per 10 years. The time sequence functions were built based on annual anomalies of 67-station average rainstorm days in the Loess Plateau from 1961-2010, and analyzed using wavelet. At 20-years time scale, the wavelet coefficients were equal to zero (abrupt changes) in about 1966, 1976, 1986 and 2000. Correspondingly, 1961-1966, 1976-1986 and 2000-2010 were multi rainstorm periods. 1966-1976 and 1986-2000 were less rainstorm periods. After 2010, the annual rainstorm days in the Loess Plateau will possibly increase. The figures were omitted.

In Inner Mongolia, the total rainstorm days for 46 stations during 1961–2010 were 663 days. The annual curve of the rainstorm days was unimodal with the peak value in July, which was 49.2% of the total rainstorm days. The total value from July to August was 83.4%, and that from October to March was 0. Rainstorms mainly occurred in July to August. The annual 46-station average rainstorm days in Inner Mongolia decreased during 1961-2010. The rate of decrease was -0.023 days per 10 years. The time sequence functions were built based on annual anomalies of 46-station average rainstorm days in Inner Mongolia from 1961-2010, and analyzed using wavelet. At 20-years time scale, the wavelet coefficients were equal to zero (abrupt changes) in about 1965, 1985 and 2000. Correspondingly, 1961-1965 and 1985-2000 were multi rainstorm periods. 1965-1985 and 2000-2010 were less rainstorm periods. After 2010, the annual rainstorm days in Inner Mongolia will possibly decrease. The figures were omitted.

In the Tibetan Plateau, the total rainstorm days for 49 stations during 1961–2010 were 50 days. The annual curve of the rainstorm days was double-peaked with the first peak value in August which was 24.0% of the total rainstorm days, and the second peak value in October which was 22.0%. The total value from December to March was 0. The annual 49-station average rainstorm days in the Tibetan Plateau decreased during 1961-2010. The rate of decrease was -0.002 days per 10 years. The time sequence functions were built based on annual anomalies of 49-station average rainstorm days in the Tibetan Plateau from 1961-2010, and analyzed using wavelet. At 20-years time scale, the wavelet coefficients were equal to zero (abrupt changes) in about 1967, 1976, 1982, 1990 and 2006. Correspondingly, 1961-1967, 1976-1982 and 1990-2006 were less rainstorm periods. 1967-1976, 1982-1990 and 2006-2010 were multi rainstorm periods. After 2010, the annual rainstorm days in the Tibetan Plateau will possibly increase. The figures were omitted.

In Xinjiang, the total rainstorm days for 52 stations during 1961–2010 were 28 days. The annual curve of the rainstorm days was unimodal with the peak value in July, which was 46.4% of the total rainstorm days. Rainstorms mainly occurred in May-September and the values in other months were 0.The annual 52-station average rainstorm days in Xinjiang increased during 1961-2010. The rate of increase was 0.002 days per 10 years. The time sequence functions were built based on annual anomalies of 52-station average rainstorm days in Xinjiang from 1961-2010, and analyzed using wavelet. At 20-years time scale, the wavelet coefficients were equal to zero (abrupt changes) in about1965, 1976, 1982, 1989, 1996 and 2004. Correspondingly, 1961-1965, 1976-1982, 1989-1996 and 2004-2010 were multi rainstorm periods. 1965-1976, 1982-1989 and 1996-2004 were less rainstorm periods. After 2010, the annual rainstorm days in Xinjiang will possibly decrease. The figures were omitted.

5. CONCLUSIONS

The 50-year rainstorm days decrease from southeast to northwest in China. The 50-year rainstorm days were equal to zero in 89 stations in west of China, which was 14.8% of the total stations in China (601). The station with maximum rainstorm days was Dongxing in Guangxi where the total rainstorm days in 1961-2010 were 737 days. In China, the total rainstorm days for 601 stations during 1961-2010 were 64424 days, and the annual curve of rainstorm days was unimodal with the peak value in July. The rainstorms occurred in every month from January to December, but mainly in June –August, and the rainstorm days from June to August were 63.4% of the total rainstorm days in China.

In the 13 regions of China, the annual rainstorm-day curves were double-peaked in Tibetan Plateau and Xisha Islands, and unimodal in other 11 regions. The peak values were in June in south China and Jiangnan, in July in northeast, north China, Jiang-Huai, Loess Plateau, Inner Mongolia, Sichuan-Chengdu, Yunnan-Guizhou and Xinjiang, in August in Tibetan Plateau and Xisha Islands, and in October in Hainan Island.

The annual 601-station average rainstorm days in China increased during 1961-2010. The annual regional-average rainstorm days increased during 1961-2010 in Hainan Island, south China, Jiangnan, Jiang-Huai, Yunnan-Guizhou, northeast and Xinjiang, and decreased in Xisha Islands, north China, Sichuan-Chengdu, Loess Plateau, Inner Mongolia and Tibetan Plateau. The correlation coefficient of the Change trend in Jiangnan only passed 0.05 confidence test. The maximum rate of increase was 0.364 days per 10 years in Hainan Island, and the Second was 0.204 days per 10 years in Jiangnan. The maximum rate of decrease was -0.162 days per 10 years in Xisha Islands, and the Second was -0.045 days per 10 years in north China. The amounts of increase were significantly greater than that of decrease in China.

After 2010, the annual 601-station average rainstorm days in China will possibly increase. After 2010, the annual regional-average rainstorm days will possibly increase in Hainan Island, Xisha Islands, south China, Jiangnan, Jiang-Huai, north China, northeast, Loess Plateau and Tibetan Plateau, and decrease in Yunnan-Guizhou, Sichuan-Chengdu, Inner Mongolia and Xinjiang.

The statistics showed that the frequency of extreme precipitation events increased during 1961–2010 and the rainstorm days after 2010 will possibly increase in most regions of China. The risks of meteorological and geological disasters such as flood inundation, mud-rock flow, landslide, etc., therefore will increase. The stations where the risks of rainstorm disasters increased are mainly located in the Lower Yangtze-Huaihe areas, the south of the Lower Yangtze River, Guangdong Province, Guangxi and Hainan Island.

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