CHINESE GEOGRAPHICAL SCIENCE
Volume 9, Number 1, pp.57-62, 1999
Science Press, Beijing, China

THE WET-DRY CHANGES IN RECENT 40 YEARS IN TAKLIMAKAN AREA①

Yuan Yujiang(袁玉江) Li Jiangfeng(李江风)
Xinjiang Institute of Meteorology Sciences, *Urumqi* 830002, *P.R.China*
Ye Wei(叶 玮)
Xinjiang Institute of Geography, *the Chinese Academy of Sciences*, *Urumqi* 830011, *P.R.China*
(Received 27 May 1998)

ABSTRACT: Using the precipitation data in recent 40 years of 48 meteorological stations in Taklimakan area and neighboring areas, this paper analyzes the stage and periodicity of the wet-dry changes in a year and four seasons. The paper also compares the correlativity of precipitation between Taklimakan area and around Mountains, and obtained some statistic conclusions as follows. (1) The precipitation changes of a year and four seasons in Taklimakan area have different wet-dry periods and change periodicities. (2) Summer precipitation has well directive sense to annual precipitation in Taklimakan area with a correlation coefficient 0.901, and the negative correlation between precipitation and temperature in summer is very remarkable. (3) There is definite correlation between annual precipitation in Taklimakan area and position of polar vortex. When longitude of polar vortex is partial west in February and its latitude is partial north in September of the last year, annual precipitation is above its mean in the area. In addition, it is beneficial to obtain more summer precipitation in the area when position of polar vortex is partial west in February.

KEY WORDS: Taklimakan area, wet-dry change, climate change

1 INTRODUCTION

Along with the petroleum exploitation of Tarim Basin, considering about water resources, people paid much attention to the study of the modern climate change in Taklimakan area. Some people had done some analyses with the meteorological data in the area (Yang, 1992; Ji *et al*., 1992; Zheng, 1991; Xue, 1989; Li, 1989; Wen *et al*., 1988). Based on the observational data of precipitation in recent 40 years, this paper carefully analyzed the wet-dry change in recent several decades in Taklimakan area and its neighboring areas (the northern Xinjiang, Qinghai and Gansu provinces), probed the statistic relationship between polar vortex and wet-dry change in the area, and obtained some beneficial results.

2 PRECIPITATION DATA AND AREAL MEAN PRECIPITATION SERIES

Because there were no long-term regular observational precipitation data in the Taklimakan hinterland, the paper had to use the precipitation data of the meteorological stations around the desert to describe the features of the wet-dry changes in recent 30-40 years in Taklimakan area.

The precipitation data of 21 stations for 30 years (1961-1990) in Taklimakan area were used to establish the areal mean precipitation series of a year, winter, spring, summer and autumn. Just as Lin Xuechun (1995) had done, this paper used single correlation coefficient between areal mean precipitation series and each precipitation series at 0.01 of confidence

① Supported by the National Natural Science Foundation of China (No. 49671009).

level as standards of areal mean precipitation series that is representative of this station's precipitation yearly change. It can be seen from Table 1 that the representativeness percentage of the mean precipitation series in a year and four seasons in the area, compared with that of 21 stations', reached 90% or above. This explained that mean annual precipitation series had very well representativeness to the wet-dry change on a large-range in Taklimakan area.

Table 1 The presentiveness of the areal mean precipitation of a year and four seasons in Taklimakan area

	Mean single correlation coefficient*	Significant correlation**	
		Station	Percentage
Year	0.67	20	95
Winter	0.61	19	90
Spring	0.62	20	95
Summer	0.67	19	90
Autumn	0.63	19	90

* between the areal mean precipitation and 21 stations' precipitation series

* * between the areal mean precipitation and 21 stations' precipitation series

3 WET-DRY CHANGE IN TAKLIMAKAN AREA

In order to obtain long-term wet-dry change series in a year and four seasons, a best series, which has the best correlativity with corresponding areal mean precipitation series, was picked out from the 4 stations (Kuqa, Yanqi, Hotan and Ruoqiang) having long-term meteorological records, and drawn in the same picture with corresponding areal mean precipitation series to be analyzed.

3.1 Annual Precipitation (January – December)

Fig. 1 shows that during 1961 – 1990 the annual rainfalls were slightly below its mean for 1961 – 1970, 1976 – 1980, and above the mean from 1971 to 1975. It shows clearly large amplitude oscillation in 2 – 3-year scale from 1981 to 1990 in Taklimakan area. In recent 30 years, the maximum annual precipitation was in 1987, and the minimum in 1985. In the recent decade, the change amplitude was greatest. Maximum entropy spectrum analysis shows that annual precipitation change had 7-year significant periodicity firstly, and 2.5 – 2.7 years secondly.

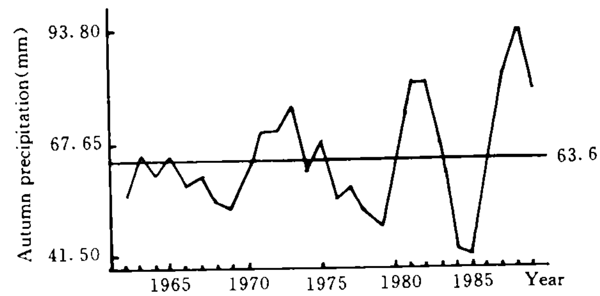

Fig. 1 The curve of 3-year moving average of annual precipitation in Taklimakan area

3.2 Winter Precipitation (November – February)

It can be seen from Fig. 2 that the winter precipitations in Taklimakan area during 1953 – 1960 and 1973 – 1979 were above its mean, and below the mean from 1961 to 1972, 1980 to 1990. In recent 30 years, the maximum winter precipitation was in 1976, and the minimum in 1963. Maximum entropy spectrum analysis indicates that the significant periodicities were 2.3, 30 years or more. Comparing temperature with precipitation in winter in Taklimakan area, it can be found that the 1980s was the warmest decade in the past 30 years but its precipitation was below its long-term mean, which agreed with the feature of winter climate change in Aksu area (Ling, 1991). This attributed to the significant increase of winter temperature. In addition, to compare the yearly anomalous changes of temperature with precipitation in winter shows that both has presented a significant inverse change since the early 1970s.

3.3 Spring Precipitation (March – May)

Fig. 3 shows that the spring precipitation in Taklimakan area during 1963 – 1973 and 1983 – 1990 was roughly above its mean for thirty years, and below the mean from 1974 to 1982. In recent 30

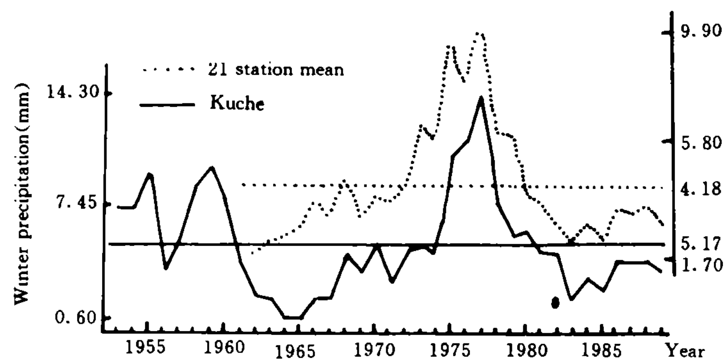

Fig. 2 The curve of 3-year moving average of winter precipitation in Taklimakan area

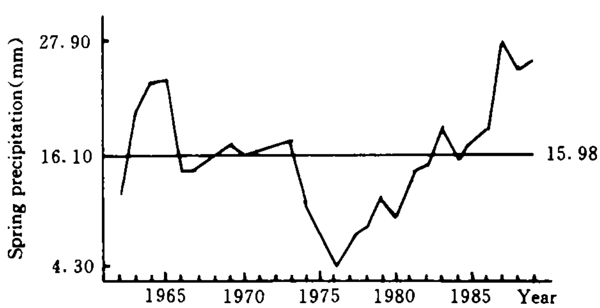

Fig. 3 The curve of 3-year moving average of spring precipitation in Taklimakan area

years, the maximum spring precipitation occurred in 1988 and the minimum in 1977. The rainfall fluctuation had a significant 2-year periodicity firstly and a 7.5-year periodicity secondly.

3.4 Summer Precipitation(June – August)

It can be seen from Fig. 4 that the summer precipitation in Taklimakan area during 1956 – 1958 and 1983 – 1990 was above its long-term mean, and from 1959 to 1970 was below. After 1975, summer precipitation entered a 6 – 8-year cycle. In recent 30 years, the maximum summer precipitation was in 1974, and the minimum in 1985. Maximum entropy spectrum analysis shows that the summer precipitation had 7.5-year and 2.5-year change periodicities, which were similar as that of the spring precipitation.

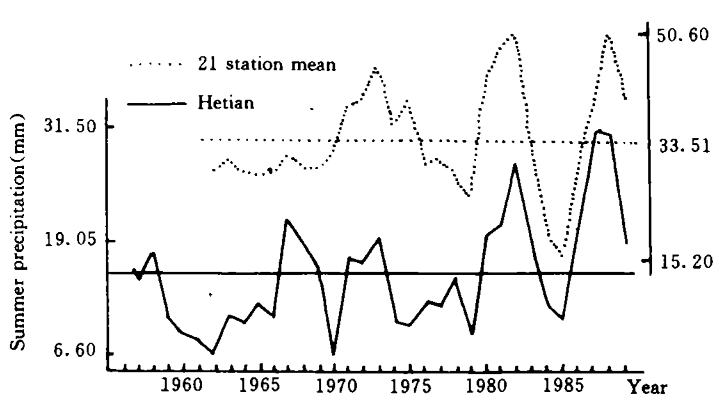

Fig. 4 The curve of 3-year moving average of summer precipitation in Taklimakan area

3.5 Autumn Precipitation(September – November)

Fig.5 shows that the change of autumn precipitation in Taklimakan area in recent 30 years, presented 5 – 6-year oscillation and increase trend from the late 1960s and the early 1970s to 1990. The maximum autumn precipitation occurred in 1962 and the minimum in 1969. Maximum entropy spectrum analysis suggests the autumn precipitation had 5-year and 2-year significant change periodicities.

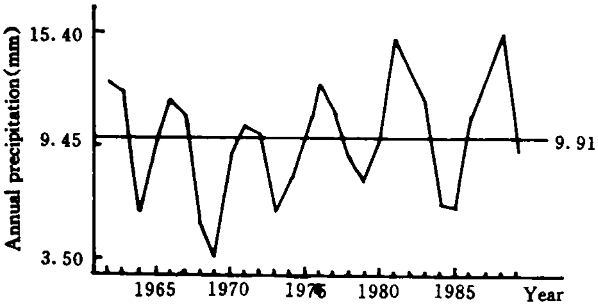

Fig. 5 The curve of 3-year moving average of autumn precipitation in Taklimakan area

4 CORRELATIVITY OF PRECIPITATION CHANGE BETWEEN TAKLIMAKAN AREA AND ITS ADJACENT MOUNTAIN, NEIGHBORING AREAS

4.1 Correlativity of Precipitation Change Between Taklimakan Area and Mountain Stations

Different topography and circulation background resulted in greater difference of precipitation changes between several meteorological stations located in the mountain areas and Taklimakan area. It can be seen from Table 2 that there was great difference of the precipitation changes in a year and four seasons among 4 meteorological stations located in mountains and Taklimakan area. Especially in spring, precipitation almost showed week negative correlativity among Tyoyun and Taxkorgan located in the western mountain and Taklimakan area, which is related with the influence of topography on precipitation as well as the general circulation. In spring, circulation pattern easily changes, the homogeneity of circulation in large extent is week, which makes the difference of local circulation become greater between the mountain area and Taklimakan area. Only in autumn, there are better correlativities of precipitation change between Taklimakan area and Tuoyun mountain area, which reaches 0.01 of confidence level.

4.2 Comparison of Correlativity of Precipitation Between Taklimakan Area and Neighboring Areas

The mean precipitation series of 6 stations (Altay, Tacheng, Iili, Usu, Urumqi and Qitai) was used to represent that of the northern Xinjiang. The mean precipitation series of 9 stations (Da Qaidam, Gangca, Golmud, Dulan, Xining, Minhe, Tongde, Yushu and Madoi) was taken to represent that of Qinghai Province, and that of 8 stations (Dunhuang, Jiuquan, Zhangye, Wuwei, Minqin, Lanzhou and Hezuo) was chosen to represent that of Gansu Province. The single correlation coefficients of areal mean precipitation series in a year and four seasons from 1961 to 1990 between 3 neighboring areas and Taklimakan area were calculated. The results indicated that the precipitation in a year and four seasons in Taklimakan area, only in spring, showed better correlativity to that of neighboring areas (the northern Xinjiang, Qinghai and Gansu), and the best correlativity presented in both Taklimakan area and Gansu (Table 3). The positive correlativity of the precipitation between Taklimakan area and the northern Xinjiang agreeded with the conclusion obtained by Yu Xinwen *et al*. (1990) who used the empirical orthogonal function to analyze precipitation in Xinjiang.

Table 2 The coefficients of single correlation between the areal precipitation series in a year and four seasons in Taklimakan area and adjacent mountain areas

	Year	Winter	Spring	Summer	Autumn
Bayanbulak	0.33	−0.01	0.03	0.37	0.28
Tuoyun	0.39	0.14	−0.10	0.19	0.57*
Taxkorgan	0.01	0.05	−0.32	0.07	0.40
Kangxiwar	0.10	0.01	−0.07	0.17	0.51

* The correlation coefficient is significant at 0.01 of confidence level; the sample number of Kangxiwar is 23, the others are 30.

Table 3 The correlation coefficients of the areal precipitation series in a year and four seasons in Taklimakan area and neighboring areas

	Year	Winter	Spring	Summer	Autumn
Northern Xinjiang	0.31	0.22	0.45*	−0.08	0.01
Qinghai	0.05	0.38	0.47*	0.09	0.21
Gansu	−0.21	0.15	0.56*	−0.18	0.16

* The correlation coefficient is significant at 0.01 of confidence level

5 SOME FEATURES OF THE PRECIPITATION CHANGE IN TAKLIMAKAN AREA AND RELATIONSHIP BETWEEN THE PRECIPITATION CHANGE AND POSITION OF POLAR VORTEX

5.1 Correlativity Among Areal Mean Precipitation Series in a Year and Four Seasons

In recent 30 years, the correlation coefficient of precipitation between summer and a year was 0.901, which was further beyond 0.001 of extreme confidence level. The result indicated that the summer precipitation had very well precursor significance to annual precipitation in Taklimakan area. Calculation showed that the correlation coefficient between summer and a year was 0.704 in the northern Xinjiang, and it was less than that in Taklimakan area. This may be related with the percentage of summer precipitation in annual precipitation in Taklimakan area. In Taklimakan area, the percentage of summer precipitation accounted for 52.6%, but 25.9% in the northern Xinjiang.

In Taklimakan area, the anticorrelativity between summer precipitation and summer temperature was stronger than that in the northern Xinjiang. The correlation coefficient of the former was −0.675, but that of the latter was −0.503, both of them reached 0.01 of confidence level. This indicates that the adjusting role of summer precipitation to corresponding seasonal temperature in Taklimakan area was stronger than that in the northern Xinjiang.

5.2 Main Features of Precipitation Fields in a Year and Four Seasons

In recent 30 years, the elements of the first eigenvectors of precipitation fields for 21 stations were all positive in Taklimakan area. This indicates that the main features of the most important spatial patterns of 5 precipitation fields were all synchronous change in different areas of Taklimakan, and the percentage of the first eigenvector in the total variance of precipitation field could reveal the intensity of such a synchronous change.

It can be seen from Table 4 that for the precipitation fields in a year and four seasons for 21 stations in Taklimakan area, the spatial synchronous change of precipitation was better in summer and in a year. In Taklimakan area, the good correlativities of first principal components and areal mean precipitation series in a year and four seasons further indicates that using areal mean precipitation series to represent the main feature of precipitation change in large extent was reliable.

Table 4 The percentage of the first eigenvector in the total variance of precipitation field and the correlation coefficients between the first principal component and the areal precipitation sequence in Taklimakan area

	Year	Winter	Spring	Summer	Autumn
Percentage*	46.7	42.9	41.2	47.9	43.8
Correlation coefficient**	0.970	0.962	0.995	0.970	0.994

* the first eigenvector accounting for the total variance of precipitation field

** the single correlation coefficient between the first principal component and the areal mean precipitation series

5.3 Statistic Relationship Between Precipitation and Position of Polar Vortex in Taklimakan Area

Because weather in Xinjiang was often affected greatly by polar vortex, the paper calculated the correlation coefficients between the areal mean precipitation series for the period 1962 – 1990 in Taklimakan area and longitude , latitude and intensity of polar vortex, and found: 1) Annual precipitation in Taklimakan area had some to do with longitude and latitude of polar vortex. It was inversely related to longitude of polar vortex in February, and correlation coefficient was −0.5. It was positively related to latitude of polar vortex in September of the last year, and correlation coefficient was 0.55. Both of two coefficients reached at 0.01 of confidence level. This indicates that annual precipitation of Taklimakan area is above its long-term mean when longitude of polar vortex in February is partial west and latitude in September of the last year is partial north. 2) The correlation coefficient between summer precipitation in Taklimakan area and longitude of polar vortex in February was −0.532, and reached 0.01 of confidence level. It shows that summer precipitation in Taklimakan area is above its long-term mean when longitude of polar vortex in February is partial west.

6 CONCLUSIONS

As mentioned above, several conclusions were obtained as regards the wet-dry changes in recent 40 years in Taklimakan area.

1) The mean annual precipitation series of a year and four seasons in Taklimakan area have better representiveness to wet-dry changes in the area.

2) The precipitation changes of a year and four seasons in Taklimakan area have different wet-dry periods and change periodicity, which almost have nothing to do with that of four seasons around mountains. On the contrary, in autumn the precipitation change between Taklimakan and Tuoyun has better correlation, and have some correlations with neighboring areas only in spring.

3) Summer precipitation has well directive sense to annual precipitation in Taklimakan area. The correlation coefficient of precipitation between summer and a year is 0.901, and the negative correlation between precipitation and temperature in summer is very remarkable.

4) The percentages of the first eigenvector in total variation of a year and four seasons change were 41% – 48% in Taklimakan area, and all have spatial distribution features of synchronous change in different areas.

5) There is definite correlation between annual precipitation in Taklimakan area and position of polar vortex. When longitude of polar vortex is partial west in February and its latitude is partial north in September of the last year, annual precipitation is above its mean in the area. In addition, when position of polar vortex is partial west in February, it is beneficial to obtaining much summer precipitation in the area.

REFERENCES

Ji Yuanzhong, Ren Yiyong, 1992. The Assessment of climate warms up during the eighties in Xinjiang and its impact. *Xinjiang Meteorological Monthly*, 15(1): 13 – 17. (in Chinese)

Li Jinglin, 1988. The Correlation analysis between 500 hPa mean circulation in winter and temperature and precipitation in spring and summer in Aksu area. *Xinjiang Meteorological Monthly*, 11(7): 1 – 4. (in Chinese)

Lin Xuechun, Yu Shuqiu, Tang Guoli, 1995. Series of average air temperature over China for the last 100-year period. *Scientia Atmospherica Sinica*, 19(5): 524 – 534. (in Chinese)

Ling Zhengzhou, 1991. Analysis on the eighties climatic feature in Aksu area. *Xinjiang Meteorological Monthly*, 14 (9): 18 – 21. (in Chinese)

Wen Kuada, Nan Qinghong, 1988. Forecast the annual flow of middle Tarim River and look forward the climate of the South Xinjiang. *Arid Land Geography*, 11(2): 61 – 66. (in Chinese)

Xue Hong, 1989. The several facts of climate warm up during the eighties in Xinjiang. *Xinjiang Meteorological Monthly*, 12(4): 23 – 27. (in Chinese)

Yang Duo, 1992. The spatiotemporal distribution features in Xinjiang climate variation for 31 years. *Xinjiang Meteorological Monthly*, 15 (6): 15 – 19. (in Chinese)

Yu Xinwen, Luo Jing, 1990. The precipitation distribution and the variation in Xinjiang. *Xinjiang Meteorological Monthly*, 13(7): 14 – 20. (in Chinese)

Zheng Mengliang, 1991. On the precipitation characteristics in summer and its flood prevention in Bayan Gol area. *Xinjiang Meteorological Monthly*, , 14(17): 25 – 26. (in Chinese)