Bulletin of Glacier Research 7 (1989) *77 – 81*

The character of the weather and climate in the West Kunlun Mountains area in summer, 1987

KANG Xingcheng and XIE Yingqin
Lanzhou Institute of Glaciology and Geocryology, Academia Sinica, Lanzhou, China

(Received December 27, 1989; Revised manuscript received January 23, 1989)

Abstract

A series of meteorological elements and climatic factors, such as air temperature, precipitation and so on, were observed during the expedition in 1987 carried out by cooperation between China and Japan. Total precipitation of 102.5mm for 70 days and mean air temperature of 2.5°C in July and August were measured at Base Camp (35°09'N, 81°03'E; 5260 m a.s.l.). This is of great interest because the precipitation during 70 days is twice the annual precipitation in the adjacent area. Based on analysis of field observational data, it is estimated that the annual precipitation is 200 – 250 mm at Base Camp and 400 – 450 mm near the snowline. The mean annual air temperature is estimated to be – 6.7°C at Base Camp, and – 10.2°C near the snowline. Meanwhile, it was found that glaciers can influence local climate – not only the diurnal variation and amplitude of air temperature, but also the time when the maximum and minimum appear, as well as relative humidity in a small area. To explain the rainy and cool weather experienced during the summer of 1987, evidence is given from both atmospheric circulation conditions and measured meteorological elements.

1. Introduction

The West Kunlun Mountains lie on the northwestern part of the Qinghai – Xizang Plateau, which is a vast dry area, but a number of glaciers exist there. It is still in question why glaciers have developed in such an arid region, and how the glaciers can be nourished. What is the climate like? This paper describes briefly the result of observations and discusses the weather and climate in the West Kunlun Mountains in summer of 1987.

2. Observations

The observations were made at southern side of the main mountain range, north of Gozha lake. Five stations, Lake site (LS, 5125 m a.s.l.), Base Camp (BC, 5260 m a.s.l.), Advance Base Camp (ABC, 5805 m a.s.l., just below Chonce Ice Cap), Station B4 (5974 m a.s.l., on the ice cap) and Station B12 (6327 m a.s.l., near the top of the ice cap) were built there. The positions of observations stations are shown in Ohata *et al.* (1989). Observed meteorological elements included solar radiation, air temperature, humidity, wind speed and direction, and precipitation. The observation period was from July 1 to August 31, 1987. Beijing Standard Time (GMT + 8 hours) is used in the present report.

3. The circulation pattern and its character

Weather and climate conditions, such as warm and cold periods, high and low precipitation, are concerned with the prevailing circulation in the region. Here, we use a 500 mb weather chart showing anomaly from normal year to analyze the condition of summer 1987. The following results were obtained.

June: The trough area is located near 40°N, 80°E on the June mean chart. In June 1987, the circulation was not obviously different from the mean chart.

July: The trough area is near 75°E on the mean chart. But in July 1987, there was a ridge area here. Especially between 20 – 45°N and 70 – 95°E, the anomaly is obvious. As shown in Fig. 1, the region north of 40°N is a positive anomaly area; a negative anomaly area appears south of 40°N. This shows that the trough is south of 40°N, the ridge north of 40°N.

August: The positions of the trough and ridge areas on the mean chart are similar to those of July. In August 1987, a ridge area occurred near 75°E from south to north. In the anomaly field, a positive anomaly area occurred between 20−45°N and 70−95°E (Fig. 2). This ridge area covered the survey area.

Thus, the circulation pattern in the West Kunlun Mountains area in summer 1987 was different from the mean years, that is to say, during July, it had much more trough and ridge area, the trough dominating, while in August the ridge dominated. Cyclones passed through the survey region 6 times in July and 4 times in August. There were many cloudy days with 75.2 mm of precipitation in July. Then, in August, the weather was better and precipitation only 16.0 mm.

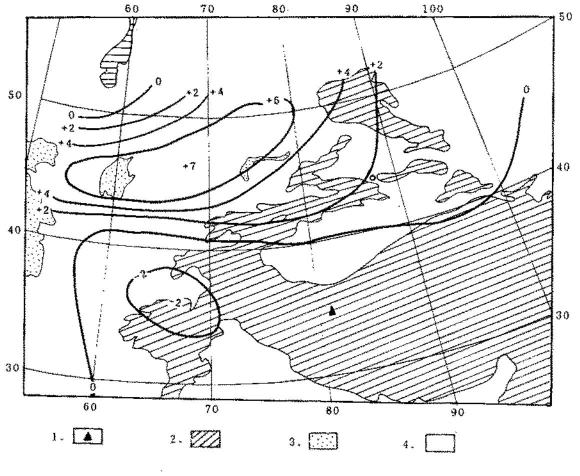

Fig. 1. Geopotential height anomaly field (m) at 500mb, July, 1987.
1: Research site.
2: Surface above 3000m a.s.l.
3: Sea or water area.
4: Surface below 3000m a.s.l.

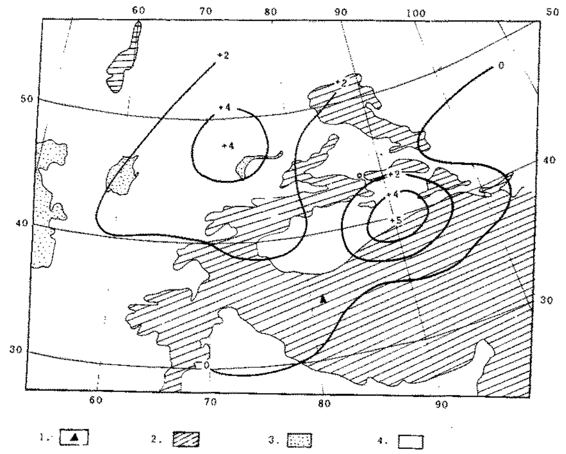

Fig. 2. Geopotential height anomaly field (m) at 500mb, August, 1987.
1: Research site.
2: Surface above 3000m a.s.l.
3: Sea or water area.
4: Surface below 3000m a.s.l.

4. Air temperature and its characteristics

Air temperature was observed at LS, BC, St. B4 and St. B12 sites in July and August, and measured by sheltered recording thermometer (Chinese made) and a digital recorder (Japanese made) at heights of 1.5 m and 2 m, respectively. Temperatures were recorded at one−hour interval.

In this area, mean air temperature was 2.4°C at Base Camp in July; the extreme maximum 14.0°C, and the extreme minimum −6.4°C. In August, the average was 2.6°C, the extreme maximum 13.2°C, and the extreme minimum −5.0°C.

4.1 Diurnal variation of air temperature

Figs. 3 and 4 show the diurnal variation of air temperature at each site in the West Kunlun Mountains area during July − August. The diurnal range of temperature in July was obviously smaller than that in August both in the non−glacier area (LS, BC) and the glacier area (B4, B12);Its diurnal range was 11.5°C at BC in July, and 13.1°C in August; whereas at St. B4, it was 6.2°C in July and 7.7°C in August. Time of occurrence of minimum temperature is delayed with increasing altitude; from BC to St. B12, it was delayed about 2 hours. Time of occurrence of maximum temperature advanced at St. B12 in both July and August.

4.2 Air temperature changes with altitude

As shown in Figs. 3 and 4, air temperature de-

Table 1. Mean air temperature and lapse rate for July, August 1987 at 7 sites.

Name of station	Altitude (m)	Mean Temp. July (°C)	Lapse Rate of Temp. (°C/100m)	Mean Temp. August(°C)	Lapse Rate of Temp. (°C/100m)
Hotan	1375	23.7	−0.56	25.4	−0.61
Kangxiwar	3986	9.2	−0.60	9.5	−0.65
Tianshuihai	4800	4.3	0.00	4.2	−0.28
LS	5125	4.4	−1.48	3.3	−0.48
BC	5260	2.4	−0.38	2.6	−0.36
St. B4	5974	− 0.3	−1.00	− 0.2	−1.41
St. B12	6327	− 3.7		− 5.0	

Table 2. Estimated monthly and annual mean air temperature at BC and station B4.

Name of station	Month 1	2	3	4	5	6	7	8	9	10	11	12	Mean
BC	−16.4	−14.0	− 9.3	− 5.3	− 3.9	− 0.7	2.4	2.6	− 2.2	− 2.2	−12.1	−15.5	− 6.7
St. B4	−19.4	−17.0	−12.3	− 8.3	− 7.2	− 5.0	− 0.3	− 0.2	− 7.5	− 9.1	−15.1	−18.5	−10.2

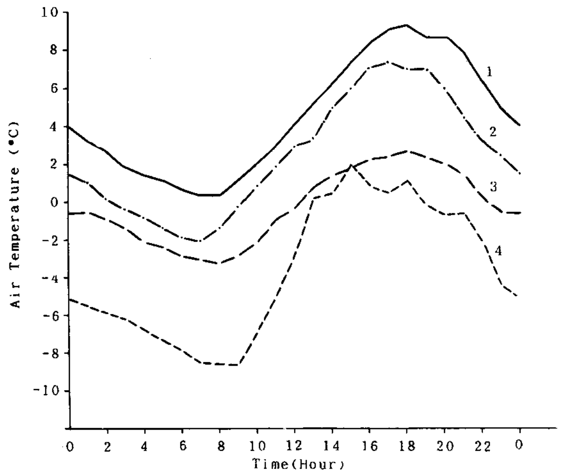

Fig. 3. Diurnal variation of monthly mean air temperature in July.
1: LS. 2: BC.
3: St. B4. 4: St. B12.

crease with increase in altitude is marked in this region. Mean air temperature at different observation sites was shown in Table 1. From the table, we can see that lapse rate differs largely in this region in summer according to altitude and months.

Here we use the results of the above mentioned observed data in 1987 and climatological data of Hotan and Kangxiwar Stations to derive a empirical formula for seasonal mean air temperature change with altitude. The following formulae are obtained from regression analysis.

$$(T_Z)_s = 32.6 - 5.7Z \qquad (R_s = -0.99), \qquad (1)$$
$$(T_Z)_w = 1.88 - 4.0Z \qquad (R_w = -0.94) \qquad (2)$$

where (T_Z)s and $(T_Z)_w$ are air temperature(°C) in summer (May to September) and winter (October to April) at height Z(km); R_s and R_w are coefficients of correlation in summer and winter, respectively.

4.3 Estimation of annual average temperature

According to the above analysis and meteorological data from Kangxiwar Station, we will use equation (1) to estimate mean air temperature at BC and St. B4 in summer (May to September), and equation (2) in winter (October to April); results are shown in Table 2. One can see from Table 2 that the annual mean temperature at BC is −6.7°C; it is −10.2°C at St. B4.

Table 3. Mean relative humidity for July, August 1987.

Name of Station	Altitude (m)	Relative Humidity(%) July	August
LS	5125	40	35
BC	5260	64	55
St. B4	5974	65	55
St. B12	6327	81	79

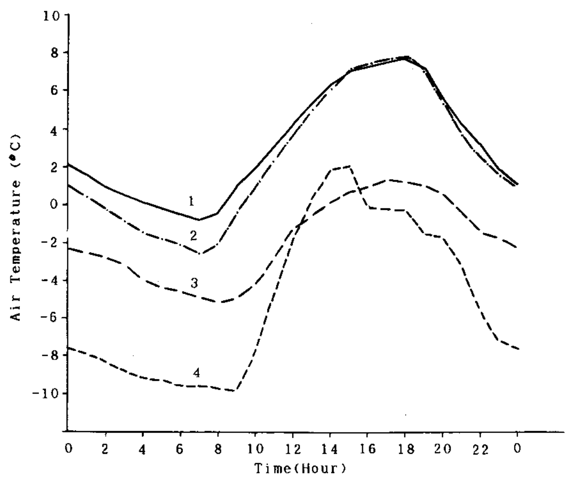

Fig. 4. Diurnal variation of monthly mean air temperature in August.
1: LS. 2: BC.
3: St. B4. 4: St. B12.

5. Relative humidity and its characteristics

Relative humidity for July and August was observed in the survey area. Table 3 shows mean relative humidity. Relative humidity increases with altitude, and relative humidity of the glacier area is about 20% larger than that of the non−glacier area. The diurnal variation of relative humidity in this area is shown in Figs. 5 and 6. The maximum relative humidity appears slightly before sunrise, and the minimum value occurs in the afternoon.

6. Evaporation

Daily evaporation was measured at Base Camp during July and August by evaporation gauge (20 cm diameter) using the China meteorological observation manual. Daily mean evaporation is 5.1 mm in July, and 5.5 mm in August. The maximum of 9.7 mm occurred on July 30; the minimum of 0.1 mm occurred in July 8. Mean evaporation on clear days were 6.6 mm, and on cloudy or snowfall days were 4.3 mm.

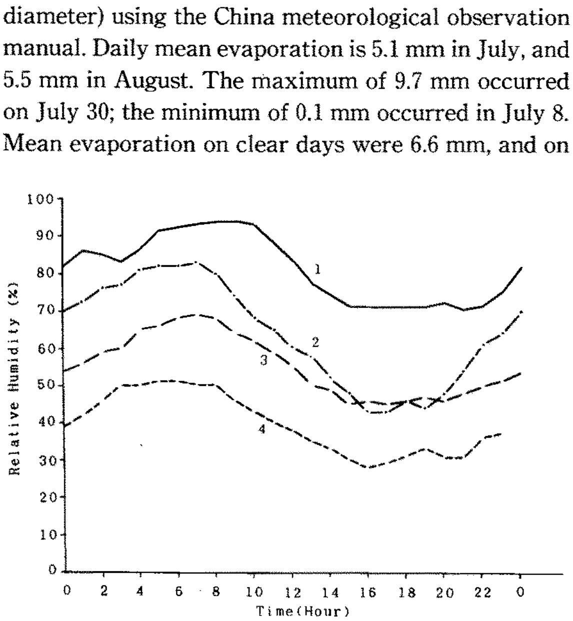

Fig. 5. Diurnal variation of monthly mean relative humidity in July.
1: St. B12. 2: BC.
3: St. B4. 4: LS.

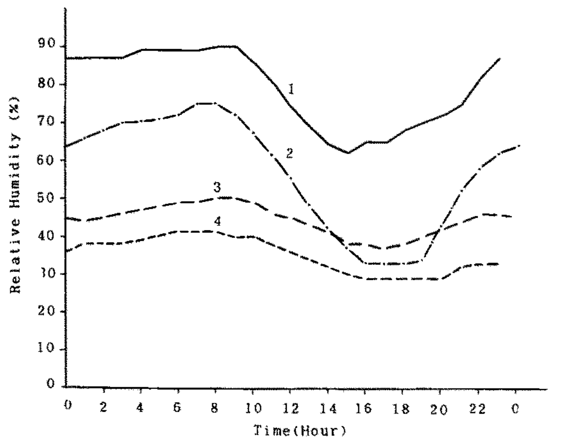

Fig. 6. Diurnal variation of monthly mean relative humidity in August.
1: St. B12. 2: BC.
3: St. B4. 4: LS.

7. Precipitation and its estimation

The precipitation in this region is interesting but complex. In the survey period, we observed precipitation of 102.5 mm at BC during 70 days (June 23 – August 31). Precipitation was 11.3 mm during June 23 – 30, 75.2 mm in July and 16.0 mm in August. It was almost 5 times as much as at Hotan, Yecheng and Kangxiwar stations in the same period; the results are shown in Table 4.

It is a well-known characteristic of the plateau climate that precipitation is concentrated in the warm season (May to Sept.); the difference between the rainy season and the drought season is quite clear. Monthly precipitation at surrounding permanent meteorological stations, results are shown in Table 5. As Kangxiwar Station is near the present observation area, it is assumed that precipitation in the present area in the West Kunlun Mountains follows the time distribution at Kangxiwar Station. Thus, we use the ratio of Kangxiwar Station data to BC data during the observation period to estimate annual precipitation in this area, which is estimated to be 251 mm at BC. We have observed precipitation at BC and ABC sites in the same period; they are shown in Table 6. The values from Table 6 indicate that ABC has almost 1.6 times as much precipitation as BC. Assuming that this ratio can be extended throughout the year, expected precipitation at ABC becomes 401 mm. In this calculation, it must be considered that the precipitation ratio in the mountains is generally different for different seasons.

In addition, the water balance method has been used to estimate the precipitation at BC site and on the glacier as 216 mm and 426 mm respectively (Cao and Ai, 1989). The results from two different methods

Table 4. Comparison of precipitation at BC and surrounding permanent meteorological stations in the same period in 1987. (Unit: mm).

Name of station	Altitude (m)	June 23–30	July 1–31	August 1–31	Total
Hotan	1375	0.0	16.7	1.4	18.1
Yecheng	1360	0.0	13.8	0.1	13.9
Kangxiwar	3986	0.4	10.8	8.1	19.3
BC	5260	11.3	75.2	16.0	102.5

Table 5. Monthly precipitation at surrounding permanent meteorogical stations.

Name of station	Items	Month 1	2	3	4	5	6	7	8	9	10	11	12	Total
Hur He *	Precipitation(mm)	3.4	7.1	14.7	2.0	14.1	33.8	8.6	12.7	19.0	1.5	2.1	4.7	123.7
Heishan *	Precipitation(mm)	9.1	7.8	7.8	10.5	17.9	35.2	24.8	21.8	12.6	5.5	0.5	0.4	153.9
Taxkorgan	Precipitation(mm)	3.5	3.6	2.5	4.4	12.0	12.3	11.3	8.2	7.5	1.1	0.5	1.3	68.2
Kangxiwar	Precipitation(mm)	0.3	0.5	0.9	2.8	6.7	7.2	7.6	5.3	3.0	2.3	0.8	0.3	37.7
Shiquanhe	Precipitation(mm)	1.5	1.3	1.7	0.9	1.7	5.6	24.8	29.0	7.4	1.8	0.6	1.2	77.5

* Hydrological observation station

Table 6. Comparison of precipitation at ABC and BC for several days in August, 1987.

Name of station	August 6	7	8	9	10	11	14	19	Total
ABC	1.0	1.3	1.4	4.8	2.7	1.5	0.3	3.0	16.0
BC	0.1	0.2	0.6	2.2	1.8	0	0.3	3.9	9.1

are quite similar. Thus, we consider that the precipitation estimates above are reasonable.

8. Characteristics of the climate in the West Kunlun Mountains area in summer 1987

Now we analyze the yearly variation of meteorological conditions in this region using mean air temperature and precipitation at Kangxiwar Station in July over the years. Fig. 7 shows the year to year variation of mean air temperature and precipitation at Kangxiwar Station for July. In the past 15 years, the maximum air temperature occurred in 1973, and the minimum in 1983. In 1987, mean air temperature in July was 0.5°C lower than the mean over the years; 1987 was basically a cold year. However, as for precipitation, its maximum appeared in 1975, and minimum in 1971. In 1987, precipitation was 3.0 mm higher than the mean value over the years. Obviously, 1987 was a high precipitation year, since average precipitation at this station over the years is only 7.8 mm.

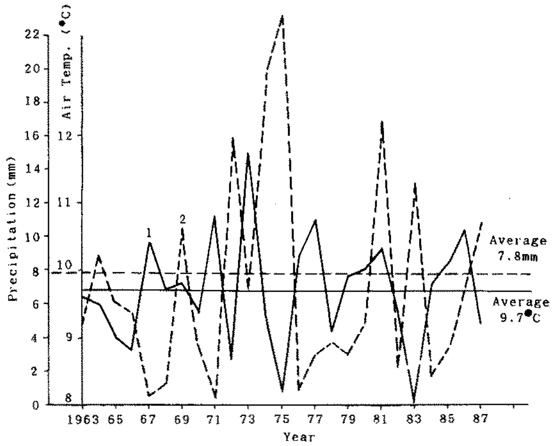

Fig. 7. Change of mean air temperature and precipitation in July at Kangxiwar Station in 1963–1987.
1: Air temperature.
2: Precipitation.

9. Conclusion

The weather and climate in the West Kunlun Mountains have the following characteristics.

1) The climate of this region has the common characteristics of plateau climate, such as the quite clear difference of precipitation in rainy and drought seasons, the precipitation concentrated mainly in the warm season (May to September).

2) According to analysis of observed data in the survey period and climatological data at surrounding permanent stations, annual mean air temperature and annual precipitation at BC were estimated to be −6.7°C and 251 mm respectively.

3) The principal characteristics of weather and climate in this area in summer 1987 in comparison with normal year were low air temperature and high precipitation.

References

Cao, Z, and Ai, S. (1989): Runoff characteristics in the Gozha Glacier region on the south slope of the West Kunlun Mountains. Bulletin of Glacier Research, **7**, 111–117.

Ohata, T., Takahashi, S. and Kang, X. (1989): Meteorological conditions of the West Kunlun Mountains in the summer of 1987. Bulletin of Glacier Research, **7**, 67–76.