

AN ATTEMPT AT RECONSTRUCTING THE HISTORICAL WEATHER SITUATIONS IN JAPAN

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INTRODUCTION

The climatologists and meteorologists who would like to reconstruct the climate and weather in the historical past of Japan have used such indicators as length of ice coverage of lake, dates of cherry blossom, number of days with snowfall and frequency of poor harvest due to unusual summer weather (Arakawa 1954, 1955, Sekiguti 1969, Yamamoto 1967). They are undoubtedly informative about the history of climate, but it is obvious that thus reconstructed climatic informations are merely concerned with average conditions of the atmosphere during a specified period in the course of year in a given place or area. One of the present authors already indicated that the seasonal march of weather or rainfall in the historical past can be well reconstructed by using the continuous weather record described in old personal documents such as diary (Maejima 1966).

Although the preparation of monthly mean pressure distribution map goes back to the 1750s in Europe, it reaches barely as far as the beginning of the 1880s in Japan (Lamb and Johnson 1966). Hence, a helpful device is needed for the reconstruction of the seasonal march of weather situations in 18th and 19th centuries in Japan.

The weather situations of summer half year of Japan is primarily controlled by seasonal migration of the polar frontal zone from which result two rainy seasons, the Bai-u and the Shurin. In the first or second decade of June the early summer rainy season, Bai-u, begins with the stagnation of the polar frontal zone along the southern coast of Japan. The polar frontal zone is most active from the last decade of June to the first decade of July in and around Japan. During this period heavy rain is frequently observed especially in Southwestern Japan.

With the northward migration of the polar frontal zone a hot dry spell of midsummer season begins around July 10 in Central and Southwestern Japan, where the North Pacific Subtropical Anticyclone exerts its influence. The northernmost position of the polar front lies in the northern portion of Hokkaido on an average during the first and second decades of August. At the end of August the polar frontal zone begins to shift southwards, thus the autumnal rainy season, Shurin, sets in with intensified activity of extratropical cyclone over Japan. During this rainy season the march of weather situation is frequently affected by tropical cyclone or typhoon.

For the purpose of reconstructing the seasonal march of weather situation, daily weather distribution will serve as a fundamental indicator. Fortunately there are still a great number of official and personal diaries in Japan, in which daily weather is reported. These documents afford valuable information to give probable pressure patterns and their day-to-day march, because the synoptic climatological explanation of the relation between the pressure pattern and weather distribution is established in Japan.

In this paper the authors try to reconstruct the weather situations of summer half year from 1860 to 1867.

DATA AND METHOD

The data used here are the daily records described in the official and personal diaries. The diaries including the daily weather descriptions during the years from 1860 to 1867 were adopted. They are Shinkakuji Diary (Kochi), Kiheitai Diary (Yamaguchi), Kokando's Diary (Tatsuno), Koume's Diary (Wakayama), Nakayama-Tadayoshi's Diary (Kyoto), Chozenkan Diary (Niigata), Sadoishin Diary (Sado), Ususekimori's Diary (Usui), Kawaji-Toshiakira's Diary (Tokyo), Hirosakihancho Diary and Umeda's Diary (Kanazawa). These localities are shown in Fig. 1.



Fig. 1 Location map

At first, the weather records for each date were classified to five categories, clear, fine, cloudy, showery or drizzly and rainy. The weather calendar diagrams for eight summers were prepared based on thus classified weather data.

Then, concerning the pronounced cyclonic weather in the weather calendar the most probable types of the pressure pattern were assumed. It was made by following procedures. First, 12 meteorological stations were selected to examine the relation between weather distribution and pressure pattern. The weather for each station from June to September of 1966–1969 were examined. Among these days 286 days in which more than half of stations with rainfall were picked out.

According to rainfall distribution pattern these cases were classified to five types: 1) Rainy over the entire country, 2) Rainy in Northern Japan, 3) Rainy along the southern coast of the country, 4) Rainy in Central and Southwestern Japan and 5) Rainy in the eastern part of the country.

The most probable types of pressure pattern associated with each rainfall distribution pattern are shown in Table 1. Based on the results of pressure pattern classification by Yoshino and Kai, the authors presented here four simplified types, because the past weather records used here were less accurate (Yoshino and Kai 1974). They are as follows; L: low

Table 1 Relationship between rainfall distribution pattern and associated pressure pattern.

Rainfall distribution pattern	Pressure pattern
1) Entire country	L, SF, T
2) Northern Japan	L, NF
3) Southern coast	NF, SF, T
4) Central and SW Japan	NF, SF
5) Eastern Japan	L, SF

The explanation of symbols is given in the text.

passing northwards over the Japan Sea, NF: a stagnant front across the Japanese Islands, SF: a stagnant front along the southern coast of Japan, and T: typhoon approaching or hitting the Japanese Islands. From these results the most probable pressure patterns associated with each marked cyclonic weather in the historical past were inferred.

Finally, by determining the periods of natural seasons and by analysing the seasonal variation of daily weather distribution for each summer half year, the past climate can be estimated in detail from the weather-climatological point of view.

SEASONAL MARCH OF SUMMER WEATHER FOR 1860–1867

In order to elucidate the day-to-day variation of the weather situations for each summer, weather calendar diagrams were prepared (Fig. 2–Fig. 9). In these figures one can easily observe the march of daily weather, the pronounced cyclonic weather situation and the period of natural season. Among eight summers the authors, in the first place, depict three extraordinary summers, unusually cool rainy or hot dry, and then the remaining intermediate ones.

Unusual summers of 1861, 1863 and 1866

Weather situations for 1861

Both the beginning and ending dates of the Bai-u season occur rather earlier than usual, so that midsummer lasts long from the end of June to the first decade of September. The Bai-u makes an earlier start on May 22, after that the polar frontal zone remains stationary along the Pacific coast of Japan until the middle of June.

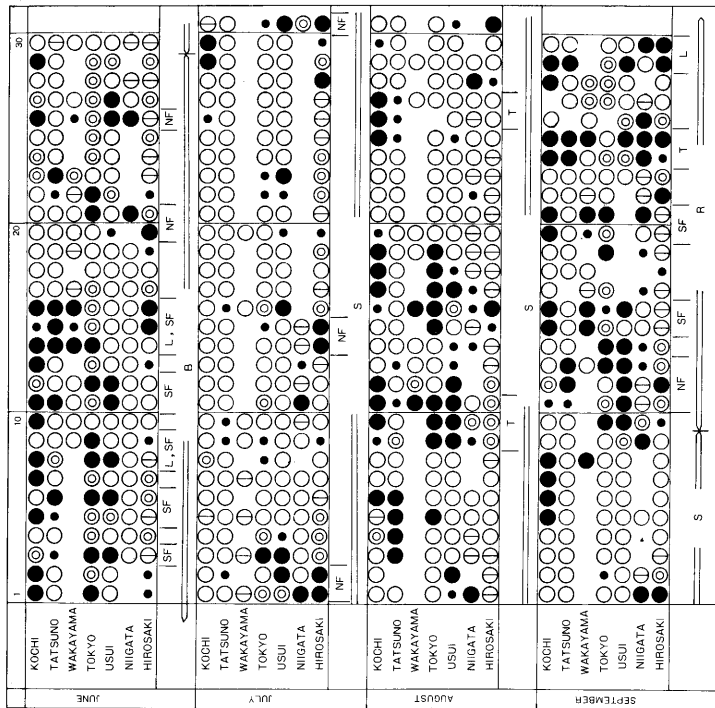
During the third decade of June the frontal zone begins moving northwards, and at the same time the midsummer season starts in Southwestern and Central Japan, whereas the beginning of the midsummer occurs during the first decade of July in Northeastern Japan.

The anticyclonic stable weather conditions of midsummer are interrupted several times by southward moving of the frontal zone and approaching of a typhoon. The former occurs around July 15 and the end of July, while the typhoons approach or hit the Japanese Islands around August 11 and 26.

Around September 10 the frontal zone begins to shift southwards, after that stagnating along the southern coast of the Japanese Islands. Thus the Shurin merges into the following season in October with an intervening episode of the approach of a typhoon on September 24 and 25 (Table 2).

The summer weather of 1861 is, in general, characterized by the less rainy spell of the Bai-u and the long hot dry midsummer. Some detailed characteristics of summer weather for

1861



○ Clear ① Fine ☉ Cloudy ● Rainy (Showery) ● Rainy
 L: Low across the Japan Sea NF: Front over Honshu SF: Front along the Southern Coast
 T: Typhoon B: Baru S: Mid-Summer R: Shurin

Fig. 2 Weather calendar for summer half year 1861

1863

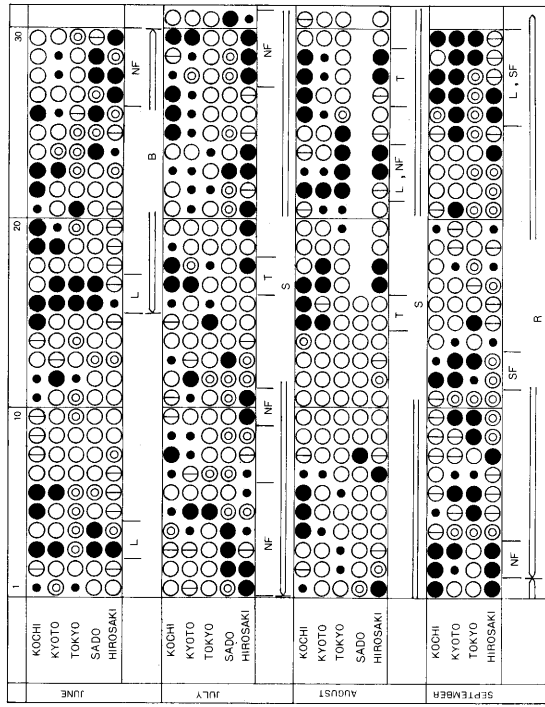


Fig. 3 Weather calendar for summer half year 1863

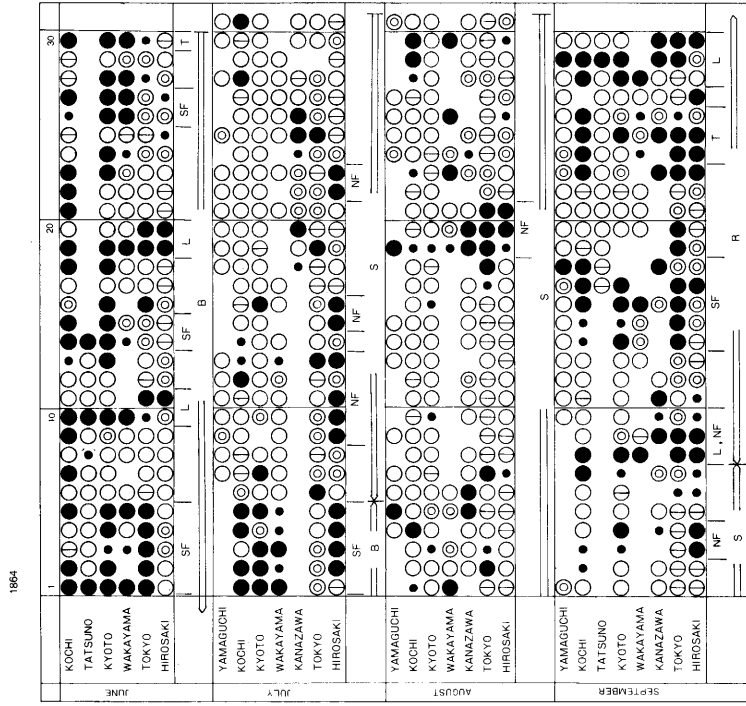


Fig. 7 Weather calendar for summer half year 1864

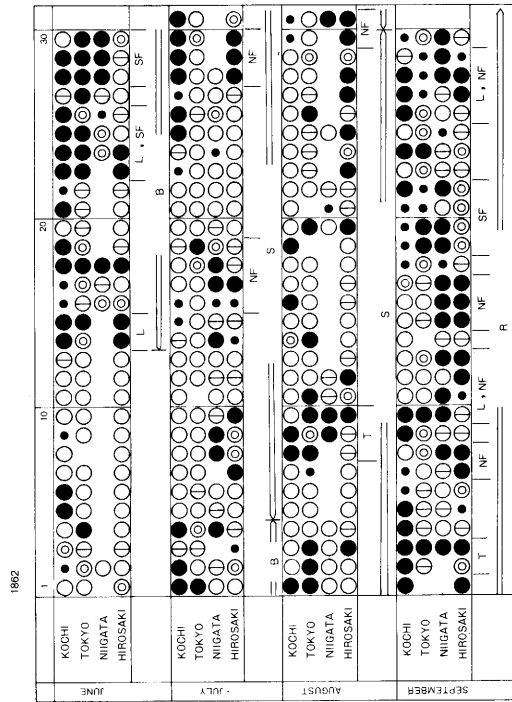


Fig. 6 Weather calendar for summer half year 1862

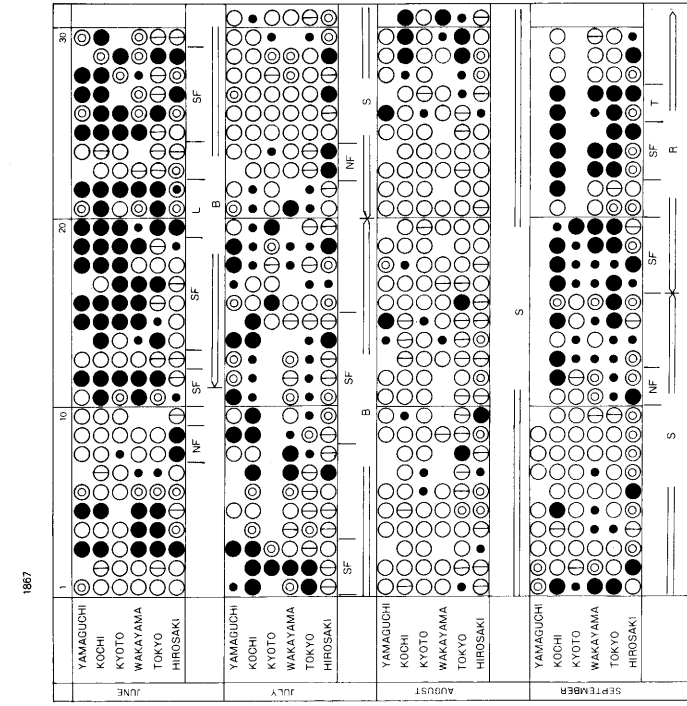


Fig. 9 Weather calendar for summer half year 1867

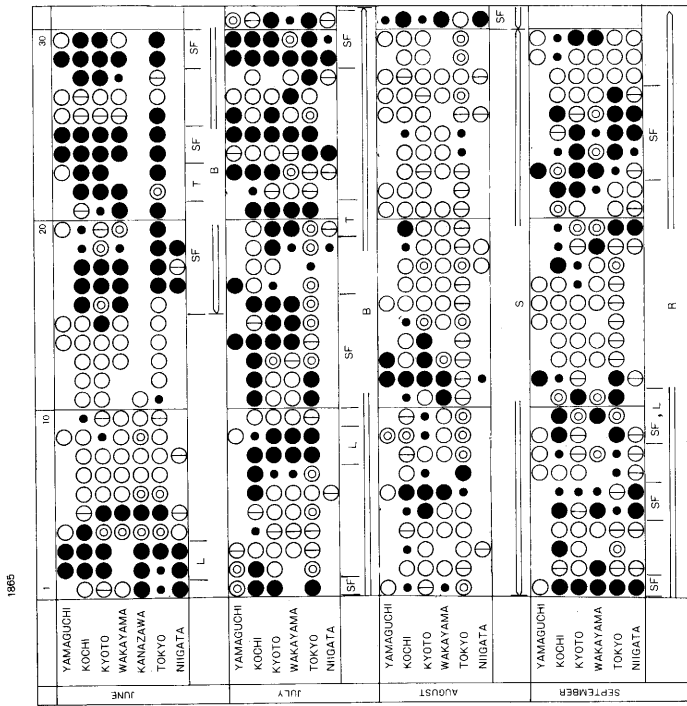


Fig. 8 Weather calendar for summer half year 1865

Table 2 Estimates of typhoon which approached or hit the Japanese Islands from May to September for 1860–1867.

year	1860	1861	1862	1863	1864	1865	1866	1867
Number of typhoon	4	3	2	4	2	2	3	2

1860–1867 are given in Table 3 and Table 4.

Weather situations for 1863

The day-to-day variation of summer weather is similar to that of 1861, which is characterized by a long spell of hot dry weather and, in consequence, the extraordinarily short periods of two rainy seasons, the Bai-u and the Shurin. This distinguishing feature is more noticeably formed in the western portion of Japan.

Around June 16 the Bai-u season sets in with the stagnation of the polar frontal zone along the southern coast of Japan. However, the polar front is inactive, moving gradually northwards at the end of June. A hot dry spell of midsummer persists for about two months until the beginning of September. Due to the frequent southward shift of the frontal zone the weather is unsettled at times in the northern mainland of Japan, while the frontal activity does not exert its influence on the western part of Japan.

The approach or hit of typhoons intervening the hot rainless weather is assumed on August 15 and August 27–29. At the commencement of September the frontal zone lies across the Japanese Islands and stagnates after September 9 along the southern coast of the country.

Weather situations for 1866

It is proved by historical documents that the rice harvest of this year was poor due to cool spell of summer weather in the northern mainland of Japan. The end of the Bai-u season is delayed and followed by a short spell of hot weather of midsummer. On June 19 the Bai-u season starts in Central and Southwestern Japan, lasting until the midst of July. The polar frontal zone begins to migrate northwards on July 15, and then a spell of stable hot weather sets in on July 21.

However, the frequent southward shift of the polar frontal zone and the approach of a typhoon on August 10 bring about interruption of the stable fine weather of midsummer. As a result, the normal weather features of midsummer occur less frequently, which leads to a poor harvest.

As early as on August 28 the commencement of the Shurin occurs with the stagnation of the polar front along the southern coast of the country. Especially, the front is in full activity in Southwestern Japan.

Normal summers of 1860, 1862, 1864, 1865 and 1867

Weather situations for 1860

The Bai-u begins relatively early on June 6. Then the polar front remains stationary along the southern coast of Japan for about a month. In the midst of July the front advances northwards, followed by the beginning of the midsummer season. Even in Northeastern Japan a hot dry spell sets in on July 19, lasting until the beginning of September. The Shurin season starts on September 4, but the front is not active except during September 12–19.

Table 3 Characteristics of the march of summer weather 1860-1867.

	BAI-U				SHURIN			
	Southwestern Japan	Central Japan	Northeastern Japan		Southwestern Japan	Central Japan	Northeastern Japan	
1860	F H throughout the season	M throughout the season	L in the middle of the season	F S	M in the middle of September	L in the first half of the season	M intermittent	M intermittent
1861	F M in the first half of the season	L intermittent	L in the middle of June	F S	M intermittent	M in the middle of September	M intermittent	M intermittent
1862	F H throughout the season	M in the last decade of June	M intermittent	F S	H in the first and the last decades of Sept.	M in the last decade of September	M intermittent	M intermittent
1863	F M intermittent	L only at the beginning of the season	M in the middle of the season	F S	L no rainy spell noticed	M in the first half of the season	M no rainy spell noticed	L no rainy spell noticed
1864	F M intermittent	M in the first half of the season	M in the latter half of the season	F S	M at the end of September	M intermittent	M intermittent	M intermittent
1865	F M in the first half of the season	M in the first half of the season	-	F S	M intermittent	M intermittent	M intermittent	-
1866	F H in the first half of the season	M intermittent	-	F S	M intermittent	M intermittent	M intermittent	-
1867	F H throughout the season	M intermittent	L no rainy spells noticed	F S	H in the first half of the season	H in the first half of the season	M intermittent	M intermittent

F: Occurrence frequency of rainy days. (H: High M: Intermediate L: Low)
S: Occurrence of rainy spell.

Table 4 Occurrence of hot dry spells in the midsummers for 1860–1867.

	Southwestern Japan	Central Japan	Northeastern Japan
1860	throughout the season	throughout the season	in the latter half of the season
1861	in the first half of the season	except in the middle of the season	in the latter half of the season
1862	except in the middle of the season	in the first half of the season	in the middle of the season
1863	throughout the season	except at the end of the season	in the latter half of the season
1864	throughout the season	in the latter half of the season	in the middle of the season
1865	in the latter half of the season	throughout the season	—————
1866	except in the middle of the season	in the middle of the season	—————
1867	throughout the season	except at the end of the season	in the middle of the season

Weather situations for 1862

The Bai-u period covers from June 14 to July 5, the length of which is somewhat shorter than as usual. During the second half of June the front is in full activity. A hot dry spell persists without break until the end of August. As usual, the frontal zone begins to stagnate across the Japanese Islands on August 31. The wet spell of the Shurin season is rather marked in Northeastern Japan.

Weather situations for 1864

The period of the Bai-u season is slightly longer than as usual, ranging from the end of May to the first pentad of July. From July 6 onwards a hot spell of midsummer continues until the first decade of September in Central and Southwestern Japan, whereas the frontal zone lies still until July 25 across the northern part of the Japanese mainland. After the midsummer season lasting until the end of August the frontal zone retreats southwards again. The Shurin season starts on September 8. A typhoon approaches or attacks the country on September 25.

Weather situations for 1865

After a spell of fine weather during the first half of June, the Bai-u season begins with the stagnation of the polar frontal zone along the southern coast of the country, lasting until the end of July. The period of the Bai-u season of this year is the longest among the eight summers concerned. On July 19–21 in the Bai-u season the earliest hit of a typhoon is proved by the weather records in the past documents. The midsummer season continues only for about a month during August. On August 31 the frontal zone begins to remain stationary on the southern coast of the country, getting weak during the second decade of September, and becomes active again after September 21.

Table 5 Summer weather conditions extracted from archives.

1860	much rain in the central part of Honshu in early summer
1861	wet spell continues in the Pacific side of Central Japan and little rain in the central part of Honshu in the Bai-u season
1862	summer drought on the Pacific side of Central Japan
1863	—————
1864	summer drought in the northern part of Honshu
1865	wet spell continues in the westernmost part of Kyushu in early summer and drought along the northern coast of the Inland Sea
1866	frequent heavy rain in Central Japan throughout summer
1867	summer drought in the northern part of Honshu and Kyushu

Weather situations for 1867

The commencement and end of the Bai-u season are much the same as the average dates in modern times, being June 12 and July 20 respectively. From July 21 onwards the midsummer season continues until the middle of September. During this season a long spell of hot fine weather is recognized, especially in Central and Southwestern Japan. At the beginning of September the northern part of the Japanese mainland is already under the influence of the Shurin front, and its southward movement bring about the onset of the Shurin season in Southwestern Japan in the middle of September. A typhoon probably approaches the Japanese Islands on September 26 and 27.

The description of summer weather situations stated above is supplemented by the weather documents extracted from archives (Table 5). Thus the reconstructed weather situations inform a detailed history of climate for 1860–1867.

CONCLUDING REMARKS

Most of the summers dealt in this paper have rather long midsummer, in consequence, the slightly weakened Bai-u and Shurin phenomena. Only in the year of 1866 a shorter spell of hot fine weather prevails.

Thus, it will be safe to say that the weather features of each summer and the year-to-year variation are much the same as those of modern times.

In this way it is sure that the method reconstructing the past weather situation by using daily weather records at several places, can provide a detailed information on the history of climate from the weather-climatological point of view. This method may be also applied to the areas and times without instrumental records outside of Japan.

The authors wish to dedicate this article with profound respect to Professor Dr. Taiji Yazawa on the occasion of his retirement from Tokyo Metropolitan University.

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