

Some Remarks on the Climatic Conditions of Kyoto during the Period from 1474 to 1533 A.D.

Ikuo MAEJIMA

Introduction

Analysis of climatic conditions during the historical period of Japan by using the weather record described in "Sanetaka's diary" is the subject of this article.

Japanese meteorologists and climatologists have contributed much to the investigation of climatic conditions during the historical period of Japan. There are opposing opinions on the problem of climatic variations during historical period in Japan. Many confirm the existence of different climatic conditions during some periods in historical time from the present. On the other hand, some assert that there were no significant changes of climate to the present, and the climatic conditions in the past have fluctuated only within the same range of variation as during the present time.

Different selection of fragmentary historical manuscripts may lead to these opposing conclusions; therefore, careful selection of data is required in discussions of climate during the periods without meteorological observation. It is desirable to use rather homogeneous long-term records, if possible, than fragmentary records of differing origin. Sanetaka's diary which was written by Sanetaka SANJONISHI, a court noble, covers 60 years, during which time weather data are inserted in descriptions of each day with few exception. These weather data offer valuable basis to reconstruct the climatic conditions of Kyoto during the 15th and 16th centuries.

Sanetaka's diary

In Sanetaka's diary, weather data are described completely or partially for 54 years excluding 6 years, 1481, 1500, 1517-1520. Although Sanetaka SANJONISHI moved his residence once in his life-time, the author took no notice of his move

and regarded the weather data in his diary as being representative of the climatic conditions of Kyoto during the period concerned.

The weather data described in his diary are concerned basically with expressions, such as fine, cloudy, rainy and snowy, partially supplemented by other phenomena, such as heat and cold, wind, thunder, fog, hail, frost, ice and so on. For most of the dates in the diary the weather conditions are recorded in such manner as fine, cloudy, rainy or snowy, with rare cases without such description.

As the old lunar calendar system was used in Sanetaka's diary, the author converted the dates to the Gregorian style. Total number of days in each month in which the number of days with weather record exceed 20 out of a month are as follows:

January	912 days for 32 years	
February	873	33
March	1213	42
April	1079	37
May	1125	38
June	992	34
July	1025	36
August	817	29
September	846	30
October	1120	39
November	989	34
December	1052	36

From this table it is easily understood that the weather data in Sanetaka's diary are valuable for discussing climatic conditions during historical time in Japan. Among historical diaries his diary includes a unique weather record which was made by a certain person with the same degree of accuracy for many years.

Number of days with precipitation

The author classified weather data for each date in the diary to four categories, fine, cloudy, rainy and snowy, and prepared a weather calendar for 60 years. Here, the days with precipitation, rainfall and snowfall, are treated.

At first, the average monthly percentage frequency of occurrence of days with precipitation for each month was calculated by using the data of months in each of which the number of days with weather description exceed at least 20 for the month. Next, they were converted to average number

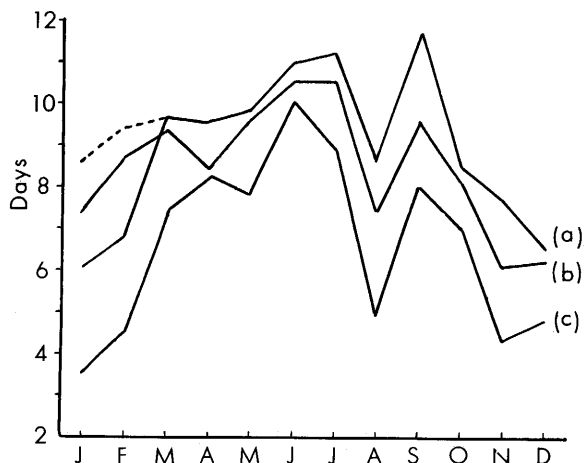


Fig.1 Annual march of number of days with precipitation. (a) Kyoto at present, (b) Sanetaka's record, (c) Taguchi's result.

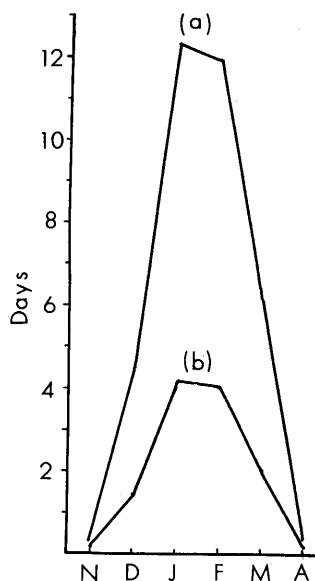


Fig.2 Seasonal march of number of days with snowfall. (a) Kyoto at present, (b) Sanetaka's record.

of days with rainfall and snowfall for each month. The annual march of average monthly number of days is shown in Fig. 1. The annual march of average number of days with precipitation of greater than 1.0 mm in Kyoto at present, which was prepared from the weather record for 30 years 1921-1950 is also included.

The results which were obtained by Taguchi (1940) from the weather record for some 20 years extracted from 6 diaries of different origin from 1028 to 1452 is added to Fig. 1. According to Sanetaka's diary, average annual number of days with precipitation is 101.7, which is somewhat greater than the value obtained from meteorological records of Kyoto at present which is 107.4, while Taguchi's result shows the number of days to be 78.9. Taguchi assumed that the fewer amount of number of days obtained by himself is due to the circumstance that the writers of diaries probably did not record light rain in their diaries. Despite the difference of absolute values, it is noteworthy that Taguchi's curve of annual march runs closely parallel with that of the present time. From this, Taguchi concluded that there was no significant difference of climate from the 11th to the 15th centuries

and that of the present time.

Observing Fig. 1 in detail, a minor difference of annual trend prepared from Sanetaka's diary from the other two is the greater number of days with precipitation in January and February. The fact does not necessarily mean excessively rainy or snowy winters existed during the 15th and 16th centuries. Because the number of days with precipitation may include snowy days which may be equivalent to less than 1.0 mm of precipitation, while for the present time the days with precipitation of more than 1.0 mm are treated. This leads to the re-examination of the number of days by Sanetaka's diary.

In Sanetaka's diary, snowfall occurs during the period from November to April, and the annual number of days with snowfall is 11.7. On the other hand, according to modern meteorological records, the number of snowy days is 35.1 during the same period. The ratio of the former to the latter is approximately $1/3$ not only in annual value but also in monthly value, hence both seasonal trends are in close parallelism with each other, as seen in Fig. 2. From this it may follow that there is a difference of criteria of snow observation between Sanetaka and the Kyoto Meteorological Observatory.

According to modern Japanese rules of observation, the number of days with snowfall are defined as the total number of days in which snowfall has been observed, disregarding intensity of snowfall. As a result it may be reasonable that the latter is greater than the former. On the other hand, it is likely that the snowfall described by Sanetaka was often with a precipitation figure of less than 1.0 mm. Snow depth that corresponds to 1.0 mm of precipitation is approximately 10 to 20 mm since the density of new snow is 0.05 to 0.1. It is not difficult to infer that the snowfall observed by Sanetaka includes those with depth of less than 10 to 20 mm.

The author attempted to analyse the number of days with snowfall in Kyoto at the present time. Taking into account the ratio $1/3$, the amount of precipitation 0.2 mm which corresponds to 2 to 4 mm of snow was adopted as a critical value by using the data of snowfall in January and February 1964, because the upper $1/3$ of precipitation in the days with snowfall in Kyoto is more than 0.2 mm. Accordingly, for the purpose of comparing rather strictly these past and present records with each other, the number of snowy days with precipitation 0.2 to 0.9 mm should be added to those with 1.0 mm in January and February in Kyoto at present. The average number of days with precipitation 0.2 to 0.9 mm is 5 in

January and February respectively, which were obtained from the table of dialy precipitation 1926 to 1950. Multiplying 5 by the ratio 1/2 with which snowfall occurs in the days with precipitation 0.2 to 0.9 mm in January and February, the author found 2.5 days which are to be added to the number of days with precipitation of more than 1.0 mm in January and February respectively. The corrected curve is shown by dashed line in Fig. 1.

It can be recognized that the trend of the corrected curve has become similar to that which was prepared from Sanetaka's diary. This is the probable reason which indicates that the climatic conditions or seasonal trend during the period 1474 to 1533 are rather similar to those of Kyoto at present.

Seasonal variation based on 5-day mean
frequency of precipitation

In order to present detail of the similarity of seasonal march based on monthly number of days with precipitation, daily percentage frequency of precipitation was prepared from the weather calendar which was determined from Sanetaka's

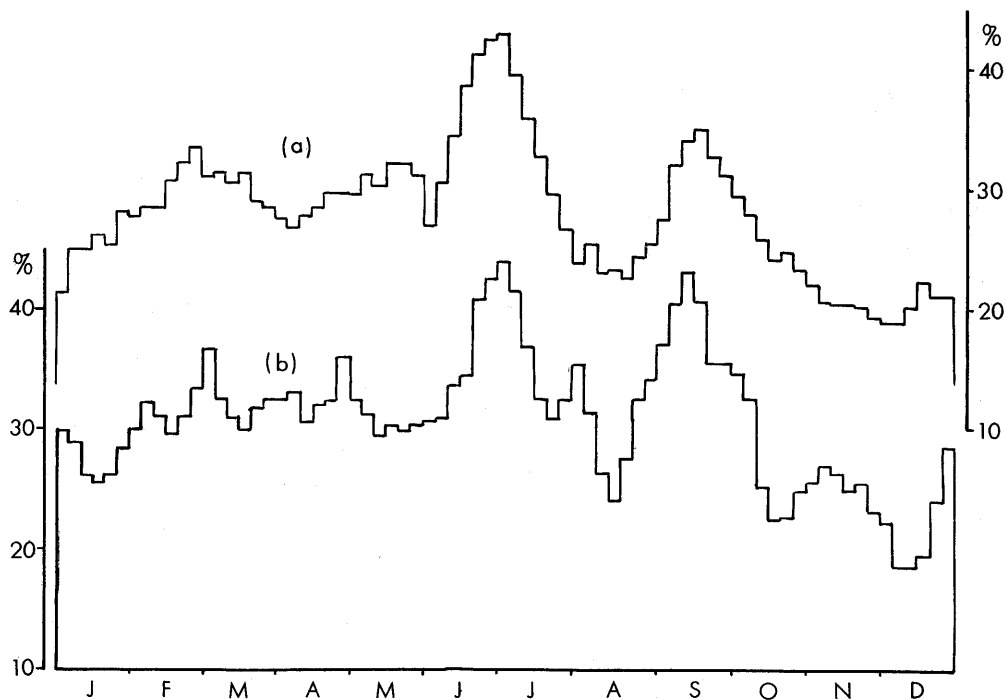


Fig.3 Annual variation of 5-day mean frequency of precipitation. (a) Sanetaka's record, (b) Kyoto at present.

diary. The annual variation of daily frequency manifests clearly that there were two outstanding rainy seasons, the Baiu and the Shurin during the 15th and 16th centuries as they occur during the present time. Such a trend is recognized in Fig. 3, the annual variation of smoothed mean 5-day frequency.

The pronounced rainy seasons, the Baiu and the Shurin, are closely related to seasonal migration of the polar front in the environs of Japan. The former is caused by the stagnation of the polar front on its northward movement in early summer and the latter by its southward movement and the invasion of typhoons in early autumn. At present the Baiu lasts generally for about 30 days from the 3rd pentad of June to the 3rd pentad of July, while the Shurin lasts for about 40 days from the 1st pentad of September to the 3rd pentad of October.

According to Sanetaka's records, as seen in Fig. 3, the Baiu occurs during the period from the 3rd pentad of June to the 3rd pentad of July and the Shurin from the 2nd pentad of September to the 3rd pentad of October. In addition, the culminating periods of these rainy seasons occur in the 1st pentad of July and the 5th pentad of September respectively. Such a tendency in the past strikingly resembles that of the present time. Following this to a conclusion would be to state that the seasonal variation of atmospheric circulation around Japan and, hence, mean position of the polar front during the 15th and 16th centuries were almost the same as those of the present time.

Snowfall

In Sanetaka's diary, snowfall occurs from November to April. The author was able to determine the dates of earliest snowfall for 19 seasons and the latest snowfall for 21 seasons. The extreme date of earliest snowfall is November 12, 1528, and the latest is April 13, 1531, while from the modern meteorological record, 1881 to 1950, November 6, 1904 and April 11, 1902 represent the earliest and latest respectively for Kyoto.

The average dates of the earliest and latest snowfall are December 17 and March 13 for Sanetaka's records, and December 4 and March 23 for the meteorological records. We cannot conclude with certainty that milder winters prevailed during the 15th and 16th centuries from these differences. Because the number of days with snowfall prepared from Sanetaka's diary are only 1/3 of those from the meteorological records and according to the examination of correlation, winter cold-

ness is not closely related to earliest and latest dates of snowfall as far as meteorological records of Kyoto are concerned.

For the sake of demonstrating winter coldness, the number of days with snowfall must be selected rather than the earliest and latest dates of snowfall, because the former has a high correlation coefficient to winter coldness. The average

Tab. 1 Climatic conditions of Kyoto around 1500 A.D.

year	number of days with snowfall	freezing date of Lake Suwa	date of cherry-viewing	annual number of days with precipitation
1476	10	Dec. 31	—	—
1478	5	Jan. 17	May 1	—
1484	8	Dec. 31	Apr. 6	—
1485	15	Jan. 1	Apr. 4	90
1486	11	Jan. 10	Apr. 9	98
1487	10	Jan. 11	Apr. 3	—
1489	14	Jan. 20	—	—
1497	21	Jan. 22	—	—
1506	10	not freezed	Apr. 16	—
1507	13	Dec. 20	Apr. 18	119
1509	15	not freezed	Apr. 12	—
1510	13	not freezed	Apr. 20	117
1511	15	not freezed	Apr. 21	122
1512	10	not freezed	Apr. 18	—
1524	15	Jan. 1	Apr. 18	—
1526	16	Dec. 14	May 8	119
1527	12	Jan. 14	Apr. 15	102
1528	5	Jan. 16	Apr. 15	94
1529	11	Dec. 27	Apr. 17	98
1530	8	Jan. 6	Apr. 17	—
1531	10	Jan. 1	Apr. 13	—

number of days with snowfall from December to March is 11.5 for 21 seasons during each of which continuous weather records could be obtained. From 1475/1476 to 1530/1531 the number of days with snowfall and those with precipitation, including snowfall, were obtained, as seen in Tab. 1.

Nishioka (1949) and Yamamoto (1948) offered the view that warm and less rainy climate dominated Japan around 1500 A.D.. This was determined by analysing, especially, the freezing record of Lake Suwa in Central Japan and the cherry-viewing records in the Court of Kyoto. The principal arguments lie in the fact that the freezing of lake surface did not occur for 8 winter seasons in the beginning of the 16th century, 1508 to 1515. The number of days with snowfall of Kyoto for these winter seasons are not always small, but somewhat greater than the years before and after. As air temperature of Kyoto varies parallel with that of Suwa during the winter months at the present, if the freezing record of Lake Suwa is sufficiently reliable, the number of days with snowfall should be expected to be fewer than during the other winter seasons. However, in considering the record of snowfall, it is difficult to say that warmer winters dominated the Kyoto area around 1500 A.D.

The record of cherry-viewing in the Court of Kyoto is found in various historical manuscripts, which have been often used as valuable phenological data for discussing the climatic variation of Japan. The dates of cherry-viewing in comparison with the number of days with snowfall and with the freezing dates of Lake Suwa are shown in Tab. 1. From this table it is accepted that the dates of cherry-viewing around 1500 A.D. are later than the others, and that they are related to the number of days with snowfall rather than the freezing dates of Lake Suwa. In addition, the annual number of days with precipitation suggest that more or less humid climate dominated around 1500 A.D..

Thus the author casts a doubt on the view that the climate was warmer and drier during the 15th and 16th centuries in Japan, reaching their maximum in about 1500 A.D.. Lamb (1963) and Fairbridge (1963) summarized from world-wide materials that colder winters, a minor ice age, dominated the earth around the 15th century. The author's results coincide with their conclusions.

Variability of rainfall régime

In order to examine the variability of rainfall régime during historical period in comparison with that of the

present, the coefficient of variability s/M in regard to the annual number of days with snowfall, annual number of days with precipitation, and number of days with precipitation in June-July were calculated by using the data available for 21, 11 and 31 years respectively, where s is the standard deviation and M the mean value. The coefficient of variability during the present time were also calculated as to the elements mentioned above for 21, 11 and 31 years respectively which were selected at random from the records of 1881 to 1950. As the result of significance test of difference regarding these 3 pairs of coefficient of variability, there was no significant difference with the level of risk 5%. From this the author reached the conclusion that the rainfall régime during the 15th and 16th centuries had fluctuated year after year within the same range as during the present time.

Concluding remarks

Analysing the weather records for 60 years described in Sanetaka's diary, the author found out the following:

- (1) It is difficult to accept the culmination of warm and dry conditions, as has been stated by some researchers, occurred around the beginning of the 16th century in Japan.
- (2) On the contrary somewhat cold and humid conditions dominated during the 15th and 16th centuries.
- (3) Such a trend agrees with that of the earth as a whole.

References

- Fairbridge, R.W. (1963): Mean sea level related to solar radiation during the last 20,000 years. "Changes of climate", Proceed. of the Rome Sympos., 229-242.
- Lamb, H.H. (1963): On the nature of certain climatic epochs which differed from the modern (1900-39) normal. "Changes of climate", Proceed. of the Rome Sympos., 125-150.
- Nishioka, H. (1949): History of warmth and coldness. Tokyo (in Japanese).
- Taguchi, T. (1940): On the climate of Japan during historical time, Umi to Sora 20, 189-203. (in Japanese).
- Yamamoto, T. (1948): Long-term cyclic variation of climate during historical time, Kagaku 18, 107-114. (in Japanese).