

Climatic Records of Japan : A Historical Overview

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Abstract

Proxy data in the historical period in Japan since the 9th century has been first described and their analyzed fluctuation series were shown. Secondly, the climatic records before and after the Meiji restoration in 1868 were mentioned. Thirdly, available date sets of historical climatic records in Japan are listed. Lastly, published records and tables for Japan during the recent years were overviewed. Some discussion on the climatic records and tables is given as concluding remarks.

Keywords Climate, Climatological study, Climatic record, Climatic table, Proxy data

1. Introduction

Climatology is one of the descriptive sciences, which are constructed by the collected data obtained through observation. Without records, needless to say, climatologists can not study anything.

In the historical periods, man has been describing climates in documents. The beginning of the periods go back to the several thousands years ago in some old countries, but only 8th century in Japan. In the present paper, it is intended to overview the records and tables available for the regional climatological studies or regional climatology of Japan.

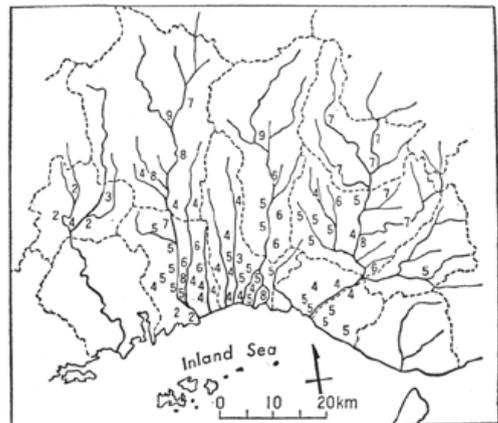


Figure 1. Distribution of grade of productivity by natural environment in Harima, an old province in SW Japan in the 8th century. 1:best of best, 2:medium of best, 3:worst of best, 4:best of medium, 5:medium of medium, 6:worst of medium, 7:best of worst, 8:medium of worst, and 9:worst of worst(Yoshino, 1975).

Table 1. Date of the banquet viewing cherry blossoms held in Kyoto (Arakawa, 1955)

812	III28*	1006	IV 4*	1322	IV 8*	1459	IV 14*	1507	IV 8*	1585	IV 15**
815	IV11*	1016	IV 14*	1323	IV 26*	1460	IV 12*	1508	IV 10*	1594	IV 19**
831	IV 2*	1018	IV 17*	1326	IV 9*	1462	IV 7*	1509	IV 2*	1597	IV 24**
851	IV14*	1029	IV 20*	1331	IV 14*	1463	III 23*	1510	IV 10*		
853	IV10*	1041	IV 7*	1332	IV 16*	1464	IV 4*	1511	IV 11*	1603	IV 13**
864	IV 5*			1344	IV 3*	1465	III 30*	1512	IV 8*	1604	IV 9**
866	IV12*	1105	IV 17*	1346	IV 9*	1466	IV 6*	1513	IV 10*	1605	IV 15**
		1127	IV 2*	1347	IV 11*	1468	IV 1*	1514	IV 5*	1606	IV 16**
912	III30*	1179	IV 6*	1366	IV 14*	1478	IV 22*	1517	IV 6*	1609	IV 18**
917	III31*	1184	V 15*			1481	IV 7*	1518	IV 15*	1612	III 27**
926	IV 3*			1422	IV 10*	1484	III 28*	1519	IV 11*	1613	IV 16**
941	IV14*	1230	IV 5*	1424	III 30*	1485	III 26*	1520	IV 4*	1622	IV 16**
949	IV12*	1246	III 22*	1426	III 31*	1486	III 31*	1521	IV 7*	1633	IV 8**
957	IV17*	1247	IV 9*	1430	IV 9*	1487	III 25*	1522	IV 3*	1651	IV 17**
958	IV14*	1263	IV 23*	1432	IV 4*	1495	III 26*	1524	IV 8*		
961	III23*	1278	IV 16*	1439	IV 15*	1498	III 29*	1525	IV 4*	1846	IV 7**
963	III30*	1285	IV 8*	1443	IV 8*	1499	IV 12*	1526	IV 28*	1847	IV 17**
965	IV 9*	1286	IV 15*	1450	IV 1*			1527	IV 5*	1851	IV 12**
966	IV 3*	1295	III 31*	1451	IV 4*	1500	III 28*	1528	IV 5*	1853	IV 12**
967	IV 8*			1452	III 23*	1501	IV 3*	1529	IV 7*	1864	IV 14**
974	IV13*	1302	III 29*	1456	IV 6*	1502	V 2*	1530	IV 7*		
975	IV12*	1307	IV 6*	1457	IV 6*	1505	IV 6*	1531	IV 3*		
		1316	IV 4*	1458	IV 13*	1506	IV 6*	1532	IV 7*		

III: March IV: April V: May. *: Julius Callendar **: Gregory Callendar

2. Proxy Data in Historical Period

2.1 Early Description of Climatic Conditions

2.1.1 In A Small Area

“Fudoki” is an old regional geography of the old provinces, which was compiled in compliance with an Imperial edict. At the present time, the description of only five territories remain intact out of the entire volume, and detailed accounts based on experience are given on the local climatic conditions. For instance, in the chapter on villages of Harima-Fudoki, degree of fertility of the “soil” was reported. The “soil” have does

not mean the soil per se, but probably means productivity of the land base on the over-all natural environment suitable for farm products; namely, the soil, water temperature, ground temperature, air temperature, wind, moisture etc. Fig.1 shows distribution of grade of productivity by natural environments in Harima, an old province in SW Japan in the 8th century (Yoshino, 1975). The grade was seemed to be judged based on subjective criteria, but this record is noteworthy as the first treatise in Japan 1,200 years ago.

2.1.2 Wind Landscape and Typhoon Visit

An old expression of violent winds associated

Table 2. Frequency(%) of the date of the banquet viewing cherry blossoms in Kyoto (Arakawa, 1955)

Century	A	B	C	D	E	F	G
9	-	43	57	-	-	7	11.3
10	7	36	50	7	-	14	11.8
11	-	20	40	40	-	5	18.4
12	-	25	25	25	25	4	17.5
13	13	13	38	38	-	8	15.4
14	-	8	58	25	8	12	17.4
15	-	43	37	17	3	30	13.1
16	-	3	77	13	6	31	17
17	10	20	70	-	-	10	12.4
18	-	-	-	-	-	0	-
19	-	30	80	-	-	5	12.4
1917- a	8	61	31	-	-	36	7
1953 b	-	31	60	9	-	35	14

A: Before 31 March
 B: 1-10 April
 C: 11-20 April
 D: 21-30 April
 E: After 1 May
 F: Number of records
 G: Mean data of April by century
 a: First date of blooming (at Kyoto Met. Obs. Sta.)
 b: Date of full blooming (at Kyoto Met. Obs. Sta.)

with typhoon visit was “Nowaki”, or “Nowake” which means “Winds or traces of wind flowing through grasses on the fields”. Particularly, educated noble man in the Heian era [794-1186], felt poetical sentiment for the landscape of the fields after “Nowaki” (Takahashi and Sato, 2002). Seisho-nagon, a famous writer in the Heian-era, mentioned “favorable winds” in the classics “Makuranosoushi” written presumably in 1001-1003; “Kogarashi” or “Arashi”, strong wind or mountain breeze in late autumn or winter, and “Hanakaze”, moderate wind in spring.

Murasaki-shikibu [978-1015?] wrote the oldest novel “Genji-monogatari” in Japan in the Heian era. In Chapter 28, “Nowaki”, she gave a vivid description of the scenery during the typhoon visit and the peoples’ cope with the strong wind blowing around the houses in Kyoto. It was studied that this was the oldest reportage in Japan; namely, this was the case

of typhoon visit on 26 September, 1003 (Julius Calendar) or 2 October, 1003 (Present Calendar) and the estimated wind velocity was 25m/sec (Yoshino, 1999).

2.2 Long-year Series of Proxy Data

2.2.1 Data of Full Blooming of Cherry Blossoms

In Kyoto, banquet of cherry blossom viewing had been held by Tenno (Emperor) or Shogun every year and the records of its date have been collected in the “Historical Meteorological Data” (Nihon-kisho-shiryō) by Taguchi (1939a). Using this records, climatic changes have been discussed by Taguchi (1939b) and Yamamoto (1952a,b). Table 1 shows the records of date compiled by Arakawa (1955, 1957). Table 2 shows the date in percentage, arranging in terms of Gregory Calendar. It was concluded that the dates from the 11th to 14th

Table 3. Mean freezing date and Omiwatari date of L. Suwa every 40yr (Arakawa, 1957)

Period	Freezing date		Omiwatari date	
-1479/80	Jan.	4.7	Jan.	7.6
1480/81-1519/20		6.9		9.2
1520-21-1559/60		8.1		10.9
1560/61-1599/1600		9.2		11.6
1600/01-1639/40		6.2		9.4
1640/41-1679/80		9.3		11.3
1680/81-1719/20		5.3		8.3
1720/21-1759/60		12.3		18.2
1760/61-1799/1800		7.3		15.2
1800/01-1839/40		12.9		17.6
1840/41-1879/80		21.7		24.9
1880/81-1919/20		4.7		-
1920/21-1953/54		8.9		13.0

centuries and the 16th century were later, indicating lower temperature in late winter and early spring, as compared with the centuries before the 10 century and after the 15 century.

Later, it was indicated that the full blooming date of cherry blossoms in Kyoto in spring shows a close relation to the percentage ratio of the rain days to the whole precipitation days from November to March in the preceding winter during the 8th to 16th centuries (Yamamoto, 1967).

2.2.2 Freezing Data of Lake Suwa

The date of freezing lake water in winter is another good indicator of climatic fluctuations, where “late” and “early” dates correspond to “warm” and “cold” winters, respectively. The date of freezing is of course a function of the temperature over a period of several days under the influence of winter pressure pattern. As the

temperature falls, the initial ice-sheet may be strongly deformed, as in the case of L. Suwa, Nagano Pref. (36 °N, 138 °E). The physical processes involved in this deformation, which occurs with successive temperature changes, are complex. Essentially, horizontal tensile stresses first accumulate until they overcome the strength of the ice, causing cracking in many directions. Temperature fluctuations then cause sufficient expansion and contraction of the ice to elevate the ruptures into peculiar ridges. These characteristic ruptures (Omiwatari) usually begin to appear 2-3 days after the full lake has become covered with ice (Fukui, 1977).

Records of the freezing and Omiwatari dates of L. Suwa have been kept variously at Suwa Shrine, Yatsurugi Temple, etc., and more recently, at the Suwa Weather Station. For climatic studies, these freezing dates have been collected into a chronological table, a project

initiated in 1921 by the late Professor S. Fujiwara (Fujiwara and Arakawa, 1954; Arakawa, 1955). The data extend back over more than 500 years, from the 15th century to the present and constitute a most valuable climatological record that has been admired throughout the world. The original table was revised and rearranged by Arakawa (1957). Mean freezing dates and Omiwatari dates for 400- years- periods of the Gregorian calendar are shown in Table 3. Clearly, the early records of L. Suwa show a long period (1450-1700), when the climate was far colder than the average. The subsequent years are characterized by warmer winters (i.e. later freezing) and include an observable number of mild winters, although there are definite fluctuations between cold and warm phases.

The date of freezing and Omiwatari have been widely used by other investigators for studies on the changing climate of Japan. For

example, Tanaka and Yoshino (1982) have reexamined the freezing date with climatic condition observed at the Weather Station located on the lakeshore and, using this relationship, reconstructed the temperature fluctuation in the historical period.

As shown in Fig. 2, the fluctuation in central Japan is slightly different from the reconstructed by freezing of rivers and lakes in China (Chu, 1973) and winter index in England (Lamb, 1977).

2.2.3 Description from the Viewpoint of Global and Regional Comparison

Comprehensive studies on the climatic change from the global viewpoint have been made since the early time of the 20th century. In the present paper, however, these are not mentioned due to space, but the recent several contributions for understanding the past climatic for conditions of Japan are introduced.

In the global scale, the past climate conditions are mentioned in the books written by Lamb (1977, 1982, 1987). Recently, Suzuki (2000) dealt with the global climate for each thousand years since the last 10,000 and for each hundred years since the 1st century, based on the results of recent literature from region to region. These help the description of the past climates of Japan through analyses of the proxy data.

In the regional scale, history of Japan was discussed in terms of climatic conditions (Yamamoto, 1976). One volume in a series of "Civilization and Environment", results of a project undertaken by T. Umehara, Sh. Ito and Y. Yasuda during 1991-1993, was dedicated to

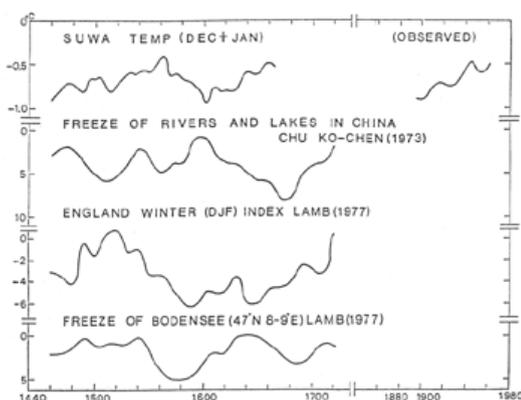


Figure 2. Comparison of freezing of lakes and rivers in East Asia and Europe (Tanaka and Yoshino, 1982).

“History and Climate” (Yoshino and Yasuda, 1995). This includes many sides of human activities in relation to climatic changes in scales of Japan, East Asia, Eurasian Continent.

Another recent contribution in a regional scale including Japan is a report of IPCC (Intergovernmental Panel on Climate Change). Chapter 10, Temperate Asia (Yoshino and Su, 1998) has been dedicated to describe the regional impacts of climate change, in particular, to an assessment of vulnerability, which reviews state-of-the-act information on the potential impacts of climate change for the natural and human environments in Temperate Asia.

2.2.4 Distribution of Weather Reconstructed

Mikami (1988, 1992b) reconstructed weather distribution in Japan for the historical period. Also Mikami (1992a, 1999) organized International Symposium and Conference in Japan, and edited special issue (Mikami, 1993) which contributed to encourage development of studies by reconstructing past climate in Japan during the periods in last several hundreds years.

The freezing date of Lake Suwa was mentioned above. In relation to coldness of winter, Fukaishi and Tagami (1992) studied weather distribution in association with winter pressure pattern reconstructed and came to a conclusion the two sets of records coincide well.

Yoshimura (1992, 1993) has been organizing two file groups, “Paleo-Climatic Data (PDCA)” and “PCREC (Paleo-Climatic Records)”, in Japan. Original data were taken from several kind of documents: an official diary of feudal and of local office clans in Edo era, and those of large temples, large shrines, families of big farmers and others. Daily weather records from about 1700 to 1889 are mainly under collection. An example of weather sequence table is shown in Fig. 3. For PCDA and PCREC, contact should be made to Minoru Yoshimura, Professor Yamanashi University, Takeda, Kofu-City, Japan.

Mizukoshi (1992, 1993) reconstructed climatic conditions during the Little Ice Age, based on the records of old documents. A lot of old documents used shows a through survey in this districts. He developed his studies to the reconstruction of Bai-u period in Kinki and Tokai districts since the 17 century, and further

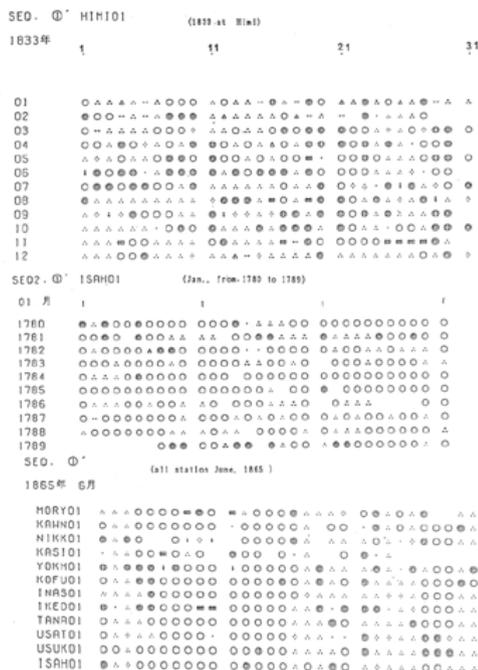


Figure 3. Example of weather sequence table (Yoshimura, 1992)

to the period during the last 600 years in Kinki-district (Mizukoshi, 2002). A complete list of records in Kinki-district attached to his report is very valuable. His contact address is: Mitsuharu Mizukoshi, Professor Shakai-fukushi, Kogakukan University, Ise-City, Mie-ken, Japan.

3. Early Meteorological Observation

3.1 Before the Establishment of Tokyo Meteorological Observatory in 1875

Since the beginning of 19th century, meteorological observation, mainly, air temperature and pressure, was carried on at the astronomical observatory at Edo (formal name of Tokyo) and by several individuals. The Meiji era began in 1868, but the systematic meteorological observations at the Tokyo Meteorological Observatory in 1875. In the period between the middle of 19th century and 1875, meteorological observation started at Nagasaki, 1845-1855; at Hakodate, 1854-1858; and at Naha, 1856-1858. Only since 1872, Japanese made the systematic observations at the dormitory of Engineering Development in Tokyo and at the Climate Measurement Station at Hakodate, Hokkaido. At the light-houses, meteorological observation started in 1874. Japanese Navy observatories started in 1877.

3.2 After the year 1875

The record of meteorological observation in January 1878 was published at first time and, after then, continuously as a monthly report. At the end of 19th century, the records contain the

observed values at 47 stations in Japan in 184 pages.

Data and reports published by the Japan Meteorological Agency (JMA) in the year of 1975 (JMA, 1975) are mentioned later with a list of publications. According to the list, one can understand that many kinds of important records and data have been publishing by JMA in Japan. In addition, some other records and data have been publishing by other publishers periodically and temporary. These are omitted here for the sake of space.

4. Published Climatic Records and Tables

4.1 Reprint Publication of Old Documents

Recently “Reprinted historical data series” compiled by Hidetoshi Arakawa into six volumes was published in 2002 by Kress-Shuppan (<http://www.kress-jp.com/>), or (e-mail: info@kress-jp.com). Among this series, the following two volumes are related to the past climate-during the historical periods. (1) Meteorological Distances during the Recent Historical period (Kinsei-kisho-saigaishi). Sample page is shown in Fig. 4. (2) Historical Data of Drought and Long Continuous Rain in Japan (Nippon-kanbatsu-riku-shiryō). A sample page is shown in Fig. 5.

The Kress-Shuppan is preparing another reprint series of “Monthly Geophysical Review” published by Central Meteorological Observatory (print Japan Meteorological Agency) in the period from 1900 to 1926. This records fined into 17 volumes, is the most comprehensive

data on monthly condition of climate, meteorological hydrological observation and earthquake in Japan (about 150 stations) and in abroad (about 90 stations).

4.2 Climatic Tables in Recent Years

A list of records and data published by JMA were mentioned above and shown in Fig.6. Among theme, the following periodical publications are important for climatological studies: Monthly Report, JMA [observed at about 155 stations], Annual Report of Climatological Stations [contains AMeDas data observed at about 1,600 stations in Japan], and Monthly Geophysical Review [mentioned above.

Contents are: climatic values, weather change, cyclone and typhoon, meteorological disasters, aero-logy, agrometeorology, earthquake, volcanic activity, ocean, geomagnetism etc.].

The most recent "Climatic Tables" for 1971-2000 observed at 159 stations are: "Normals" (JMA, 2001a) and "Mesh-Data" (JMA, 2001b), which is available in a form of CD-ROM.

"The climate of Japan in the 20th century" has been published by the JMA (2002) in forms of book and CD-ROM. The secular changes of some climatic aspects, such as cool summer air temperature, annual precipitation amount, maximum depth of snow accumulation during the last too years are of importance.



Figure 4. A sample page of "Meteorological Disasters during the recent Historical Period" (Kinsei-kisho-saiishi)

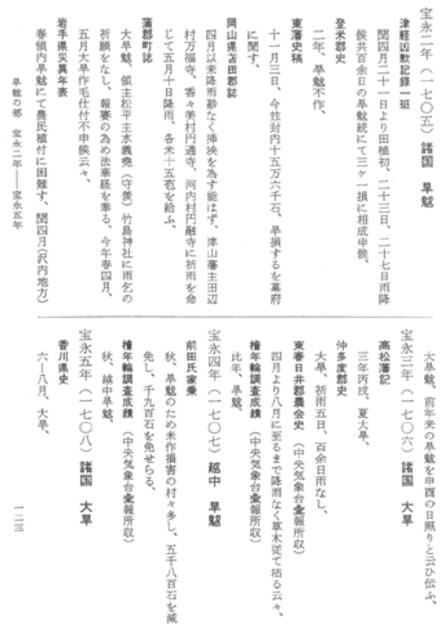


Figure 5. A sample page of "Historical Data of Drought and Long Continuous Rain in Japan" (Nippon-kanbatsu-rim-shiryō)

5. Concluding Remarks

The nature of climatic data, sources of climatic data, historical records, instrumental data etc. in climatology have been summarized comprehensively in the “Encyclopedia of Climatology” (Oliver and Fairbridge, 1987). However, those in Japan were not shown in the description. Present paper intended, therefore, to add some information on the climatic data and records in Japan. Internationally, it is hoped to develop the ways collecting, keeping, managing, using, and exchanging the climatic records and data effectively. Not only officers in the meteorological bureaus, services, agencies etc., but also researchers related to climatology

should recall the starting point of “World Climate Data Programme”, one of the four main sub-structures among the “World Climate Programme” established several years ago.

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| 気象要覧 (Geophysical Review) 1900~ | 全国海流月報 (The Ten-day Marine Report) 1946~ |
| 気象庁年報 (Annual Report of JMA) 1874~ | 潮位表 (Tide Table) 1931~ |
| 高層気象月報 (Aerological Data—Radiosonde) 1947~1949. | 潮汐観測 (Tidal Observation) 1941~ |
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| 上高層月報5年報 (Aerological Data of Japan, 5-year Period Averages) 1951~1955~ | 台風経路図 (Trajectories of Tropical Cyclones) 1939~ |
| 地震年報 (Seismological Bulletin of JMA)1925~1950. | 毎朝天気図 (Daily Weather Maps) 1883~ |
| 地震月報 (Seismological Bulletin of JMA) 1951~ | 高層印刷天気図 (Upper Air Charts) 1954~1958. |
| 火山報告 (Volcanological Bulletin) 1951~ | 北半球天気図 (Northern Hemisphere Weather Map) 1946~1949. |
| 全国気象年報 (Daily Climatological Data of Japan) 1952~1964. | 長期予報平均天気図 (Mean Maps) 1960~ |
| 観測所気象年報 (Annual Report of Climatological Stations) 1966~ | 日本気候表 (Climatological Data of Japan)1941~1970. |
| 気温報告 (Report of Air Temperature Observations) 1916~1960. | 日本気候図 (Climatic Atlas of Japan) 1. II 1971, 1972. |
| 雨量報告 (The Rainfall of Japan) 1901~1965. | 台風資料 (Data of Typhoons) Vol. 1~3, 1944~1950. |
| 日射報告 (Pyreheliometric Bulletin) 1934~1957. | 富士山頂の気象 (Weather at the Summit of Mt. Fuji) 1949~1958. |
| 日射観測成績 (Actinometric Bulletin) 1936~1957. | 東亜気象資料 (Far Eastern Weather Record) 1941~1942. |
| 日射報告 (Report of Radiation Observation) 1958~1966. | 世界気象資料 (World Weather Record) 1943 |
| 雷雨報告 (Report of Thunderstorm) 1924~1951. | 山岳気象報告 (Climatological Data for Mountain Weather Stations) 1951 |
| 農業気象年報 (Annual Report of Agricultural Meteorology) 1940~ | 北太平洋天気図 (海)・南洋気象台) 1923 |
| 気象雑纂 1918~1931. | |
| 大気放射能観測成績 (Bulletin of the Atmospheric Radioactivity) 1955~ | |

Figure 6. List of meteorological/climatological records and data published by Japan Meteorological Agency(1975)

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