

Climate in the Little Ice Age over Japan

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ABSTRACT

To understand climatic aspects in the Little Ice Age over Japan I have prepared the following two tables and two figures. The tables show the march of climate over each district of Japan. These tables show the different climatic tendencies in the latter half of the little Ice Age, and between Tohoku and other parts of Japan is especially clear. Long-term variations of the starting date of seasonal phenomena, the first snow fall etc., show the nature of climatic conditions along the years. For example, the Tenmei Era (1781–1789) has the long Bai-u season extended in both directions, at the beginning and end of the season, while experiencing a near normal length of winter season. However, the Tenpo Era (1831–1845) has a near normal length in the Bai-u season and a long winter. Finally there is a map showing the distribution of estimated anomalous precipitation and temperature in the summer months from 1781 to 1789. These years are well known as famine years in Japan. Cool rainy conditions appear in different places and months. It will be possible to point out climatic conditions in historical ages near the observation times. From a climatological point of view it is important to establish a more detailed structure of each famine.

INTRODUCTION

As R. Brdly *et al.* (1992) pointed out, there are two basic ideas on the starting dates of the Little Ice Age. One believes that it began in the thirteenth century, the other stresses that the starting point is the early-sixteenth century. However, several hemispheric cool episodes of a few decades in duration appear in the 1590s–1610s, the 1690s–1710s and the 1800s–1810s etc. The 1650s, 1730s and 1820s are warm periods. The climatic conditions of Japan in these periods are different from each other. Different analysis of location and time span bring disagreements in views. In recent years, many attempts have been made to reconstruct the climate of Japan in its historical ages. Two reviews on the reconstruction of historic climate (T. Mikami: 1989, and M. Yoshimura: 1991) have appeared. Daily descriptions of weather in diaries are very useful for the reconstruction of the historic climate. Particularly, those of the Edo Era feudal clans, large temples, shrines and important farmers provide us with an enormous amount of climatic information. The author intends to present the climate of the Little Ice Age from three different view points.

THE MARCH OF CLIMATE

Using the results of recent studies that analyzed daily weather descriptions, two tables have been constructed that show climatic conditions by regional base. Tab. 1 shows the summer climate. Assumptions from the original table or figure changed into a symbol use the following conditions; Descriptions by words or letter are changed into symbols. Curves or diagrams of rain frequency are divided into separate conditions. Large peaks and deep troughs assign extreme climatic conditions. Some of these can be used to estimate the monthly amount of precipitation. In Tab. 1 regional differences appear in the 1730s–1750s and in the 1800s–1820s. In the first case only in the Tohoku District is there indicated a change from cool to warm conditions. In the other regions cool or rainy conditions are dominant. In the second case over a station in the Tohoku District, cool, rainy conditions continued. At other stations in Tohoku and in other districts, warmer or a little rainier conditions were developing. As far as the Tenmei and Tempo Eras are concerned, the Kanto District shows a partially similar movement with the northern part of the Tohoku District. For the winter climate, the snow fall ratio is a common index used to estimate winter temperature. Winter conditions shown in Tab. 2 also have a different development. The northern Tohoku District is particularly different. It suffered longer and probably colder conditions than those experienced in other places. Around the 1700s and 1820s cold conditions are dominant. The climate near the 1750s is milder than the above two periods in winter. In other districts in Japan, around 1700 and 1780, there appear to have been mild conditions. In contrast the years around the 1750s, the 1810s and the 1830s have cold conditions. According to the above the Tenpo Era has a nation-wide cold winter decade. Differences in lengths within the data series can occasionally cause different conclusions. However, disagreements between data length can not explain everything. It is useful to investigate the nature of climatic conditions in an abnormal period which has appeared in the records of disaster analysis of seasonal phenomena. Mikami (1983) shows national diagrams of the warm season for each year of the Tenmei Era, and discusses the nature of that era. Yoshimura (1991) constructed a diagram showing the long-term variations of the natural season in Nikko. The onset or retirement of seasonal phenomena in each year can be obtained through descriptions that appear in old diaries, and have been collected in the Historical Weather Data Base Version 11. The 1780s (Tenmei Era) and 1830s (Tenpo Era) are well known famine years. The Tenmei Era has a longer Bai-u season than the Tenpo Era. In the former era both the onset and retirement of the Bai-u season was abnormal. In the Tenpo Era the end date of winter was prolonged into late-March, and was longer than in the Tenmei Era. In Fig. 1 a departure of more than five days from the normal date of seasonal phenomena is marked in shadow. A long winter season is observed in the years from about 1800 to 1810 and 1820 to 1840. Summer conditions are not the same as those in winter, and some interruption of the long Bai-u season must have occurred.

Table. 1 Estimated climatic condition in the later half of the Little Ice Age over Japan (Summer)

Data Years	TOHOKU				KANTO			CHUBU			KINKI	FARTHER WEST JAPAN	
	(1)	(2)	(3)	(4)	(2)	(3)	(5)	(2)	(6)	(5)	(2)	(7)	(2)
-	cc&R												
-	↓												
-	↓												
-	↓												
1650	↑												
-	h												
-	↓	R											
-	↓	R											
-	↓	R		D?									D
1700	cc&R	R		D?			R					N	?
-	↓	N		D?			N					R	D
-	↓	R		D	N		R			N		N	D
-	c	N		N	R		R	R		R	R	R	D
-	↓	N		R	R		R	R		R	N	N	D
1750	n	N		R	R		N	R	c&R	R	N	R	N
-	↓	N		N	N		N	N	c&R	N	N	R	N
-	h	R	n>c	R	D	c>w	D	N	w&D	N	N	D	N
-	↓	R	c>n	R	R	n	R	D	c&R	N	N	R	R
-	↓	D	w>h	N	D	n>w	N	D	c&N	D	D	N	N
1800		D	w	N		w/n	N		w&D	N	D	D	N
-		D	n>w	D		c>w	D		w&D	N	N	D	N
-	cc&R	D	w>n	D		w>n	R		c&R	N	N	N	N
-			c	R		n	N		n&N	R	R	R	N
-				D			N		n&N	R	R	N	N
1850	↓			D			N		n&N	N	N	N	D
-	w						N				R	R	

Thermal Condition

Humid Condition

cc: very cool

c: cool

n: normal

w: warm

h: hot

>: means change the condition from left hand side to right hand side of ">"

data

(1) I. Maejima and Y. Tagami (1983)

(3) T. Mikami (1992)

(5) A. Murata and M. Yoshino (1988)

(7) M. Mizukoshi (1986)

R: rainy

N: normal

D: a little precipitation

&: means combination of the two conditions

(2) Y. Tagami and K. Fukaisi (1992)

(4) M. Yoshimura (1991)

(6) M. Yoshimura (1990)

Table. 2 Estimated climatic condition in the later half of the Little Ice Age over Japan (Winter)

Data Years	TOHOKU		KANTO		CHUBU		KINKI	FARTHER WEST JAPAN		
	(1)	(2)	(3)	(2)	(4)	(2)	(5)	(2)	(2)	
—	↑ cc&HS									
—	↓									
1650	↓									
—	m&LS	n		cc						
—		c		c						
—		c		cc						
1700	↑ cc&HS									
—		c		n				m		
—		m	sw	n				m		
—		n	lw	cc				c	c	
—		w	nn	n		c		c	c	
1750	↓ m&LS									
—	c&S	m	sw	?	c			n	c	
—	m&LS	c	nn	m	n			m	n	
—		c	sw	n	c			m	w	
—		n	sw	w	w	w		n	n	
1800	↓									
—			lw	c	w	w	n	m	c	
—			lw	?	n	cc	c	c	n	
—			sw	w	cc		n	n	c	
—			lw	c	n	c	n	c	c	
—	↑ cc&HS									
1850	↓									
—			lw		m	n	w	n	w	
—					n	w	w	n		
—							w	c	c	

Thermal Condition					Humid Condition				
cc: very cold		lw: long winter		HS: Heavy Snow					
c: cold		sw: short winter		LS: LIGHT Snow					
n: normal		nn: normal length							
m: mild									
w: warm									
data									
(1) I. Maejima and Y. Tagami (1982)		(2) Y. Tagami and K. Fukaisi (1992)							
(3) M. Yoshimura (1990)		(4) M. Yoshimura (1989)							
(5) M. Mizukosi (1992)									

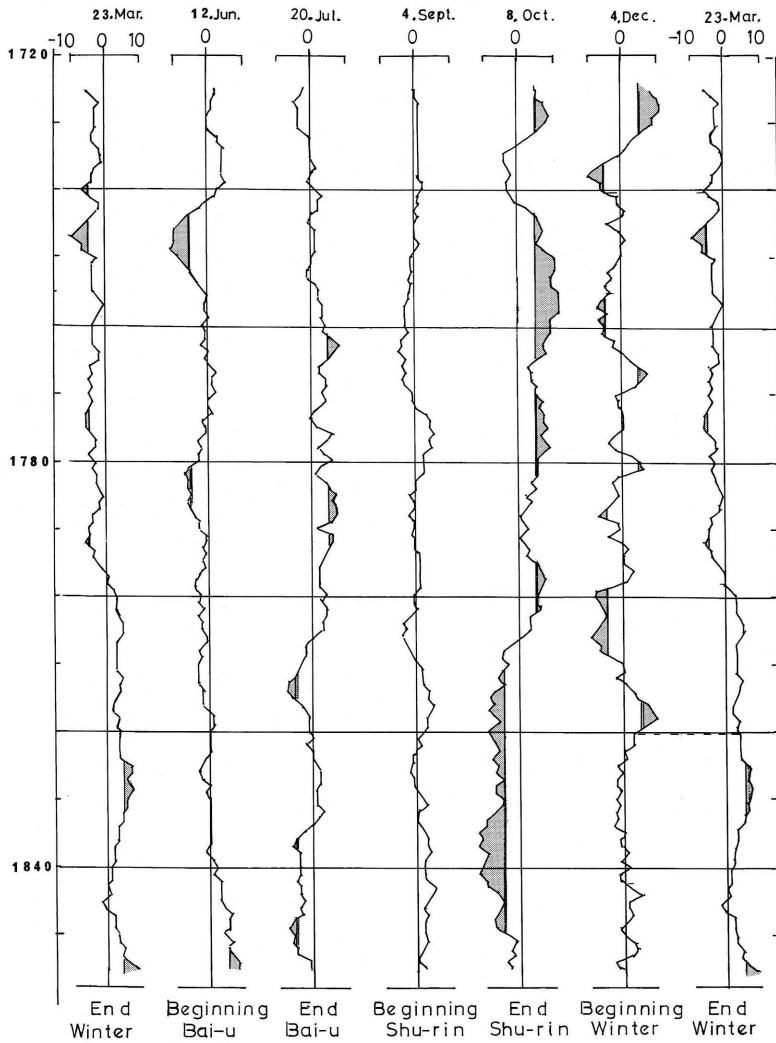


Fig. 1. Long-term variation of natural season in Nikko date is 10 year running mean. Yoshimura (1991)

ESTIMATION OF CLIMATIC CONDITION IN A FAMINE YEAR

The last problem is the differences amongst the lean years. For instance, such proxy data as a single data point per year does not show weather conditions for each month of the year. To understand details of climatic conditions more detailed proxy data is required. This is a reason to consult dairy weather information in historical times.

Fig. 2 shows ranks of anomalous precipitation and temperature in the summer months from 1781 to 1788. Those for precipitation are estimated in the following ways. At

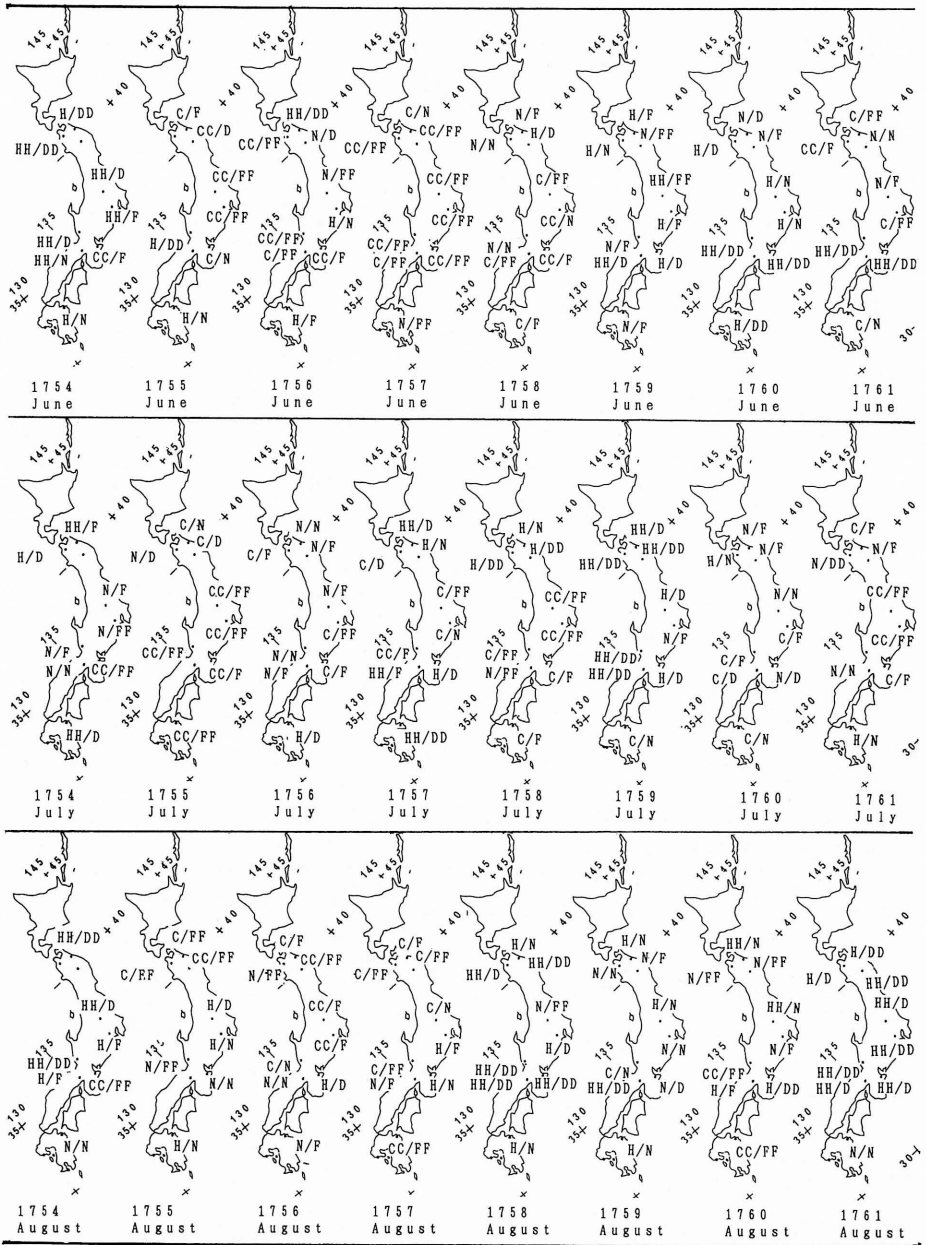


Fig. 2.

first PI (precipitation index) is counted by the use of monthly frequency of weather types. Eleven weather types that have a relationship with precipitation can be counted. The eleven frequency types accumulate as three kinds. The total frequency of each kind is multiplied by certain constant (1, 2 and 5) according to mean strength of rain-

fall. The total value of PI has a high correlation to monthly precipitation. A one hundred year series of PI for each summer month at each location gives one of five ranks. "FF" is the mean 20% which is at the top. "F" is the second 20% group. The months with "DD" include the bottom twenty percent of PI. "D" are the 20% of PI months that are above "DD". The lowest are shown as "N". The mean monthly temperature in the summer months have a high correlation to the number of fine days. This relationship is useful in estimating temperature anomaly. Each 20% group of months gives marks of "HH", "H", "N", "C" and "CC" according to numbers of fine days. Combinations of thermal and moisture conditions in each month have large differences even in famine years. Except in Hokkaido the period of poor conditions for the whole of Japan is limited to two months of the year. Occasionally there are observed combination of cool, rainy months and hot, dry months in a single summer. The year 1784 is such a summer. The combination of a cool, rainy summer in northern Japan and hot, dry summer in western Japan is seldom seen in the Tenmei Era. The reconstruction of climate in historical ages and the analysis of climate structure in famine years probably requires further research.

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