

Document-based reconstruction of past climate in Japan

MASUMI ZAIKI¹, M.J. GROSSMAN² AND T. MIKAMI³

¹Department of Economics, Seikei University, Tokyo, Japan; mzaiki@econ.seikei.ac.jp

²Department of Geography, Southern Illinois University Edwardsville, USA; ³Department of History, Teikyo University, Tokyo, Japan

Proxy and instrumental data from historical documents in Japan provide a picture of climate variability during the “Little Ice Age”.

Paleoclimate reconstruction is essential for understanding past climate variability and its driving mechanisms within the global climate system. From the abundant historical documents preserved in Japan, unique climate reconstructions have been developed using qualitative meteorological information contained in them. Additionally, documents with instrumental meteorological data collected before 1872, when official meteorological observations began, were recently discovered and prepared for scientific analysis. Such approaches to reconstructing past climates are included in the field of historical climatology. In this article, the characteristics of these proxy and instrumental data from documentary sources are introduced and reconstructed climatic variations in and around Japan are described.

Qualitative meteorological information from historical documents

In Japan, official meteorological data collected by the Japan Meteorological Agency (JMA) have been available only since 1872. There are however, several kinds of historical documentary sources, which enable reconstructions of climate variations before the 19th century in and around Japan. Historical documents including diaries of individuals, logs of clan offices, government documents, and reports from temples and shrines are preserved in local libraries and museums. These documents often contain daily weather descriptions such as “cold”, “fine”, “rainy” and “windy”, and mention special climate-related natural phenomena such as “lake freezing” and “flower blooming”.

Figure 1 is an example of a summer temperature reconstruction based on daily weather descriptions from the Ishikawa diaries; continuous family diaries kept in the western suburbs of Tokyo from 1721 to 1940 (Mikami 1996). Under present conditions, generally hot summers are experienced in Japan under the influence of strong subtropical highs, which bring dry and sunny weather conditions. Cool summers occur under the influence of stagnant polar fronts and

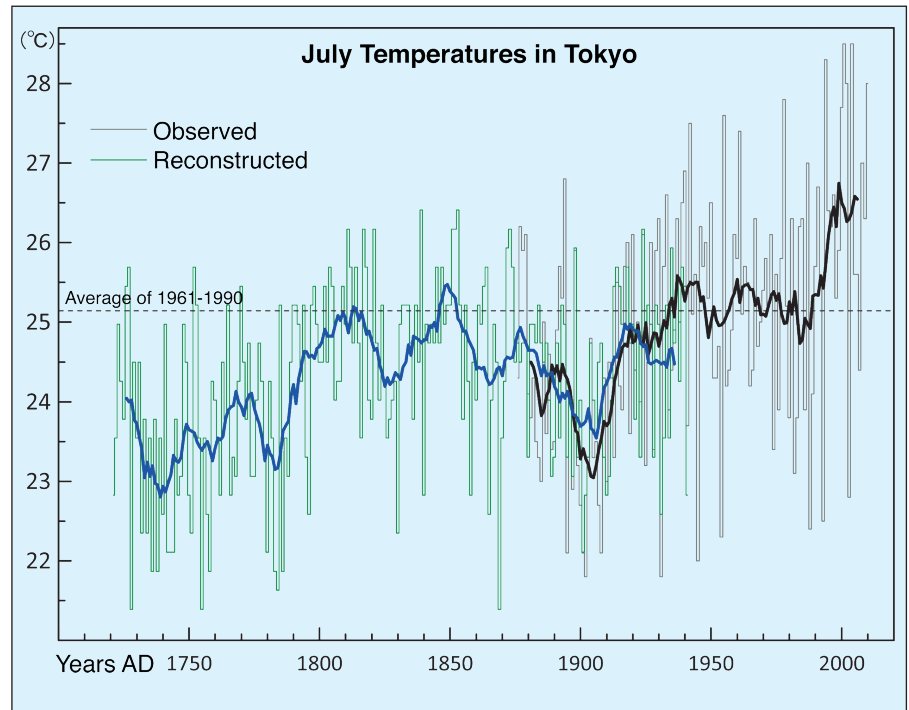


Figure 1: Time series of reconstructed (green lines) and observed (black/gray lines) July temperatures in Tokyo for 1721-2000. Thin lines indicate year-to-year variations and thick lines indicate 11-year running mean. Figure modified and updated from Mikami (1996).

passing extra-tropical cyclones, which bring cloudy and rainy weather conditions. As the number of rainy days highly correlates with the mean temperature in a summer month, especially in July (the correlation coefficient is -0.70 based on the JMA data for 1876-1940), it is possible to reconstruct July temperatures in Tokyo for the period 1721-1940 based on the weather records in the Ishikawa diaries. The reconstructed temperature series show several cooler and warmer periods. From 1721 to 1790, temperatures are estimated to have been about 1 to 1.5°C lower than at present. It should be noted that the temperatures in the 1780s were often very low with large inter-annual variations. In the summer of 1783, an extremely poor rice harvest occurred due to exceedingly cool and wet conditions, and this unusual weather led to a severe famine in Japan. In the 19th century, in contrast to the warmer periods of the 1810s and the early 1850s, the 1830s, late 1860s and late 1890s were relatively cool, and great famines occurred in the 1830s as they had in the 1780s. For the temperatures during the modern period, it is also

notable that Tokyo has a very strong urban heat island effect and this is likely to have contributed to warming evident in the 20th century.

As with the reconstruction of summer temperatures, winter temperatures in Nagasaki, in southwestern Japan have been reconstructed based on a highly correlated relationship between snowfall ratio and monthly winter temperatures (Mikami 1992).

In addition to the temperature reconstructions, historical documents and other documentary sources have been used to reconstruct a chronology of typhoons affecting Japan in the 19th century based on diary weather descriptions of “strong wind” and “strong rain” which could be assumed to describe typhoon events. These weather descriptions were corroborated by reports in other historical documents (Grossman and Zaiki 2009).

Information about special climate-related natural phenomena such as “lake freezing” and “flower blooming” are also contained in historical documents. The dates of the complete freezing of Lake Suwa in central Japan have

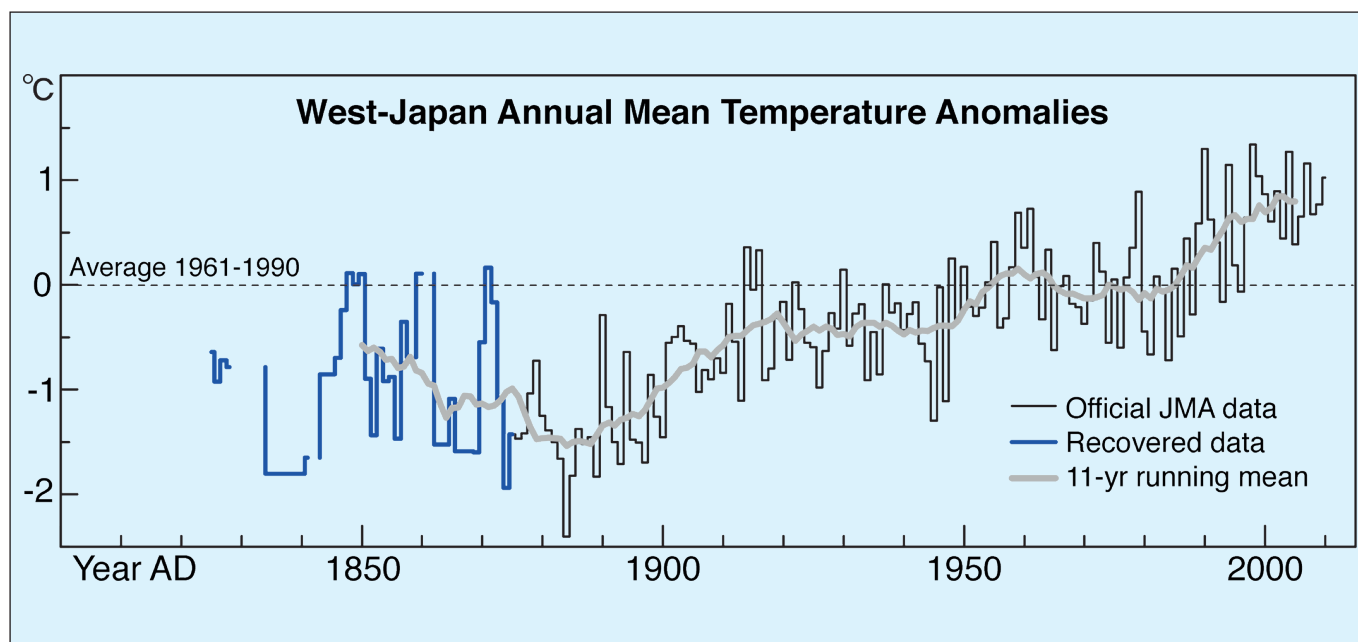


Figure 2: Time series of West-Japan Temperature (WJT) anomaly for the period 1820-2010. Blue line is derived from newly recovered meteorological data, black line is from official JMA data, and the gray thick line is a smoothed 11-year running mean. Figure modified and updated from Zaiki et al. (2006).

been recorded by the Suwa shrine since the 15th century and winter temperatures were reconstructed based on correlations between the freezing dates and December/January temperatures (Mikami and Ishiguro 1998). Additionally, March mean temperatures in Kyoto since the 9th century have been derived from the cherry blossom flowering date records (Aono and Kazui 2008; Aono and Saito 2010).

Instrumental records before the foundation of the Meteorological Agency

Prior to the founding of JMA, no instrumental meteorological records were believed to exist in Japan apart from qualitative weather descriptions in historical documents. However, documents containing instrumental meteorological data collected in several locations in the 19th century have been (re)discovered. Sub-daily meteorological records from the first half of the 19th century were collected routinely by Dutch scientists living in Japan and by the so-called “Dutch Study”, Japanese scholars who learnt modern western science from the Dutch. Also, in the second half of the 19th century at the end of the period of international isolation of Japan, various Europeans (French, German, Russian) and Americans came to Japan and carried out meteorological observations.

The recovered instrumental observations cover the periods 1825-1828, 1839-1855, and 1872-1875 in Tokyo; 1860-1874 in Yokohama; 1828-1833 and 1869-1871 in Osaka; 1869-1871 and 1875-1888 in

Kobe; and 1819-1878 in Dejima/Nagasaki (Können et al. 2003; Zaiki et al. 2006). Before the scientific analysis of the recovered data, the temperature and pressure data were converted to modern units and digitized into a computer readable format. The pressure data were corrected for temperature, elevation, and gravity where needed. The temperature data were homogenized to compensate for changes in recording location. Then, both data sets were homogenized to account for varying observation schedules. The corrected and homogenized data were shown to be reasonable after further testing for homogeneity and comparison with modern JMA data.

The availability of the recovered 19th century temperature observations taken at five locations made it possible to construct a West-Japan Temperature (WJT) series, a representative temperature series for the western Japan region (Fig. 2; Zaiki et al. 2006). The results indicate the existence of a relatively warm period from the late 1840s to the 1850s with a few interspersed cold years over western Japan followed by a downward temperature trend that lasted until the early 20th century as previously observed in the documentary data.

The significance of historical meteorological data recovery in Japan reaches beyond just being an extension of the Japanese instrumental record back in time. First, the recovered series occur in a region of the world that is poorly covered by instrumental data, and second, it overlaps with the series of qualitative weather

descriptions in historical documents kept at many places in Japan.

Conclusions

A number of climate reconstructions based on qualitative weather descriptions have been carried out in Japan. Although the reconstructed data represent temperatures in particular months or seasons, they have sufficient time resolution to characterize inter-annual variations. Additionally, using this approach for reconstructing a chronology of typhoons further demonstrates the importance of historical climatology in Japan. The instrumental meteorological data collected before the founding of the JMA provide sub-daily meteorological data. In the future, more records will be needed to fill in gaps in this fragmented record.

Past climate variations reconstructed from Japanese historical documents partly enable us to discuss the “Little Ice Age” period especially with regard to regional differences and the magnitude of the cold. To achieve this, further exchange of and constructive corroboration with past climate information reconstructed from various proxy sources will be needed.

Selected references

Full reference list online under:

http://www.pages-igbp.org/products/newsletters/ref2012_2.pdf

Aono Y, Kazui K (2008) *International Journal of Climatology* 28: 905-914

Grossman MJ, Zaiki M (2009) *Weather* 64: 315-322

Können GP et al. (2003) *Journal of Climate* 16: 118-131

Mikami T (1996) *Geographical Reports of Tokyo Metropolitan University* 31: 157-165.

Zaiki M et al. (2006) *International Journal of Climatology* 26: 399-423

