- Intercalibration of documentary records from central Chile and annually resolved dendroclimatic data from both Chile and Argentina.

- Modeling of the dynamics of regional atmospheric circulation pattern that might account for changes in the ENSO teleconnection system at interannual to interdecadal time scales.

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Summer and Winter Temperature Reconstructions in Japan

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In Japan, a great number of weather diaries from most parts of the country are preserved in local libraries and museums (Fig. 1). Some outstanding official diaries have been kept continuously since the seventeenth century. Over the last few decades, most of the known daily weather records were digitized and added to the Historical Weather Database of Japan (e.g., Mikami 1988 and 1999). Another valuable source for historical climatology in Japan is the freezing date record of Lake Suwa (central Japan). These dates were systematically recorded from the fifteenth century onwards. In this paper, we explain how summer and winter temperatures were estimated, based on a century long weather diary and the half millennial Lake Suwa record.

The reconstruction of summer (JJA) temperatures draws on the monthly number of rainy days in Tokyo from 1721, which were obtained from the "Ishikawa diaries" (Mikami, 1996). Initially, the data were calibrated with the long temperature series of Tokyo over the period from 1876 to 1940, using linear regression techniques. It turns out that the correlation between the monthly number of rainy days and mean monthly temperatures was highest for July (r=-0.70, significant at 1% level). This is related to the prevailing weather situations. Under the influence of a strong subtropical anticyclone, July is hot and dry, whereas stagnant polar fronts and passing extratropical cyclones are associated with cool and rainy weather situations. Consequently, July temperatures were estimated from the recorded number of rainy days for the period 1721 to 1875, using a regression equation. Finally, the estimated temperatures were used to extend the instrumental series of Tokyo (1876 to 1995) back to 1721 (Fig. 2).

Fig. 1: An example of a weather diary from Japan, 18th century. Daily weather conditions are described in detail. The boxed area says "a little rainfall in the morning, but became fine in the evening."

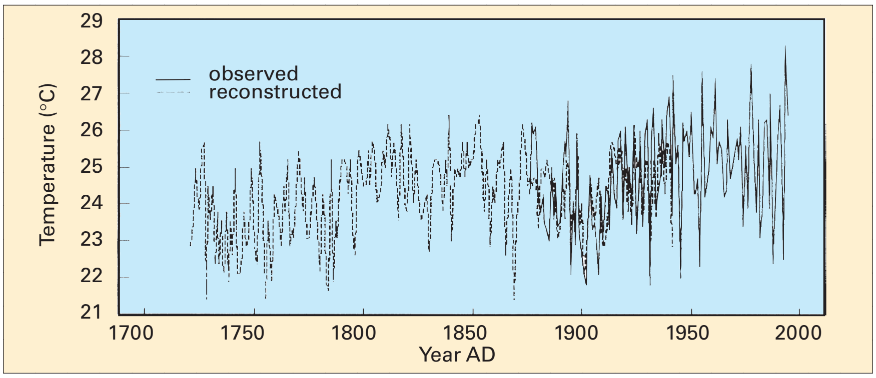

Fig. 2: July temperature variations in Tokyo for 1721-1995.

Long temperature trends can be explained using weather diaries, as in Figure 1. From 1721 to 1790, July temperatures were about 1 to 1.5°C lower than the 1961-1990 mean. During this period of cool summers, July temperatures displayed a large year-to-year variability. Cold summers were registered in 1728, 1736, 1738, 1755, 1758, 1783, 1784 and 1786. During the 1780's severe famine occurred repeatedly. On the other hand, many warm summers stand out in the record for the nineteenth century, in particular in the 1810s and from 1851 to 1853. July was again remarkably cool around 1900. This observation is clearly captured by both estimated and measured temperature series.

The reconstruction of winter temperatures is based on the Lake Suwa record. When the lake froze, shrinkage and expansion of the ice sheet due to diurnal temperature variations caused an ice cracking phenomenon called "Omiwatari," which was said to resemble "a bridge crossing the lake" (Fig. 3). The ancient village people might have believed it to be the track of a god visiting a goddess on the opposite shore. Since the fifteenth century, the formation of "Omiwatari" has been celebrated in a ceremony a couple of days after its occurrence. The dates of "Omiwatari" have been recorded by the Suwa shrine since the 15th century,

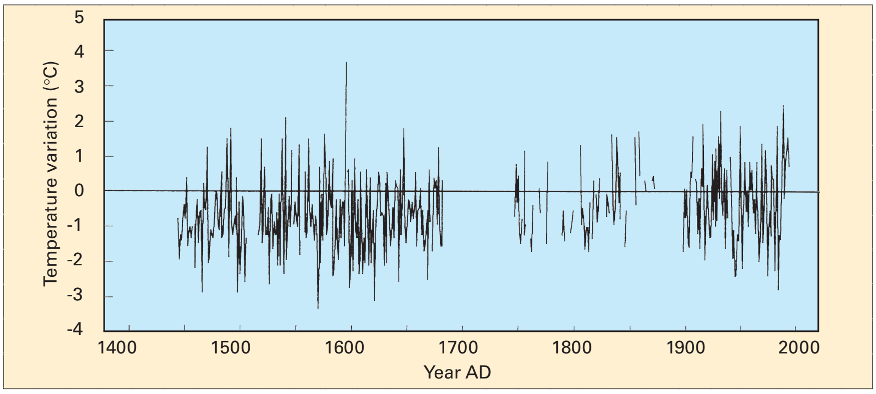

Fig. 4: Interannual variations in December-January temperatures at Lake Suwa during 1444-1870 (reconstructed) and 1891-1995 (observed).

and also by the Suwa meteorological observatory independently since 1951. During a cold winter, "Omiwatari" would already have occurred by mid- December, whereas in a warm winter, it would be delayed until the end of February, or no "Omiwatari" would occur at all.

A linear regression of the freezing dates with the instrumental series of the Suwa meteorological observatory revealed that December-January mean temperatures are highly correlated (r=0.80, significant at 1% level) with the Lake Suwa series over the calibration period 1945-1990. Based upon the regression equation, win-

Fig. 3: The "Omiwatari" phenomenon, described as "a bridge crossing the lake" on Lake Suwa (January 31, 1998).

ter temperatures were estimated for central Japan from 1444 to 1995 (Fig. 4). Although the lake freezing records are not continuous from the late seventeenth century to the nineteenth century, a clear warming trend stands out in Figure 4, during the final stage of the Little Ice Age from the 1750s to the 1850s. On the other hand, the coldest period since the 15th century was the early 1600s, when reconstructed mean winter temperatures were about 1 to 1.5°C lower than at present (1961-1990). In order to verify the reliability of this estimated temperature series, we made some comparisons with other climate reconstructions on the basis of different proxy records, such as tree-rings (Sweda and Takeda, 1994). The results show a relatively good agreement with our winter temperature reconstruction. As for the long-term freezing records of Lake Suwa, the reliability of yearly records is still not assured for some periods. More effort should be made in the verification and calibration of these valuable documentary records. Comparison with instrumentally observed data during the overlapping period is a vital prerequisite to producing a robust reconstruction (Konnen et al., 2002).

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2000 Years of Temperature History in China

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In the 8th lunar month (10/9-9/10), AD 17, Wang Mang went to the southern suburb in person to build a large DOU (a kind of ancient container). On the day of building the DOU, it was so frosty that many officials and horses froze to death. (from Hanshu, History of the Han Dynasty).

Over 2000 years of records documenting cold and warm events are archived at the Institute of Geographic Sciences and Natural Resources Research (IGSNRR), Chinese Academy of Sciences. These records include both direct and indirect, or proxy evidence. As described by Pfister et al (this issue), direct evidence refers to observations of temperature and its impact on humans, as illustrated above. Indirect, or proxy evidence, refers to information on plant growth and other phenological observations, agricultural data including not only sowing and harvesting times but also changes in the northern boundary of tropical and sub-tropical crops (e.g. citrus, tea, bamboo), and observed snow and ice features. This may include the first and last frost and snowfall dates, and the duration of frost, snow or ice cover. The following excerpts illustrate indirect, or proxy evidence.

In the 11th lunar month of the 2nd year in the Guangqi Reign, Tang Dynasty (886), Huainan was continually cloudy with rain and snow until the 2nd lunar month of the next year. (From Xintang Shu,History of the New-Tang Dynasty), Wu-Xing-Zhi. The records of Five Elements, Vol. 3). In the 2nd year of theDazhongxiangfu Reign, Northern Song Dynasty (1009), Jingshi (the capital city) was warm and without rivers freezing. (from Songshi, History of the Song Dynasty, Wu-Xing-Zhi, The Records of Five Elements).