Palaeogeography, Palaeoclimatology, Palaeoecology 435 (2015) 203–209

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

journal homepage: www.elsevier.com/locate/palaeo

Reconstructed July temperatures since AD 1800, based on a tree-ring chronology network in the Northwest Pacific region, and implied large-scale atmospheric–oceanic interaction

Shunsuke Tei [a,b,*], Hitoshi Yonenobu [c], Shinya Suzuki [d], Motonari Ohyama [e], Katsuya Gotanda [f], Takeshi Nakagawa [g], Atsuko Sugimoto [b,h]

[a] National Institute of Polar Research, Tachikawa 190-8518, Japan
[b] Graduate School of Earth Environmental Science, Hokkaido University, Sapporo 060-0810, Japan
[c] College of Education, Naruto University of Education, Naruto 772-8502, Japan
[d] Tokyo Metropolitan Archaeological Center, Tokyo 206-0033, Japan
[e] Botanical Gardens, Tohoku University, Sendai 980-0862, Japan
[f] Faculty of Policy Informatics, Chiba University of Commerce, Ichikawa 272-8512, Japan
[g] Research Center for Palaeoclimatology, Ritsumeikan University, Kusatsu 525-8577, Japan
[h] Faculty of Environmental Earth Science, Hokkaido University, Sapporo 060-0810, Japan

ARTICLE INFO

Article history:
Received 2 March 2015
Received in revised form 29 May 2015
Accepted 9 June 2015
Available online 18 June 2015

Keywords:
North Pacific
Tree rings
PDO
Summer temperature
SST

ABSTRACT

We present a large-scale dendroclimatic reconstruction of July temperatures from 42–52°N to 140–145°E in the Northwest Pacific region for the period from 1800 to 1996. A multiple regression model with principal components (PCs) of a tree-ring chronology network was used for the reconstruction, which accounted for 31.7% of the temperature variance in the calibration period (1901–1996). The reconstructed spatially-averaged July temperatures show large fluctuations, which are comparable to previously published dendroclimatic reconstruction of spring temperatures in northeast Asia. It also shows stable relationships with other datasets, notably sea surface temperatures (SSTs) in a wide area of the North Pacific and the Pacific Decadal Oscillation (PDO), indicating atmospheric–oceanic interaction in the Northwest Pacific region since AD 1800.

1. Introduction

Climate variability in the North Pacific has significant impacts on a wide range of environments and human societies around the region (Gurshunov et al., 1999; Diaz and Markgraf, 2000). For example, it is now well known that such variability has significant influences on the societal and economic activities of the people of Alaska and the Pacific Northwestern United States through changing productivity in fisheries (Mantua et al., 1997; McGowan et al., 1998; Finney et al., 2000).

These influences are not restricted to regional-scale phenomena, but are spread over a broader spatial scale. Coherent patterns of variability have been reported between North Pacific sea surface temperatures (SSTs) and atmospheric circulation, accumulation of atmospheric CO_2, and global air temperature (Chaves et al., 2003). Despite the importance of North Pacific climate variability, its nature is poorly understood, due to limitations in the length and distribution of instrumental climatic records, especially in the Northwest Pacific region.

Tree-ring based reconstructions of past climate variability offer a promising approach to extend the short-term instrumental record (e.g., Davi et al., 2002; D'Arrigo and Wildosn, 2006; Cook et al., 2010; Tei et al., 2013a,b). Many efforts have been made to extend the record for the Northeast Pacific region. Several of these reconstructions have used a network of tree-ring chronologies in coastal areas of the region, and successfully estimated large-scale climate variability, including SSTs, the Pacific Decadal Oscillation (PDO) and windstorms (e.g., Biondi et al., 2001; D'Arrigo et al., 2001; Black et al., 2009; Knapp and Hadley, 2012).

In the Northwest Pacific region, meanwhile, paleoclimatic data are still sparse. Although there have been recent improvements in coverage of dendroclimatic reconstructions for the region (Gostev et al., 1996; D'Arrigo et al., 1997; Davi et al., 2002; Jacoby et al., 2004; Ohyama et al., 2013; Sano et al., 2009, 2010), there still remains an insufficiency of such records.

Moreover, unlike the Northeast Pacific region, only local tree-ring chronologies (rather than a regional chronology network) have been

* Corresponding author at: Graduate School of Environmental Science, Hokkaido University, Hokkaido, Japan. Tel.: +81 11 706 2233.
E-mail address: stei@ees.hokudai.ac.jp (S. Tei).

http://dx.doi.org/10.1016/j.palaeo.2015.06.012
0031-0182/

developed and used for climatic reconstructions, due to the lack of spatial coverage of the individual chronologies. Recently, D'Arrigo et al. (2014) reported a summer temperature reconstruction for Nemuro, coastal Hokkaido Island, from a regional tree-ring chronology network and indicate an atmospheric–oceanic interaction in the Northwest Pacific region. However, this dataset still provides only a point-scale reconstruction for Nemuro, and therefore estimation for the past large-scale climate variability in the Northeast Pacific region is still lacking.

Around the study region, Ohyama et al. (2013) provided the only attempt at using a regional tree-ring chronology network for large-scale climatic reconstruction. They assembled seven tree-ring chronologies in Northeast Asia and successfully reconstructed spring temperatures from 35–40°N to 125–140°E, for the period of 1784–1990, showing coherent variations of spring temperatures across the region. The study clearly shows that the reconstruction from the tree-ring chronology network provides new insights for past climate variability in the region. It is therefore essential to better understand the nature of Northwest Pacific climate variability by extending the geographic range of past climatic information. The purpose of our present study is therefore to reconstruct the spatio-temporal variability of summer temperature data for the Northwest Pacific region using a network of tree-ring chronologies. To this end, we assembled eight tree-ring chronologies around the region and developed three new chronologies from Sakhalin Island to improve the spatial coverage of the network. We subsequently confirmed their potential to demonstrate summer temperature reconstruction. The reconstruction is then compared with SSTs from the North Pacific and with the PDO, in order to identify atmospheric–oceanic interaction.

2. Material and methods

2.1. Tree-ring chronologies

A total of 11 ring-width chronologies were used to find an optimal calibration model for the past summer temperature in the Northwest Pacific region. Seven of these were derived from raw measurements in the International Tree-Ring Data Bank (ITRDB, http://www.ncdc.noaa.gov/paleo/treering.html), including those across Hokkaido Island, Kunashir Island (Kuriles) and the Kamchatka Peninsula (Table 1). A chronology from the Tsugaru Peninsula, Honshu Island, was obtained from Kaneko (2006). Since a ring-width chronology of Sakhalin Island was entirely lacking, we developed three new chronologies in this study: Okha (53° 29′N, 142° 35′E), Tayozny (49° 15′N, 142° 38′E) and Dolinsk (47° 19′N, 142° 48′E).

Among these, five chronologies (Moshiri, Teshio, Kamchatka, Tsugaru and Tayozny) were eliminated for further analyses because they are short or unrepresentative for reconstructing the past climate. A total of six chronologies were used for the final calibration model in our climate reconstruction (Fig. 1).

2.2. Climate data

We used the gridded (0.5° longitude by 0.5° latitude degree) temperature and precipitation data set of the Climatic Research Unit (CRU), East Anglia University (Harris et al., 2014). The monthly records between 30–60°N and 130–160°E were extracted for analysis.

In order to identify the broad spatial scale atmospheric–oceanic interaction in the North Pacific region, our reconstruction was compared with the gridded (1° longitude by 1° latitude degree) sea surface temperature (SST) record from the HadISST1 data set (Rayner et al., 2003) and the Pacific Decadal Oscillation (PDO) (http://jisao.washington.edu/pdo/). The PDO is defined by the leading empirical orthogonal function (EOF) of the monthly anomalies of sea surface temperatures (SSTs) in the Pacific poleward of 20°N, and is a key index of major variations in North Pacific climate and ocean productivity (Mantua et al., 1997).

2.3. Chronology building

Standard techniques of dendrochronology were employed in sample processing and chronology development (e.g. Baillie and Pilcher, 1973; Cook and Kairiukstis, 1990) in this study. These include measurement of total ring widths for two radii of a sample at a precision of 0.01 mm, followed by a visual crossdating using the PAST5 program (SCIEM, Inc.). The quality of crossdating was later checked using the COFECHA program (Holmes, 1983).

Detrending using 128-year spline fits was used to obtain standardized indices for all raw ring-width chronologies (Table 1), which were then averaged to generate standard chronologies using the ARSTAN program (version 41d; Cook, 1985). The quality of the chronologies was assessed by the expressed population signal (EPS), with a value greater than 0.85 providing a good compromise to determine the reliable part of a chronology (Wigley et al., 1984).

2.4. Correlation analysis

Correlation function analysis was performed to examine the relationships between the climate and tree-ring variables. We computed Pearson's correlation coefficients over the complete overlapping period of the records. Running correlations using a 31-year moving window were also computed using the Dendroclim2002 program (Biondi and Waikul, 2004) to test the temporal stability of the relationships.

To identify the spatial correlation patterns between our reconstruction and SSTs, we utilized the Climate explorer (http://www.knmi.nl/) of the Royal Netherlands Meteorological Institute (KNMI) (van Oldenborgh and Burgers, 2005).

Table 1
List of chronologies.

Site	Island/peninsula	Location	Species	Ref. no.	ITRDB
Tsugaru	Honshu	40°56′N, 140°32′E	*Thujopsis dolabrata* var. *hondae*	1	
Tokachi	Hokkaido	43°30′N, 143°12′E	*Picea glehnii*	2	JAPA014
Asahidake	Hokkaido	43°46′N, 142°33′E	*Picea glehnii*	3	JAPA008
Kunashir	Kunashir	43°54′N, 145°36′E	*Quercus crispula*	4	RUSS219
Shiretoko	Hokkaido	44°06′N, 143°49′E	*Picea glehnii*		JAPA011
Moshiri	Hokkaido	44°21′N, 142°11′E	*Picea glehnii*	2	JAPA013
Teshio	Hokkaido	44°57′N, 142°07′E	*Picea glehnii*	2	JAPA012
Dolinsk	Sakhalin	47°19′N, 142°48′E	*Abies sachalinensis*	5	
Tayozny	Sakhalin	49°15′N, 142°48′E	*Picea jezoensis*	5	
Okha	Sakhalin	53°29′N, 142°35′E	*Picea jezoensis*	5	
Kamchatka	Kamchatka	55°00′N, 160°30′E	*Larix gmelinii*	6	RUSS209

1: Kaneko (2006); 2: PAGES 2k Consortium (2013); 3: Davi et al. (2002); 4: Jacoby et al. (2004); 5: this study; 6: Cook et al. (2010).
ITRDB; International Tree-Ring Data Bank (http://www.ncdc.noaa.gov/data-access/paleoclimatology-data/datasets/tree-ring).