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DATA PAPER

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A database of Holocene temperature records for north-eastern North America and the north-western Atlantic

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Abstract

Centennial-to-millennial temperature records of the past provide a context for the interpretation of current and future changes in climate. Quaternary climates have been relatively well studied in north-east North America and the adjacent Atlantic Ocean over the last decades, and new research methods have been developed to improve reconstructions. We present newly inferred reconstructions of sea surface temperature for the north-western Atlantic region, together with a compilation of published temperature records. The database thus comprises a total of 86 records from both marine and terrestrial sites, including lakes, peatlands, ice and tree rings, each covering at least part of the Holocene. For each record, we present details on seasons covered, chronologies and information on radiocarbon dates and analytical time steps. The 86 records contain a total of 154 reconstructions of temperature and temperature-related variables. Main proxies include pollen and dinocysts, while summer was the season for which the highest number of reconstructions were available. Many records covered most of the Holocene, but many dinocyst records did not extend to the surface, due to sediment mixing, and dendroclimate records were limited to the last millennium. The database allows for the exploration of linkages between sea ice and climate and may be used in conjunction with other palaeoclimate and palaeoenvironmental records, such as wildfire records and peatland dynamics. This inventory may also aid the identification of gaps in the geographic distribution of past temperature records thus guiding future research efforts.

KEYWORDS

Canada, climate, dinocyst, palaeo, proxy

Dataset

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Creator: Simon van Bellen

Title: Holocene temperature reconstructions for north-eastern North America and the north-western Atlantic

Publisher: PANGAEA Data Archiving & Publication

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Resource type: Dataset

[†]See ClimHuNor Members in Appendix section.

1 | INTRODUCTION

Long-term climate records provide a context for the interpretation of recent environmental changes. Such records are particularly valuable at high latitudes of the Northern Hemisphere as recent and ongoing climate warming is most pronounced there (Screen and Simmonds, 2010). The Quaternary climate dynamics have been intensively studied in north-east North America and the adjacent Atlantic Ocean, but the ensemble of terrestrial and marine records from this vast region have never been aggregated and presented as a coherent source of information. Here, we present a database of climate records that covers the eastern Canadian Arctic and Greenland in addition to the boreal and temperate regions of north-east North America and the north-west North Atlantic, which include some of the records presented by Sundqvist *et al.* (2014). Climate reconstructions are generally obtained from sediment cores by the analysis of past assemblages of fossilized organisms and isotope data combined with chronologies established by radiometric dating methods, such as ^{14}C. Other sources include tree rings and ice core characteristics. The climate reconstructions presented here include variables directly related to air temperature, such as lake and sea surface temperature as well as sea ice cover, representing an indirect indicator of temperature.

The geographic extent of the database is 43.5–81.4°N and 28.7–98.5°W, covering the north-west Atlantic, including the Labrador Sea and Baffin Bay, eastern Canada and part of the north-east USA. The region is influenced by outflow from the Arctic to the North Atlantic through Canadian Arctic Archipelago, the Baffin Bay and the Labrador Sea and by the relative proximity of the Greenland Ice Sheet, meltwater discharge and sea ice dynamics in adjacent seas as well as weather patterns over the continent (Vavrus *et al.*, 2017).

2 | DATA PRODUCTION METHODS

Data were compiled from existing databases, published scientific papers and theses. Besides personal archives and contributions, NOAA's Paleoclimatology database was explored as a source of data. Representing a high diversity in study sites and indicators, the publications cover a period of several decades and were generated by a great diversity of researchers, and therefore, the methodologies to obtain reconstructions are highly diverse.

During the Holocene, a major part of the terrestrial sections of the region remained covered by the Laurentide Ice Sheet for extended periods (Dyke and Prest, 1987; Dyke *et al.*, 2002; Tarasov and Peltier, 2004), limiting the length of the palaeoclimate records. As a result, the period of interest included any part of the Holocene and records covering only a subsection of this period were not excluded. In order to be included in the dataset, records further needed to present direct or indirect linkages with atmospheric temperature. For marine sites, the dataset was limited to sea surface temperature and measures of the duration of sea ice cover; air or lake temperature records were included for terrestrial sites. The records may present annual, seasonal or monthly averages, and any analytical time step was allowed. Therefore, the diversity of the records in terms of time span, analytical resolution and chronological control is high. We aimed to provide detailed metadata in order for the user to identify appropriate records for intended use, applying specific terms to describe the data. Each sample site presents one or several records, identified at the indicator level. The metadata table refers to these records, that is to a single file. Each record includes one or several reconstructions of particular variables. For example, a single dinoflagellate cyst (or dinocyst) record may include reconstructions of both sea surface temperature and sea ice cover (e.g. Ledu *et al.*, 2010). When available, temperature reconstructions also include the counts or the raw data records on which they were based.

2.1 | Data updates

2.1.1 | Calibration of dinocyst assemblages

Among data from marine sediment cores based on dinocysts, 23 records were re-calibrated thus representing an update of the previously published articles, following the creation of a new modern analogue dinocyst dataset (de Vernal *et al.*, 2019) since the original publication (de Vernal *et al.*, 2001). The records based on the other indicators were not re-calibrated.

2.1.2 | Age-depth modelling and chronologies

New age-depth models were created for seven records, using the Bacon package (Blaauw and Christen, 2011) in R (R Core Team, 2016), which provided uncertainty estimates for each depth value, along with best age estimates, based on the mean value of a multitude of iterations. Creation of new models was motivated by the fact that for some records, the original chronologies were not preserved and only the dated sample information remained.

The mean analytical time step of each record was calculated by dividing the number of years separating the first and the last sample of the sequence by the number of samples analysed, minus one.

2.2 | Data details

The database presented includes 86 records, of which 55 are terrestrial and 31 marine (Figure 1). The 31 marine records are all based on core sections, and the terrestrial sites include records from lake sediments (46), ice (4), peat (3) and tree rings (2). The most frequently used indicators are pollen (37 records) and dinocysts (26 records); other indicators include chironomids, alkenones, varve characteristics and isotopes (Table 1). In total, the database comprises 154 temperature and temperature-related records.

Temperature records are available for summer, winter and annually, with the seasons defined by one, or several months (Figure 2). A total of 77 summer temperature records are included, 56 records of annually averaged conditions and 21 representing winter conditions.

2.2.1 | Chronological coverage and analytical time step

The chronological coverage is relatively uniform along the latitudinal extent (Figure 3). Most lake records start in the early Holocene and have a continuous coverage to the present; many of the northernmost sites present complete Holocene records, despite the proximity of the Laurentide Ice Sheet. Several marine records do not extend to the present, mainly due to sediment mixing or missing chronologies. Dendroclimatological records are limited to the last millennium before present. Generally, modelled chronologies do not extend beyond the deepest dated sample, as extrapolating chronological models may be hazardous (Blaauw and Heegaard, 2012) because sediment accumulation processes are not stable in time. As a result, several records do not present age data for one or multiple samples at the bottom of the sequence.

Chronological uncertainties are available for a minority of sites. The median analytical time step is 127 years, with 15 records, mostly shorter and sampled from lakes and tree rings, having a mean time step of less than 20 years and one pollen record attaining 817 years. Varves and tree ring records had a one-year time step.

2.2.2 | Reconstruction uncertainties

A measure of uncertainty in the records is available for 61 records. Of these, 30 present a measure of the variability in analogues used to infer the reconstruction. For 24 records, the standard deviation of the mean is used, with a few remaining records presenting similar measures, such as standard errors, confidence intervals or the root mean square errors of prediction. In 25 cases, no measure of uncertainty is available.

The variations in uncertainty measures are related to the statistical methods used to infer reconstructions. It should be noted that the uncertainty is only associated with the statistical method of converting the assemblage data (e.g. pollen or dinocysts) into a climate record. It does not account for any errors related to taxonomy, any misidentification of taxa or

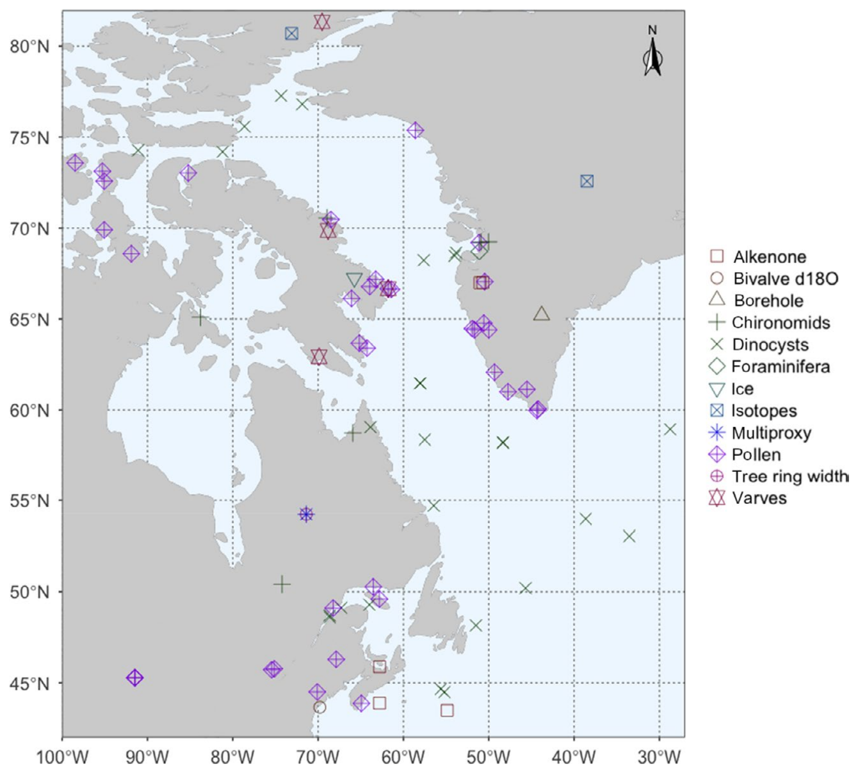

FIGURE 1 Localization of records presented

possible counting or compilation errors. A majority of pollen records, 24 out of the 37 records presented, have uncertainty expressed as the standard deviation of the mean inferred value of the most similar samples using the modern analogue technique. The average of the mean standard deviation for these records of July temperature is 1.2°C. Five records used the minimum and maximum values of the analogues as a measure of the uncertainty. Dinocyst record uncertainties of modern analogue-based estimates were defined by the minimum and maximum nearest corresponding analogues. The error of prediction estimated based on validation exercises is 1.7°C and 1.2°C for summer and winter sea surface temperatures, respectively.

TABLE 1 Number of different proxy types, and the number of records represented per site type

Proxy type	Terrestrial[a]	Marine	Total
Pollen	37	0	37
Dinocysts	0	26	26
Chironomids	6	0	6
Alkenone	2	3	5
Varve characteristics	4	0	4
Isotopes	2	0	2
Bivalve d^{18}O	0	1	1
Borehole temperature	1	0	1
Foraminifera	0	1	1
Multiproxy	1	0	1
Tree ring width	1	0	1
Ice characteristics	1	0	1

[a]Lakes included.

3 | DATASET LOCATION AND FORMAT

The dataset is available at PANGAEA (https://www.pangaea.de/). It is composed of a metadata table, each line of which refers to a record with a single identification. Each record is presented in a separate file, containing at least one reconstruction and a chronology, and in some cases depths. Additional variables include sample depth along the core, chronological and reconstruction uncertainties and assemblages on which the reconstructions were based.

4 | DATASET USE AND REUSE

The database will be used to explore linkages between sea ice and climate. In addition, it allows for the evaluation of

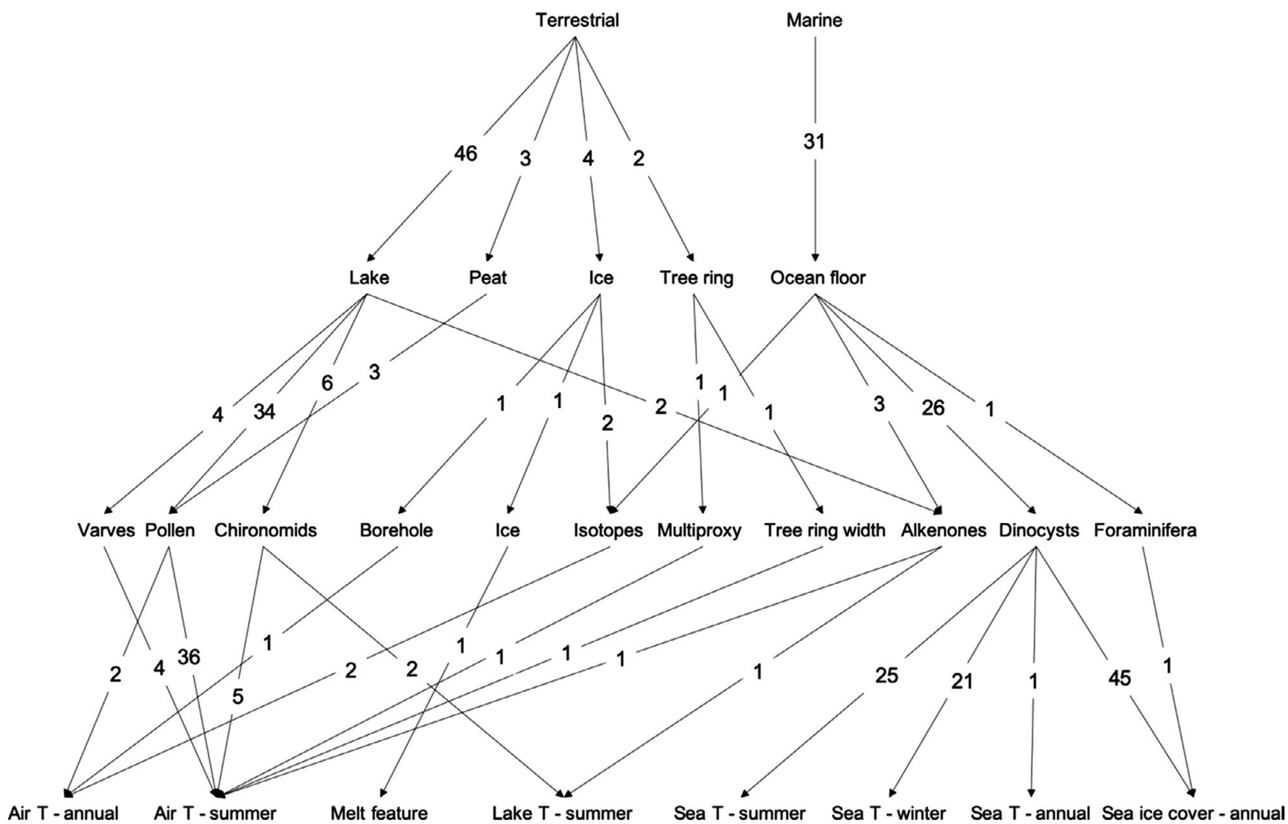

FIGURE 2 Dataset structure showing linkages between archives, indicators and reconstructed variables. Numbers represent the number of reconstructions available

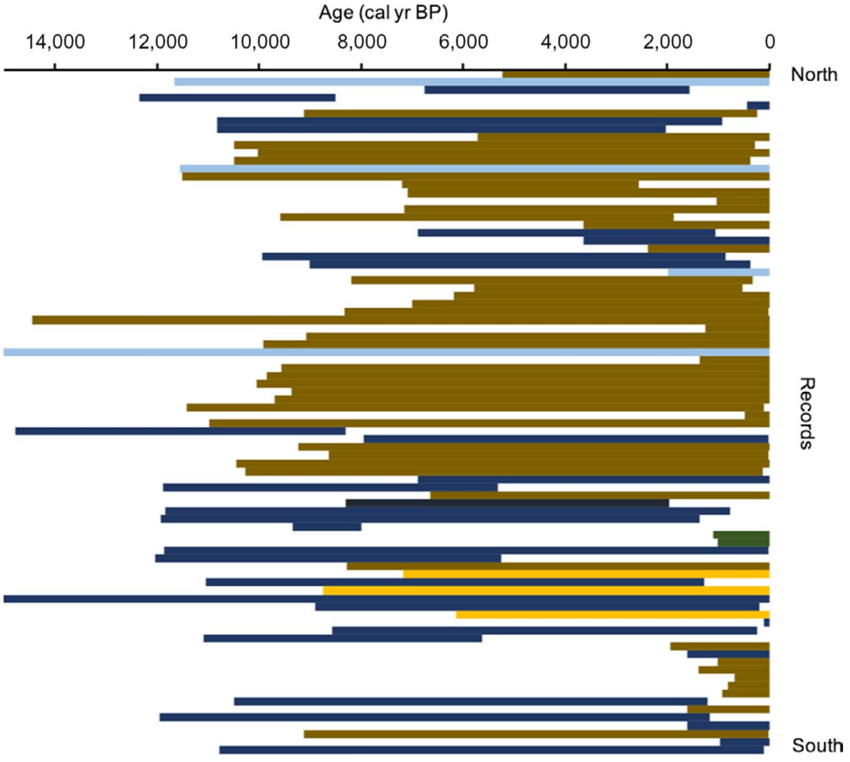

FIGURE 3 Dataset structure showing record coverage and type. Dark blue = marine; light blue = ice; brown = lake sediments; yellow = peat; green = tree rings. Record are sorted from North to South

trends in summer and winter temperature for both terrestrial and marine environments and it will aid the interpretation of other palaeoclimate and palaeoenvironmental records available or to be created, such as wildfire records and peatland dynamics. Finally, this inventory may aid the identification and evaluation of gaps in the current geographic distribution of palaeotemperature records and therefore guide future research efforts towards specific regions that may need increased coverage.

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APPENDIX

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