Regional climate reconstructions in northern North America

K Gajewski & AE Viau

Department of Geography
University of Ottawa
Ottawa, ON K1N 6N5 Canada

gajewski@uottawa.ca

Abstract

We have developed continental-scale quantitative estimates of temperature and precipitation for North America, as well as regional series for northern North America and Greenland using a combination of high resolution and radiocarbon dated pollen records. New records from the Canadian Arctic along with data extracted from the Global Pollen Database are used to provide estimates of past climates for the Holocene and the past 2ka. Millennial-scale climate variations are coherent between North America and Europe, as well as between different proxy-climate records such as ice cores and ocean sediments. Climate variations such as the Medieval Warm Period and Little Ice Age are expressed across Northern North America, although warmer in central Canada and colder in Labrador. The use of regional to continental-scale series permits higher resolution than if only individual sites are used

Introduction

Pollen data offer the possibility for developing paleoclimate time series across the globe, especially as large numbers of sites are available in public databases (Grimm, 2009; www.ncdc.noaa.gov/paleo). Regional paleoclimate records, derived by averaging across many sites have several advantages over single point-derived series, as local disturbances are averaged and have less effect on the resultant climate series. This is the strategy that dendroclimatologists have long used, and is applied here to develop continental and regional time series of temperature and precipitation for the Holocene from across North America.

Data & Methods

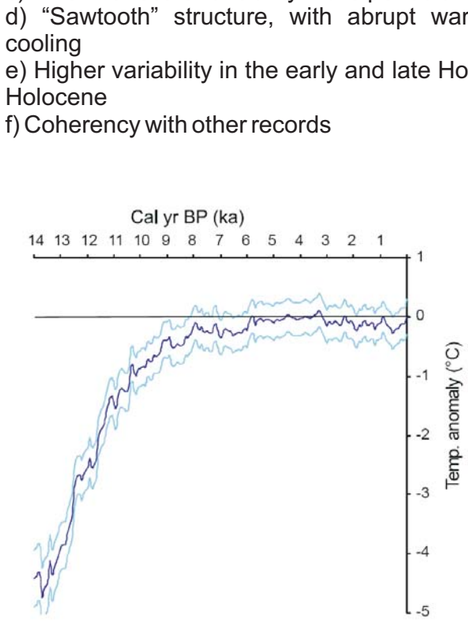
We used data from the NAPD (Grimm, 2009). This includes 752 pollen records (>30k pollen samples and >2.5k ^{14}C dates) from across the continent. Most of our reconstructions are based on the modern analogue technique, using the NAMPD (Whitmore et al., 2005; WIlliams et al., 2005).

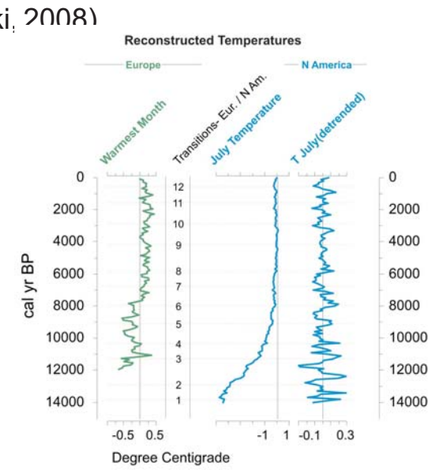
N. American Continental-scale reconstruction & Comparison to Europe

A curve of the mean July temperature (Viau et al 2006) with a resolution of 100 yr for North America shows several characteristics:

a) ~4°C warming from 14-10ka
b) A 4-part Holocene, with abrupt transitions at 8ka, 6ka & 3.2ka
c) Millennial-scale variability with a period of 1150 yr
d) "Sawtooth" structure, with abrupt warming and gradual cooling
e) Higher variability in the early and late Holocene than in mid-Holocene
f) Coherency with other records

Gajewski et al (2006) further showed that major transitions in North American and European pollen diagrams were synchronous, thus showing that climate impacts the vegetation comparably in both climates in spite of the cultural landscape of Europe. The continental reconstruction shows similarities to that from Davis et al (2003)(see Gajewski, 2008)



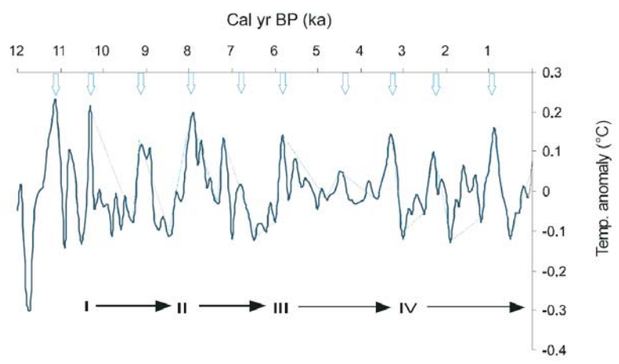


Left: Mean July temperature anomaly for North America from pollen records

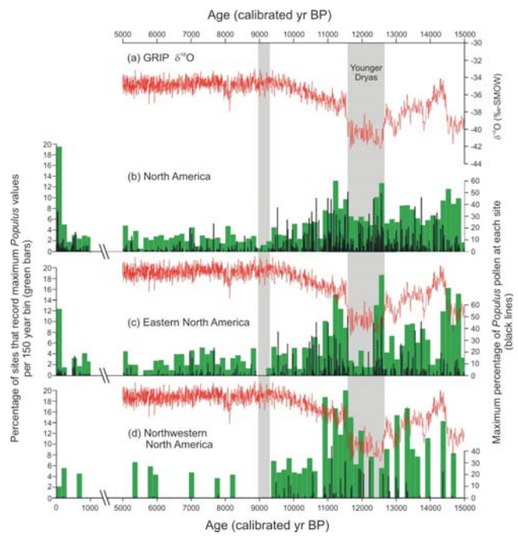
Right: July temperature of North America compared to warmest month temperature from Europe. Numbers are major transitions in vegetation seen in both Europe and North America.

Below left: De-trended curve, indicating sawtooth structure, transitions, and 4 part division of the Holocene

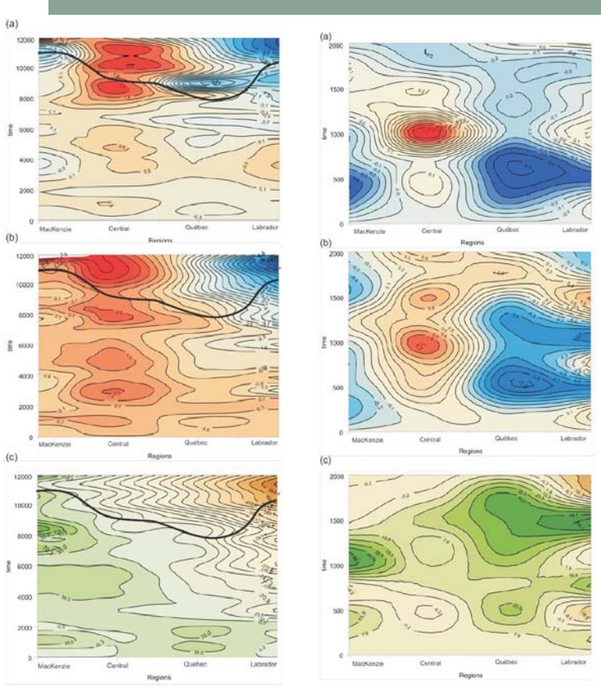
Below right: Histograms showing the timing of peaks in *Populus* pollen from diagram from across North America, northwestern and Eastern N America in relation to the del18O of the GRIP ice core. Note that maximum Populus percentages are found at the beginning and just after the YD.



An analysis of *Populus* pollen data from across North America (Peros et al, 2008) shows the continental-scale impact of the Younger Dryas on the vegetation of North America.



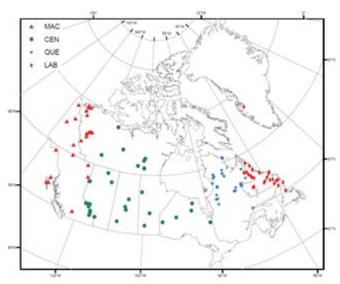
Postglacial Climates of Boreal Canada



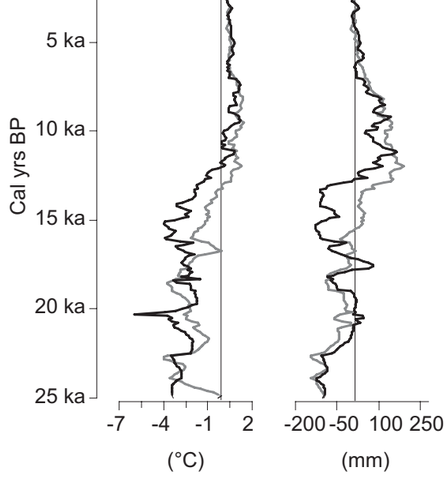
For all pollen data in the chosen regions (see map), the modern analogue technique was used to reconstruct the climate variables for every pollen spectrum. The reconstructed series were interpolated to 100-year intervals and regional averages computed from all diagrams. Details are in the paper, but the 4 time series are used to create these time space diagrams. Note the warm early Holocene in the central part of the continent and cold conditions in the east. Millennial-scale climate variability is clearly evident as well, especially in the central portion of the continent.

In the past 2000 years, the Medieval Warm Period and Little Ice Age are clearly evident in the entire boreal zone; warm conditions especially in the central portion of the country and cold conditions in the east.

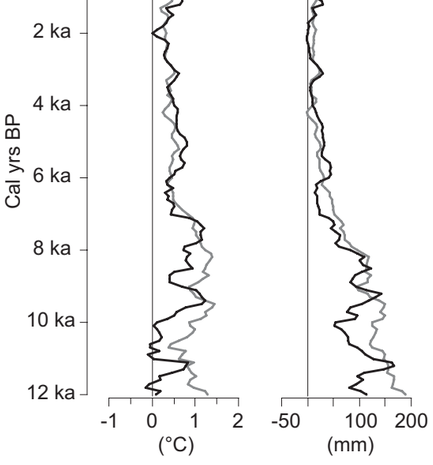
a) July temperature
b) January Temperature
c) Annual Precipitation



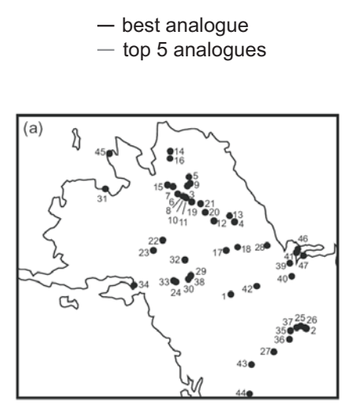
Paleoclimate time-series of Beringia



Holocene: There was a long-term cooling and drying since the early Holocene. Millennial-scale climate variability is apparent, although less pronounced than in the Full glacial. Regional differences are studied.



Full and late-Glacial: Temperatures were colder than present during the Full Glacial, and drier during some time periods. Analogues could be found for most levels during the Full glacial, but some non-analogues were found in the late-glacial (not shown).
Using 5 analogues produces a warm bias in the reconstructions, especially during the Full Glacial. Mapping of the analogues chosen for the various fossil spectra is a useful strategy for analysis of the climate reconstructions, see Viau et al., 2008



Literature Cited

- Davis, B, S Brewer, A Stevenson, J Guiot & data contributors 2003. The temperature of Europe during the Holocene reconstructed from pollen data. Quaternary Science Reviews 22: 1701–16.
- Gajewski, K. 2008. The global pollen database in biogeographical and paleoclimatic studies. Progress in Physical Geography 32: 379-402.
- Gajewski, K, A Viau and M Sawada. 2007. Millennial-scale climate variations in the Holocene – the terrestrial record. Pp 133-154 in: Kutzbach, G, Ed. Climate Variability and Change: Past, Present and Future. John E Kutzbach Symposium. Center for Climatic Research, University of Wisconsin. Madison, Wi.
- Gajewski, K, A Viau, M Sawada, D Atkinson and P Fines. 2006. Synchronicity in climate and vegetation transitions between Europe and North America during the Holocene. Climatic Change 78: 341-361
- Grimm, E. 2009. North American Pollen Database. www.ncdc.noaa.gov/paleo
- Peros, M, K Gajewski and A Viau. 2008. Continental-scale tree population response to rapid climate change, competition and disturbance. Global Ecology and Biogeography 17: 658-669.
- Viau, A and K Gajewski. 2009. Reconstructing millennial-scale, regional paleoclimates of boreal Canada during the Holocene. Journal of Climate 22: 316-330.
- Viau, A, K Gajewski, M Sawada and J Bunbury. 2008. Low- and High-frequency climate variability in Beringia during the past 25,000 years. Canadian Journal of Earth Sciences 45: 1435-1453.
- Viau, A, K Gajewski, M Sawada and P Fines. 2006. Millennial-scale temperature variations in North America during the Holocene. Journal of Geophysical Research – Atmospheres 111, D09102.
- Whitmore, J, et al. 2005. Modern Pollen Data from North America and Greenland for Multi-scale Paleoenvironmental Applications. Quaternary Science Reviews 24: 1828-1848
- Williams, J et al. 2006. An Atlas of Pollen-Vegetation-Climate Relationships for the United States and Canada. AASP, Dallas, TX.

Acknowledgements

We thank all contributors to the North American Pollen Database (NAPD) and North American Modern Pollen Database (NAMPD) and our several collaborators, including M Peros, J Bunbury, M Sawada, P Fines, J Whitmore.
This work is funded by grants from NSERC and CFCAS.