Publications of the Academy of Finland 6/95

Pirkko Heikinheimo (Ed.)

INTERNATIONAL CONFERENCE ON PAST, PRESENT AND FUTURE CLIMATE

Proceedings of the SILMU conference held in Helsinki, Finland, 22–25 August 1995

Ministry of Education
The Academy of Finland

Painatuskeskus

Cover: Arja Puolimatka
The SILMU logo: Riitta Lestinen

ISBN 951-37-1721-6
ISSN 0358-9153

PAINATUSKESKUS OY
Helsinki 1995

Regional temperature patterns across Northern Eurasia: tree-ring reconstructions over centuries and millennia

Keith R. Briffa[1], Philip D. Jones[1], Fritz H. Schweingruber[2], Wibjörn Karlén[3], Thomas Bartholin[4], Stepan Shiyatov[5], Eugene A. Vaganov[6], PenttiZetterberg[7] and Matti Eronen[8]

[1]Climatic Research Unit, University of East Anglia,
Norwich NR4 7TJ, UK

[2]Swiss Federal Institute of Forest, Snow and Landscape Research,
Zürcherstrasse 11, CH-8903 Birmensdorf, Switzerland

[3]Department of Physical Geography, University of Stockholm,
S-10691 Stockholm, Sweden

[4]Laboratory of Quaternary Biology, University of Lund,
Tornavägen 13, S-22363 Lund, Sweden.

[5]Institute of Plant and Animal Ecology, Ural Branch of the Russian
Academy of Sciences, 8 Marta St., Ekaterinburg 620219, Russia

[6]Institute of Forest, Akagemogorodok, Krasnoyarsk 660036, Russia

[7]Karelian Institute, Secction of Ecology, University of Joensuu,
PO Box 111, SF-90101 Joensuu, Finland

[8]Department of Geology, P.O. Box 11 (Snellmaninkatu 3), FIN-00014
University of Helsinki, Finland

Spatial patterns during recent centuries

As part of a continuing European project in dendroclimatology, a network of temperature-sensitive tree-ring collections is being developed, at generally high-latitude or high-altitude sites extending across northern Fennoscandia and northern Russia. Intensive Russian sampling was carried out in 1991 and 1992 as a collaboration between the Swiss Federal Institute of Forest, Snow and Landscape Research, Birmensdorf; the Institute of Plant and Animal Ecology, Ekaterinburg; and the Institute of Forest, Krasnoyarsk. Together with earlier west European collections, this has provided an initial network made up of tree increment core samples at over 100 sites, many with data for different tree species. All of the collections are being analysed to produce tree-ring density as well as ring-width data, and todate nearly 70 chronologies for each of these variables are available in Russia.

Established multivariate transfer function techniques are being used to associate regional patterns in the tree growth variables with patterns of gridded summer temperature averaged over 'seasons', equating locally to cumulative degree days above a 5(C threshold. The ultimate aim of this work is to apply these transfer functions to past tree growth variations so as to provide a detailed regional picture of year-by-year changes of summer temperatures across northern Eurasia. The results will be produced in the form of detailed anomaly maps and gridpoint temperature series representing annual-to-multidecadal variability with high statistical confidence for periods up to 250-300 years.

At present, the effective spatial resolution of these reconstructions is restricted by the density of site chronologies produced. Todate, this is good west of the Ural Mountains but poor in central and eastern regions (though laboratory analysis and fieldwork are currently underway to improve this). Provisional results of chronology comparisons, intra- and inter-site data analyses, climate calibration and provisional temperature reconstructions are already available and will be described.

The Last Millennium in Northwest Eurasia

At specific locations in northern high-latitude regions it is possible to extend the tree-growth record back beyond the life span of living trees by amalgamating the measurements from overlapping, absolutely-dated series of measurements made on dead wood from historical or archaeological provenances or naturally surviving above ground, in peat or alluvial sediments, orpreserved in lakes. At two locations in northern Eurasia the availability of sufficient subfossil pine material has enabled separate ring-width and maximum-latewood-density chronologies to be produced, each spanning more than 1000 years. The first pair of (ring-width and density) chronologies, made up from samples at several locations adjacent to Lake Torneträsk, northern Sweden, have been used to reconstruct summer (April-August) temperatures representing a large region of northern Fennoscandia (65-70(N; 10-30(E) from A.D. 500 to 1980. Similar data from samples of larch on the eastern slopes of the northern Urals have been used to reconstruct regional summer (May-Sept.) temperatures representing a region of northwestern Siberia (62-68(N; 65-75(E) for the period 914 to 1990. The approach used in constructing these tree-ring chronologies was one in which sample-age bias is removed from the individual tree measurement series but long-timescale (potential climate) variability is preserved in the mean chronology. Hence the temperature reconstructions represent longer timescale temperature variations than would be possible if more 'usual' data processing techniques had been employed.

Both the Fennoscandian and the Russian temperature records show marked high-frequency (interannual - to - century) timescale variability. However, they also demonstrate that marked long-timescale (multicentury) variations in summer temperatures have been a characteristic feature of climate in each region during the last millennium. On the basis of instrumental temperature comparisons over the present century, we would not expect significant correlation between these records (at least on interannual - to - decadal timescales). However, a comparison of the long-timescale variability in the two records reveals up until about 1600, temperature anomalies were largely out of phase between the regions. This is dramatically illustrated between 950 and 1200 when it was generally warm in northern Fennoscandia and cool over the northern Urals (the period of the so-called Medieval Warm Epoch). However, both areas appear to have experienced very cool conditions during the late 16th and the 17th centuries (though the cool period set in earlier in the Russian series, in the early 18th century). After this time, summers appear to have followed similar long-term paths, warming to the mid 18th century, slight cooling to the end of the 19th and a sharp rise to a period of generally warm summers during the present century. In the context of extended Fennoscandian record, the 20th century warmth is not anomalous. However, the recent temperatures over the northern Urals do appear unusual in the context of the 1000-year record.

Despite cool summers during the late 1960s and 1970s, summer temperatures over the northern Urals, averaged over the whole 20th century todate (1901-90), were warmer than for any other 90-year period in the record. The period from 1919-1968 was also warmer than any other 50-year period, though the warmest 20-year value this century (1948-1967) is only the second warmest (after 1461-1480).

While acknowledging the real uncertainty that is always particularly associated with attempts to capture long-timescale variability in the series, it is still interesting to note that model-based scenarios of future temperature change in these regions is at least consistent with the recent temperature trends that we have reconstructed. Recent long runs of coupled atmosphere-ocean general circulation models with perturbed greenhouse-gas forcing suggest that future warming may be greatest at high-latitudes and continental regions and might be reduced (or absent) in the vicinity of the North Atlantic due to the effects of North Atlantic Deep Water formation. We also note, however, that conditions in Fennoscandia and the polar Urals during the 13th century caution against viewing the recent level of warmth as necessarily evidence of regionally enhanced greenhouse warming.

Fennoscandia during the Holocene

In Fennoscandia, two projects currently underway aim to build continuous multimillennial pine ring-width chronologies, spanning 7-8000 years. The Finnish project is described in another contribution to this meeting (Zetterberg et al.). The current status of the northern Swedish project, centred on the region around Lake Torneträsk will be described.

A continuous, absolutely dated ring-width chronology currently spans the period from A.D. 1 to 1981. Prior to this over 300 subfossil series have been incorporated within two 'floating' chronologies, one 4450 years and the other 823 years long. Based on calibrated conventional radiocarbon dates these probably span the periods 5480-1131 and 1111-289 B.C. The 19-year gap between them is supported by comparison with another floating Finnish chronology that is continuous over this period (based on data supplied by P. Zetterberg, Pers. Comm.). The replication is very poor in certain areas of the early chronologies and they should only be considered as provisional at this point in time. Despite this, they suggest major multicentury variability of climate during the last 7000 years with anomalous warmth at about 5300, 5100, 4650, 3850, 3700, 3400, 2900, 1300 and 750 B.C. A mid Holocene period of protracted warmth is suggested between about 4000 and 3300 B.C., though interrupted by relatively cool conditions after 3600.

The gap in the long chronology after 300 B.C. is coincident with other evidence of poor subfossil wood preservation and independent evidence of wetter conditions and therefore supports the hypothesis of a major widespread climate anomaly at this time. The long chronologies as constructed at present do not show any evidence for millennial-timescale lowering of summer temperatures as would be expected on the evidence of falling alpine tree lines, latitudinal retreating tree lines and calculated summer insolation. To some extent, this reflects a lack of sensitivity in the tree-ring data to very long-term changes in temperature as a result of the way the long chronologies are constructed. Adjusting the data to take account of the elevation of the source material may overcome this to some extent.

Acknowledgements

The research described above is supported by the Swiss National Science Foundation and the EC Environment Programme in Climatology and Natural Hazards under contract EV5V-CT94-0500: Tree-ring Evidence of Climate Change in Eurasia during the last 2000 years.