From: GERNER THOMSEN <gerner@get2net.dk>
To: Keith Briffa <k.briffa@uea.ac.uk>
Subject: Ph.D. in Sweden
Date: Mon, 19 Jan 1998 06:15:55 +0100
Reply-to: gerner <gerner@get2net.dk>

Dear Keith!

I contacted Hakan Grudd last week. He is also positive about a Ph.D. for me in Stockholm.
I have tried to make a formulation of a project. Please, read it and let me know what you think. Maybe the project is overlapping with that of Grudd or maybe you have better ideas. It could also be that I have misunderstood some points.
I have sent the project formulation to Schweingruber, Grudd and Kalen. I send it to Schweingruber because I already contacted him last week (before I got the message from you). He is also interested in the project and anyway he will get involved if I am going to train in Birmensdorf.

Best regards from:

Gerner Thomsen

Description of project

1. Background
Dendroclimatology can be defined as the use of tree rings to study and reconstruct past and present climate (Kaennel & Schweingruber, 1995). Global average surface temperatures have risen by 0.3-0.6 °C since the middle of the 19th century (Folland et al., 1990). Climatologists seek to establish the extent to which this rise may be attributable to an enhanced greenhouse effect and so need to distinguish anthropogenic from 'natural' climate fluctuations (those that would occur without anthropogenic influences) to help them make predictions of future climate changes (Briffa et al., 1996a). Clearly the century-long instrumental record is not long enough to accomplish this. Paleoclimatic fluctuations older than meteorological measurements can be inferred from a variety of data sources, including tree rings, records of vegetation processes (e.g. pollen in lake sediments), records of ice layer in ice cores, historical records, etc. (Eddy, 1992). However, within a time frame of the last two millennia dendroclimatology has shown to be the most powerful tool available to provide globally distributed, annually resolved paleoenvironmental records (Luckman, 1996). The growing influence of dendroclimatology in paleoenvironmental studies can be seen in the fact that almost a third of Bradley and Jones' volume Climate since AD 1500 (Bradley & Jones, 1992) deals with dendrochronology and dendroclimatic reconstruction.
Near the polar and altitudinal tree lines, tree growth is mainly dependent on summer temperature. As northern latitudes are regarded as being strongly affected by global climate changes, a network of chronologies is established along the polar tree-line in Eurasia (Briffa et al., 1996b). At specific locations in these 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 archeological provenances or naturally surviving above ground, in peat or alluvial sediments, or preserved in lakes. The first pair of (ring-width and density) chronologies, made up from samples of Scots pine (Pinus sylvestris L.) 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 from AD 500 to 1980 (Briffa et al., 1990, 1992). The Fennoscandian temperature records show that marked high-frequency (interannual-to-century) timescale variability together with marked long-timescale (multicentury) variations in summer temperatures have been a characteristic feature in this region during the last millennium.

Similar data from samples of larch (Larix sibirica) on the eastern slopes of the northern Urals have been used to reconstruct regional summer (May-September) temperatures representing a region of north-western Siberia for the period 914 to 1990 (Briffa et al., 1995b). As a part of developing the north Eurasian chronology network, two projects currently underway aim to build continuous multimillennial pine ring-width chronologies in northern Sweden and Finland, spanning 7000-8000 years (Briffa et al., 1995a). In Russia a similar project underway aim to build larch ring-width chronologies in Yamal Peninsula, also spanning 7000-8000 years (Shiyatov, 1997).

The application of radiodensitometry in the analysis of conifer rings throughout Europe (Schweingruber, 1985) show the considerable amount of additional information lying in density, as compared with total ring width. Obviously, external factors have a more uniform influence on cell wall growth in latewood (density) than on cambial activity (ring-widths). In trees of the northern and subalpine timberlines, maximum latewood density is essentially a measure of mean summer temperature (ibid.).

2. Purpose of this study

2.1. Main objective

The main objective of this study is to provide additional information for a more precise climate reconstruction based on the already existing Torneträsk-chronology in northern Sweden (AD 500 to 1980) and a future supra-long chronology (BC 7000 to 1996), based on ring-widths and maximum latewood density of Scots pine (Pinus sylvestris L.) from the same area.

2.2. Elaboration of the main objective

One of the most fundamental underlying principles in dendroclimatology is the assumption of uniformitarianism in the response of data to climate forcing. The uniformitarian principle implies that "the physical and biological processes which link today's climate with today's variations in tree growth must have been in operation in the past" (Fritts, 1976). However, it is a moot point whether the assumption of uniformitarianism holds when past climate variations are inferred from long chronologies. The problem arises because the extrapolation always is based on a regression model calibrated on very short meteorological records. Long chronologies, as those seen in northern Scandinavia and Siberia, are made up from trees of different ages growing under more or less uniform conditions. In such chronologies there must always be uncertainty regarding the long-term stability of (non-climate) environmental influences or differing climate sensivity due to the inhomogeneity in the sampled material (Briffa, 1995a, Briffa et al., 1996a). The climate signals in chronologies may, to some extent, be affected by:

1.
Inhomogeneity in the site characteristics of the samples (soil fertility, water holding capacity of the soil, altitude, exposure of slope, etc.)

2.
Inhomogeneity in series length of samples (tree age)

3.
Inhomogeneity in tree growth form and population density of samples

4.
Anthropogenic influence (nitrogen deposition, raise in CO2 level) producing enhanced tree growth in the recent part of the chronology

5.
Series replication in the chronology

6.
The technique used to remove the non-climatic, age-related bias in individual series (a technique known as standardization in dendroclimatology)

This study will focus on the influence of point 1-3 on the climate signal seen in densities of Scots pine from the area of Torneträsk in northern Sweden. It is well-known that the Torneträsk-chronology is subject to the inhomogenity in samples described in point 1-3, but it is not clear to what extension these inhomogenities affect the climate signal in the chronology. Thus, a study of the influence of inhomogenity in the samples will provide valuable additional information for a more precise interpretation of the summer-temperature record inferred from the already existing Torneträsk-chronology. In the same way it will highly increase the value and confidence of climate reconstructions from future supra-long pine-chronologies in this region. The growth parameter under investigation is maximum latewood density. In this way the study will complement an ongoing similar study on ring-widths of Scots pine from the same region (Grudd, 1998).

2.3. Partial objectives of the study and publications

Methodologically, the project can be divided into three, but overlapping stages:

1.
Building of density pine-chronologies around Torneträsk from different sites. Various site conditions (mainly soil fertility, water holding capacity of the soil, altitude, and tree population density) and different age classes must be taken into consideration. No less than 10-12 chronologies must be estimated.

2.
Analysis of climate-growth relationships of the pine-chronologies, focusing on differences between high-frequency and low-frequency variability in the climate date. The results are compared and conclusions are drawn about the diversity of climate signal seen in density-chronologies from Scots pine growing under various conditions in the area around Torneträsk.

3.
Re-interpretation of the already existing Torneträsk-chronology on the basis of the new information provided by the study in case and the ongoing similar study of ring-widths from the same region (Grudd, 1998)

The results are published in three articles with the following provisional titles:

a)
"Site-induced differences in climate-growth response of Pinus sylvestris L." (The article focuses on differences in climate-growth response for trees growing on different soil types and for trees from stands with different population density)

b)
"Altitude and age as parameters of climate-growth response in Pinus sylvestris L." (The article focuses on differences in climate-growth response for trees growing at different altitudes and trees in different age-classes)

c)
"Possible site-induced changes in the climate-growth response of the 1,400 year tree-ring chronology from northern Fennoscandia" (A re-interpretation of the existing Torneträsk-chronology is made on the basis of the new information)

3. Methods

3.1. Sampling strategy

3.1.1. Selection of sites and stands
As already pointed out, various site conditions and different age classes must be taken into consideration. Site homogeneity largely determines the

quality of the chronology. That is, the factor under investigation which is assumed to affect the climate-growth response must be constant all over the site, and other possible affecting factors are minimised. It is important that the stand have not been similarly damaged by fires, wind, or other catastrophic factors to extract reliable climatic information. Site characteristics will be noted (typography/geomorphology, soil conditions, vegetation description, signs of human impact, etc.).

3.1.2. Selection of trees
Trees should be in a dominant position (with the possible exception of stand density studies), without irregular growth which probably disturb the climate signal in the tree-rings. Individual variability in the final chronology decreases with an increasing number of samples. Consequently, two cores from at least 12 living trees are necessary to obtain a site-chronology of sufficient quality. It is best to sample a few more trees than necessary so that anomalous cores may be discarded. Trees of different age classes will be cored to allow for systematical studies on age-related bias in the climate-growth response.
Samples are taken at breast height with an increment borer. The cores are stored in air-dry conditions after labelling with a pencil. Growth irregularities (compression wood, wound tissue, etc.) are excluded by avoiding sampling in the vicinity of wound and of upslope and downslope sides of trees growing on sloping ground. Cores are taken as nearly perpendicular to the fibre orientation as possible. This can greatly reduce the variability owing to technical processing in densitometric studies (Schweingruber et al., 1990). Core characteristics will be noted (tree height, stem diameter at breast height, crown size and condition, injuries and irregular growth, coring direction and height, etc.). Sites and trees will be documented photographically.

3.2.Sample preparation, measurement, and chronology building

3.2.1. Preparation
Resins and heartwood substances must be chemically removed as they will influence on the X-ray absorption (Schweingruber, 1990). This is done through distillation in Soxhlett device; resins are extracted with alcohol, heartwood substances with water. After removal of resins and heartwood substances, laths of equal thickness have to be cut from the round cores. The Birmensdorf system may be used where the core is glued to a wooden support with the radial surface uppermost and a 1.25-mm-thick lath cut out with a small twin-bladed circular saw. To obtain comparable density values, the moisture content of the wood must be kept constant.

3.2.2. Measurement of density

The irradiation of film can be done with different methods. Two methods, which have proved to be useful are:

1.
Irradiation of a film (Kodak, Type R, single-coated industrial X-ray film) resting on the moving stage. The film is transported at five cm/min under the radiation source, which is 31 cm above, and irradiated at 20kVh and 2mA (Vancouver system)

2.
Irradiation of a film (Kodak, Type X-Omat TL, double coated medical X-ray film) resting on a stationary stage at 11 kVh and 20 mA for 90 min. The source is 250 cm above the film (Nancy system)

The film is developed and the different gray levels produced on the radiograph by the wood samples are converted to wood density values. The basic instrument used is the densitometer (ibid). Analog or digital processing of the actual measurements produces a density profile from which the desired parameter (maximum density) is registered.

3.2.3. Dating and chronology building
For dating, chronology building and quality control, the program COFECHA

(Holmes et al., 1986) may be used. In addition a manual dating control has to be done at the light table or monitor, comparing each curve with an existing master chronology. The procedure ensures precise dating of every tree ring.

3.3. Data processing

3.3.1. Standardization of tree-ring data
Before averaging tree-ring curves to mean chronologies which shall be used for dendroclimatological purposes, the raw values must be standardized to index values. In the same process, one has to remove the natural age trend of trees and eventual density variations caused by stand dynamics, and not representing climate. Also in this process, it is crucial to control the effect of detrending at the light table or on the monitor, comparing the original with the detrended curve. Much depends from this process, as the dendrochronologist here decides which portion of low frequency variation that is removed from the series. This in turn affects climate information inferred from the chronology. Therefore, several detrending methods have to be tested in this study.

3.3.2. Computing climate-growth response
Climate-growth models will be computed for all individual chronologies. The period selected for climate-growth modelling, is the period for which climate data are available (the earliest series start in AD ??). Different techniques are existing for estimation of the climate-growth response. For example, simple correlation analysis may be used or a regression-technique based on principal component analysis. It may be relevant to detect non-linear relationships between climate variables and ring growth, as well as to study single years with special tree-ring (pointer years) and climate events. To detect changes in climate-response over time the Kalman filter can be used.

4. Time schedule
The project will be performed during three years (June 1998 to June 2001). The Ph.D. student will follow courses corresponding to 40 weeks of studies. >From earlier working, the following assumptions regarding time consume for field work and measuring can be made: It can take a number of days to become familiar with the localities and to find the most suitable pine stands. At each site, one to two days are needed for sampling and site description, provided that the pines do not stand too scattered, and long walking distances can be avoided. Time for measuring and chronology building should be estimated rather high (2-3 weeks per site).

1998:
Summer:
Preparing of a detailed sampling strategy for the whole project (2 weeks) and field work (6 weeks). The field work will focus on sampling of trees from about six sites with varying conditions (soil fertility and water holding capacity).

Autumn semester:
Training in use of densitometry equipment at the institute of Forest, Snow and Landscape in Birmensdorf, Switzerland. Measurement of samples collected in the summer.

1999:
Spring semester:
Continued measuring of samples at the university in Stockholm. Systematical analysis of standardization methods and construction of six site chronologies. Start of analysing climate-growth response in chronologies.

Summer:
Field work (6 weeks) which will put focus on sampling trees from about six sites in different altitudes and with different stand densities.

Autumn semester:

Measuring of the summer's material at the university in Stockholm. Systematical analysis of standardization methods and construction of six new site chronologies. Analysing climate-growth response in chronologies.

2000:
Spring semester:
Analysing climate-growth response in all chronologies. Preparation of publication (a).

Autumn semester:
Analysing age-related climate-response. Preparation of publication (b). Comparison of results with similar study on ring-widths (Grudd, 1998).

2001:
Spring semester:
Last statistics, preparation of publication (c), preparation of disputation.

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