Large-scale temperature information in tree-ring density data

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There now exists a growing network of temperature-sensitive tree-ring density chronologies spanning much of the higher-latitude and high-elevation regions of the Northern Hemisphere (**Figure 1**). Here we present several illustrations of the large regional-scale nature of the temperature signal in many of these data (**Figures 2** and **3**), data that were produced at the Institute of Forest, Snow & Landscape Research, Birmensdorf, Switzerland from data collected from generally cool and moist sites spread across the western United States, Canada, Europe, Fennoscandia and northern Siberia (**Figure 1**).

We show some examples of the information that has been gleaned about past temperature variability from these data (**Figures 4**, **5**, **6** and **7**). Despite a generally strong and consistently maintained relationship between extended summer warmth and density variability on the interannual time scale, there is an apparent increasing divergence in the decadally-smoothed trends of growth and temperatures over the recent few decades (Briffa *et al.*, 1998b) that may indicate an anthropogenic-related change in the climate/growth response (**Figures 4** and **5**). To investigate this in more detail requires a significant international initiative to update and improve the sample data base for the last few decades.

Figure 1. Location of the 387 chronologies with tree-ring density measurements, and the 9 regions used in the analyses from which examples are illustrated here. [From Briffa *et al.* (2000a)]

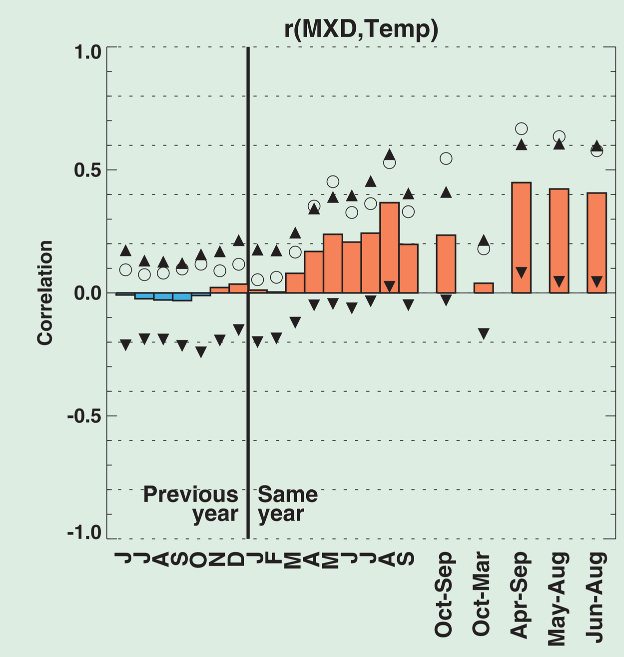


Figure 2. A summary of the individual temperature response functions for all maximum latewood density chronologies in the network. The triangles show the lower 5 to upper 95 percentile ranges of all site correlations against local temperature for individual months prior to and during the growing season, and for some averaged 'seasons'. The histograms show the mean value of the individual correlations, while the circles show the simple correlations between the single chronology formed as the average of all individual sites chronologies, and the average temperature drawn from all co-located areas.

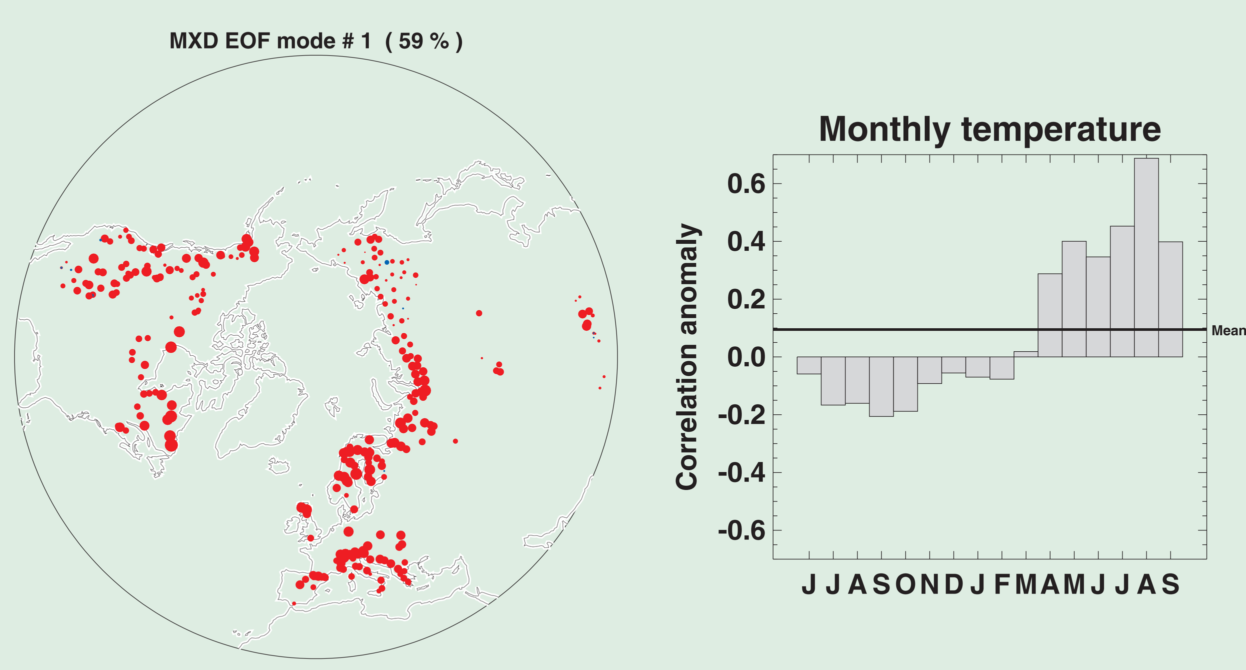


Figure 3. The dominant climate response structure within the tree-ring density data set, identified by Principal Component Analysis of the set of correlations between each chronology and monthly temperatures (from the previous June, through to the September of the year of growth). Red dots indicate those chronologies with a similar pattern of seasonal temperature response to that shown on the right, with greater similarity indicated by larger dots. [From Briffa *et al.* (2000a)]

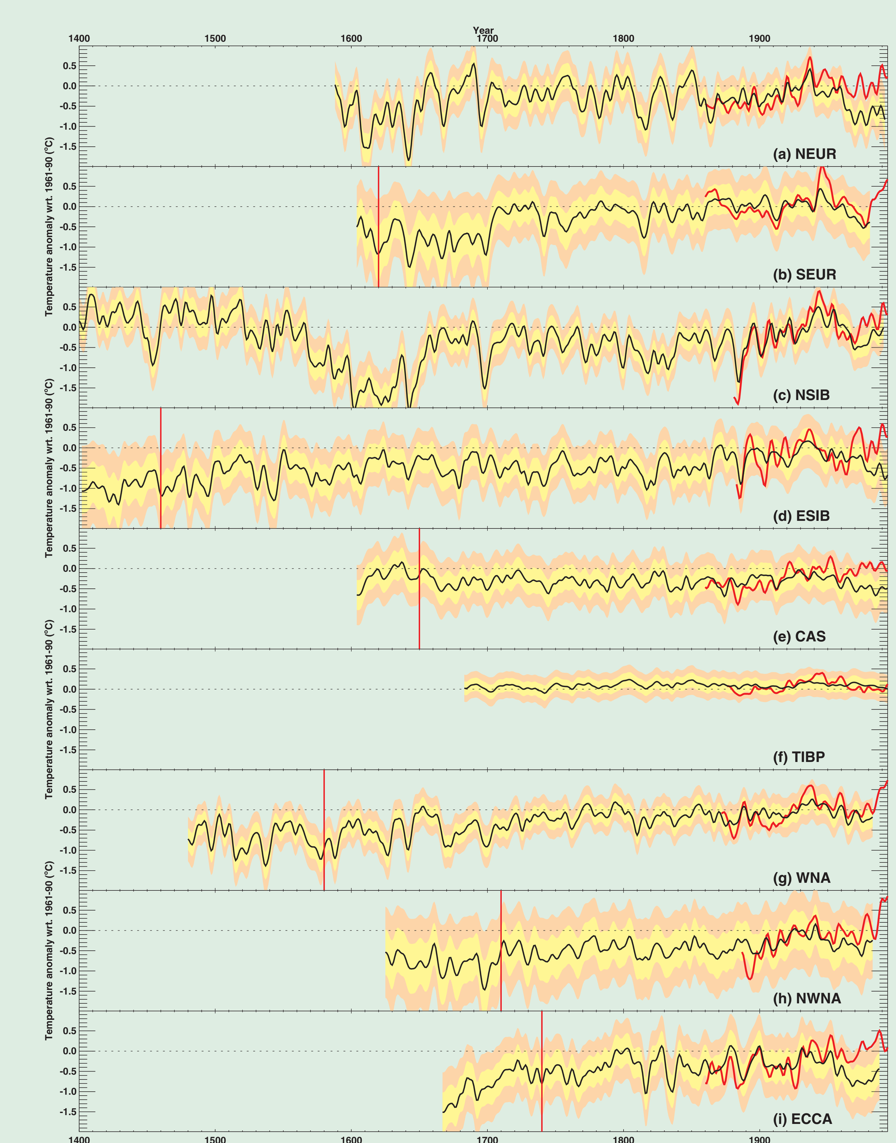


Figure 4. Reconstructions (black lines with shading to indicate the 1 and 2 standard error ranges) of the 9 regional summer (April-September) temperatures, calibrated against the observed record (red lines). The tree-ring density data were processed using an age-banding technique, to remove the age-bias effect without losing low-frequency variations. The vertical red lines indicate when the early parts of the reconstructions have reduced reliability. All curves have been smoothed with a decadal filter. [From Briffa *et al.* (2000b)]

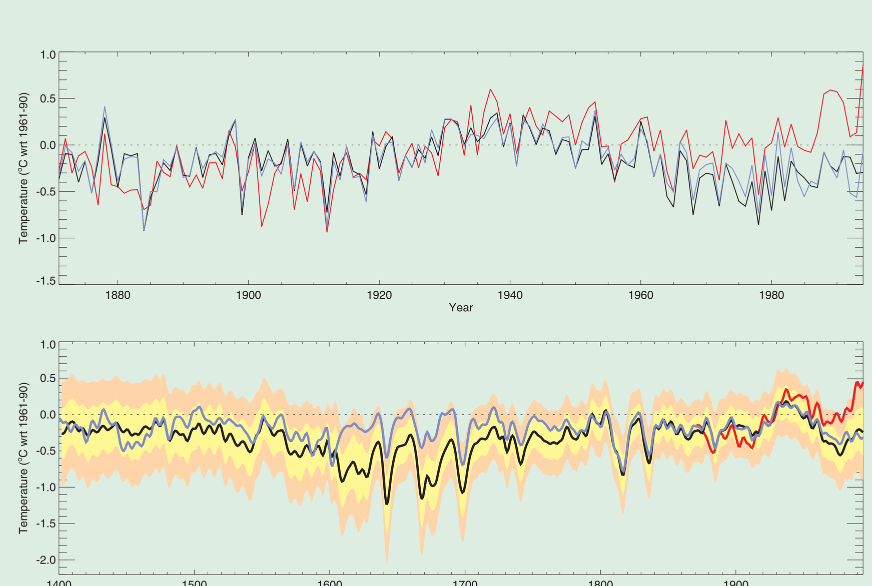


Figure 5. Reconstruction of the summer temperature from all land areas covered by the tree-ring density data, for the recent period (upper panel) and decadally-smoothed for the past 600 years (lower panel). The observed temperatures (red lines) are reconstructed using two alternative approaches to minimising the effect of age-related trends in the raw data: (i) by 'age-banding' the density data (black lines, with shading to indicate the 1 and 2 standard error ranges), a method that preserves long-timescale variability in the final chronology, but that requires large numbers of sample series, representative of different age trees and well distributed over time; or (ii) by standardising the density data (blue lines), by taking the 'more traditional' approach of taking residuals from modified exponential (Hugershoff) functions fitted to individual measurement series.

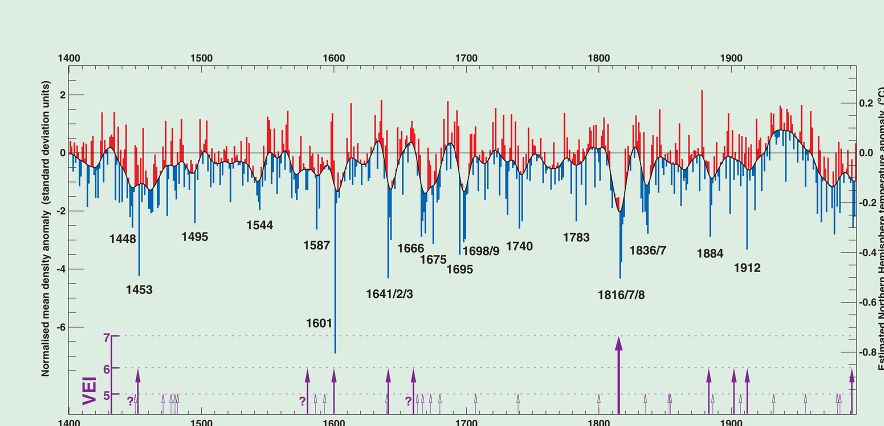


Figure 6. Reconstruction of summer temperature over the Northern Hemisphere land, based on Hugershoff standardised tree-ring density data. These data provide excellent reliability at interannual to multi-decadal time scales, and exhibit a clear response to explosive volcanic eruptions (indicated by the purple arrows). [From Briffa *et al.* (1998a)]

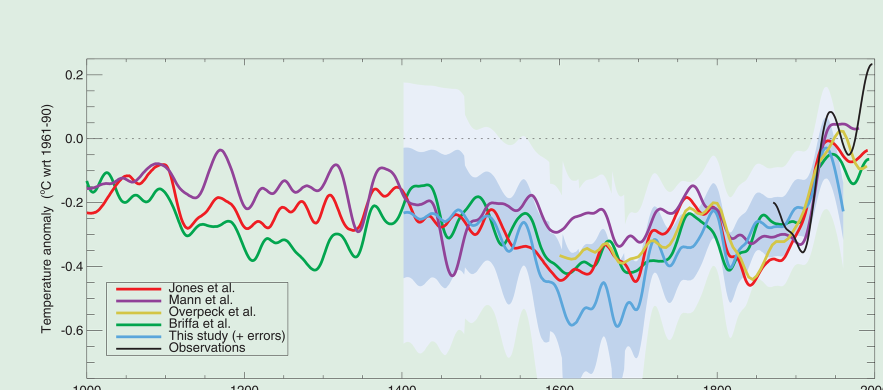
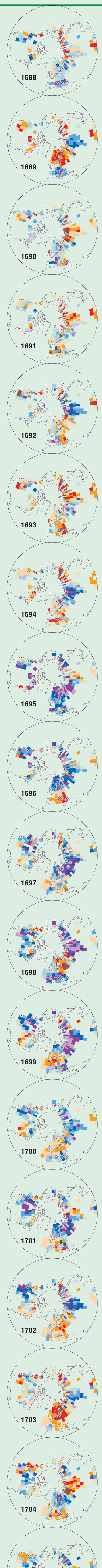
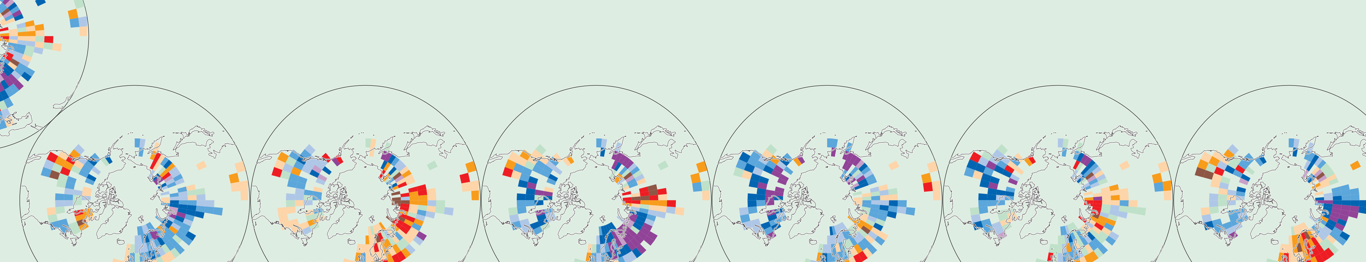
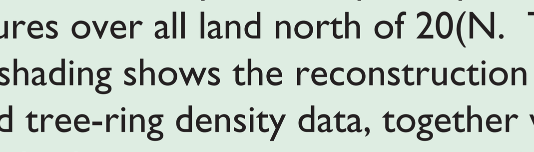


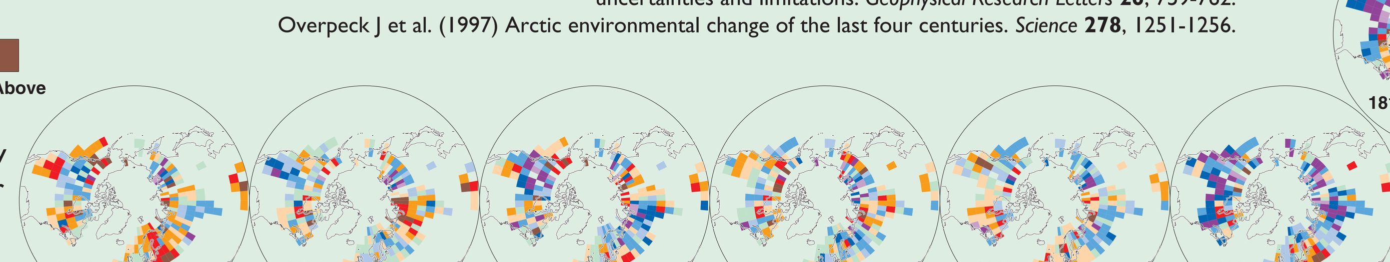
Figure 7. Comparison of various quasi-Northern Hemisphere temperature reconstructions, all recalibrated to represent April-September temperatures over all land north of 20(N. The blue curve and shading shows the reconstruction based on age-banded tree-ring density data, together with its 1 and 2 standard error uncertainty ranges. All curves have been filtered by a 50-yr filter. [From Briffa & Osborn (1999) and Briffa *et al.* (2000b)]

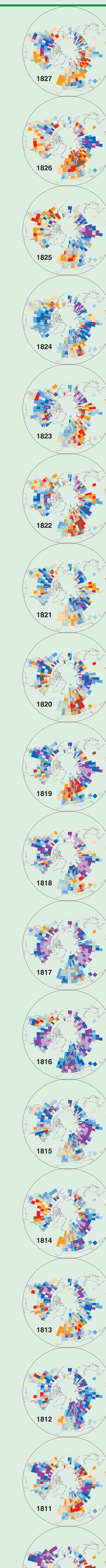






Two periods (1688-1711 and 1804-1827) from the 560 yearly maps of reconstructed summer temperatures, based on tree-ring density data. [From Briffa et al. (2000a)]





Acknowledgements

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