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CLIMATE ANALYSIS BASED ON NORWEGIAN PROXY DATA

Abstract: Within the NORPAST project various proxy data sources are put together in order to reconstruct climate during the whole Holocene. Farmers' diaries contain direct weather descriptions which may be classified in an *index system*, in which written weather information is shown converted to a relative scale, which may be related directly to temperature by regression analysis. Four independent diaries led to reconstructions of 19th century temperature series that showed almost the same increasing trend towards the climate optimum of the 1930s. During the 19th century and the first two decades of the 20th century, the temperature has increased by 1°C. This is also in agreement with a tree-ring reconstruction from Austlandet. However, around 1770 a discrepancy between the reconstructions occurs. The reconstruction based on tree-rings reveals much higher temperatures than those based on diaries.

Key words: farmers diaries, temperature reconstruction, tree-rings, Norway.

1. Introduction

Instrumental observations are sparse in Norway before the Norwegian Meteorological Institute (DNMI) was founded in 1866. It is, however, possible to use proxy data for climate reconstruction in order to amplify our knowledge of climate variations and long-term trends. Within the NORPAST project (http://www.ngu.no/prosjekter/Norpast/norsk/norpast.htm) various proxy data sources are put together in order to reconstruct climate during the whole Holocene. For the near instrumental and the early instrumental periods one promising proxy is farmers' diaries, until recently an unused source of information on Norwegian climate.

The diaries contain direct weather descriptions which may be classified in an *index system*, in which written weather information is shown converted to a relative scale, see for example Pfister (1992) and for Norwegian data Kastellet et al. (1998). Historical documents may also contain biological information. These may be related directly to temperature by regression analysis. Examples are climate reconstructions

based on the wine harvest (Le Roy Ladurie, Baulant 1980), and the ripening time of rye (Tarand, Kuiv 1994). In Norway, the most common cereals are barley and oats. Both of them have been used for temperature reconstruction purposes (Nordli 2000). A few results based on these proxies will also be presented in this paper.

2. Method of Temperature Reconstruction

In the regression analysis the start of the grain harvest was chosen as predictor and mean summer temperature as predictand. The regressions were established with overlapping periods varying from 10 to 39 years. With the restriction that mean temperatures were available for calendar months only, best possible correlations were obtained by using the mean temperature in the period May-August.

For the different analyses the correlation coefficients vary from 0.74 to 0.97, i.e. 55-93% of the variance is accounted for by the regressions. All regressions seem to fit nicely into the linear model and the residuals are normally distributed.

The standard deviations of the residuals (cross-validated) vary from 0.3 to 0.6°C. Thus, values of summer mean temperature derived from reconstructions are more noisy than those derived from instrumental observations. However, under the assumption of randomness, the standard deviation of the mean temperature of a decade reduces to only 0.1-0.2°C. Thus, the proxy-data method seems to be highly suitable for the study of long-term variations and trends in summer temperature.

3. Climate Reconstructions, Composite Series

By use of the climate reconstructions composite series of instrumental and proxy data were established. These are shown in Figure 1 as an ensemble of four series, three from the Møre and Trøndelag district and one from south-eastern Norway (Austlandet).

The series were analysed for variations on time scales of 10 and 30 years by a Gaussian low pass filter (shown as curves in Fig. 1) and the trends were studied by the Mann-Kendall test. Despite the fact that the series origin from different climate regions (Hanssen-Bauer, Nordli 1998) the local maxima and minima are located to the same decades and they also reveal similar long-term trends. A significant long-term trend terminating before the 1930s was detected. Thus, the highest mean temperature during 5, 10, 30 and 50 years periods were all located after 1929, and the coldest periods were located before 1930.

The decades of the 1800s and the 1810s, the last parts of the 1830s and the 1840s were especially cold periods. In the 1860s a cluster of bad harvests occurred, and it may be noted that some of the springs were extremely cold. An abrupt temperature increase through the 1820s is seen in all series, and even a larger shift in the series occurs in the 1920s, leading to a temperature maximum in the 1930s. Since 1930 the summer temperature has been in a steady state, about 1°C higher than in the mid and early 19th century. However, there have been decadal variations also since 1930.

There exist a tree-ring series from south-eastern Norway (Austlandet) based on trees near the tree limit. Kalela-Brundin (1999) reconstructed July–August

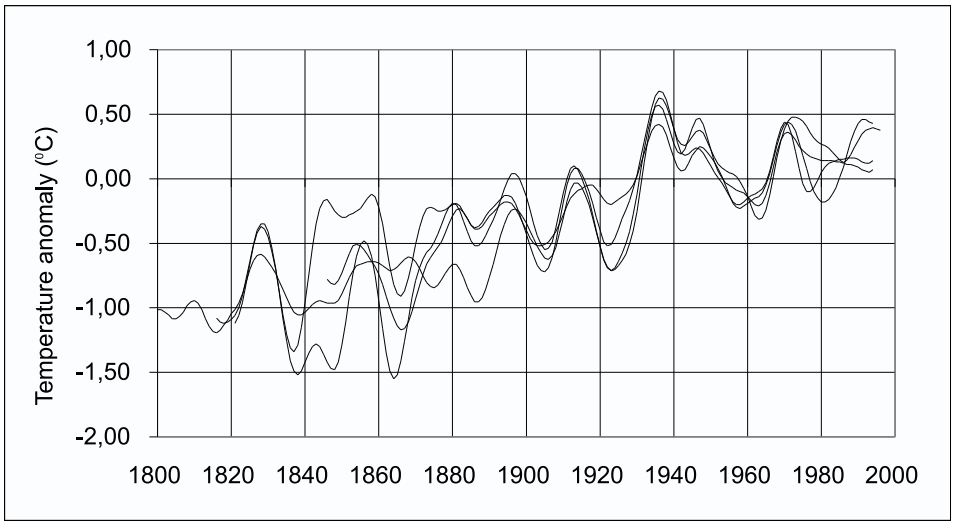

Fig. 1. An ensemble of composite series of mean summer temperature (May–August) during the 19th and 20th centuries seen through a Gaussian low pass filter with standard deviation in the distribution of 3 years, i.e. variations on a decadal scale. Reference period 1901–1990.

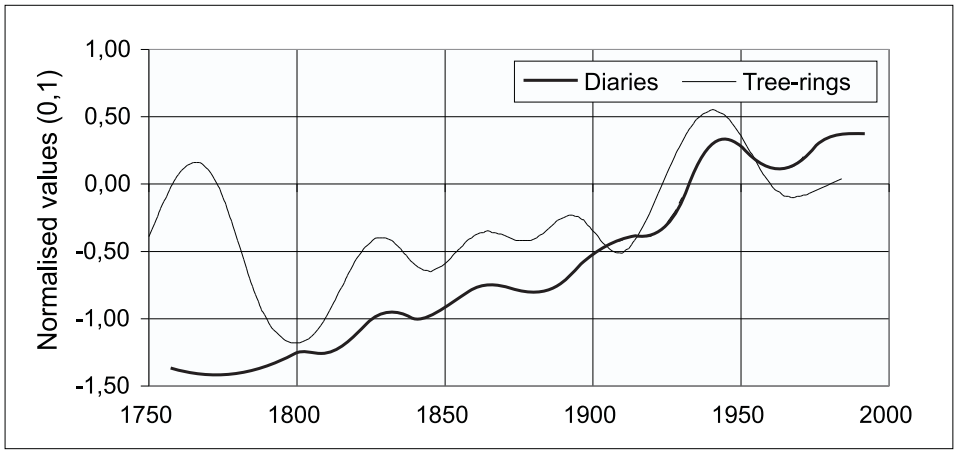

Fig. 2. Reconstructions of mean May–August temperatures based on farmers diaries and mean July–August temperature based on tree-rings. The diaries and tree-rings origin from Austlandet (south-eastern Norway). The variations are seen through a Gaussian low pass filter with standard deviation in the distribution of 9 years, i.e. on a time scale of about 30 years. Reference period 1901–1990.

temperatures that are shown together with the reconstructed May–August temperatures at Austlandet. The oldest diary at Austlandet, that from the farm Åker near Hamar, dates back to 1749. This enables comparison between the reconstructions during 250 years. During the last two centuries the long-term temperature increase seems to be similar in both reconstructions, but around 1770 the reconstructed temperatures based on tree-rings are appreciably higher than those based on the diary.

4. Conclusion

The use of farmers' diaries for temperature reconstruction purposes seems to be a promising source for climate reconstructions. Four independent diaries led to reconstructions of 19th century temperature series that showed almost the same increasing trend towards the climate optimum of the 1930s. During the 19th century and the first two decades of the 20th century, the temperature has increased by 1°C. This is also in agreement with a tree-ring reconstruction from Austlandet. However, around 1770 a discrepancy between the reconstructions occurs. The reconstruction based on tree-rings reveals much higher temperatures than those based on diaries.

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