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THE ÅLESUND SERIES. A COMPOSITE SERIES OF SUMMER TEMPERATURES (1843 - 1903)

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ABSTRACT

A farmers' diary containing barley and oat harvest data exists from the farm Frøystad on the island Leinøya in Herøy municipality in Western Norway for the period 1843 - 1875. From the near by town Ålesund instrumental observations is also available during the years 1861-1903. Linear regression analysis during the overlapping period (1861-1875) shows that the first harvest day and the mean summer temperature May - August are well correlated (r = 0.86 for barley and r = 0.89 for oat). The summer climate could be reconstructed back to 1843 by use of the regression, and together with the instrumental data a composite series were established for the period 1843 - 1903. The standard deviation of the residuals was 0.4°C which amounts to about 0.1°C on a decadal scale. A possible bias in the mean value of the series is consider to be ±0.2°C.

At Frøystad barley and oat were growing simultaneously so that it is possible to check the reconstructions from the two cereals against each other. This was done by applying Student's t-test on the reconstructions, for details see text. No time dependant difference was found between the reconstruction based on barley and that based on oat. This indicates that no new early-ripening cereals have been used during the period of the diary writing.

The composite Ålesund series was analysed for variations on time scales of 10 years by a Gaussian low pass filter. On a decade scale local maxima were found in the 1850s, around 1880 and in the 1890s, and local minima in the 1840s, 1860s and 1880s.

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THE ÅLESUND SERIES.
A COMPOSITE SERIES OF SUMMER TEMPERATURES (1843- 1903)

1 Introduction

In 1860 the Norwegian Telecommunication established 5 meteorological stations along the coast of Southern Norway, among them was a station in the city of Ålesund. Later on the station network increased as a result of the foundation of the Norwegian Meteorological Institute in 1866. Before 1860 instrumental climate data are sparse in Norway and the quality of the data may be dubious (Nordli 1994). An alternative or a supplement to instrumental data is to use proxy data, e.g. farmers' diaries. Fortunately one such diary exists in the vicinity of Ålesund on the island Leinøya (62° 20' N, 5° 4' E) in Herøy municipality, Fig. 1.

The diaries contain direct weather descriptions in addition to weather related information. This information could have been classified in an index system (Pfister 1992; Kastellet 1996) i.e. to convert written weather information to a relative scale. One serious problem connected to the index method is the lack of an absolute scale. However, an absolute scale can be established by use of some biological «constants» like the ripening time for rye (Tarand & Kuiv 1994). In the present paper barley and oat are used, the most common cereals in the western part of Norway.

2 Description of the available data from Herøy/Ålesund.

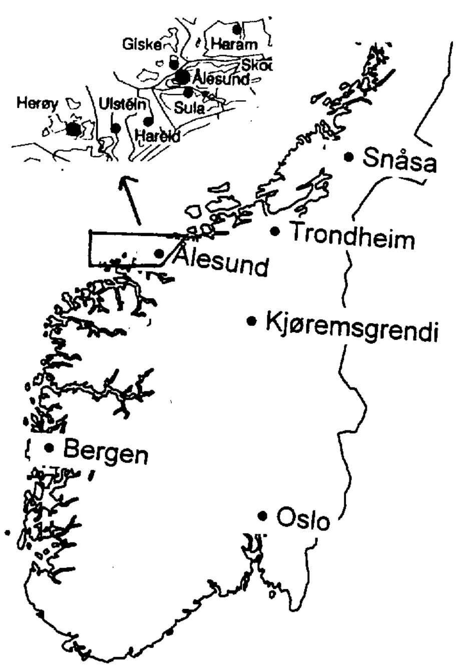

Fig. 1 Map of Southern Norway.

The diary origins from the farm Frøystad and covers the years 1843 - 1875. Herøy Local Historical Society (Herøy sogelag 1978) has printed the text and made it easily available. The printed text is said to be complete, but this author has had no opportunity to check the print against the original material. The entire diary is written by one person, Ingebrigt Kristofferson Frøystad, born in 1814 at Leine. In 1843 he settled down at the Frøystad farm where he already the same year started the diary-writing, and continued until his death in 1875.

The diary contains information of the people from the cradle to the grave, of prices and economy and last but not least, of the weather and the work on the farm. Of special interest to this author are the dates of the start and finish of the spring work, the haymaking and the harvest.

The Frøystad farm. The farm is situated on the south side of the island Leinøya. Rather atypical for this island, the farm's fields do not reach down to the sea. But the farm had a base for sea activity at the village Steinsvika where the farmers from Frøystad were allowed to have their fishing boats.

The fields of the farm are south-facing, sloping steep in the upper parts while in the lower parts the fields are almost flat and the soil is wet. In the upper parts the soil is dryer, sandy and stony.

The Ålesund series of instrumental observations. In the last part of 1860 regular meteorological observations were established at five telegraph stations along the coast. These were Sandø(y)sund, Mandal, Skudenes, Ålesund and Kristiansund, among them Ålesund is of special interest in connection to the Herøy series of proxy data. The Ålesund meteorological station was situated only 10 m a.s.l., but in August 1878 the telegraph station was moved and the new altitude was 15 m a.s.l. As far as we know, this was the only relocation from the start to the closing of the station in 1903. It was reopened in 1921, but closed again in 1932. This last data period is not used in the present work.

3 The method used for climatological reconstruction

Simple regression analysis was used to establish relationships between 6 weather related events noted in the Herøy diaries, and mean temperature in Ålesund during appropriate periods of the summer. The weather related events were: The start and finish of the spring work, the haymaking and the harvest. Best correlation was obtained between the harvest data and the mean temperature for the whole summer. Thus, the start of harvest was chosen as subject for further studies.

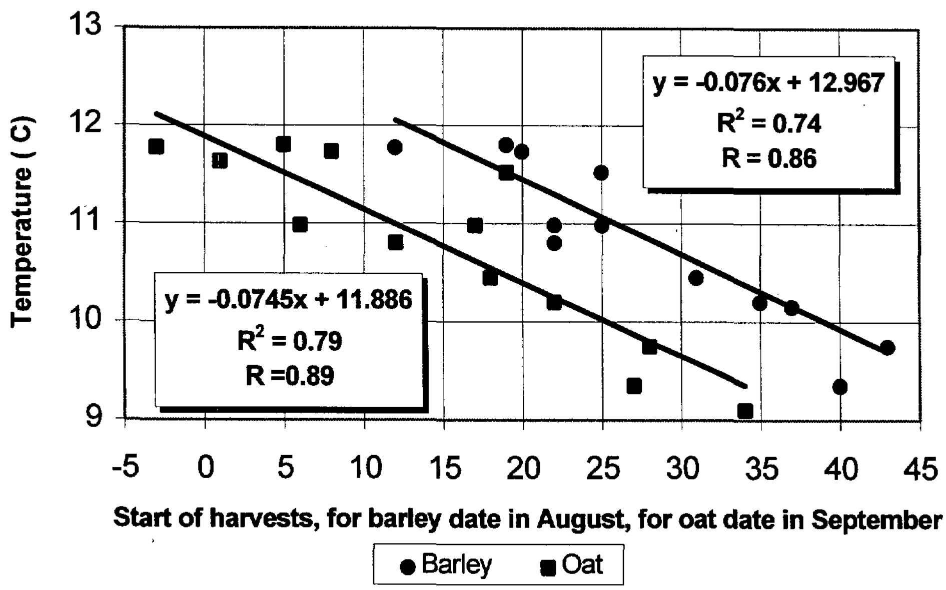

Fig. 2 Start of barley and oat harvests at the farm Frøystad at Herøy plotted against mean air temperature May - August at Ålesund in the period 1861 - 1875. There are missing harvest data so that the material is reduced to 12 and 13 years for barley and oat respectively.

To make optimal use of the proxy data, the instrumental data for calibration should be chosen so as to obtain the highest possible correlation. However, as the entire

Ålesund series is available on monthly basis only, instrumental data were restricted to contain calendar months. It was readily seen that the end of the season should be 31 August. It was, however, more doubt about the optimal start of the season, whether 1 April or 1 May should be chosen. In Fig. 2 and 3 regression analyses are performed for both alternatives, showing correlation coefficients of 0.86 for barley and 0.89 for oat during the season May - August compared to 0.81 for barley and 0.78 for oat during the season April - August. Thus, in this case the season May - August seems to be the optimal choice.

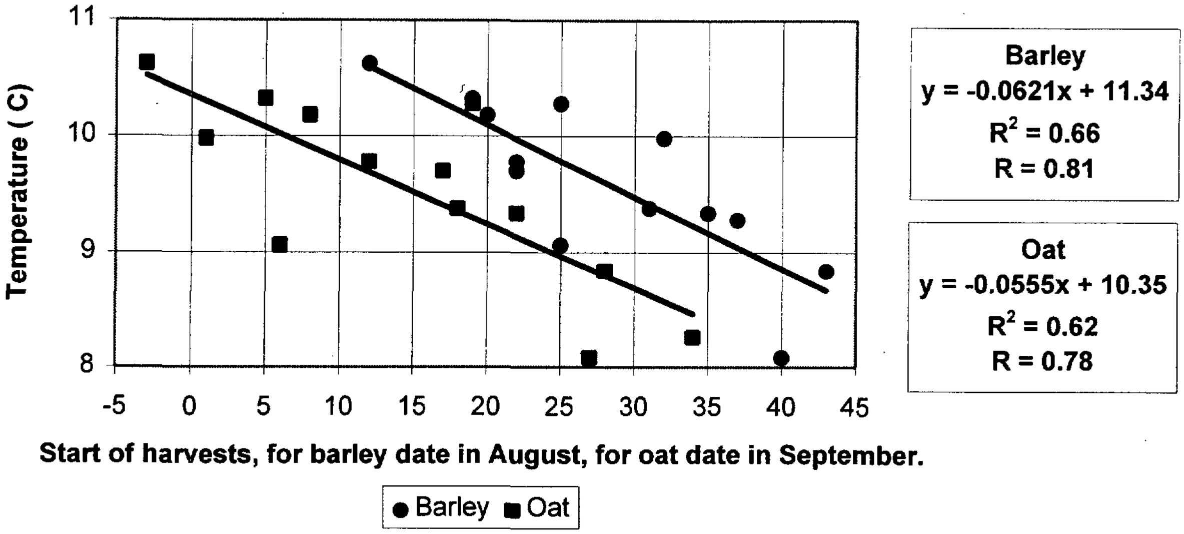

Fig. 3 Barley and oat harvests at the farm Frøystad at Herøy plotted against mean air temperature April - August at Ålesund in the period 1861 - 1875. There are missing harvest data so that the material is reduced to 12 and 13 years for barley and oat respectively.

The obtained regressions were used to reconstruct summer temperature May - August for the period 1843 - 1861 so as to form a composite series together with the Ålesund instrumental series1843 - 1903. The finally adopted, reconstructed series, T_a, was calculated by using weighted means of the barley and oat series by the following procedure:

$$(1) \qquad T_a = \frac{\rho_b^2 T_b + \rho_o^2 T_o}{\rho_b^2 + \rho_o^2}$$

where b and o denotes barley and oat respectively. T is the mean temperature May - August and ρ is the correlation coefficient between summer temperature and start of the harvests. Squared correlation coefficients are commonly used as weights for optimal generation of data sets, see e.g. Alexandersson (1997). In this case the weights are 0.74 and 0.79 for barley and oat respectively. In the period of reconstruction 1843 - 1860 the start of the oat harvest was missing in 1847, 1855 and 1860. In those years the series of the weighted summer temperature, T_a, from equation 1 was substituted by the summer temperature from the barley regression line, T_b. With this modification included, the entire composite series was complete.

Possible inhomogeneities of the proxy data should also be examined. Nordli (1997) has shown that changes from one field to another might change the ripening conditions for the grain and thus lead to inhomogeneities of the reconstructed series. In the Herøy diary the farmer does not tell much about where the fields are located. However, it should be expected that he should reserve the best fields for the very important grain production.

Another problem is connected to the cereals, the question of different types. For examples barley has changed significantly with many new early-ripening varieties (Tarand & Kuiv 1994). This is probably not the case before 1875 as research on barley in Norway started around 1900 (Ringlund pers. comm.). At Frøystad barley and oat were growing simultaneously so it is possible to check the reconstructions from the two cereals against each other. Barley and oat have different ripening times, the difference in the period 1843-75 was 18 ± 5 days. This is enough time for the barley harvest to be finished before the start of the oat harvest. Thus, the start of the barley harvest is not considered to impede the start of the oat harvest.

To check the homogeneities of the two reconstructions against each other, the following test procedure was used: In the period 1843 to 1875 there are 26 years of complete information, both barley and oat harvest data are available, Fig. 4. The data were divided into subgroups of equal size comprising the years 1843-57 and 1858-75. After having applied the regressions on the harvest data within each subgroup, the temperature difference between the subgroups were tested by Student's t-test, table 1.

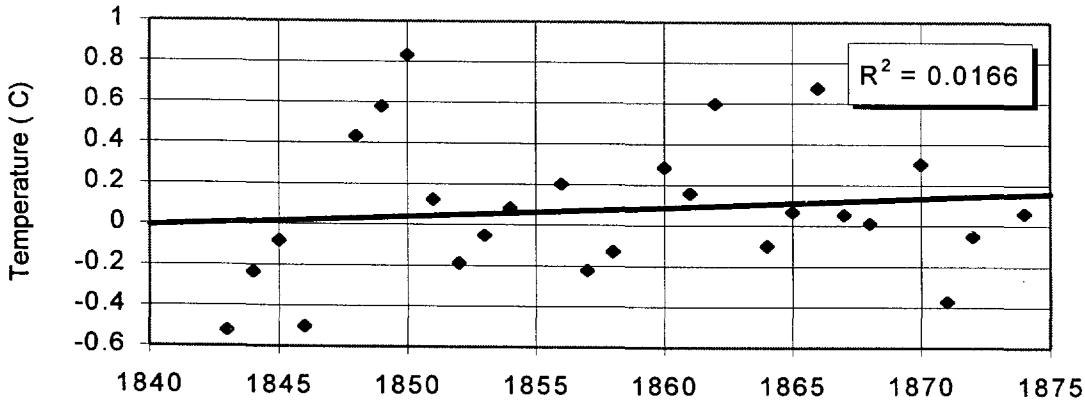

Fig. 4 Difference between reconstructed temperature series base upon harvest data of barley and oat on Herøy near Ålesund (barley minus oat).

Table 1 Data for Student's t-test, mean difference of barley and oat regression temperatures (°C) within each subgroup.

Period	1843 - 1857	1858 - 1875
Barley, mean value	11.00	10.98
Oat, mean value	10.97	10.86
Difference, barley - oat	0.03	0.12
Standard deviation of the difference	0.39	0.28

With significance level 0.05 and 13 observations in each group, larger differences than 0.28 are significant. But in our case the difference of the reconstructed temperature between the subgroups is only 0.09°C and thus not significant. The result indicates that there have not been significant changes of type of cereal or grain field during the period.

In order to test the method of proxy data, the entire composite series of Ålesund was compared to the nearest instrumental series by Nordli (1997). It was found that the normalised series was closely interrelated to the Kjøremsgrendi series, but differed from the Trondheim series. It was suggested by comparison to the nearest proxy and instrumental series that the Trondheim series was biased too warm during the period of the composite Ålesund series, and that the difference might have non-climatic reasons.

Comparing the Herøy diary to two diaries from the inland village Kjøremsgrendi (Nordli 1997) there is one important difference. The farmers at Kjøremsgrendi considered harvesting as far more important than all other work at the farm. Delay of harvesting would increase the risk of frost damages on the grain. At Herøy frost damages are rare and it seems like herring fishery had a higher priority than harvesting. Thus, it might be expected that the standard deviation of the residuals should be higher for the Herøy data set than for the Kjøremsgrendi data set. However, the standard deviation of the residuals of Herøy is small compared to Simenrud at Kjøremsgrendi, and are not much higher than at Systugu Synstbø.

Table 2 The standard deviations of the residuals (°C) of proxy series of barley from four different farms.

District/village Farm	Kjøremsgrendi Systugu Synstbø	Kjøremsgrendi Simenrud	Herøy Frøystad	Snåsa Brunstad
No. of years	10	39	12	13
Standard dev.	0.3	0.6	0.4	0.5

Averaging over a decade the standard deviation of the residuals (0.3 - 0.6°C) reduces to only 0.1 - 0.2°C. However, with overlapping periods of 10 years Nordli (1997) using the data of Simenrud, showed that a reconstruction with an overlapping period of 10 years could lead to a bias in mean temperature of ±0.3°C. With a combination of two cereals and a slightly longer overlapping period in the Herøy data a possible bias is consider to be less, probably ±0.2°C. This is of the same order as the bias in 19th century thermometers. Thus, homogeneous proxy data series may be of the same quality as instrumental observations for the study of temperature fluctuations on a decadal scale.

4 Results

The composite series of Ålesund is analysed by a low pass filter of Gaussian type. By choosing a standard deviation in the Gaussian distribution of 3 years, climatic variations on a time scale of about 10 years may be studied, Fig. 5. The Ålesund series stops in 1903 so that long term trends up to present data can not be analysed by this series alone. The series correlates well with the Kjøremsgrendi series, and long term analyses are given by Nordli (1997).

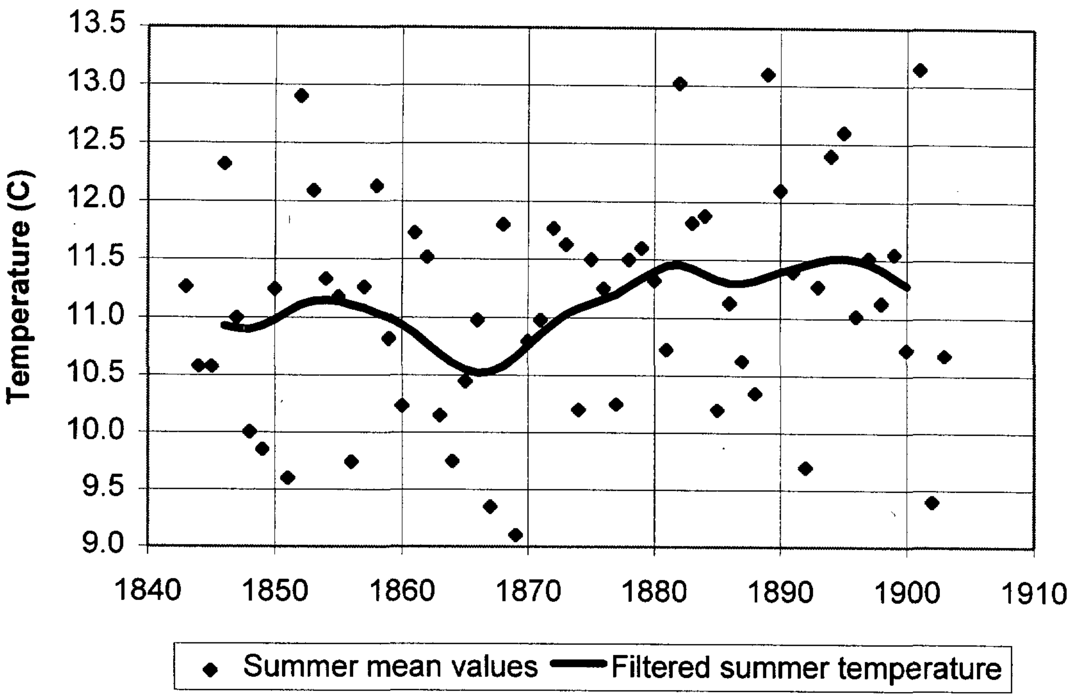

Fig. 5 The Ålesund composite series of mean air summer temperature (1843 - 1903), actual values (dots) and long term variations (curve). A Gaussian filter is used with standard deviation in the distribution of 3 years.

On a decadal scale the same local maxima and minima as at Kjøremsgrendi are found, i.e. maxima in the 1850s, around 1880 and in the 1890s, and local minima in the 1840s, 1860s and 1880s. The temperature in the 1860s at Ålesund is remarkably low, about 0.5°C lower than the local minimum in the 1840s while at Kjøremsgrendi these minima are almost equal. Another interesting feature is the summer of 1901. In the period in question the 1901 summer was the far warmest one in the Kjøremsgrendi series, while in the Ålesund series it is also the warmest one, but not much warmer than the summers of 1882 and 1889.

5 Conclusions

A regression line was established with summer temperature (May - August) as predictand and the start of the barley and oat harvests as predictors. The data origin from Western Norway, the temperature data from the meteorological station Ålesund and the harvest data from the near by island Leinøya (Frøystad farm) at the Herøy municipality. The data sets overlap in the period 1861-75 and the climate could be reconstructed back to 1843 by use of the regression. Together with the instrumental data a composite series was established for the period 1843 - 1903. The standard deviation of the residuals was 0.4°C which means that the standard deviation of the mean value of a decade is only about 0.1°C. However, there might be a bias in the mean value of the series, probably of the order ±0.2°C.

At Frøystad barley and oat were growing simultaneously so that it is possible to check the reconstructions from the two cereals against each other. This was done by applying Student's t-test on the reconstructions, for details see text. No time dependant difference was found between the reconstruction based on barley and that based on oat. This indicates that no new early-ripening cereals have been used during the period of the diary writing.

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