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Under Global Warming

Downscaling of temperature and precipitation in Norway based upon multipple regression of the principal components of the SLP field.

REPORT NO. 21/99

Inger Hanssen-Bauer

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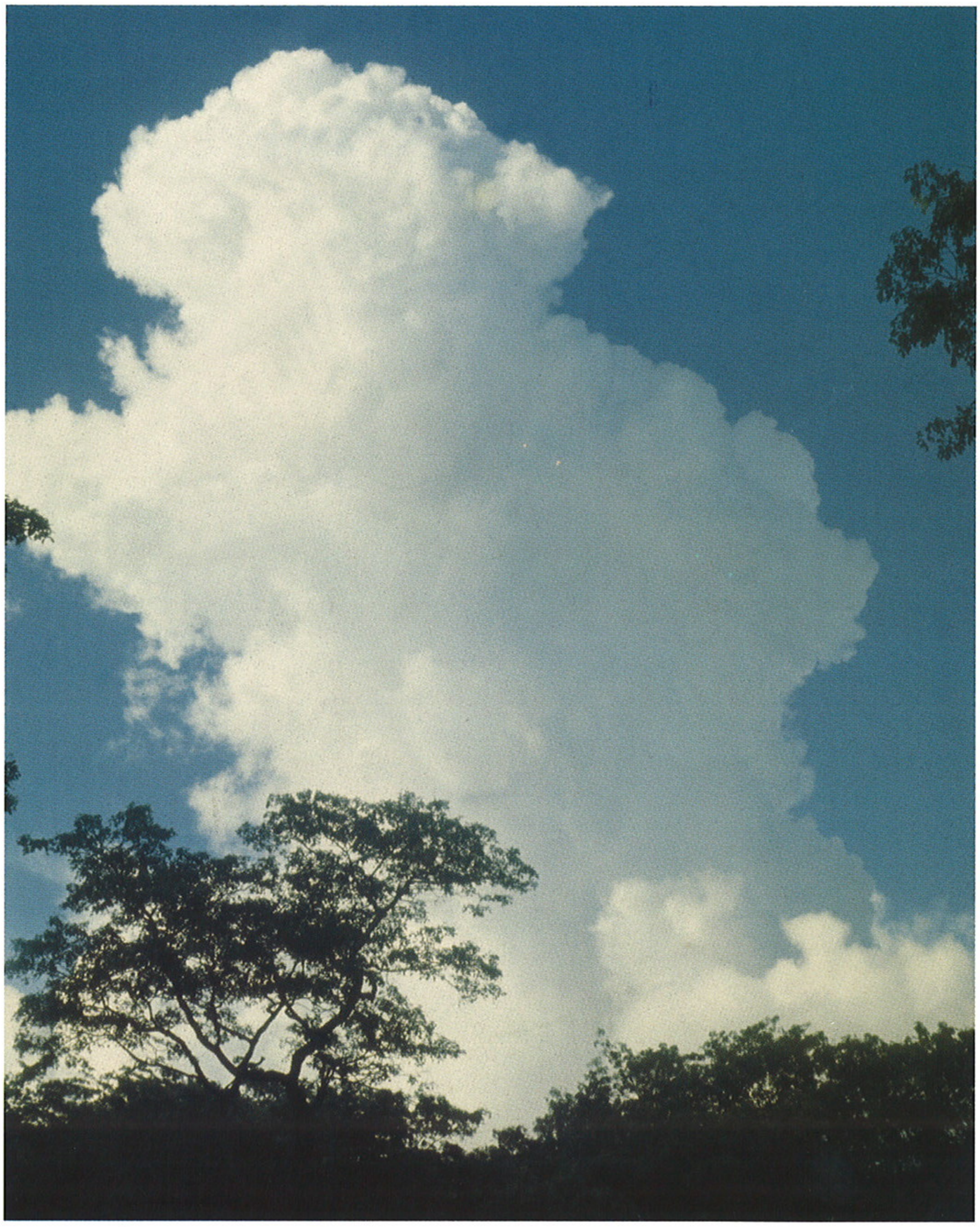

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TITLE

Downscaling of temperature and precipitation in Norway based upon multiple regression analysis of the principal components of the SLP field.

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PROJECT CONTRACTORS

Norwegian Research Council (Contract No 120656/720) and the Norwegian Meteorological Institute

Abstract

Empirical downscaling models were developed and tested on monthly series of temperature and precipitation from different parts of Norway. The main aim was to identify to which degree decadal scale variability and long-term trends can be attributed to variation in the dominating atmospheric circulation patterns. The monthly mean SLP field over the northern North Atlantic and northern Europe was used as predictor. Principal components deduced from this field were used as a basis for stepwise multiple regression analysis.

Norway was earlier divided into 6 temperature regions and 13 precipitation regions, for which representative series of monthly mean temperature/monthly precipitation have been calculated. These series were used as predictands in the present analysis.

The downscaling models were developed using the period 1925-1969 as a training period, while the periods 1900-1924 and 1970-1994 were used as test periods. Most of the models account for between 50-80% of the inter-annual variance. Exceptions are some precipitation models, especially in north-eastern regions, which account for less than 50% of the variance, and some precipitation models in western regions which account for more than 80% of the variance. The best performance of the temperature models was found for the summer and winter seasons. For precipitation, the best results were found during autumn and winter.

Testing of the models revealed that the temperature variability during 1970-1994 in most cases was better simulated than the variability during 1900-1924. For precipitation, smaller differences were usually found between the first and last decades in this century.

The models were used in order to calculate long-term trends and decadal scale variability in temperature and precipitation in different regions. The models reproduced most of the main observed features from 1940 to present. They also reproduced the precipitation trends in western Norway before 1940. The temperature increase which was observed all over the country in the period 1900-1940 was, however, not reproduced. Neither was the increased winter precipitation in south-eastern regions during the same period.

The conclusion is that while the temperature and precipitation changes which have been observed in Norway during the later decades mainly may be attributed to variations in the atmospheric circulation system, this is not true for much of the changes which happened during the period 1900-1940. Variation in the precipitation conditions in eastern parts of the country, and in temperature all over the country during this period are probably connected to changes in external forcings and/or atmosphere-ocean interactions.

SIGNATURE

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Downscaling of temperature and precipitation in Norway based upon multiple regression analysis of the principal components of the SLP field.

FOREWORD

The present report is a result from the project «Regional climate development under global warming» (Reg Clim) (Iversen et al. 1997), which is supported by the Norwegian Research Council (NRC Contract No 120656/720). The work is done within the frames of Principal Task 3 «Empirical downscaling», subtask 3.2 «Development of statistical relationships between observed large-scale atmospheric fields and local climate variables».

1. Introduction

One of the overall aims for the Norwegian Reg Clim project (Regional Climate Development Under Global Warming), is to estimate probable changes in the regional climate in Norway, given a global climate change. In Norway, the natural inter-annual climate variability is large, and a great deal of this variability is connected to variability in the dominating atmospheric circulation patterns (e.g. Førland 1986, Hurrell 1995, Tveito 1996). Changes in the global climate may have a direct influence on the local climate, but it may also influence the dominating atmospheric circulation patterns and affect the local climate in this way. It is thus important to investigate how the large scale atmospheric circulation conditions affect the local climate in different parts of the country, and to which degree circulation changes may explain the variability we have seen in local climate conditions during the last century. Climate variability during this period which cannot be explained by variability in the dominating atmospheric circulation patterns, should be explainable by changes in one of the external forcings of the air-sea-earth system (e.g. the "greenhouse-forcing" or changes in solar radiation), or by internal interactions (e.g. air-ocean interactions). In the opposite case, i.e. if all changes in the local climate may be explained by changes in atmospheric circulation, there may still be a "greenhouse-signal" in the observation, but in this case, it would be a "secondary" effect rather than the "direct" radiation effect.

In the present paper, the aim is to develop empirical models for connecting the large-scale circulation to the local climate in different parts of Norway. The models will then be applied to identify to which degree the local climate variability in Norway during the last century may be explained by variation in the dominating atmospheric circulation conditions.

2. Data

2.1 Predictands

We want to model temperature and precipitation in different parts of Norway. Hanssen-Bauer & Nordli (1998) concluded that the temperature time-variation in Norway since 1876 is described fairly well by standardised temperature series from 6 regions (Figure 1a). Hanssen-Bauer & Førland (1998a) concluded that standardised precipitation series from 13 regions (Figure 1b) are needed in order to describe the time-variation of precipitation in different parts of Norway during the present century sufficiently well. The regional series are, as far as possible, based upon homogenised series of precipitation (Hanssen-Bauer & Førland 1994) and temperature (Nordli 1997). We thus feel confident that the regional series are of high quality. The only exception is that there may be some uncertainty about the data from the earlier decades (before ~1920) in the two northernmost regions, as there were quite few stations in this area during the earlier decades.

In the present paper, the regional standardised monthly series of temperature and precipitation are used as predictands. Regional temperatures are given as anomalies from the 1961-1990 monthly average ("normal value"), measured in standard deviations for the actual month. It is thus possible to get back to any local temperature series by multiplying the actual regional series by the 1961-1990 standard deviation for the station, and then add the 1961-1990 average for the station. Both these values are given on monthly basis, for a number of Norwegian stations, by Hanssen-Bauer and Nordli (1998).

Regional precipitation is given in percentage of the 1961-1990 monthly precipitation normal. Thus, precipitation in millimetres for a given station is found by multiplying the regional value by the 1961-1990 average of monthly precipitation for the actual station. These monthly precipitation normals are published for a large number of Norwegian stations (Førland 1993).

Data from the period 1900-1994 are used in the present study, as both precipitation and temperature series for all regions are then available, as well as the gridded SLP data which are used as predictors.

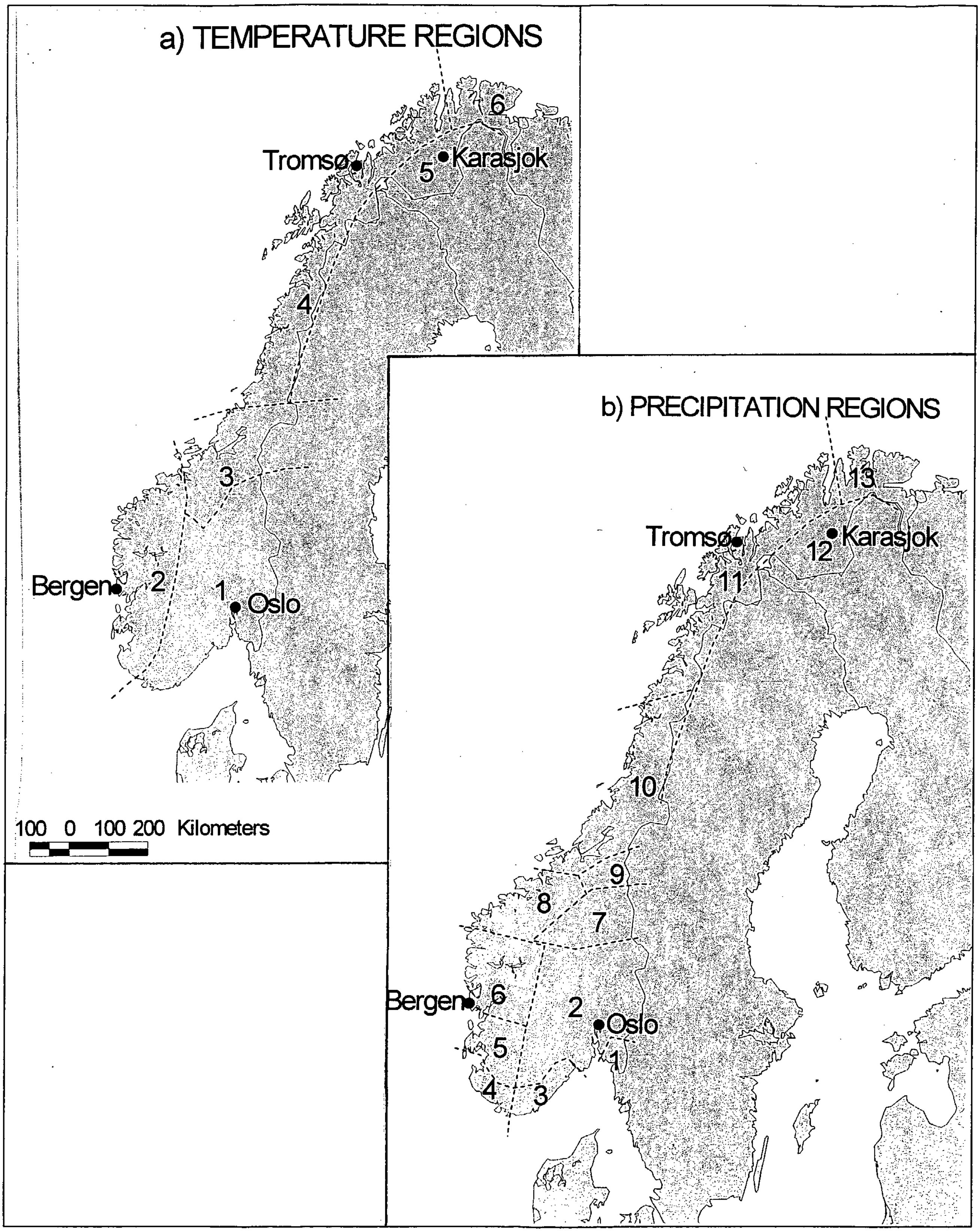


Figure 1. Maps showing a) temperature -, and b) precipitation regions for which standardised time-series of temperature or precipitation, respectively, were used as predictands.

2.2 Predictors

The predictors are, for the period 1900-1949, based upon the monthly averaged gridded SLP-fields (Sea Level Pressure) from the UK Met Office, in the area 50 - 90°N, 20°W - 40°E (Figure 2). Jones (1987) warned about systematic errors in this data-set in Arctic areas, especially over the polar basin, parts of Siberia and northern Canada and Greenland. This is an argument for not including areas west of 20°W. The errors could still affect the two northernmost grid-points in the data-set used for the present analysis. In order to evaluate the possible influence of these errors, some analyses were run excluding the two northernmost grid-points. No major differences were found, and it was thus concluded that the effect of the errors mentioned by Jones (1987) on the present models is minor. During the period 1950-1994, monthly SLP values from the same grid-points (Figure 2) were deduced from the NCEP data-set. Comparisons of monthly SLP values from selected grid-points during the period 1949-1984 showed no systematic differences between of the UKMO and NCEP data-sets (Benestad 1998).

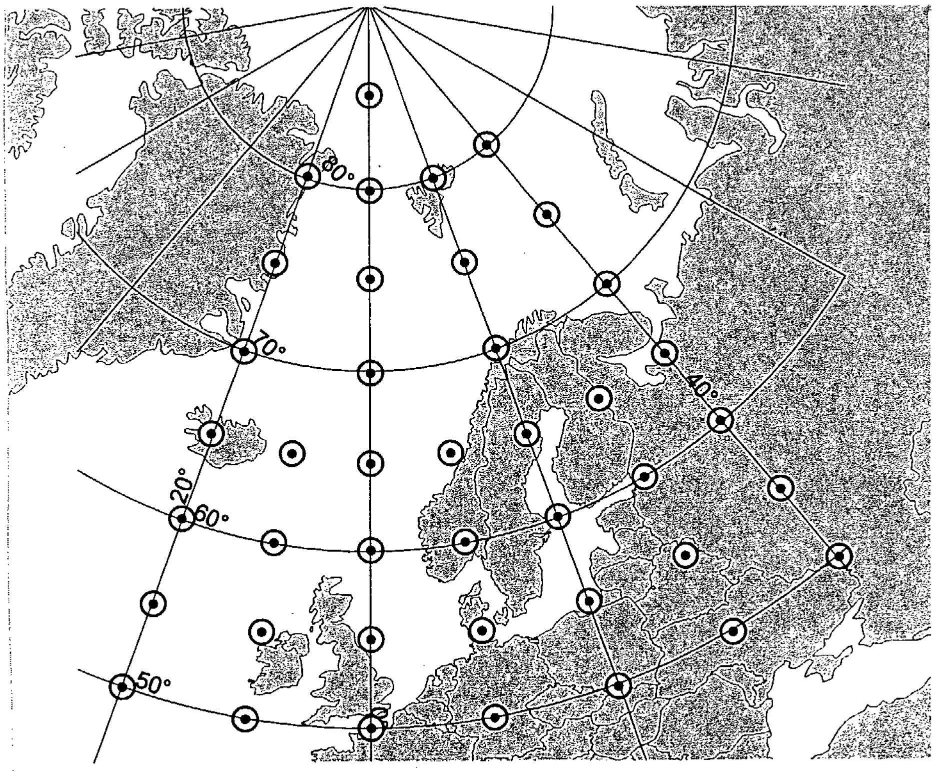


Figure 2. Map showing the SLP grid-points which were included in the predictor data-set.

3. Methods and models

3.1 Principal component analysis

The dimensionality of the gridded SLP data-set was reduced using principal component analysis (e.g. Preisendorfer 1988). The analysis was applied in S-mode, according to the terminology used by Huth (1996), which implies that the eigenvectors (loadings) describe spatial patterns, while the principal components (amplitude functions) describe the time variation. The analysis was performed on the entire data-set, without differing between the 12 calendar months. The 16 leading principal components, including more than 99% of the variance in the SLP field (table 3.1), were used as predictors in the regression model describer in the next section. The principal component analysis was applied using the SAS software procedure PRINCOMP (SAS Institute Inc. 1988).

Table 3.1. Eigenvalues of the covariance matrix based upon the monthly mean SLP-field during the period 1900-1994. (Total Variance = 1509.9400024)

Principal component	Eigenvalue	Difference	Proportion	Cumulative
1	644.88	327.37	0.427	0.427
2	317.52	26.63	0.210	0.637
3	290.89	217.45	0.193	0.830
4	73.44	9.81	0.049	0.879
5	63.64	13.66	0.042	0.921
6	49.98	31.18	0.033	0.954
7	18.80	7.54	0.012	0.966
8	11.26	3.03	0.007	0.974
9	8.23	2.20	0.005	0.979
10	6.03	0.69	0.004	0.983
11	5.34	2.27	0.004	0.987
12	3.07	0.63	0.002	0.989
13	2.44	0.59	0.002	0.990
14	1.85	0.13	0.001	0.992
15	1.72	0.40	0.001	0.993
16	1.33		0.001	0.994

3.2 Multiple linear regression analysis

Models expressing regional temperature and precipitation as functions of the 16 principal components deduced from the gridded SLP data-set, were developed using multiple linear regression analysis. Models were developed for each calendar month (12), for temperature in 6 regions and precipitation in 13 regions. The proportion of the variance in the regional temperature or precipitation accounted for by a certain principal component varies from region to region, and from month to month (Figures 3 to 5). In south-eastern Norway, the first principal component is the most important for the winter temperatures, while the third and fourth components are more important for the summer temperatures (Figure 3a). For precipitation in south-eastern Norway, the second component is the most important (Figure 3b,c,d). In south-western regions, on the other hand, it is clearly the first component (representing a "NAO"-like pattern) which accounts for most of the precipitation variability (Figure 4b,c,d). In northern Norway, the third principal component accounts for a considerable part of the temperature variability during autumn and winter, while the second and fourth components are more important during summer (Figure 5a and c). The second component is most important for the precipitation in the north-west (Figure 5b), while the connection between the principal components and the precipitation in the northern inland region generally seems to be poor (Figure 5d).

Stepwise regression was applied for deciding which components to include in the final models for different regions, climate variables and months. A significance level of 0.15 was used as the condition for entry of new variables into the models. The models were developed using data from the period 1925-1969 (training period), while the rest of the data (1900-1924 and 1970-1994) were saved for testing the models (validation periods). The stepwise regression analysis was applied using the SAS software procedure REG (SAS Institute Inc. 1988). The 228 resulting models are all given in table A.1 in Appendix.

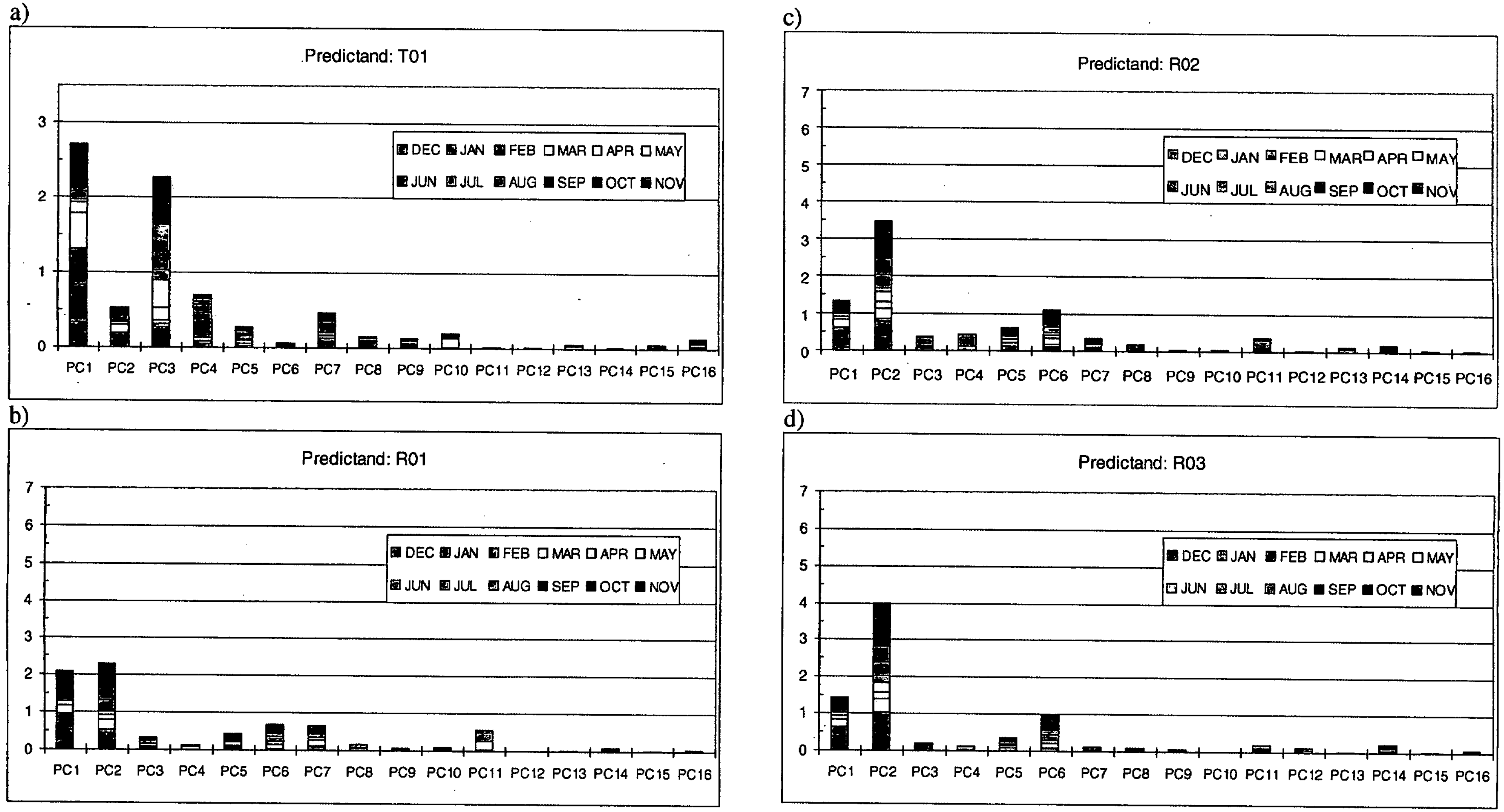


Figure 3. Part of the variance in different predictands accounted for by the 16 leading principal components from the SLP field. The bars show the values for the individual calendar months stacked on top of each other. Months in the same season are represented by the same colour. Predictands are temperature and precipitation from south-eastern Norway:
a) Temperature, region T-01, b) Precipitation, region R-01, c) Precipitation, region R-02, d) Precipitation, region R-03

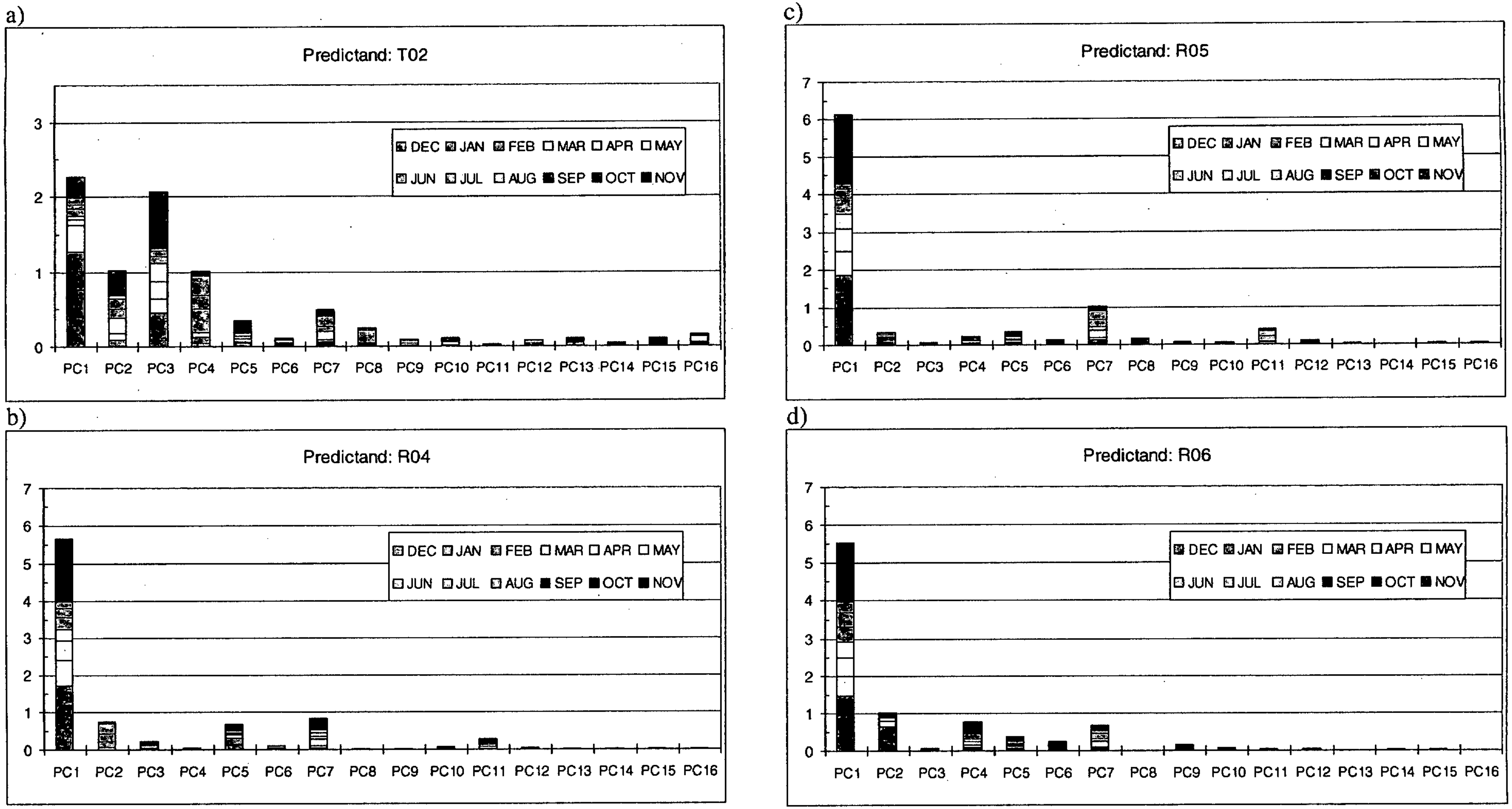


Figure 4. Part of the variance in different predictands accounted for by the 16 leading principal components from the SLP field. The bars show the values for the individual calendar months stacked on top of each other. Months in the same season are represented by the same colour. Predictands are temperature and precipitation from south-western Norway:
a) Temperature, region T-02, b) Precipitation, region R-04, c) Precipitation, region R-05, d) Precipitation, region R-06

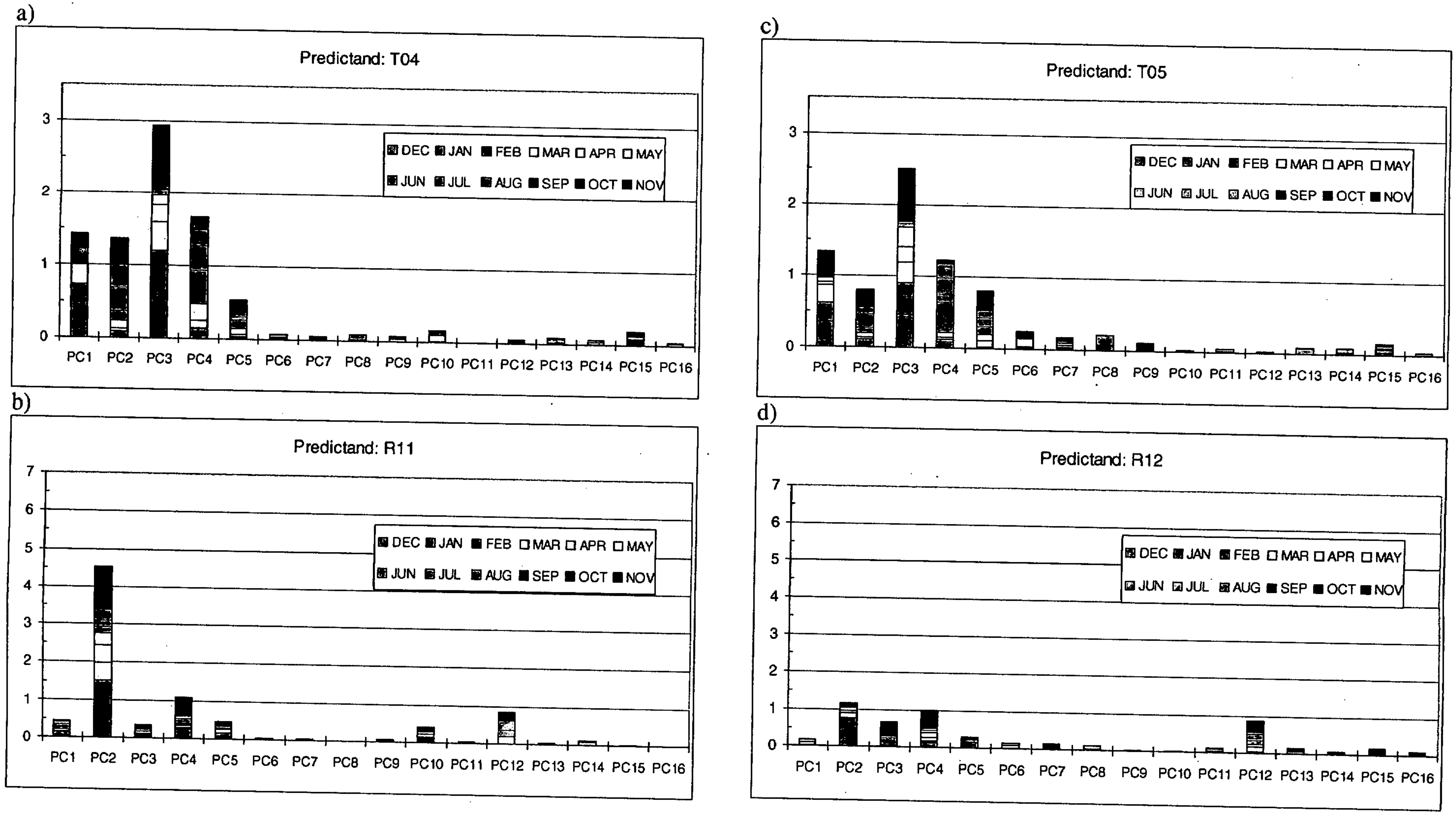


Figure 5. Part of the variance in different predictands accounted for by the 16 leading principal components from the SLP field. The bars show the values for the individual calendar months stacked on top of each other. Months in the same season are represented by the same colour. Predictands are temperature and precipitation from north-western Norway (a,b) and northern inland areas (c,d):
a) Temperature, region T-04, b) Precipitation, region R-11, c) Temperature, region T-05, d) Precipitation, region R-12

3.3 Testing the regression models

For all predictands, the correlation coefficients between observed and modelled values based upon the test period were compared to those based upon the two validation periods. Figures 6 (temperature) and 7 (precipitation) show the correlation coefficients between observed and modelled predictands for selected months. Most of the correlation coefficients based upon the training period (black bars) are between 0.7 and 0.9, implying that 50-80% of the inter-annual variance in the training period is accounted for by the models. Exceptions are several precipitation models in the central region R-07, the northern inland region R-12 and the north-eastern region R-13, which account for less than 50% of the variance. Region R-07 is as a "transition zone" between south-eastern and north-western regions rather than a uniform region (Hanssen-Bauer et al. 1997). It is thus reasonable that precipitation models based upon circulation indices do not work very well in this region. Concerning regions R-12 and R-13, the SLP grid-net used in the present analysis (Figure 2) is probably not optimal for calculating precipitation in this area. Several precipitation models for regions along the west-coast, on the other hand, account for more than 80% of the variance during the training period.

In winter, spring and summer, the correlation coefficients for the temperature models (Figure 6) are in most cases rather similar for the training period and at least one of the evaluation periods. In the autumn, both evaluation periods usually show considerably lower correlation than the training period. Thus the temperature models for the autumn months seem to have an artificial skill, while the other temperature models work satisfactory in at least one of the validation periods (in most cases the last one).

For precipitation, there is also in most cases a good agreement between the correlation coefficients based upon the test period and at least one of the validation periods (Figure 7). Exceptions are found in the regions R-07, R-12, and R-13, and in summer also in other regions. The precipitation models for the summer months thus show an artificial skill in the training period in many regions.

We conclude that the models seem to account for a considerable part of the temperature and precipitation variability in southern and north-western parts of Norway, while they (especially the precipitation models) are less satisfactory in a "transition zone" in mid-Norway, and in the north-eastern part of the country. The best performance of the temperature models was found for the

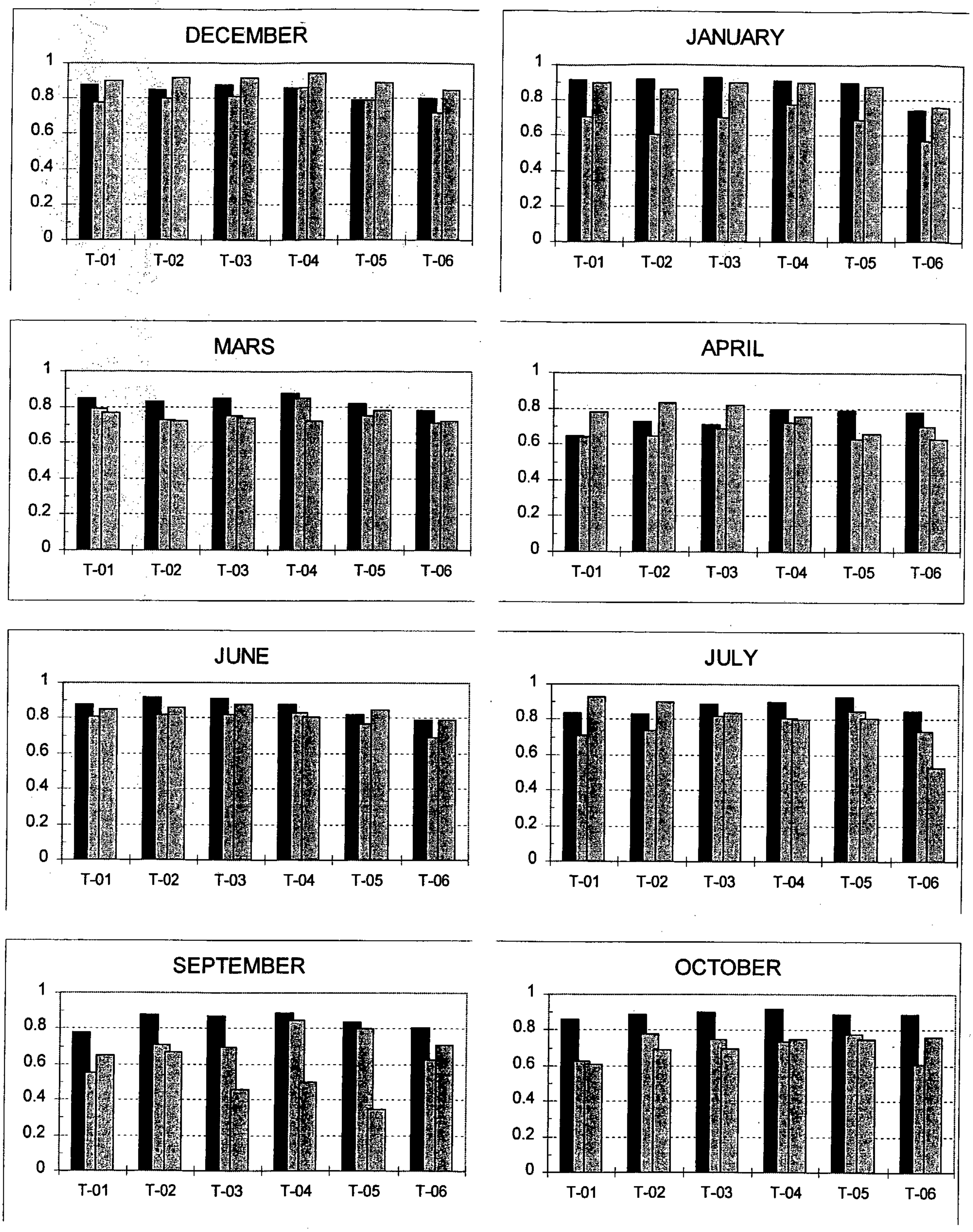


Figure 6. Correlation coefficients between observed and modelled monthly mean temperature in 2 winter months, 2 spring months, 2 summer months and 2 autumn months for the 6 temperature regions (Figure 1a). Black bars show coefficients for the training period, while grey bars show coefficients for the evaluation periods.

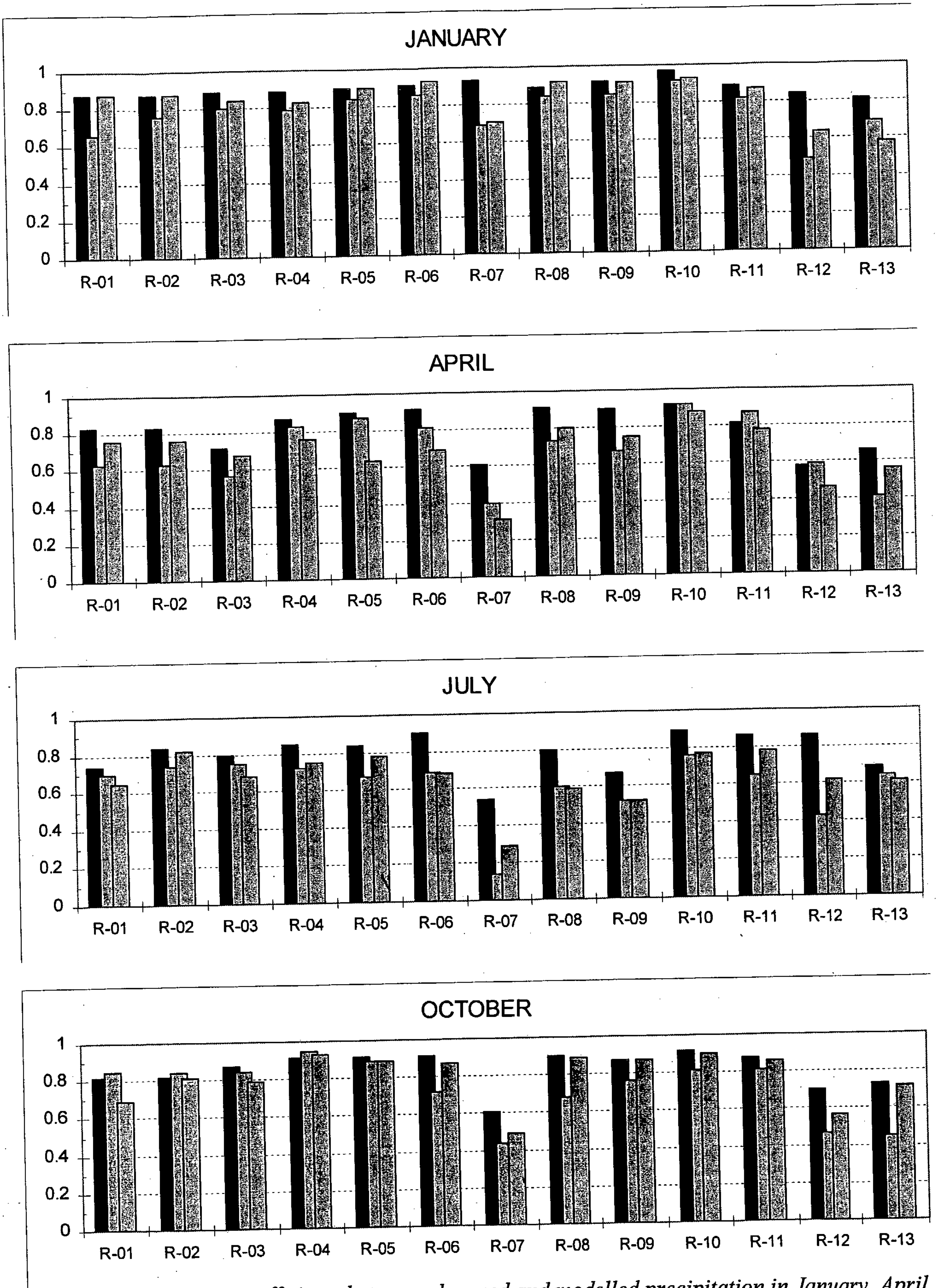


Figure 7. Correlation coefficients between observed and modelled precipitation in January, April, July and October for the 13 precipitation regions (Figure 1b). Black bars show coefficients for the training period, while grey bars show coefficients for the evaluation periods.

summer and winter seasons, while the autumn temperature models show an artificial skill in the training period. For precipitation, the best results were found during autumn and winter, while several summer-models show an artificial skill in the training period.

For several models, large differences are found between the correlation coefficients for the two validation periods. This may indicate a non-stationary character of the connections between atmospheric circulation and regional climate conditions.

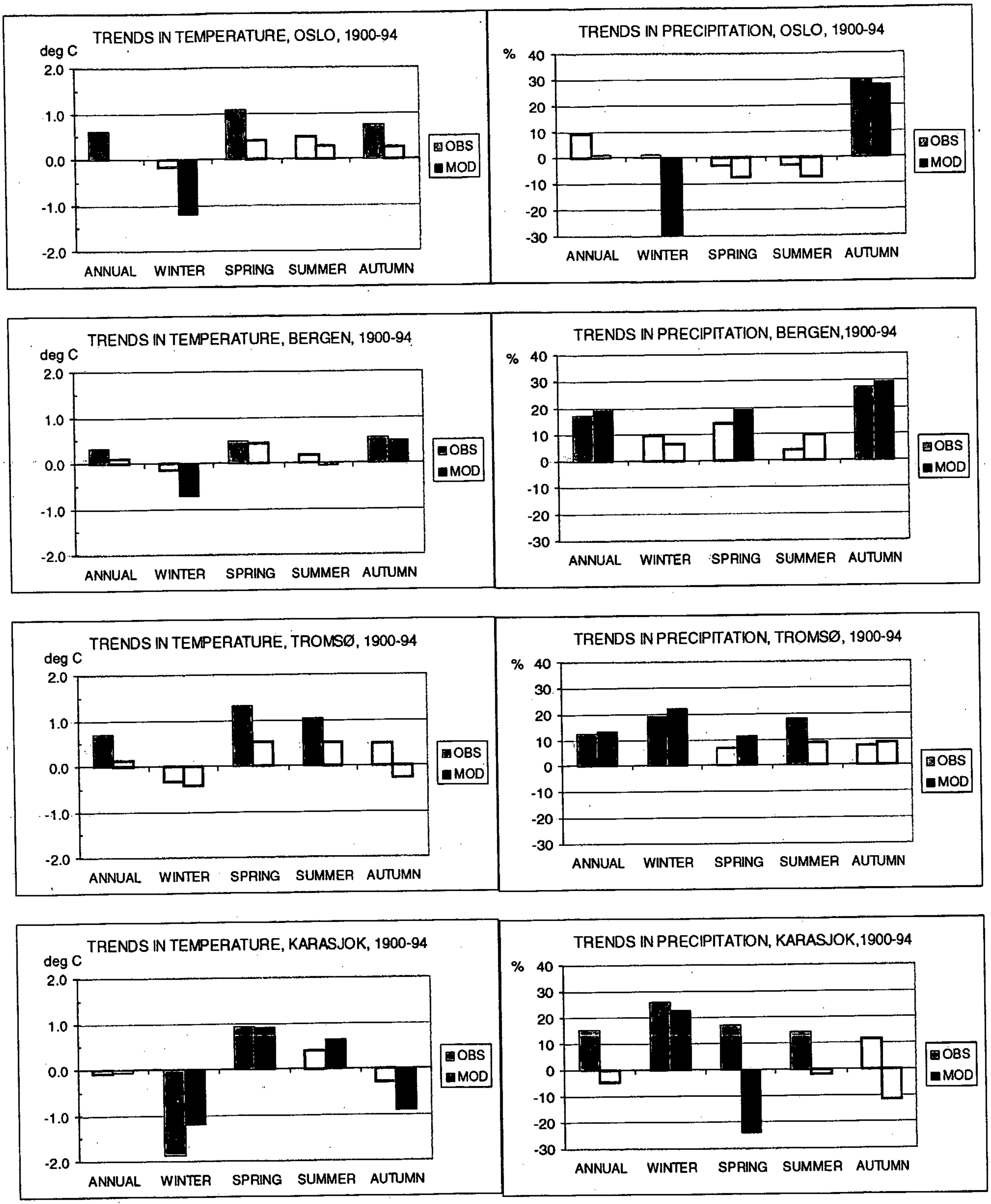


Figure 8. Linear trends in observed (red) and modelled (blue) temperature anomalies (left) and precipitation (right) during the period 1900-1994. Trends are given on annual and seasonal basis. Statistically significant trends (5% level, Mann-Kendall non-parametric test) are given as solid bars, while open bars symbolise trends that are not significant at this level. Trends are given as total accumulated change over the period, temperature in °C and precipitation in %.

4. Results

Generally, the different months within the same season show the same main features. The results are therefore presented on a seasonal basis rather than month by month, as this gives a better overview of these main features. In order to get from the normalised monthly to seasonal series it is necessary to know typical values for monthly temperature standard deviations and monthly precipitation sums. As these values vary substantially within each region, "key positions" within the regions were chosen, for which the results are presented here. It should be noted that similar time series may be calculated for any location in Norway, if the 1961-1990 monthly precipitation sums and temperature standard deviations are known. In the present report, results will be shown for Oslo (south-eastern Norway, T-01 and R-02), Bergen (south-western Norway, T-02 and R-05), Tromsø (north-western Norway, T-04 and R-11) and Karasjok (northern inland, T-05 and R-12). The "key positions" are shown in Figure 1.

Note that the "observed" series presented in the following comparisons with modelled series are not really the observed ones at the 4 key positions, but rather the regional series adapted to the respective localities. Thus local influences like the urban heat island effect are avoided in these series, and are thus not responsible for the trends which are found. Results are presented on annual and seasonal basis, and focus is put on trends and decadal scale variability.

4.1 Trends

Figure 8 shows comparisons of linear trends in observed vs. modelled mean temperature (left) and precipitation (right) during the period 1900-1994. Trends which are statistically significant at least at the 5%level according to the Mann-Kendall non-parametric test (Sneyers 1995), are given as solid bars, while those which are not statistically significant are given as open bars.

At all locations except Karasjok there was observed a statistically significant annual temperature increase of around 0.5 °C, which was not modelled. In southern Norway, this is partly because the observed positive trends in spring and autumn temperature were larger than modelled, but also

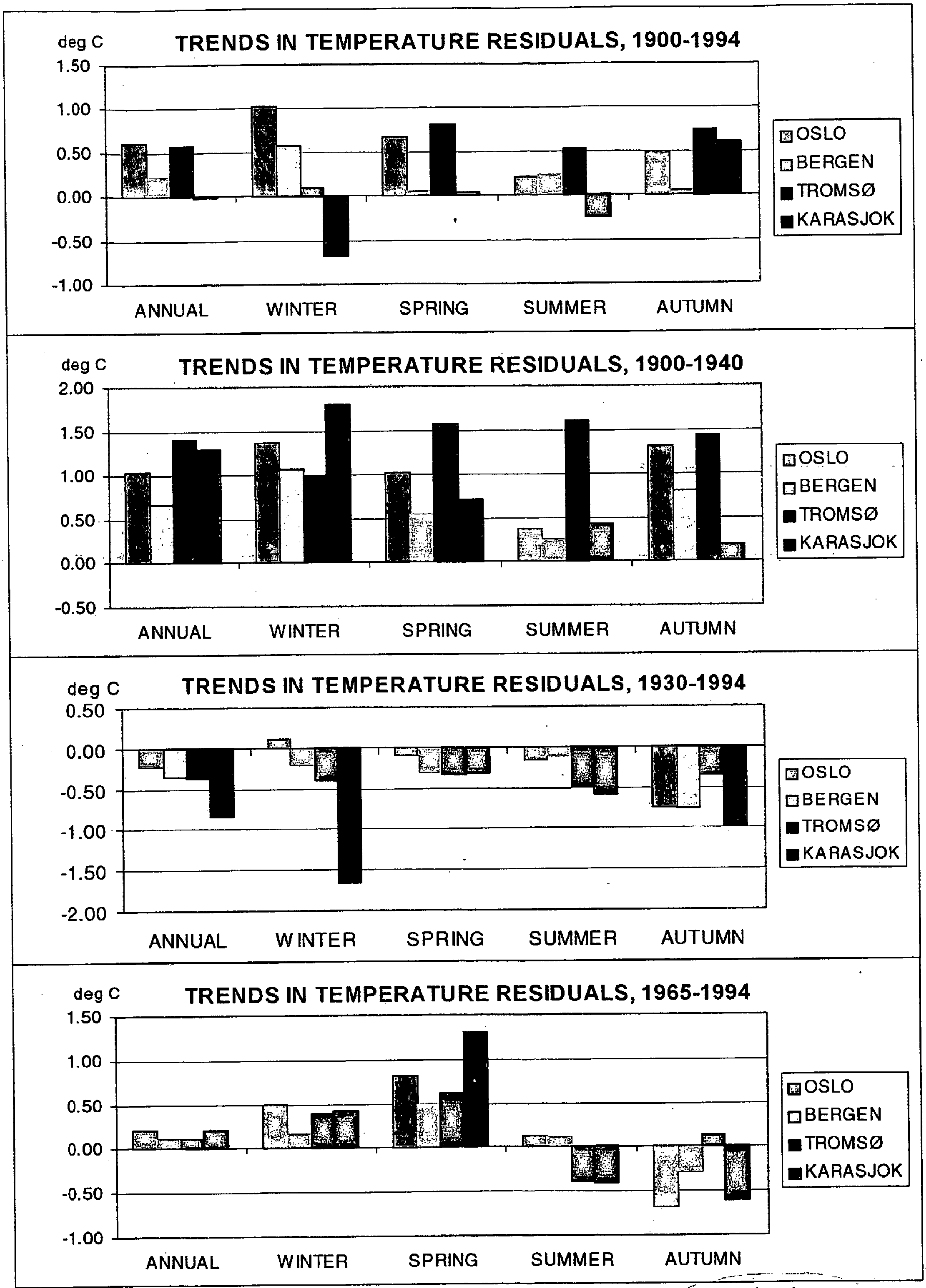


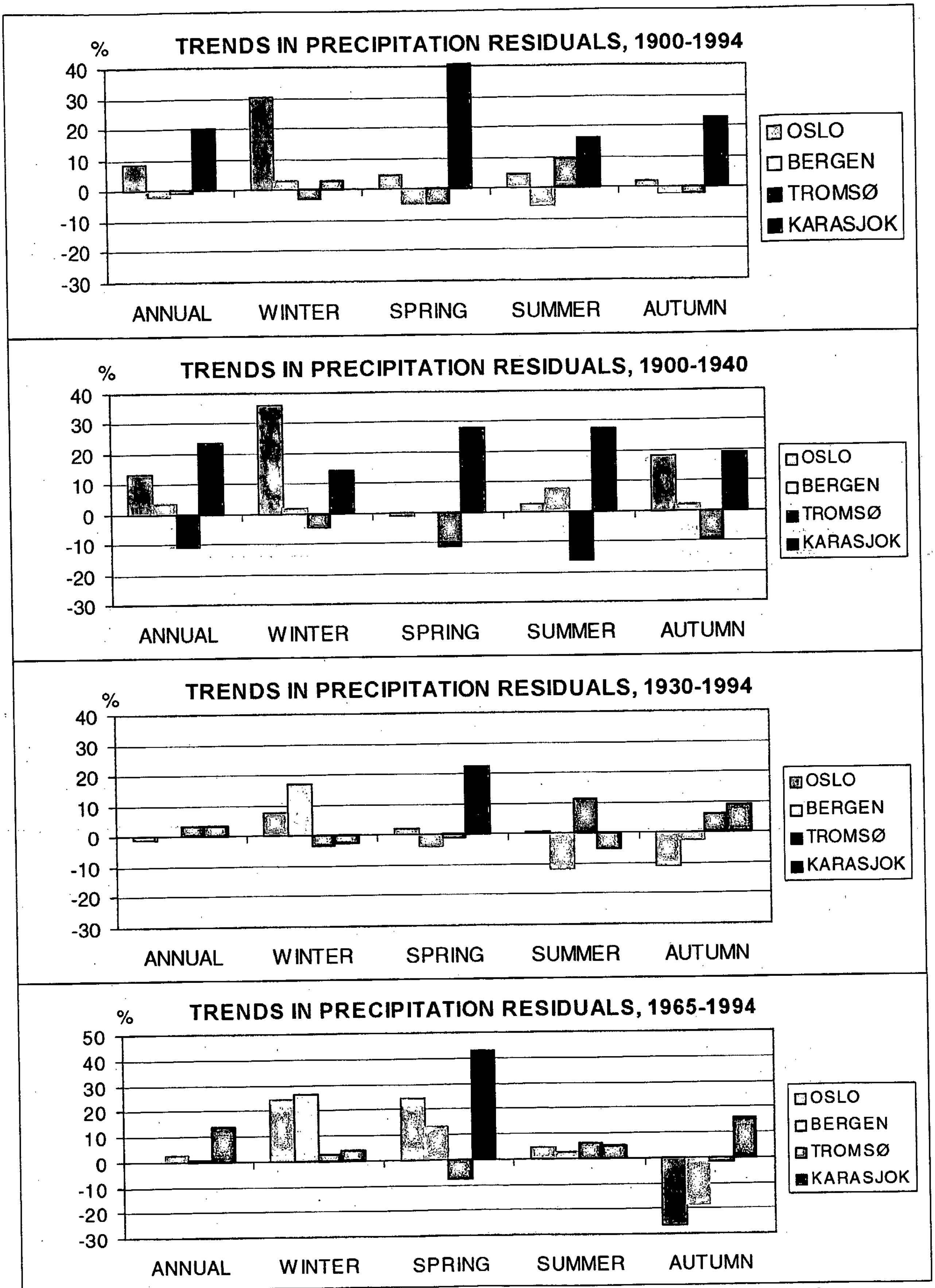
Figure 9. Linear trends in annual and seasonal temperature residuals at the 4 key locations during 4 different time periods. Statistically significant trends (5% level, Mann-Kendall test) are given as solid bars. Trends which are not statistically significant are given as shaded bars. The trends are given as total temperature change (°C) over the actual period.

because the models actually give a negative trend in winter temperatures, while no such trend was observed. In Tromsø, the observed positive trends in spring and summer temperatures were not satisfactory modelled.

The general impression is that the observed precipitation trends are modelled fairly well. Except for winter precipitation in Oslo, which according to the regression model should have decreased by 30 %, but which actually hasn't changed, major discrepancies are only found in Karasjok. Here, the model skills are rather low (cf Figs 6d and 7), and the discrepancies between observed and modelled trends in spring, summer and autumn are hardly surprising.

In order to investigate closer the mismatch between observed and modelled trends, we have studied trends in the residuals during different periods. Figures 9 and 10 show trends in residuals between observed and modelled seasonal mean temperature and precipitation, respectively, for the periods 1900-1994, 1900-1940, 1930-1994 and 1965-1994. Statistically significant trends (5% level) are given as solid bars. In the opposite case, the bars are shaded.

For the period 1900-1994, the temperature residual series show positive trends in all regions and seasons, except the northern inland region represented by Karasjok (Figure 9, upper panels). In southern Norway, the trends in the residuals have significant positive values in winter and partly in the spring. In Tromsø, the trends have significant positive values spring, summer and autumn. A reasonable question is if these positive trends might be caused by enhanced greenhouse effect. The answer to this question is probably no, for studying the trends in the periods 1900-1940 and 1930-1994 (Figure 9, panels 2 and 3 from the top), makes it clear that the positive trends in the residuals mainly are found in the first of these periods. Consequently, it is mainly the temperature increase before 1940 that cannot be explained by changes in the atmospheric circulation patterns. From 1930 to 1994 trends in the residuals are mostly negative. When looking for consequences of the increased concentrations of greenhouse gases, one should, however, probably look only at the last 3 decades of these series (Figure 9, lower panels). In this period most trends are small and none of the trends in annual temperature residuals are statistically significant at the 5% level. Still, there are statistically significant positive trends in the residual of spring temperature in south-eastern and northern inland parts of the country. The trends in the spring temperature residuals are not far from being significant in the other regions as well. Thus, some of the spring temperature increase we have experienced during the last 3 decades is not explainable by changes


TRENDS IN PRECIPITATION RESIDUALS, 1900-1994

TRENDS IN PRECIPITATION RESIDUALS, 1900-1940

TRENDS IN PRECIPITATION RESIDUALS, 1930-1994

TRENDS IN PRECIPITATION RESIDUALS, 1965-1994

Figure 10. Linear trends in annual and seasonal precipitation residuals at the 4 key locations during 4 different time periods. Statistically significant trends (5% level, Mann-Kendall test) are given as solid bars. Trends which are not statistically significant are given as shaded bars. The trends are given as total precipitation change (%) over the actual period.

in the atmospheric circulation.

Most of the trends in precipitation residuals for the period 1900-1994 (Figure 10, upper panel) are small and not statistically significant. Exceptions are significant positive trends in Karasjok, which simply may be the results of the limited skills of the precipitation models in this area. The spring precipitation residuals in Karasjok shows positive trends in all sub-periods (Figure 10, all panels), while the trends in the residuals in the other seasons mainly are caused by malfunction of the models in the period before 1940. The discrepancy between observed and modelled trends in winter precipitation in Oslo (Figure 8, right, upper panel) results in a statistically significant trend in the winter precipitation residuals (Figure 10, upper panels). This is also mainly caused by malfunction of the model before 1940. In Bergen, there is a significant positive trend in the residuals of winter precipitation during the last 3 decades (Figure 10, lower panel).

4.2 Decadal scale variability

Figures 11-15 show low-pass filtered series of observed and modelled temperature anomalies (left) and precipitation (right) at the 4 key locations. Two low-pass filters are applied (e.g. Hanssen-Bauer and Nordli 1998).

The impressions from figures 9 and 10 are confirmed by the low-pass filtered time-series, which in Fig.11 are shown on an annual basis. For temperature (left), the models are unable to reproduce the warming prior to 1940, while the main features after 1940 to a large extent are reproduced by the model, especially in southern Norway. For precipitation (right), the models give very good results concerning the decadal scale variability in Bergen (south-west) and Tromsø (north-west), while the models in Oslo and Karasjok are unable to reproduce the observed trends and decadal scale variability before 1940.

Comparisons of the seasonal time-series show that the lacking ability to reproduce the observed positive temperature trends before 1940 to a large degree is caused by malfunction of all the models in the autumn (Figure 15). In Oslo, Bergen and Karasjok, it is also caused by malfunction in the winter (Figure 12). In Tromsø, on the other hand, the winter models are rather satisfactory,

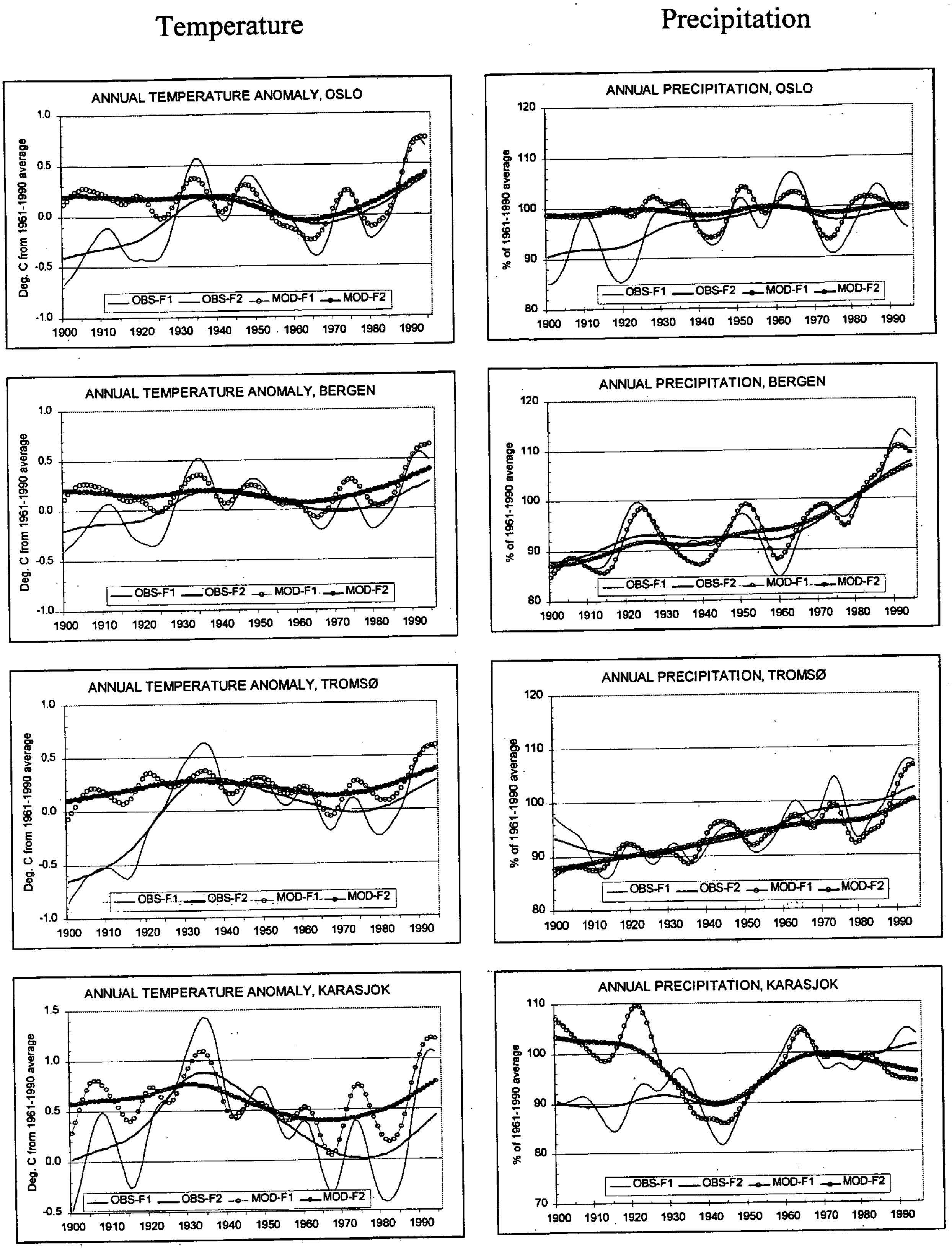


Figure 11. Low-pass filtered series of observed and modelled annual temperature anomalies (left) and annual precipitation (right). The filters include Gaussian weigthing of the observations. The standard deviations of the Gauss distributions are 3 years (F1) and 9 years (F2).

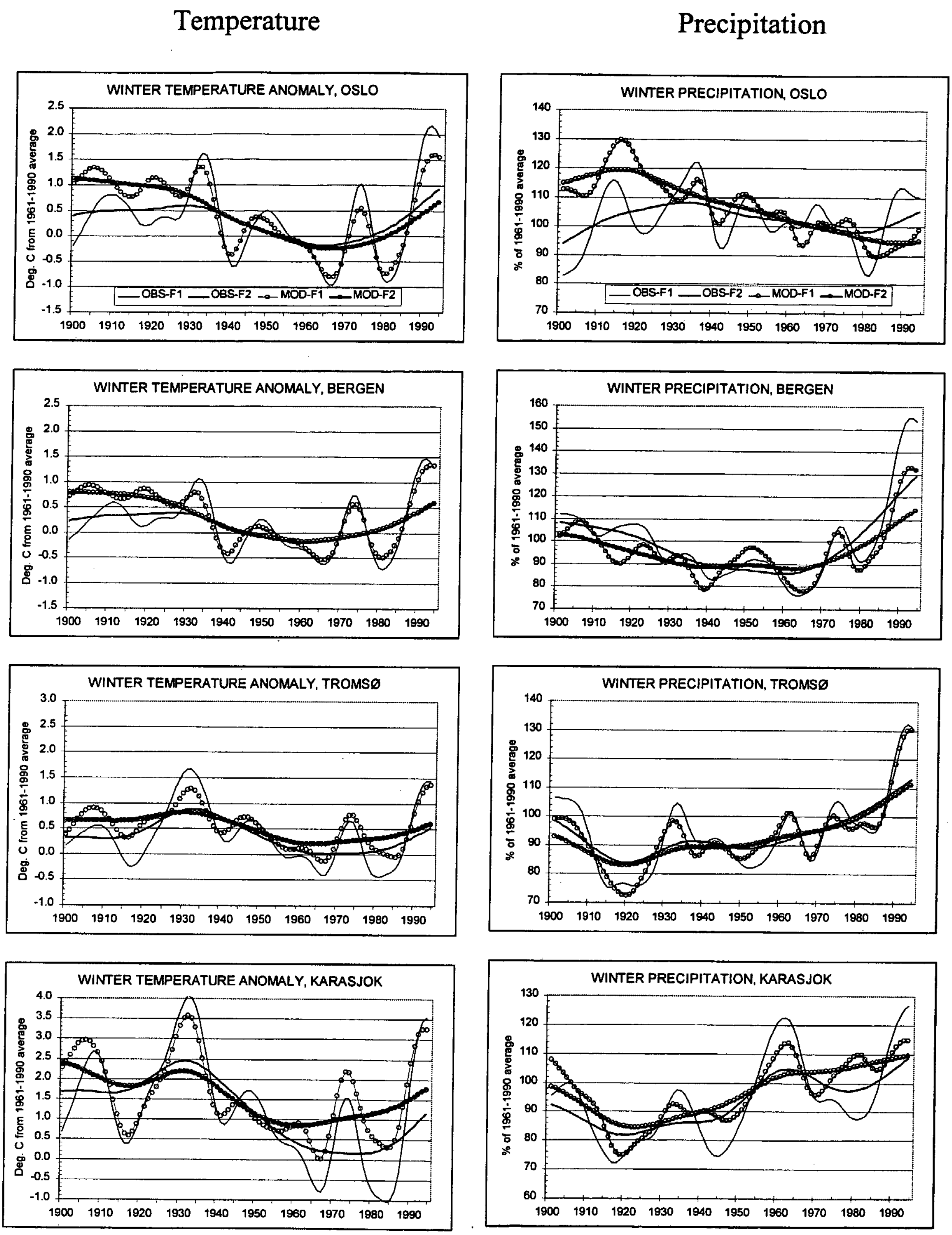


Figure 12. Low-pass filtered series of observed and modelled winter temperature anomalies (left) and annual precipitation (right). The filters include Gaussian weigthing of the observations. The standard deviations of the Gauss distributions are 3 years (F1) and 9 years (F2).

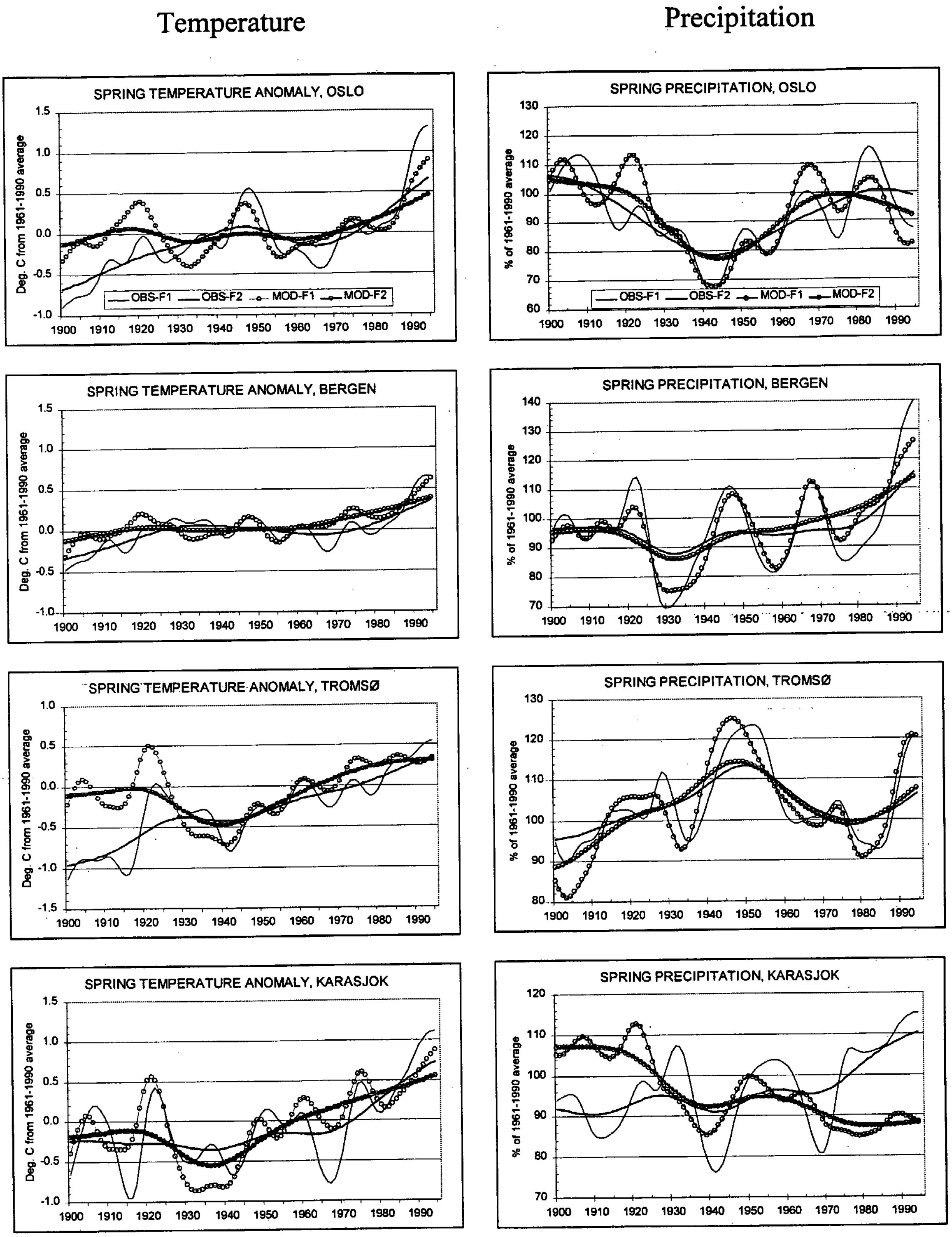


Figure 13. Low-pass filtered series of observed and modelled spring temperature anomalies (left) and annual precipitation (right). The filters include Gaussian weigthing of the observations. The standard deviations of the Gauss distributions are 3 years (F1) and 9 years (F2).

Temperature

Precipitation

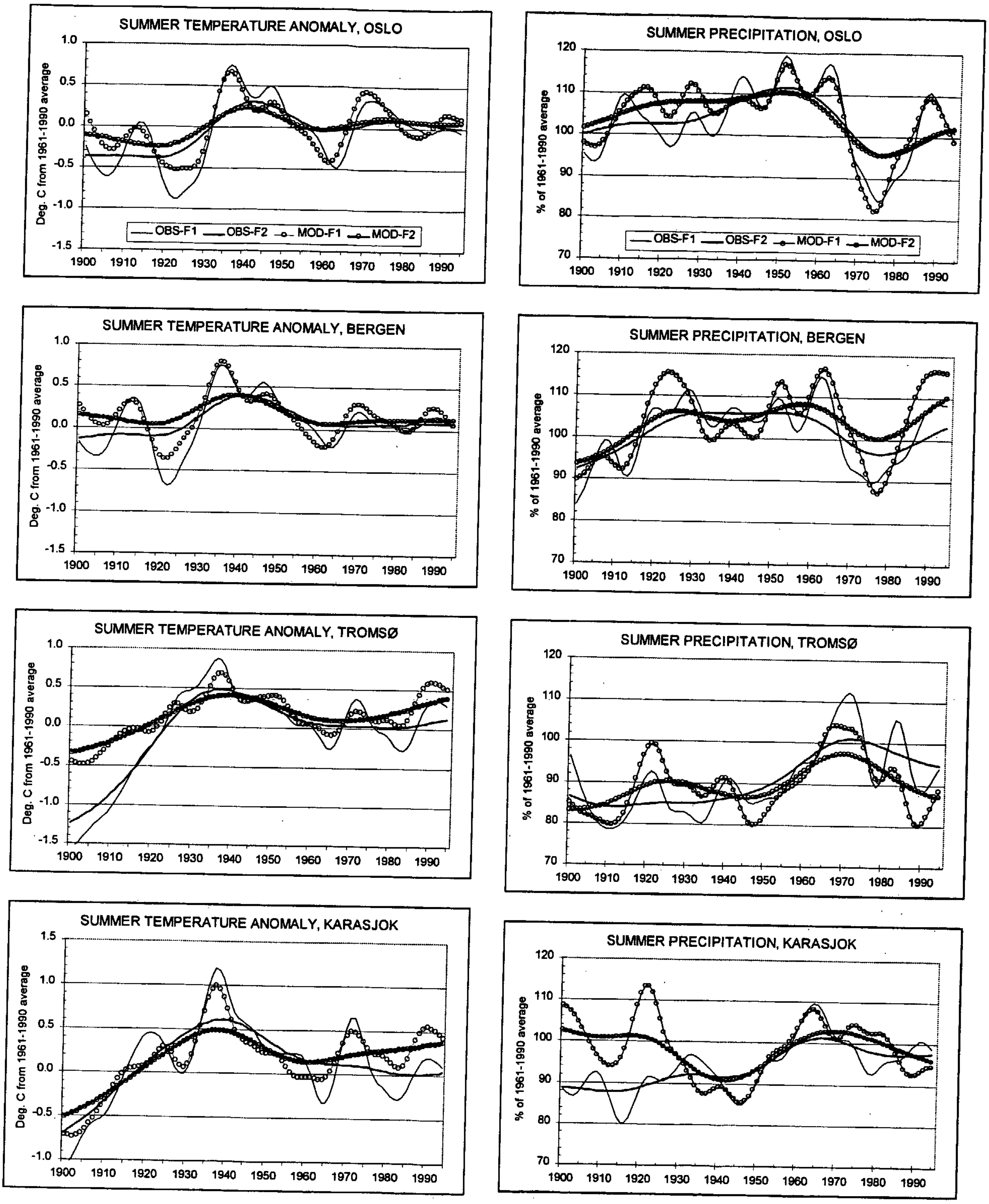


Figure 14. Low-pass filtered series of observed and modelled summer temperature anomalies (left) and annual precipitation (right). The filters include Gaussian weigthing of the observations. The standard deviations of the Gauss distributions are 3 years (F1) and 9 years (F2).

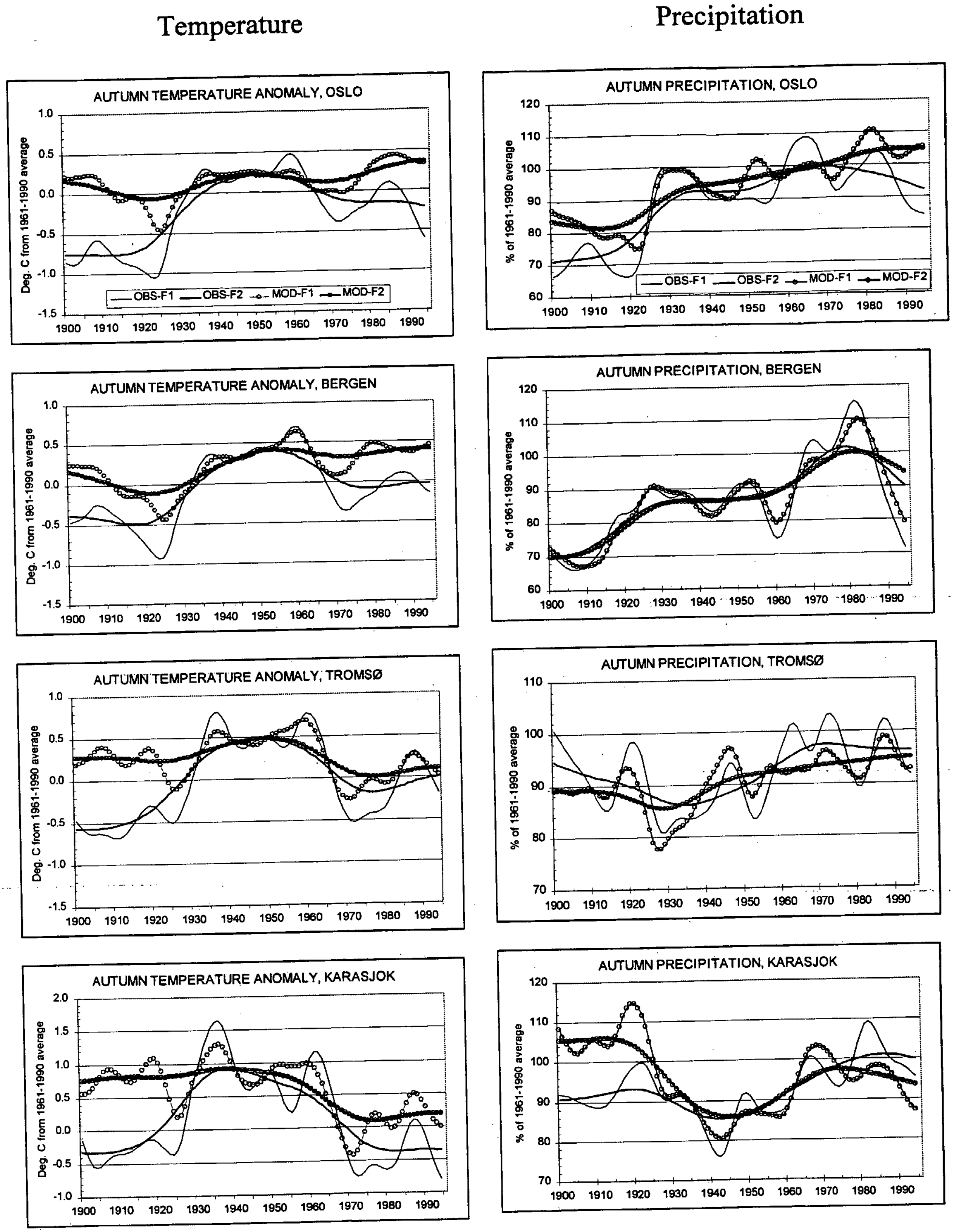


Figure 15. Low-pass filtered series of observed and modelled autumn temperature anomalies (left) and annual precipitation (right). The filters include Gaussian weigthing of the observations. The standard deviations of the Gauss distributions are 3 years (F1) and 9 years (F2).

while the spring- and summer models contribute seriously to the "missing warming" before 1940 (Figures 13 and 14).

Concerning the "missing" precipitation trend in Oslo before 1940, it is clear that malfunction of the winter models is the main reason for this (Figure 12), though there are also some problems with modelling the autumn precipitation (Figure 15). Spring- and summer precipitation (Figures 13 and 14) are modelled quite satisfactory Oslo. In Bergen and Tromsø, long-term trends and decadal scale variability are modelled very well in all seasons. In Karasjok, on the other hand, only the winter precipitation is modelled satisfactory, while spring precipitation models are quite useless, and the summer and autumn models fail to give the observed trends before 1940.

5. Conclusions and discussion

5.1 Conclusions concerning the models

The models, which use principal components from the SLP-field as input, account for a considerable part of the temperature and precipitation variability in southern and north-western parts of Norway. In a "transition zone" in mid-Norway, and in the north-eastern part of the country, the models (especially the precipitation models) are less satisfactory. For several models, large differences were found between the correlation coefficients for the two different validation periods. This may indicate a non-stationary character of the connections between atmospheric circulation and regional climate conditions.

5.2 Conclusions concerning temperature and precipitation variability and trends

Main results, precipitation:

- Long-term trends and decadal scale variability in annual and seasonal precipitation in western parts of Norway (both in the north and in the south) are very well accounted for by the models.
- The only serious discrepancy between the model results and the observed precipitation in south-eastern Norway, is that the winter precipitation increased during the period 1900-1940, while the model gave no such increase.
- In the northern inland region, there are serious discrepancies between observed and modelled precipitation in all seasons except during the winter.

Main results, temperature:

- Long-term trends and decadal scale variability in temperature were reasonably well accounted for after 1930, at least during winter, spring and summer.
- The main discrepancy between the model results and the observed temperature, is that the model gives no warming in the period 1900-1940, while observations from the entire country show a statistically significant warming during this period.

Concerning the mismatch between the observations and model results in the northern inland region (especially for precipitation), we conclude that it is at least partly caused by the fact that the SLP-area (Figure 2) is not optimal for describing the atmospheric circulation modes in this area. The results from this region are thus not referred to in the following discussion.

Concerning the southern and north-western parts of Norway, we conclude that the variation in atmospheric circulation can explain most of the observed trends and decadal scale variability we have seen in temperature and precipitation since 1940. In western parts of the country, variation in atmospheric circulation can also explain most of the observed trends and decadal scale variability in precipitation during the period 1900-1940. In south-eastern parts of the country, however, there was a positive trend in winter precipitation in the period 1900-1940, which our models do not reproduce. In this period, there was also a positive trend in the annual mean temperatures all over the country, which we are unable to model using the SLP field as the only predictor.

5.3 Discussion of the results

We want to focus on two aspects of the above results:

1) Why don't the models account for the warming before 1940?
2) Why do the models mainly account for the warming during the last 3 decades ?

The reason why the models don't account for the warming before 1940, might have been that the data quality was inferior to what it has been in the later years. However, this possibility was excluded (cf. chapter 2). We therefore conclude that the temperature increase from 1900 to 1940 (and probably parts of the following temperature decrease) was not caused by systematic changes in the atmospheric circulation. Thus, we suggest that this warming was caused either by changes in one of the external forcings of the climate system, or by internal air-sea (eventually air-sea-ice) interactions, or maybe by a combination of these. We suggest the following possibilities:

- Increased concentration of greenhouse gases is one candidate for explaining this warming. However, we do not believe that this is the full explanation, as the concentration of greenhouse gases did not increase that much during this period (e.g. IPCC 1996).

- Variation in aerosol concentration is another candidate for explaining the warming in the period before 1940. The direct effect of an increase in antropogenic sulphate aerosols should rather contribute to a cooling, but natural variation in volcanic aerosols might be able to explain some of the observed temperature increase.
- Variation in cloud cover would affect the radiation budget of the ground. Tuomenvirta et al. (1999) documented that, especially during winter, minimum temperatures increased more than maximum temperatures in Fenno-Scandia from 1910 to the 1930s. This is consistent with the fact that the cloud cover anomaly shows a positive trend during the same period. During winter at high latitudes, increased cloud cover often leads to a warming, as net heat loss from the ground is reduced. However, if increased cloud cover is the main reason for the warming prior to 1940, it still remains to find the reason for the increase in the cloud cover.
- Variation in solar radiation connected to solar activity is a somewhat controversial candidate for explaining the temperature increase before 1940. Several studies show statistical indications for connection between solar activity and the global temperature mean (Friis-Christensen and Lassen 1991, Schönwiese et al. 1994). Recently, Tett et al. (1999), after considering several candidates concluded that "solar forcing may have contributed to the temperature changes early in the century". However the physical connection is not fully understood or explained, though Svensmark and Friis-Christensen (1997) suggest that influence of cosmic ray flux on global cloud cover may be "the missing link".
- Air-sea (evt. air-sea-ice) interactions might also explain the temperature increase from 1900 to 1940, e.g. if variations in the ocean circulation has led to changes in the SSTs or in the sea-ice distribution in the northern North Atlantic.

It remains a challenge to find the reason for the warming which was observed during the period 1900-1940. This warming, though it is reflected also in the global temperature series, has a spatial signature quite different from - and less uniform than - the global warming which has taken place during the last 3-4 decades. The 1900-1940 warming was most pronounced at high northern latitudes. Among the Norwegian series, we find the most pronounced warming at the Svalbard archipelago, where the temperature level in the 1930's is the highest in the present century (Førland et al. 1997). Also on Svalbard, a simple circulation model based upon gridded SLP values failed to account for this temperature increase (Hanssen-Bauer & Førland 1998b).

The second question we want to address is how these circulation based models can account for the warming during the last 3 decades, which on a global scale is probably, at least partly, the result of increasing concentrations of greenhouse gases (e.g. IPCC 1996). We have two comments on this:

- Results from GCM runs with increasing concentrations of greenhouse gases show an area with relatively small thermal response in the northern North Atlantic. Thus it may be true that Norway has not experienced very much of the "global warming" yet.
- The enhanced greenhouse effect may have affected the atmospheric circulation system. Thus it may still be an indirect cause of the warming which is accounted for by the models.

5.4 Implications for downscaling of future climate

The above results demonstrate that the dominating atmospheric circulation patterns have large influence on the climate in Norway. Changes in the frequencies of such patterns, whether they are natural or not, will thus influence the local climate. Empirical downscaling models including relevant circulation indices will take care of this aspect.

However, the local climate is also affected directly by changes in the external forcings. A central point when using empirical downscaling, is that the climate signals caused by changes in external forcings should be expressed by at least one of the large-scale predictors. In the present report, the aim was to identify the local climate variability that was connected to atmospheric circulation alone. Thus the SLP-field was used as the only predictor. But the SLP-field does not reflect the direct "greenhouse signal". When developing downscaling models for making local future climate scenarios, it is consequently important to include an additional large-scale predictor which carries this signal. For developing temperature scenarios, the large-scale air temperature, the SST or e.g. the 500–1000 hPa thickness may be used as predictor in addition to some circulation index.

But still: No downscaling model can describe changes or variability that is not somehow included in the AOGCM from which the predictor fields are taken. It is thus important that all relevant changes in the external forcings are described by the AOGCM. Changes in the "greenhouse-forcing" are certainly taken care of by these models, and increased concentrations of antropogenic aerosols are included in several of the later model runs. But the inability of the AOGCMS to reproduce the global warming prior to 1940 show that there are still mechanisms that are not sufficiently well described by these models.

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APPENDIX

Regression coefficients in the equation:

$$X = B0 + \sum_{i=1}^{16} Bi*Pi \quad ,$$

where X is the standardised regional temperature (T01,..,T06) or precipitation (R01,...,R13), B0 is the constant term and Bi is the regression coefficient corresponding to the i'th principal component Pi.

Table A-1 : JANUARY

	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
T01	-0.65	-0.025		0.010	0.033	0.013		0.029		0.064	0.042					-0.080	-0.155
T02	-0.84	-0.029	-0.008	0.013	0.042	0.010		0.025		0.053	0.043						-0.221
T03	-0.65	-0.026	0.003	0.016	0.044	0.008		0.028		0.058			-0.072		-0.036	-0.102	-0.188
T04	-0.22	-0.019		0.029	0.042	0.015			0.023						-0.122	-0.115	
T05	0.01	-0.016		0.026	0.048	0.014		-0.023	0.061						-0.115	-0.095	
T06	-0.25	-0.021		0.030	0.045			-0.029				-0.025	0.102			-0.063	
R01	0.84	-0.008	-0.009	-0.008		0.003	0.000	0.027		0.021	0.026	0.045				-0.058	
R02	0.85	-0.006	-0.013	-0.007		0.007	-0.009	0.023		0.023	0.021	0.068				-0.057	
R03	0.81	-0.008	-0.015	-0.000		0.006	-0.016	0.017		0.013	0.000	0.070				-0.079	
R04	0.70	-0.015		-0.002	0.013	0.012	-0.004	0.031		-0.002	0.007	0.019					
R05	0.61	-0.016	0.002		0.013	0.010	0.000	0.031		0.007	0.000					-0.000	
R06	0.57	-0.017	0.005		0.027	0.012	0.011	-0.018		0.021	0.000					0.068	
R07	0.90	-0.004	0.008	-0.006		0.000		0.028		0.038	0.029					-0.000	
R08	0.92	-0.007	0.020	-0.005		0.003	0.005	0.023	-0.020	0.031	0.000		-0.005				
R09	1.10		0.020	-0.003		0.000	0.003	0.018	-0.009	0.012	0.000		-0.036		-0.045		
R10	0.88	-0.006	0.016	0.002	0.023	0.008			-0.014	0.000	-0.035		-0.036		-0.048		
R11	0.95	-0.002	0.018	0.007	0.026	-0.018			0.018	0.000	0.000					-0.032	
R12	0.89		0.011		0.016	-0.009	0.000			0.000	0.000	-0.047					
R13	0.84		0.005	-0.006	0.016	-0.012	0.013			0.000	0.000				0.046		-0.006

Table A-2 : FEBRUARY

	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
T01	0.03	-0.017	0.016			0.016	0.011		0.068	0.022							0.062
T02	-0.01	-0.020	0.011			0.011	0.014	0.019	0.081						0.097		
T03	-0.20	-0.021	0.017	0.007	0.020	0.010			0.077	0.018					0.101		
T04	-0.34	-0.016	0.010	0.022	0.022	0.006		-0.044						-0.022	0.076		
T05	-0.19	-0.015	0.018	0.011	0.017									-0.076			
T06	-0.20	-0.017	0.012	0.008	0.028									-0.128	0.043		0.140
R01	0.84	-0.012	-0.007	-0.007		0.004	-0.010	0.017	0.026						0.100		
R02	1.05	-0.012	-0.013	-0.005		0.008	-0.013	0.024	0.044			0.065	0.028		0.118		
R03	1.12	-0.014	-0.020	-0.005		0.011	-0.017	0.011	0.050			0.092	0.080		0.110		
R04	1.00	-0.011		-0.008		0.018	0.003	0.009			0.058	0.075					
R05	0.97	-0.016	0.006	-0.005		0.018	0.009	0.030					-0.059				0.102
R06	1.13	-0.015	0.015	-0.006		0.016	0.015	0.047		0.003			-0.078		-0.075		0.113
R07	1.12	-0.004	0.015	-0.012		0.007		0.034		0.018	0.034			0.041			
R08	1.19	-0.007	0.023	-0.014		0.012		0.037		0.018	0.008		-0.066	0.047	-0.076		
R09	0.98	-0.002	0.020	-0.006	0.017		0.005			0.035	0.023	-0.037		0.089			
R10	0.95	-0.007	0.015		0.023		0.016			0.014		-0.036		0.029	-0.063		
R11	0.95	-0.002	0.015	0.002	0.012	-0.009	0.012			-0.023	-0.025	-0.026					
R12	1.10		0.014	-0.003	0.005	-0.013	0.010		0.022			-0.016					
R13	1.25	0.008	0.008	-0.012		-0.023	0.003			-0.043			-0.008		-0.046		

Table A-3 : MARCH

	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
T01	0.04	-0.024	0.016	0.013			0.017										-0.119
T02	-0.04	-0.030		0.029			0.027						0.084				-0.224
T03	0.06	-0.031	0.012	0.031	0.006				0.011								-0.145
T04	-0.09	-0.024		0.042	0.008	0.020		-0.047								-0.020	
T05	-0.24	-0.022		0.030	0.018	0.013	-0.005	-0.053				-0.066				-0.061	
T06	-0.20	-0.013	0.005	0.027			-0.027	-0.051						-0.112			
R01	0.72	-0.012	-0.015	-0.003		0.020	-0.012	0.012			0.035						-0.090
R02	0.75	-0.010	-0.014			0.009	-0.020			-0.007	0.034	0.025	0.054			0.068	-0.085
R03	0.82	-0.009	-0.019	-0.005	-0.009	0.008				-0.013		0.021					-0.104
R04	0.80	-0.015		-0.005		0.013		0.015				0.022					
R05	0.79	-0.020	0.003	-0.004	0.010	0.017		0.017									
R06	0.85	-0.019	0.009	-0.001	0.013	0.016	0.016	0.007							-0.020		
R07	1.02	-0.009	0.007	-0.006	0.011	0.009			0.012		0.071		0.085	0.056	0.076		
R08	1.02	-0.006	0.025	-0.007		0.002	0.014	0.011		0.039					-0.087		
R09	1.24		0.026	-0.005			0.026	0.028		0.057	0.057						
R10	1.10	-0.008	0.025		0.011		0.015							0.041	-0.129		
R11	1.06	-0.003	0.024	0.007	0.024	-0.022					-0.051					0.036	
R12	0.87	-0.006	0.004		0.024						0.041	-0.038				0.048	
R13	1.15	0.004		-0.009	0.020	-0.010	0.021			-0.039							

Table A-4 : APRIL

	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
T01	0.56	-0.030	0.008	0.021				-0.043			-0.135						-0.103
T02	0.71	-0.026	-0.019	0.037				-0.048			-0.110		0.188				-0.162
T03	0.70	-0.029	-0.017	0.042				-0.036			-0.137		0.073				-0.111
T04	0.34	-0.024	-0.018	0.039	-0.029	0.043	-0.021	-0.052			-0.063					-0.036	-0.085
T05	0.37	-0.030	-0.011	0.050		0.045	-0.057	-0.065			-0.031						
T06	0.50	-0.034	-0.007	0.035		0.058	-0.041	-0.055		0.091							
R01	1.24	-0.011	-0.022			0.017	-0.034	0.044	0.050		0.037	0.010			0.048		
R02	1.17	-0.008	-0.025			0.028	-0.052	0.017	0.058		0.070				0.011		
R03	1.12	-0.009	-0.024			0.029	-0.048	0.009				0.011			0.033		
R04	1.44	-0.023		-0.006	0.006	0.011		0.019				0.023	-0.043				
R05	1.55	-0.028	0.007	-0.009	0.010	0.005		0.035									
R06	1.61	-0.031	0.023		0.008		0.034	0.030		0.036	-0.056				-0.114		
R07	1.10		-0.003	-0.008	-0.002		-0.021	0.008	0.046		0.075			0.120	0.071	-0.048	
R08	1.08	-0.013	0.028	-0.009	0.028					0.038		-0.077		0.027			
R09	0.97	-0.004	0.025	-0.005	0.022		0.017			0.013	-0.026	-0.046		0.051			-0.069
R10	1.13	-0.016	0.019		0.028		0.007	-0.003		0.017	-0.039	-0.045			-0.049	0.040	
R11	1.19	-0.010	0.015	0.012	0.018	-0.010		-0.012			-0.019					0.073	
R12	0.94	-0.004			0.021	0.028					0.028		-0.070		-0.081		
R13	0.87			-0.013	0.030	0.008			0.009	-0.018		-0.029				0.089	

Table A-5 : MAY

	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
T01	-0.01		-0.020	0.069		-0.023	0.051	-0.079			-0.043						
T02	-0.41	0.010	-0.062	0.053	-0.016	-0.016		-0.086	-0.109				0.137				
T03	-0.38		-0.061	0.058	-0.026			-0.019	-0.078		-0.061						
T04	0.03	-0.008	-0.053	0.057	-0.046	0.062	-0.015		-0.024	0.050	-0.055		0.075				
T05	0.58	-0.019	-0.040	0.067	-0.026	0.055	-0.029		-0.078	0.073		-0.037					
T06	0.98	-0.024	-0.034	0.076		0.072	-0.014	-0.062	-0.034	0.115		-0.016					
R01	1.34	-0.015	-0.019	-0.007		0.034	-0.004	0.016			0.058	0.085		0.048	0.117		
R02	1.22	-0.012	-0.028		-0.015	0.018	-0.021	0.034				0.068			0.091		
R03	1.46	-0.016	-0.037			0.006	-0.015	0.016							0.132	0.148	
R04	1.55	-0.023	-0.021			0.015	-0.019	0.040									
R05	1.47	-0.022	-0.009			0.011		0.049				0.065	-0.038	0.043			
R06	1.56	-0.024	0.012		0.021	0.005	0.013	0.065		0.038					-0.021		0.077
R07	0.68				-0.028	0.028	0.014	0.055			0.009	0.139		0.148		-0.136	
R08	1.35	-0.014	0.024	-0.010	0.026			0.059						0.022	-0.058		
R09	1.25	-0.008	0.016		0.017			0.036	0.032	0.007	-0.008		-0.076	0.046	-0.075		
R10	1.26	-0.011	0.018		0.029			0.033			-0.054		-0.125	0.053	-0.122		
R11	1.08	-0.004	0.022	0.004	0.025	-0.023				-0.037	-0.038		-0.170		-0.138		
R12	1.18	-0.008			0.039	-0.003				0.005	0.079		-0.158	-0.046		0.072	
R13	1.14		0.009		0.060	-0.015			0.019	-0.055		-0.029				0.042	

Table A-6 : JUNE

	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
T01	-0.52	0.015	-0.027	0.050	-0.070	-0.037	0.047	-0.087		-0.058							
T02	-0.16	0.022	-0.062	0.039	-0.086	-0.020		-0.091	-0.050	-0.090			0.121		0.089		
T03	-0.01	0.001	-0.062	0.047	-0.095			-0.048		-0.069			0.100				
T04	0.02		-0.054	0.013	-0.092	0.060					-0.007		0.097		-0.182		
T05	0.32		-0.039	0.045	-0.075	0.079				0.034	-0.028	-0.009	0.098				
T06	0.59	-0.027	-0.015	0.041	-0.039	0.058		-0.014		0.074							
R01	1.07	-0.005	-0.008		-0.014	0.030	-0.036	0.031	0.021		0.029	0.050			0.077		
R02	1.12	-0.008	-0.011	-0.010	-0.026	0.013	-0.034	0.027				0.062			0.133		
R03	1.40	-0.013	-0.021	-0.015	-0.025	0.015	-0.040					0.030	0.070		0.225	-0.050	
R04	1.39	-0.022	-0.006			0.014		0.029			-0.020	0.057		-0.057	0.086		
R05	1.43	-0.027				0.018		0.032				0.038	-0.049				
R06	1.43	-0.033	0.015		0.012	0.006	0.015	0.033		0.078	-0.010		-0.067				
R07	0.86				-0.014	0.014		0.020	0.090			0.098	-0.035				
R08	0.96	-0.011	0.029	-0.011	0.013		0.024	0.024	0.042	0.035	-0.011		-0.089				
R09	1.00	-0.006	0.026		0.012		0.016	0.055	0.060		-0.066		-0.078				
R10	1.38	-0.016	0.021		0.036	0.006		0.028		0.013	-0.072	-0.052	-0.071	-0.072		0.057	
R11	1.16	-0.014	0.023	0.006	0.026						-0.028		-0.063		-0.067		
R12	0.54		0.017	-0.023			-0.018			0.005			-0.159	-0.093	-0.146	-0.111	
R13	1.08		0.006		0.029	-0.018	-0.023			-0.059		-0.084		-0.009			

Table A-7 : JULY

	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
T01	0.07	0.021	-0.039	0.047	-0.072	-0.070		-0.166		-0.244	-0.134	-0.147				-0.148	
T02	0.22	0.013	-0.066	0.027	-0.091	-0.060		-0.128		-0.199				0.193			
T03	0.06	0.014	-0.084	0.037	-0.126			-0.071		-0.157				0.225			
T04	0.09		-0.075	0.012	-0.111	0.068		0.028					0.030	0.022	-0.079		-0.116
T05	0.11		-0.071	0.030	-0.121	0.096								0.262	-0.102		-0.140
T06	0.15	-0.026	-0.047	0.024	-0.076	0.134			-0.066	0.149				0.120		-0.108	
R01	1.08	0.007	-0.022	-0.018	-0.006	0.008	-0.042			0.022							
R02	1.12	0.007	-0.024	-0.016	-0.005	0.010	-0.029	0.022				0.024			0.061	0.078	
R03	1.49	-0.006	-0.039	-0.010		0.012	-0.013						0.020		0.260		
R04	1.12	-0.012	-0.012					0.040			-0.062	0.020	-0.057				
R05	1.20	-0.014			0.016			0.056		0.023		0.067	-0.032			0.105	
R06	1.60	-0.024		0.013	0.033	0.025	0.019	0.052		0.016		0.031				0.078	
R07	1.08						-0.026		0.062				-0.082		-0.196		
R08	1.00	-0.015	0.004	-0.009	0.010		0.016	0.027	0.022	-0.048			-0.071				
R09	1.25	-0.012	0.002		0.025		0.012	0.020			0.038		-0.045	0.043	-0.073		
R10	1.25	-0.013	0.011	0.005	0.034	0.008	0.018	0.010		0.010	-0.003		-0.088		-0.049		-0.046
R11	1.22	-0.011	0.012	0.010	0.037					0.014	-0.040		-0.061				
R12	1.00	-0.006	0.010		0.011	0.024	-0.014	0.014					-0.072		-0.099	-0.065	
R13	0.80		0.018		0.014	-0.011	-0.019			-0.019			-0.121	-0.048			

Table A-8 : AUGUST

	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
T01	-0.16	0.031	-0.017	0.034	-0.061	-0.014	0.018	-0.062	-0.086	-0.024		-0.153	-0.064				
T02	-0.38	0.042	-0.038	0.022	-0.101	-0.012	0.015	-0.054	-0.060	-0.064							
T03	-0.29	0.033	-0.057	0.035	-0.098				-0.077	-0.048						0.174	
T04	0.09		-0.074	0.004	-0.094	0.054	0.031		-0.077							0.172	
T05	0.09		-0.066	0.009	-0.115	0.084		-0.051	-0.114						-0.075		
T06	0.14	-0.010	-0.034	0.013	-0.076	0.064			-0.123	0.232							
R01	1.07	-0.009	-0.023		-0.011	0.003		0.017	0.061		0.057	0.118					
R02	1.02	-0.010	-0.031		-0.021	0.007	-0.018	0.037				0.123			0.134		
R03	1.22	-0.011	-0.041		-0.021		-0.018		0.021	-0.078		0.151					
R04	1.22	-0.020	-0.017														
R05	1.36	-0.024	-0.014		0.015	0.004		0.022				0.062				0.123	
R06	1.17	-0.026	0.009		0.020	0.008	0.023	0.022				0.072	-0.082			0.102	
R07	0.92					0.006			0.040	-0.063		-0.044					-0.101
R08	1.54	-0.029	0.008	-0.006	0.031	0.035		0.020		0.043					-0.084	0.212	
R09	1.28	-0.023	0.018	-0.022	0.011	0.044							-0.069	0.064	-0.084	0.121	
R10	1.03	-0.018	0.024	-0.007	0.025		0.022	0.003			-0.023		-0.115	0.067		0.041	
R11	0.92	-0.002	0.018	0.004	0.023	-0.014	-0.014				-0.042		-0.055	-0.012			
R12	1.06	-0.003	0.010		0.019	0.023			0.056				-0.099		-0.052	-0.057	
R13	1.32	-0.003	0.017		0.045	0.015	-0.006	0.018				-0.107	-0.044	-0.056			

Table A-9 : SEPTEMBER

	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
T01	0.34	-0.008	-0.023	0.050		-0.023	0.012		-0.035		-0.084						
T02	0.53		-0.044	0.043	-0.007	-0.040	0.008	-0.021	-0.011	-0.039	-0.046						-0.138
T03	0.66	-0.005	-0.046	0.037				-0.067	-0.021							0.035	-0.279
T04	0.64	-0.013	-0.050	0.025	-0.043	0.030	0.010	-0.109	-0.013	0.052				0.042			-0.201
T05	0.65	-0.016	-0.039	0.024	-0.028	0.037		-0.117		0.072			-0.050			-0.013	-0.217
T06	0.04	-0.013	-0.005	0.025	-0.076	0.047	0.031			0.062	-0.061	0.166	-0.078				
R01	0.76	-0.005	-0.007		-0.006	0.015	-0.004	0.060	0.085	-0.062	0.034	0.077				-0.075	0.096
R02	1.05	-0.002	-0.020	-0.003	-0.006	0.013	-0.015	0.017				0.043		0.010	0.076		
R03	1.07	-0.001	-0.024	-0.006	-0.002		-0.022			-0.036		0.032			0.096		
R04	0.86	-0.013	-0.004			0.014	-0.009	0.043				0.008	-0.020		0.042		0.089
R05	0.83	-0.014	-0.005		0.002	0.016	-0.013	0.032									0.117
R06	0.76	-0.015	0.005		0.009	0.019		0.019			-0.007	0.007					
R07	0.97				-0.001			-0.024			0.007		-0.075		0.010		
R08	0.79	-0.010	0.015	-0.001	0.012	0.005			0.030		0.024				-0.113		-0.075
R09	0.80	-0.004	0.017	-0.005	0.014		0.006	0.014						0.015	-0.085		
R10	0.85	-0.006	0.014		0.025		0.005				-0.022	-0.029	-0.044		-0.054		
R11	0.87		0.018	0.005	0.023	-0.028					-0.068		-0.081	-0.012		-0.069	
R12	0.98		0.003	-0.007	0.009	-0.013			0.054		-0.015		-0.129	-0.051	-0.095		0.061
R13	1.11	-0.002	0.006		0.024	-0.008							-0.066		0.061		0.056

Table A-10 : OCTOBER

	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
T01	-0.76	-0.022	-0.009	0.033	0.014	0.019		0.088			-0.117	0.098		0.163		-0.078	
T02	-0.87	-0.023	-0.024	0.040	0.033	0.019		0.071			-0.154	0.101	0.088	0.190			
T03	-0.91	-0.022	-0.017	0.054	0.019	0.024		0.057		0.023	-0.127			0.138			
T04	-0.42	-0.017	-0.012	0.052	-0.019	0.029		0.019	-0.015		-0.096	-0.016					
T05	-.20	-0.016		0.048	-0.038	0.026	-0.008				-0.049		-0.122	-0.025			
T06	-0.26	-0.021	-0.001	0.050	-0.030	0.031	-0.016		-0.015	0.014			-0.095	-0.053			
R01	0.67	-0.014	-0.015	-0.004		0.003	-0.016	0.035							0.061		-0.058
R02	0.71	-0.009	-0.016			0.013	-0.028	0.037					0.044		0.081		-0.062
R03	0.80	-0.007	-0.015		-0.008	0.014	-0.028	0.036	0.015						0.078		-0.022
R04	0.72	-0.014	-0.006	-0.006	0.007	0.010		0.022				0.005		0.026			-0.047
R05	0.79	-0.014		-0.005		0.012	0.004	0.033			0.011	0.010	-0.021				
R06	0.74	-0.014	0.004		0.012	0.005	0.001	0.036		0.041	0.013						
R07	0.86										-0.014		0.042				
R08	0.86	-0.008	0.023	-0.011	0.013		0.004	0.024	0.025							-0.053	
R09	0.94	-0.005	0.021	-0.008	0.017		0.006	0.017	0.016								0.088
R10	0.78	-0.005	0.018		0.017			0.025			-0.015				-0.011	-0.031	
R11	0.70	-0.003	0.013	0.006	0.022	-0.011	-0.002				-0.039						
R12	0.84			-0.002	0.011			0.028	0.025				-0.044	-0.044	-0.005		
R13	0.91	0.001	0.008	-0.004	0.015	-0.011			0.022	-0.049							0.083

Table A-11 : NOVEMBER

	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B1
T01	0.01	-0.023	-0.001	0.014	0.017	0.035	0.018	0.053					-0.223	0.023			0.0
T02	-0.07	-0.022	-0.012	0.015	0.024	0.032	0.028	0.060	-0.047							-0.183	0.0
T03	0.27	-0.018	-0.001	0.017	0.022	0.048	0.019	0.046			-0.031		-0.225	0.032		-0.175	
T04	0.23	-0.016	-0.005	0.028	0.019	0.045	-0.037				-0.067		-0.207		-0.127	-0.118	
T05	0.00	-0.020	-0.006	0.029	0.025	0.042	-0.007	-0.037		0.031			-0.129	-0.068		-0.096	
T06	-0.33	-0.023	-0.008	0.026	0.035	0.039	-0.028			0.062							
R01	0.77	-0.011	-0.010	-0.004	0.008	0.005	-0.011	0.021					-0.047				-0.0
R02	0.74	-0.010	-0.014			0.009	-0.013	0.023							0.018		
R03	0.83	-0.011	-0.019			0.018	-0.011	0.030					-0.057		0.070		
R04	0.64	-0.014	-0.004	-0.002	0.017	0.014		0.027				0.022					-0.0
R05	0.57	-0.016	-0.002	-0.001	0.023	0.011	0.002	0.017			-0.019	0.016					
R06	0.60	-0.015	0.004		0.025	0.015	0.007	0.011		0.002	-0.009						
R07	0.89			0.006		0.005				-0.020	-0.031			0.024			
R08	1.04	-0.005	0.022	-0.004	0.003	-0.009	0.020					-0.025		0.023	-0.006		0.17
R09	1.05		0.018	-0.007	0.014		0.021			0.003		-0.043		0.029			0.168
R10	1.02	-0.003	0.017		0.019		0.014					-0.042	-0.073		-0.049		0.100
R11	1.01	-0.001	0.017	0.005	0.019	-0.004	0.006					-0.031	-0.084	-0.044	-0.043		
R12	1.02		0.008	-0.005	0.008	-0.002		0.026	0.029			-0.009	-0.098	-0.024	0.003		0.037
R13	0.94		0.002	-0.006	0.010	-0.014	0.009					-0.007		-0.050			

Table A-12 : DECEMBER

	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16
T01	-0.31	-0.021		0.018	0.018	0.007	0.015	0.012			0.036	0.048		0.066		-0.077	
T02	-0.37	-0.023		0.020	0.018	0.010	0.017							0.065		-0.072	
T03	-0.35	-0.018		0.024	0.032	0.008								0.043		-0.043	
T04	-0.05	-0.013		0.032	0.019	0.006	-0.012	-0.032								-0.103	-0.073
T05	0.13	-0.011		0.028	0.016	0.006	-0.022	-0.034					-0.143			-0.023	
T06	-0.21	-0.012		0.037	0.045	0.010	-0.047	-0.045			0.096			-0.066			
R01	0.71	-0.015	-0.013	0.003	0.008	0.018	-0.007	0.020				0.027					
R02	0.82	-0.008	-0.021			0.020	-0.018					0.037		0.088			
R03	0.71	-0.014	-0.028	0.011		0.005	-0.019	0.017						0.037	0.104		
R04	0.65	-0.015			0.002	0.017	0.010	0.027		0.017		0.010		0.032			
R05	0.51	-0.016	0.002		0.011	0.017	0.012	0.016		0.028						0.015	0.033
R06	0.65	-0.013	0.009	-0.003	0.002	0.011	0.019	0.020		0.017							
R07	0.97	-0.002	0.007	-0.008	-0.008	0.008				0.009	0.029			0.084			
R08	0.79	-0.006	0.014	-0.006			0.013	0.008	-0.020	0.023				0.028			
R09	0.99		0.014	-0.008	0.003		0.020			0.002				0.033			
R10	0.86	-0.005	0.013		0.010		0.011				-0.021		-0.038		-0.019		0.012
R11	0.76	-0.004	0.012	0.008	0.021	-0.005		-0.019			-0.018	-0.030					0.036
R12	1.16		0.008	-0.007	0.002	-0.017		0.018		-0.016			-0.065			-0.034	0.085
R13	1.15	0.003	0.007	-0.012		-0.013	0.013		0.037	-0.037				0.038			